







UNCLASSIFIED



# HISTORY OF AIR DEFENSE WEAPONS

## 1946 - 1962

by RICHARD F. Mc MULLEN

### FORMERLY RESTRICTED DATA

Unauthorized disclosure subject to  
Administrative and Criminal Sanctions.  
Handle as Restricted Data in Foreign  
Dissemination Section 144.b., Atomic  
Energy Act 1954.

HISTORICAL DIVISION  
OFFICE OF INFORMATION  
Hq Air Defense Command

EXTRACT CONSISTING OF COVER AND PAGES  
160, 161, AND 291.

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW	
1ST REVIEW DATE: 3-7-76	DETERMINATION (CIRCLE NUMBER(S))
AUTHORITY: <input type="checkbox"/> AD <input type="checkbox"/> AC <input type="checkbox"/> DC <input type="checkbox"/> DD	1. CLASSIFICATION RETAINED
NAME: <i>James C. J...</i>	2. CLASSIFICATION CHANGED TO: <input checked="" type="checkbox"/> F 10
2ND REVIEW DATE: 3-11-76	3. CONTAINS NO LOG CLASSIFIED INFO
AUTHORITY: ADD	4. COORDINATE WITH: <input checked="" type="checkbox"/> DOD
NAME: <i>McMullen</i>	5. CLASSIFICATION CANCELLED
	6. CLASSIFIED INFO BRACKETED
	7. OTHER (SPECIFY): <i>DC (AC) (FR)</i>

UNCLASSIFIED



1950  
1951  
1952

1953  
1954  
1955

1956  
1957  
1958





OFFICE OF  
THE STAFF JUDGE ADVOCATE


4 April 97

TO: 21 CS/SCBR (FOIA)

I HAVE REVIEWED THE PROPOSED HO  
RESPONSE TO THIS FOIA AND  
CONCUR.

Upon completion of the NORAD/  
IS downgrading/declassification,  
PLEASE RETURN THE FILE FOR  
final review.

If you require any further  
assistance, please feel free to call  
4-9193

  
Edward J. Monahan, LtCol, USAF  
Assistant Staff Judge Advocate





~~SECRET~~



NORTH AMERICAN AEROSPACE DEFENSE COMMAND  
AND  
UNITED STATES SPACE COMMAND



07 Apr 97

UNCLASSIFIED

MEMORANDUM FOR 21 CS/SCBR (FOIA)  
660 MITCHELL STREET STE 520  
PETERSON AFB CO 80914-1150

THRU: HQ NORAD/USSPACECOM/JS

FROM: HQ NORAD/USSPACECOM/HO  
250 S. PETERSON BLVD STE 116  
PETERSON AFB CO 80914-3160

SUBJECT: Freedom of Information Act (FOIA) Request, Review of Classified Document  
(FOIA #93-388) (JS Tasker 97-1366)

1. HO received FOIA Case #93-388 on 4 Apr 97. The FOIA request is based upon a letter from Mr. Robert Gates dated 08/16/93, to the ACC FOIA Office. The ACC FOIA Office (thru the 21 SW FOIA Office) sent the letter to USSPACECOM/HO. Copies of the documents were provided by the ACC/FOIA Office. Upon review of these studies, the following comments are provided:

a. ADC Study 14: *History Of Air Defense Weapons, 1946-1962*. Based upon the accompanying correspondence from Air Force Space Command/DOO and Dept of Energy (DOE), this study is releasable except for portions bracketed by DOE on pages 161, 291, and the entire page on 300. Based on this information, ACC/FOIA had authority to release a redacted copy of Study #14 to Mr. Gates. Forwarding of Study #14 to NORAD/HO was not required. **Action:** Study #14 be returned to ACC/FOIA for redacting and release to Mr. Gates. (See Atch #1)

b. ADC Study 15: *The Air Defense Command in the Cuban Missile Crisis*. Correspondence accompanying the study revealed that Air Force Space Command/DOO reviewed this document in November 1985 and annotated a significant number of pages/passages that were still considered classified at that time. **Action:** Under the provisions of the new Executive Order 12958, HO will forward this document to NORAD/JS for downgrading/declassification review.

THIS MEMORANDUM IS UNCLASSIFIED WHEN  
ATCHS #1 & 2 ARE WITHDRAWN

ATCH #1 & 2 ARE FORMERLY RESTRICTED DATA  
US EYES ONLY

~~SECRET~~

UNCLASSIFIED



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UNCLASSIFIED

c. ADC Study 20: *Nuclear Armament: Its Acquisition, Control and Application to Manned Interceptors, 1951-1963*. This document was previously reviewed by Air Force Space Command/DO3 in 1985. At that time, DO3 indicated the document "contain[s] no information pertaining to current capabilities or employment philosophies." A caveat DO3 added was that TAC/DOY review portions pertaining to EC-121 capabilities. (The EC-121 has not been in the USAF inventory for a number of years.) DOE annotated portions of Study #20 in 1985, and 1989 to reflect information that was still carried as Formerly Restricted Data (FRD). During a subsequent DOE review in June 1996, they identified additional information within the study which dealt with locations of nuclear weapons in DOD custody within the United States. They remarked these paragraphs accordingly. Based on this information, ACC/FOIA had authority to release a redacted copy of Study #20 (sans the FRD paragraphs/portions) to Mr. Gates. Forwarding of Study #20 to NORAD/HO was not required. **Action:** Study #20 be returned to ACC/FOIA for redacting and release to Mr. Gates. (See Atch #2)

d. ADC Study 28: *The ADC Airborne Early Warning and Control Program, 1946-1964*. Mr. Gates' letter asked for ADC Study 23 with a title *The ADC Airborne Early Warning and Control Program, 1946-1964*. However, the ADC Study #23 ACC/FOIA sent to us has a different title (*The Air National Guard Manned Interceptor Force, 1946-1964*). Checking our records, we do have a copy of *The ADC Airborne Early Warning and Control Program, 1946-1964*, but it is ADC Study 28. This study was previously declassified on 6 Nov 85. **Action:** A copy of the declassified Study #28 is attached for release to Mr. Gates. (See Atch #3)

e. ADC Study 25: *Interceptor Dispersal, 1961-1964*. Correspondence accompanying the study revealed that DOE reviewed the study and remarked it from Restricted Data to Formerly Restricted data. Also, there is no indication that the document has been previously reviewed by Air Force Space Command or NORAD. **Action:** Under the provisions of the new Executive Order 12958, HO will forward this document to NORAD/J3 for downgrading/declassification review.

2. Request an extension of the suspense for reviewing Study #15 and #25 from 15 April 1997 to 16 May 1997. This will permit sufficient time for NORAD/J3 to complete a declassification review of these two studies.

3. Please refer any questions to the undersigned or Mr. Schroeder, 4-5999/3385.



THOMAS FULLER  
Command Historian

3 Atch

1. ADC Study 14 (S/FRD) *History Of Air Defense Weapons, 1946-1962*.
2. ADC Study 20 (S/FRD) *Nuclear Armament: Its Acquisition, Control and Application to Manned Interceptors, 1951-1963*.
3. ADC Study 28 (U) , *The ADC Airborne Early Warning and Control Program, 1946-1964*.

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UNCLASSIFIED







~~SECRET~~  
DEPARTMENT OF THE AIR FORCE

21ST SPACE WING (AFSPC)

U.S. AIR FORCE



MEMORANDUM FOR USSPACECOM/JS

HQ USSPACECOM/HO

HQ USSPACECOM/JA

IN TURN

04 APR 1997

FROM: 21 CS/SCBR (FOIA)  
660 MITCHELL ST STE 500  
PETERSON AFB CO 80914-1150

SUBJECT: Freedom of Information Act (FOIA) Request from Robert S. Gates -  
97-U-014 SUSPENSE DATE: 15 Apr 97

1. Attached FOIA request is forwarded for your action per DoD 5400.7-R, DoD Freedom of Information Act Program. The attached documents were forwarded from the HQ ACC/SCBP (FOIA) Langley AFB VA, for your review and recommendations regarding releasability (attachment 1).
2. To meet the requirements of DoD 5400.7-R, paragraph 5-203, do the following:
  - a. A "line-by-line" review of the record that qualifies for withholding under FOIA.
  - b. Disclose meaningful, nonexempt portions that can reasonably be separated.
  - c. Delete exempt portions. Justify deletions in writing and cite the applicable FOIA exemption(s) in DoD 5400.7-R, paragraph 3-200. For each record or portion that technically qualifies for withholding under a FOIA exemption, there must also be a significant and legitimate government purpose served by withholding. Note: We must provide this rationale to the requester when denying a record or any portion of a record.
  - d. If exemption "b(1)" is used to deny records or portion(s) of records, include in your reply that "Those records (portion(s) of records) denied using Exemption "b(1)" have been reviewed and are currently and properly classified pursuant to Executive Order 12958."
3. You will need to prepare a letter to us providing your recommendation on the releasability of this document.
4. Provide the following if record is:
  - a. Total denial. One unsanitized copy (bracketed IAW para 2c above).
  - b. Partial Denial. One unsanitized copy and one sanitized copy (see para 2c above).
  - c. Total Release. One copy.

WHEN SEPARATED FROM ENCLOSURES  
THIS DOCUMENT BECOMES UNCLASSIFIED



*Golden Legacy. Boundless Future... Your Nation's Air Force*



5. Coordinate the package with your security manager.
6. Complete and return DD Form 2086 with FOIA package (attachment 2).
7. To comply with FOIA time limits, please respond by 15 Apr 97. If you cannot meet this suspense date, you must send us a letter requesting an extension and justify why the extension is needed. This request for extension must arrive at our office before the established suspense. Our facsimile number is 6-6497. ALWAYS HAND CARRY FOIA .....ESPONDENCE.
8. The POC for this action is the undersigned, extension 6-7733.



WARREN G. CHRISTIAN  
Assistant FOIA Manager

Attachments:

1. FOIA Request w/atchs
2. DD Form 2086







~~SECRET~~ / ~~TOP SECRET~~

DEPARTMENT OF THE AIR FORCE  
HEADQUARTERS AIR COMBAT COMMAND  
LANGLEY AIR FORCE BASE, VIRGINIA

UNCLASSIFIED

31 Mar 97

MEMORANDUM FOR 21 CS/SCBR (FOIA)

660 Mitchell Street, Suite 520  
Peterson AFB CO 80914-1150

FROM: HQ ACC/SCBP (FOIA)  
204 Dodd Boulevard, Suite 303  
Langley AFB VA 23605-2777

SUBJECT: Freedom of Information Act (FOIA) Request, Review of Classified Document -  
FOIA #93-388

1. Reference the attached FOIA request from Robert S. Gates for copies of various Air Defense Command (ADC) studies. The requester has already received releasable copies of all studies except for studies 14, 15, 20, 23, & 25. Four of the studies (14, 15, 20, & 25) were reviewed by AFSPACECOM in 1985. However, under the new Executive Order 12958, the documents may require an additional classification review. We are also including study 23, as it may include information that requires your review. All previous reviews are included after the cover sheet of each study.
2. Please have interested OPRs review studies 14, 15, 20, 23, & 25 to determine what portions, if any, can be declassified and released to the requester.
3. Make a line-by-line review to determine if the classification is proper and current. If the information can be declassified and released, advise this office of your determination. If you do not recommend declassifying the information, provide a specific reference to the exemptions from 5 United States Code, Section 552(b), and a concise statement of the government interest that would be jeopardized by the release.

WHEN THE ATTACHMENTS ARE WITHDRAWN,  
THIS LETTER IS UNCLASSIFIED

*Global Power For America*


~~SECRET~~

~~TOP SECRET~~

UNCLASSIFIED



4. Include in your response back to us the time spent reviewing the document for declassification and release. Refer any questions to Bill Dooley at DSN 574-2261. This referral was accepted per telecon with Ms. Drayer on this date.

  
JACKIE CANNAN  
Freedom of Information Act Manager  
Office of Information Management

Attachments:

1. Request Letter
2. ADC Historical Study No. 14 (S/FRD)
3. ADC Historical Study No. 15 (S)
4. ADC Historical Study No. 20 (S/RD)
5. ADC Historical Study No. 23 (S/FRD)
6. ADC Historical Study No. 25 (S/FRD)





P.O. Box 1609  
Idaho Falls, ID 83403-1609  
08/16/93

HQ ACC/IMD  
Langley AFB, VA 23665-5583

Dear Sirs,

Under the Freedom Of Information Act, I would like to request copies of the following Air Defense Command Historical Monographs:

199  
200  
The Aerospace Defense Anti-Bomber Defense, 1946-1972, AADC Study 39, 1973

210  
Air Defense and National Policy 1951-1957, Study 24

220  
The Birth of SAGE, 1951-1958, Study 33

230  
Aircraft in Air Defense, 1946-1960, Study 14

240  
Command and Control Planning, 1958-1965, ADC Study 35

250  
History of Air Defense Weapons 1946-1962, Study 14

260  
Radar Programs for Air Defense, 1946-1966, Study 34

270  
The ADC Airborne Early Warning and Control Program 1946-1964 ADC Study 23

280  
History of BMEWS, 1957-1964, Study 31

290  
A History of Texas Towers in Air Defense 1952-1964 Study 29

300  
Interceptor Dispersal, 1961-1964 Study 25

310  
Nuclear Armament: its Acquisition, Control and Application to Manned Interceptors, 1951-1963, Study 20

320  
The History of the Ground Observer Corps, Study 36

330  
Seaward Extension of Radar, 1946-1956, Study 10

340  
The Air Defense Command in the Cuban Missile Crisis, Study 15

350  
U.S. Air Defense in the Northeast, 1940-1957, Study 37

230  
I will be willing to pay up to \$400.00 in Search and Reproduction fees. Should my request exceed that, please contact me

Sincerely

  
Robert S. Gates

23 AUG 1993

DENNIS  
93-383

*St. Luke's Episcopal Church*



U.S. DEPARTMENT OF ENERGY LIST OF ATTACHMENTS

Page: 1

Receipt Number: TRSAA20003828

Action Number: 96SA20B000122

Description (Must be Unclassified)	Document Number	Date of Document
ADC HISTORICAL STUDY NO. 14 HISTORY OF AIR DEFENSE WEAPONS 1946-1962 W/ATTACHMENTS Document Type: COMPILED Short Title: 14 Author: RICHARD F MCMULLEN Originating Agency: AF	SAB200099540000	01/01/62
ADC HISTORICAL STUDY NO. 20 NUCLEAR ARMAMENT ITS ACQUISITON, CONTROL AND APPL. TO MANNED INTERCEPTORS 1951-1963 W/ATTACH Document Type: COMPILED Short Title: 20 Author: THOMAS W RAY	SAB200099550000	01/01/63



U.S. DEPARTMENT OF ENERGY LIST OF ATTACHMENTS

Page: 1

Receipt Number: TRSAC20004640

Action Number: 94SA20C000150

Description (Must be Unclassified)	Document Number	Date of Document
HISTORY OF AIR DEFENSE WEAPONS 1946-1962 (U) Document Type: REPORT Author: RICHARD F MCMULLEN Originating Agency: AF Number of Pages: 11	SAC200072670000	
ADC HISTORICAL STUDY NO. 25 INTERCEPTOR DISPERSAL 1961-1964 (U) Document Type: REPORT Author: THOMAS W RAY Number of Pages: 26	SAC200072690000	11/19/85
NUCLEAR ARMAMENT ITS ACQUISITION CONTROL AND APPLICATION TO MANNED INTERCEPTORS 1951-1963 (U) Document Type: COMPILED Author: THOMAS W RAY Number of Pages: 18	SAC200072680000	
INFORMATION FOR REQUESTOR Document Type: CORSPNDNCE	SAC200092740000	



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ADC HISTORICAL STUDY NO. 14

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UNCLASSIFIED

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~~SECRET~~  
~~SECRET~~

# HISTORY OF AIR DEFENSE WEAPONS

## 1946 - 1962

by RICHARD F. Mc MULLEN

### FORMERLY RESTRICTED DATA

Unauthorized disclosure subject to  
Administrative and Criminal Sanctions.  
Handle as Restricted Data in Foreign  
Dissemination Section 144.b., Atomic  
Energy Act 1954.

HISTORICAL DIVISION  
OFFICE OF INFORMATION  
Hq Air Defense Command

EXTRACT CONSISTING OF COVER AND PAGES  
160, 161, AND 291.

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW	
1ST REVIEW DATE: 3-4-76	DETERMINATION (CIRCLE NUMBER(S))
AUTHORITY: <input type="checkbox"/> AOC <input type="checkbox"/> ADC <input type="checkbox"/> ADD	1. CLASSIFICATION RETAINED
NAME: <i>James C. Lewis</i>	2. CLASSIFICATION CHANGED TO: <i>FOUO</i>
2ND REVIEW DATE: _____	3. CONTAINS NO DOE CLASSIFIED INFO
AUTHORITY: ADD	4. COORDINATE WITH: <i>DOD</i>
NAME: _____	5. CLASSIFICATION CANCELLED
	6. CLASSIFIED INFO BRACKETED
	7. OTHER (SPECIFY): _____

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1870-1880  
1880-1890  
1890-1900





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UNCLASSIFIED

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In reply refer to:  
94SA20C000150-JCL

Ms. Jackie Cannon  
Headquarter, ACC/IMD Freedom of Information Act  
230 E. Flight Line Road, Suite 100  
Langley Air Force Base, Virginia 23665-2781

Dear Ms. Cannon:

This responds to your memorandum dated February 7, 1994, which requested that this office review the documents at enclosures 1-3 pursuant to a Freedom of Information Act (FOIA) request by Mr. Robert S. Gates.

On the first pages of each document, we have indicated the results of our review and the name of another agency that we recommend review the document prior to their release. Since the document at enclosure 1 consists of a number of separate and distinct documents, we have marked the results of our review on the first page of each included document. We have removed the Restricted Data markings from the documents at enclosures 1-2 because they no longer contain any Department of Energy (DOE) ~~classified~~ information, and we have marked them Formerly Restricted Data (FRD) pending completion of your review. If you determine that these documents do not contain FRD, please mark them appropriately. We have bracketed in black the DOE classified information that must be deleted before the documents at enclosures 1 and 3 may be released, and we have indicated in the margins the appropriate FOIA exemption category for each deletion.

In your reply to Mr. Gates, please provide the information contained in enclosure 4 regarding DOE classified information that is being withheld.

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Document Transmitted Herewith Contains

~~RESTRICTED DATA / NOFORN~~

~~SECRET~~

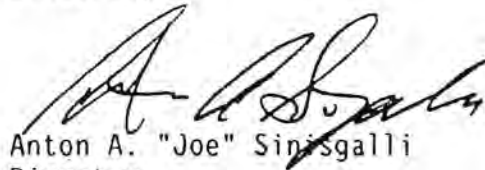
When separated from enclosures, handle this document as

UNCLASSIFIED



If you have any questions, please contact Dr. Andrew P. Weston-Dawkes at (301) 903-5478.

Sincerely,



Anton A. "Joe" Sinisgalli  
Director  
Document Declassification Division  
Office of Declassification  
Office of Security Affairs

Enclosures  
(See listing next page)



~~SECRET~~

UNCLASSIFIED

JUN 20 1996

In reply refer to:  
96SA20B000122-PG

Ms. Jackie Cannan  
Freedom of Information Act Manager  
Office of Information Management  
Headquarters Air Combat Command/IMC  
230 E Flight Line Road, Suite 108  
Langley Air Force Base, Virginia 23665-2781

Dear Ms. Cannan:

This responds to your memorandum (93-388) dated April 17, 1996, which requested that this office review the documents at enclosures 1-2 pursuant to a Freedom of Information Act (FOIA) request from Mr. Robert S. Gates.

We have indicated the results of our review on the first page of each document. We have determined that the document at enclosure 1 no longer contains Department of Energy (DOE) classified information; accordingly, we have no objection to its declassification and release. We have bracketed in red (page 81) the DOE classified information that must be deleted before the document at enclosure 2 may be released, and we have indicated in the margins the appropriate FOIA exemption category for the deletion. Please disregard all other brackets.

During our review, we identified additional information primarily under the purview of the Department of Defense (DOD) that may be classified as Formerly Restricted Data (FRD) under joint DOE/DOD classification guidance. This information deals with locations of nuclear weapons in DOD custody at military locations within the United States, nuclear weapon utilization or deployment matters, and stockpile subcategories. Since this information is primarily within the purview of the DOD, we defer to the judgement of the DOD regarding the classification of it.

Please note that we have changed the classification category of the documents from Restricted Data (RD) to FRD because the information contained in the documents is no longer RD.

In your reply to Mr. Gates, please provide the information contained in enclosure 3 regarding DOE classified information that is being withheld.

JUN 1996

Document Transmitted Herewith Contains

~~FORMERLY RESTRICTED DATA~~

NOFORN

~~SECRET~~

When separated from enclosures, handle this document as

UNCLASSIFIED

(Insert proper classification)



If you have any questions, please contact Dr. Andrew P. Weston-Dawkes at (301) 903-5478.

Sincerely,

Ant "Joe" Sinisgalli  
Director  
Document Declassification Division  
Office of Declassification  
Office of Security Affairs

Enclosures  
(See listing next page)





**UNCLASSIFIED**

**DEPARTMENT OF THE AIR FORCE**

HEADQUARTERS SPACE COMMAND

PETERSON AIR FORCE BASE, COLORADO 80914-5001

18 OCT 1985



DOO

FOIA Request from Federation of American Scientists (Your Ltr, 7 Oct 85)

HO

1. After reviewing subject documents, we find the ADC Historical Studies No. 14, No. 18, and the messages attached to the DOE letter contain no information which reflect our current procedures and capabilities. We have no objection to release of these documents. DOE should review the historical reports to determine releaseability.

2. We do not want Historical Studies 15 and 25 released. They contain numerous references to our force posturing policies which are still in effect. The documents also give sensitive information pertaining to our national decision making policies which could be used to show our intent in a similar real world crisis. It would definitely be to an detriment to release posturing information and would limit our flexibility in future situations.

*Rodney L. Martin*

RODNEY L. MARTIN, Colonel, USAF  
Director, Air Defense Systems

*wj*  
~~1 Atch  
HO SPACECOM/HO Ltr, 7 Oct  
85 w/6 Atch (S)~~

Department of Energy letter, 19 May 86, to HQ AFSPACECOM/DAD refused to declassify Restricted Data pages.

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GUARANTEED FRONTIER

UPON REMOVAL OF RESTRICTED DATA  
THIS COPY MAY BE  
DOWNGRADED TO *Unclass*

**THIS PAGE ONLY**  
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DOE/OFFICE OF DECLASSIFICATION  
J.C. LINER A.D.C. *set* DATE: 3/4/96



~~SECRET~~  
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FROM: ADC/XP

2 APR 1980

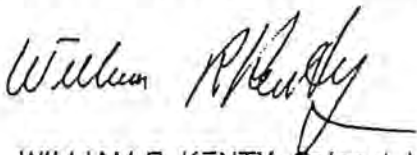
SUBJECT: History of Air Defense Weapons, 1946-1962 (U),  
ADC Historical Study No. 14 (Yr ltr 20 Mar 80)

TO: ADC/HO

We have reviewed the subject document and the following  
comments are offered:

- a. Pg 135-144: Unclassified
- b. Pg 161: Secret
- c. Pg 221-243: Secret *Top half of 221 is unclassified  
at Kansas  
AF 100, USAF*
- d. Pg 252: Secret
- e. Pg 255-262: Secret
- f. Pg 276-301: Secret
- g. Pg 330 & 334: Secret
- h. Pg 354-356: Secret
- i. Pg 359-365: Secret

In the BOMARC area we have no expertise and therefore can  
offer no pertinent comments.



WILLIAM R. KENTY, Colonel, USAF  
Asst DCS/Plans, Policy, Programs  
and Requirements

1 Atch  
ADC Hist Study No. 14 (S)

**UNCLASSIFIED**

~~SECRET~~

When atch(s) (is) (are)  
withdrawn or not attached,  
this letter is unclassified.

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DOE/OFFICE OF DECLASSIFICATION  
J.C. LINER A.D.C. jcl DATE: 3/4/96

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~~SECRET~~

~~SECRET~~



DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AEROSPACE DEFENSE CENTER

PETERSON AIR FORCE BASE, CO 80914

HO

20 Mar 80

Regrading of Secret RD Document - History of Air Defense Weapons, 1946-1962 (U), ADC Historical Study No. 14 (Yr ltr, 5 Feb 80)

NORAD/ADC DO (J-3)

1. The NORAD/ADC JAG has required that DOD 5200.1-R/AFR 205-1, para 4-202, be complied with, and a further review of the following pages be conducted to determine if specific portions can be declassified:

135-144 - declassified	330
161 ND	344
221-243 declassified	347
252 declassified	354-356
255-262 declassified	359-365
276-301	

2. Request the attached document with the results of your review be returned to HO by 4 Apr 80.

*Robert M. Kipp*  
ROBERT M. KIPP  
Chief, Office of History

1 Atch  
ADC Hist Study No. 14 (S)

1st Ind, ADC/DO

3 APR 1980

TO: ADC/HO

1. Subject document has been reviewed. Authority is granted to declassify the following pages: 135-144, 221-243, 255-262, 276-289.

2. Declassification of remaining pages concerns restricted data which must be cleared by AEC personnel. Recommend you contact Air Force Weapons Laboratory, ADCOM Rep ATTN: Lt Col Fanechie, Kirkland AFB, NM, to declassify the following pages: 161, 290-301, 330, 344, 347, 354-356, and 359-365.

*Lonnie B. Nelson Jr.*  
LONNIE B. NELSON, JR., LtCol, USAF 1 Atch  
Actg Dir, Air Def Operations nc

**THIS PAGE ONLY**

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DOE/OFFICE OF DECLASSIFICATION  
JG LINER A.D.C. 152, DATE: 3/1/94

attachments are withdrawn  
if attached, this document  
classified.

~~SECRET~~  
~~SECRET~~

~~RESTRICTED DATA~~  
~~ATOMIC ENERGY ACT~~

UNCLASSIFIED

1954



~~SECRET~~

UNCLASSIFIED

FROM: ADC/XP

15 FEB 1980

SUBJECT: Regrading of Secret RD Document - History of Air  
Defense Weapons, 1946-1962 (U), ADC Historical Study No. 14

TO: ADC/HO

1) We have completed a general review of subject document  
and believe that all of its contents may be releasable with  
the exception of:

a. (U) Capabilities and limitations of current and  
planned aircraft, fire control systems and armament.

b. (U) Information pertaining to nuclear weapons and  
their possible employment.

1 Atch  
History of AD Weapons  
1946-1962 (S/RD)

*J. H. Harris Jr.*  
JOHN H. HARRIS JR., Capt, USAF  
Executive Officer, DCS/Plans,  
Policy, Programs and Requirements

~~CONFIDENTIAL~~  
~~EXCLUDED FROM AUTOMATIC DOWNGRADING AND DECLASSIFICATION ACT 1954~~

WHEN ATTACHMENT IS WITHDRAWN  
THIS LETTER IS UNCLASSIFIED

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CONFIRMED TO BE UNCLASSIFIED  
DOE/OFFICE OF DECLASSIFICATION  
J.G. LINER A.D.C. DATE: 3/4/96  
102

UNCLASSIFIED





# UNCLASSIFIED

5 FEB 1980

FROM: NORAD/J-30

SUBJECT: Regrading of Secret RD Document - History of Air  
Defense Weapons, 1946-1962 (U), ADC Historical  
Study No. 14 (Your Ltr, 25 Jan 80)

TO: NORAD/HO

The referenced historical document has been reviewed for  
declassification. With the exception of two sections, it is  
recommended that the remainder of the book be downgraded to  
unclassified.

These two sections deal with subjects beyond the expertise  
of the J-3 staff and will have to be further evaluated for  
declassification by other agencies. The two areas concerned  
are:

a. Page 262, last paragraph, beginning with "Test flying  
of the ASG-18...." to the bottom of the page.

b. Pages 289-301, entire section dealing with nuclear  
armament.

*James K. Lowe*

JAMES K. LOWE, Colonel, USAF  
Director of Air Defense Operations

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW	
1ST REVIEW DATE: 3-5-96	DETERMINATION (CIRCLE NUMBER(S))
AUTHORITY: <input type="checkbox"/> AOC <input checked="" type="checkbox"/> ADC <input type="checkbox"/> ADD	1. CLASSIFICATION RETAINED
NAME: <i>James K. Lowe</i>	<input checked="" type="checkbox"/> CONTAINS NO DUE CLASSIFIED INFO
2ND REVIEW DATE: 3-8-96	<input checked="" type="checkbox"/> COORDINATE WITH: <i>60</i>
AUTHORITY: ADD <i>DO Little</i>	5. CLASSIFICATION CANCELLED
NAME: <i>DO Little</i>	6. CLASSIFIED INFO BASED ON
	7. OTHER (SPECIFY):

THIS PAGE ONLY

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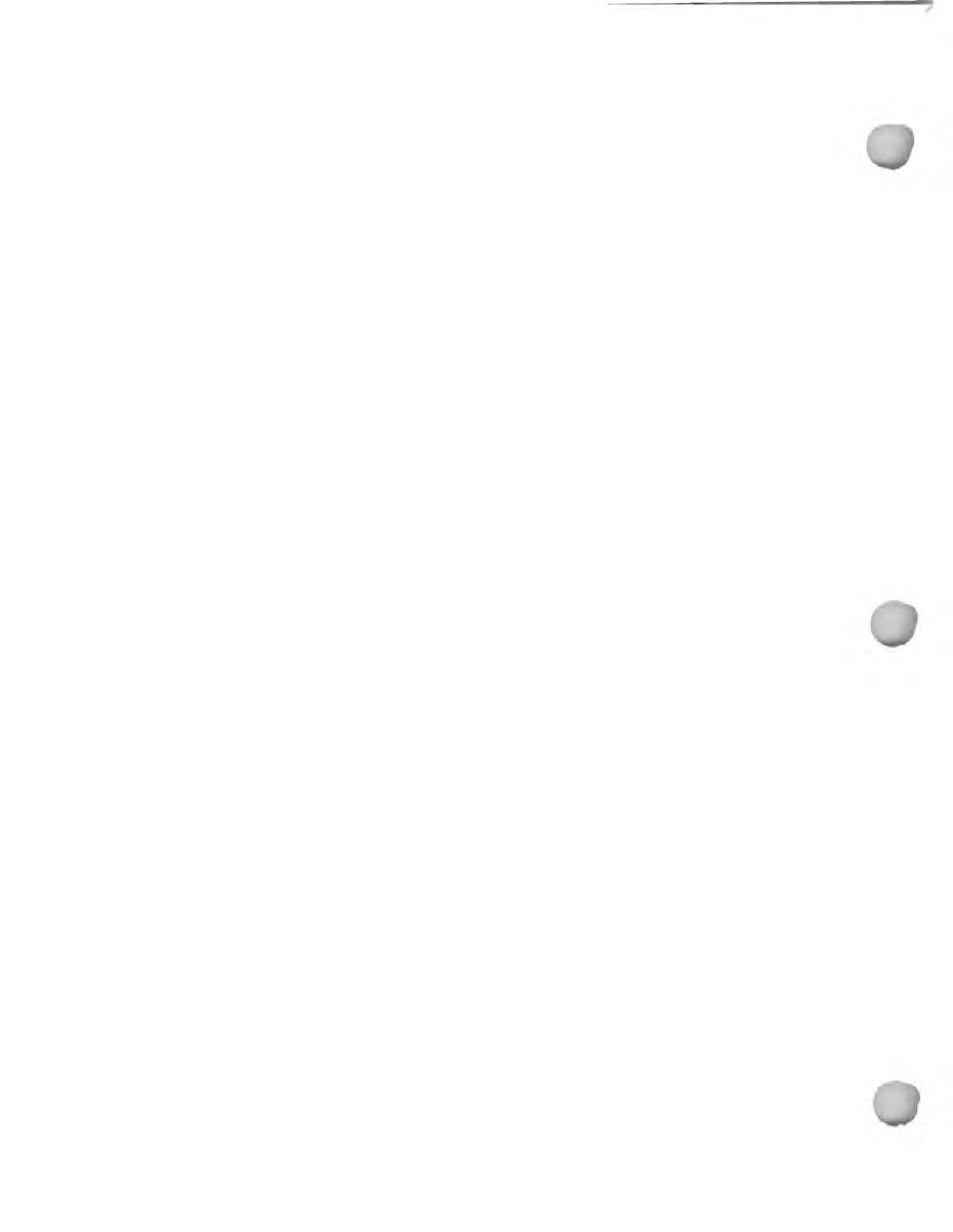
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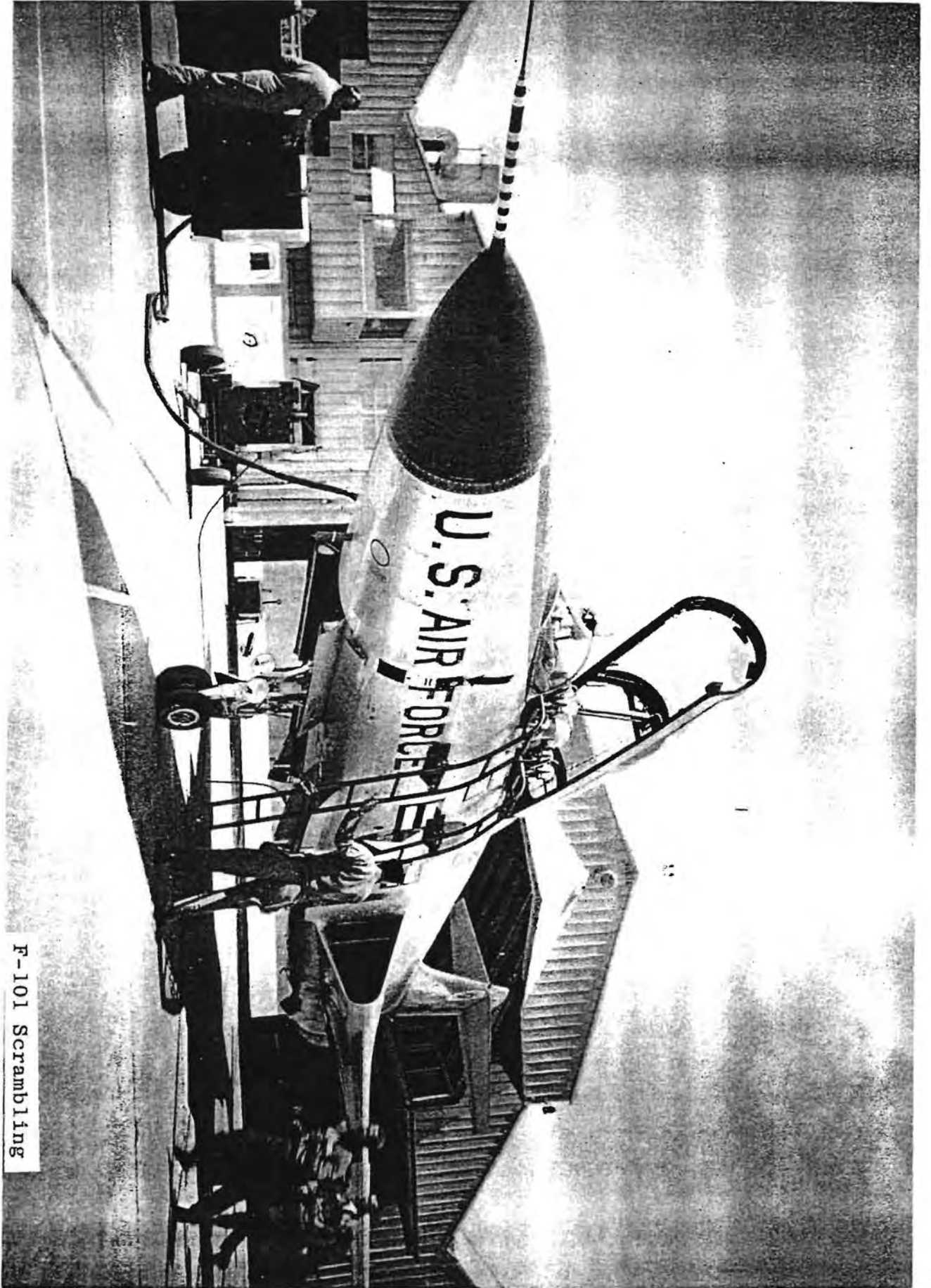
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F-101 Scrambling





## FOREWORD

The weapons held ready by the Air Defense Command changed vastly during the first 16 years of ADC's existence. While progress often seemed agonizingly slow, progress was made. The F-102A/F-101B/F-106A weapons systems of 1962 were tremendously advanced over the P-47, P-51 and P-61 of 1946. The BOMARC was unknown in 1946. It was fully operational in 1962.

The intent of this work is to trace the evolution of these weapons systems -- outlining the problems, delays, false starts and "state-of-the-art" advances that led to the 1962 position. It will demonstrate that development of modern weapons is likely to be a long, and often frustrating, process.



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PART ONE

THE CREATION OF AN  
"IN-BEING" WEAPONS FORCE, 1946-1954





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CHAPTER ONE

WORLD WAR II

Most of the elements of a modern air defense weapons system, at least in primitive form, became available to the United States Army Air Forces during World War II. Specially designed night-fighters, airborne radar, and IFF -- all these were developed during the war. But only IFF was used in the defense of the continental United States, since the need for continental defense had disappeared by the time much of the development work had resulted in usable hardware. The first modern American air defense weapons system was put to some use in the overseas theaters, however, particularly the Pacific. The British, who had a continuing air

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defense problem, used American airborne radar. The United Kingdom, in fact, took the lead in much of the development work with respect to air defense weapons, because British need was much more immediate than that of the United States. The North American continent at the time of World War II was still protected from sustained aerial attack by broad oceans. The American air war strategy, therefore, stressed the offense. Development of defensive weapons, as a result, did not command the highest priorities.

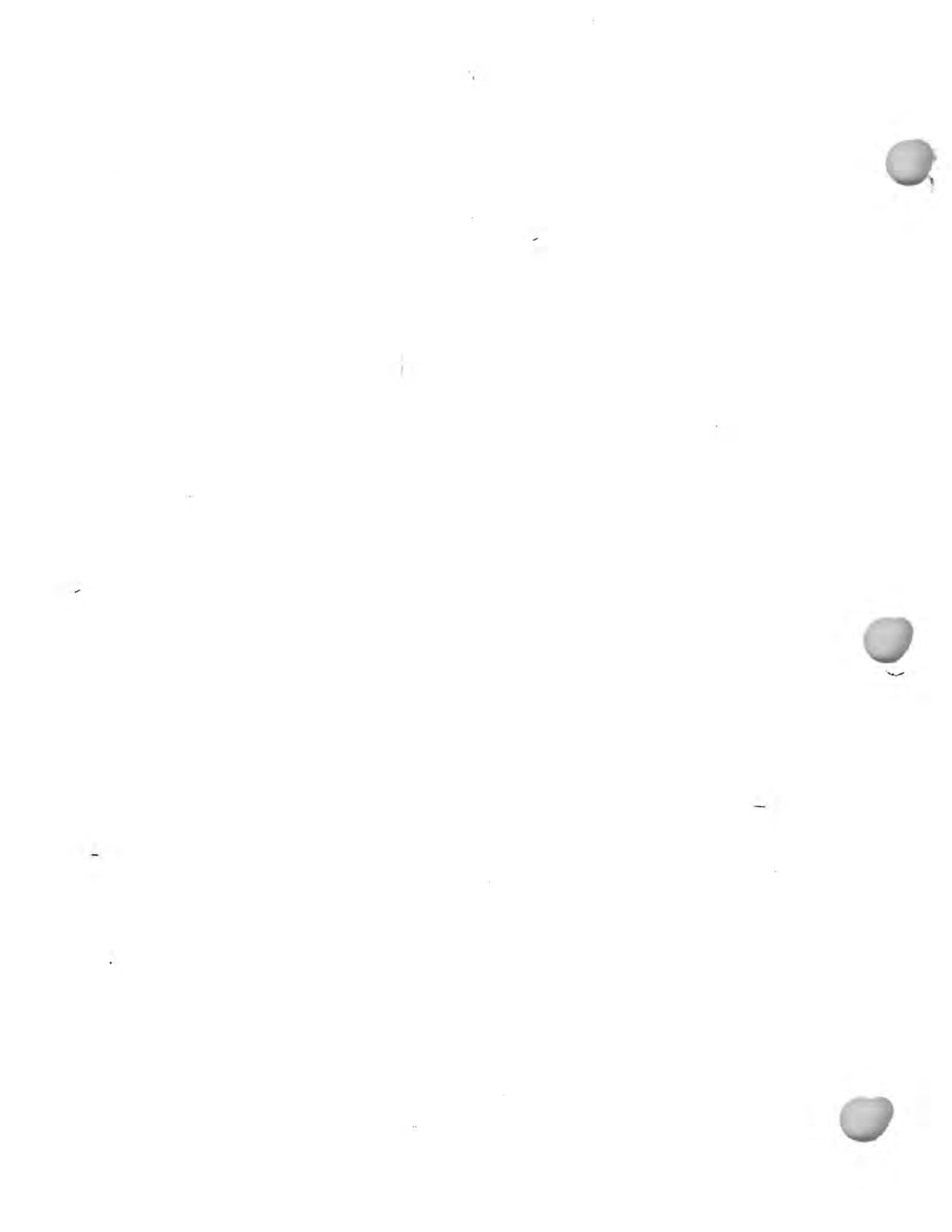
#### AIRCRAFT

At the time of United States entry into the war, the most modern fighters available in quantity were the P-39 Aircobra and the P-40 Warhawk. Both these aircraft were intended for defense purposes, but neither was equipped with target-seeking radar and neither was of much value in bad weather or darkness. The practical ceiling of both the P-39 and P-40 was about 15,000 feet. The P-38 (Lightning) was beginning to come off the production line when war began, but only 69 were on hand at the time of Pearl Harbor. The Lightning was an improvement over the P-39 and P-40, since it was capable of a speed of 400 miles per hour and had a somewhat higher ceiling. But the P-38 was also at a

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REPUBLIC P-47N "THUNDERBOLT"



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great disadvantage when the sun went down, because it did not carry radar and was not designed for night operations.

Two other day fighters, the P-47 (Thunderbolt) and P-51 (Mustang), were produced in considerable numbers during the war. When the fighting ended the Thunderbolt was the principal weapon of the AAF fighter forces. After January 1944 more than 40 per cent of AAF fighter units had the P-47. The experimental model of the P-47 made its first flight in May 1941 and production began at about the time of Pearl Harbor, although the first P-47 was not used in combat until April 1943. The Mustang was developed relatively early and produced relatively late, because the need for a long-range fighter escort was not recognized until AAF bombers began to experience difficulty with German fighters over the European continent. The long-held theory that a bomber was capable of battling its way through defending fighters was exploded in the summer and early fall of 1942. North American Aircraft Company designed the Mustang, essentially an improved P-40, for the British in 1940 and modest production for the British began in late 1941. The first AAF order for the P-51 was not placed until November 1942. The initial P-51 unit got to England in November 1943 and flew its first mission on 13 December 1943. The P-47 had a speed of 460 miles an hour

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and could operate at an altitude of 25,000 feet. The P-51 was capable of 487 miles an hour and a ceiling of 40,000 feet. Neither, however, had much capability as a night fighter. Neither carried radar.

An early attempt to create a night fighter from the A-20 attack bomber was a failure. This conversion, known as the P-70, was undertaken in 1942. Two hundred sixty-nine A-20's were converted to P-70 configuration. The first P-70 unit to reach a combat area was the 6th Night Fighter Squadron which arrived on Guadalcanal in February 1943. Unfortunately, however, it took 45 minutes for the P-70 to reach an altitude of 22,000 feet and at that altitude Japanese medium bombers could outrun it. Although the P-70 remained in the Pacific theater until late 1944, not much use was made of it.

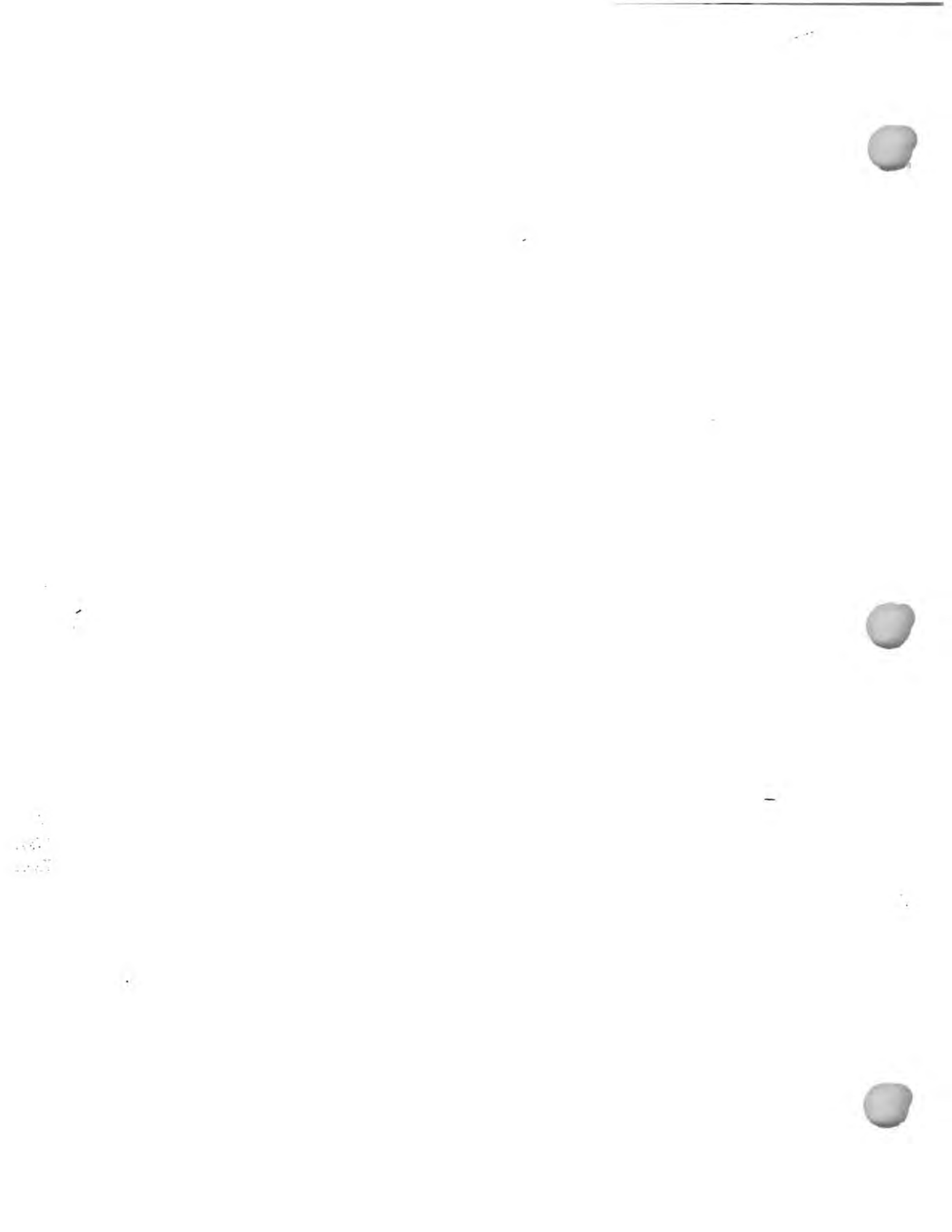
The only true night fighter developed and used during the war was the P-61 (Black Widow). Northrop began designing this aircraft in November 1940, but the experimental model did not fly until 26 May 1942 and the AAF did not begin to take delivery until July 1943. Only 682 were produced. The P-61 was a large two-seated aircraft, nearly as big as a medium bomber. It was relatively slow at 360 miles per hour, but was highly maneuverable and could reach an altitude of 30,000 feet. During the last year of the war

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NORTH AMERICAN P-51D "MUSTANG"



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it appeared in most active theaters, though it was very seldom put to its intended use because the Allies enjoyed universal air superiority by the time the P-61 became operational. Fourteen squadrons of P-61's were operating in overseas theaters at the end of the war -- seven in the Pacific, three in the Mediterranean, two in Europe and two in China-Burma-India. In one of the few instances where the P-61 was used for air defense purposes, the results were not encouraging. Between October 1944 and January 1945 the Japanese made 63 night bombing raids on Morotai, an important AAF base approximately midway between New Guinea and the Philippines. GCI radar detected 33 of these and P-61 aircraft went aloft to make the interception 61 times. On only five occasions was the raiding bomber destroyed. Malfunctions in the airborne radar were most often blamed for unsuccessful interceptions.

#### AIRBORNE RADAR

The British, who needed it badly, made first use of airborne radar. A group of British scientists under the leadership of Robert A. Watson-Watt gave some thought to the problem as early as October 1935. Watson-Watt formally recommended development of such a device on 10 February 1936.

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Approval was given and a rudimentary airborne radar set was being tested by late 1936. When World War II came, the British were ready with airborne radar and 30 Blenheim light bombers were equipped with it by the end of September 1939. Despite the advantage of radar, the Blenheim was an obsolescent light bomber and radar-aided night-fighters were not credited with an official kill, according to Watson-Watt, until november 1940, when the new, and much improved, Beaufighter became available.

The earliest form of airborne radar was not highly efficient because it used a beam one-and-one-half centimeters in width. The wide beam "floodlighted" a large area and thereby limited the range of airborne radar to the altitude of the aircraft. At greater ranges the radar began to pick up echoes from the ground, since the beam was directed toward the ground as well as toward the air-space directly ahead of the aircraft. All this was changed, however, when a group of researchers at the University of Birmingham (England) developed a cavity magnetron in the summer of 1940. It then became possible to direct a powerful electronic beam along a narrow path. Ground clutter was no longer a problem and development of "10 meter" airborne radar became possible.

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In one of the truly magnanimous gestures of World War II, the British gave the secret of the cavity magnetron to the United States in August 1940. The gift was tendered by a British technical mission headed by Sir Henry Tizard. The new Radiation Laboratory of Massachusetts Institute of Technology and Bell Laboratories immediately went to work and by April 1941 the Radiation Laboratory was ready to begin airborne tests on a radar set known originally as AI-10. By early 1942 the Signal Corps was beginning to produce the first American airborne radar, standardized as SCR-520. The Signal Corps also produced 580 copies of the British Mark IV one-and-one-half centimeter set (designated SCR-540), but these never worked to the satisfaction of the AAF and were never put to operational use.

By the time the SCR-520 was available in quantity, however, the possibility of airborne attack against the United States had faded to virtual nothingness, so a considerable number of the interceptor radars were converted to anti-submarine use (SCR-517, ASV radar). Anyway, the AAF did not have a night-fighter in which to install the SCR-520, since the Black Widow (P-61) did not become available until the summer of 1944.

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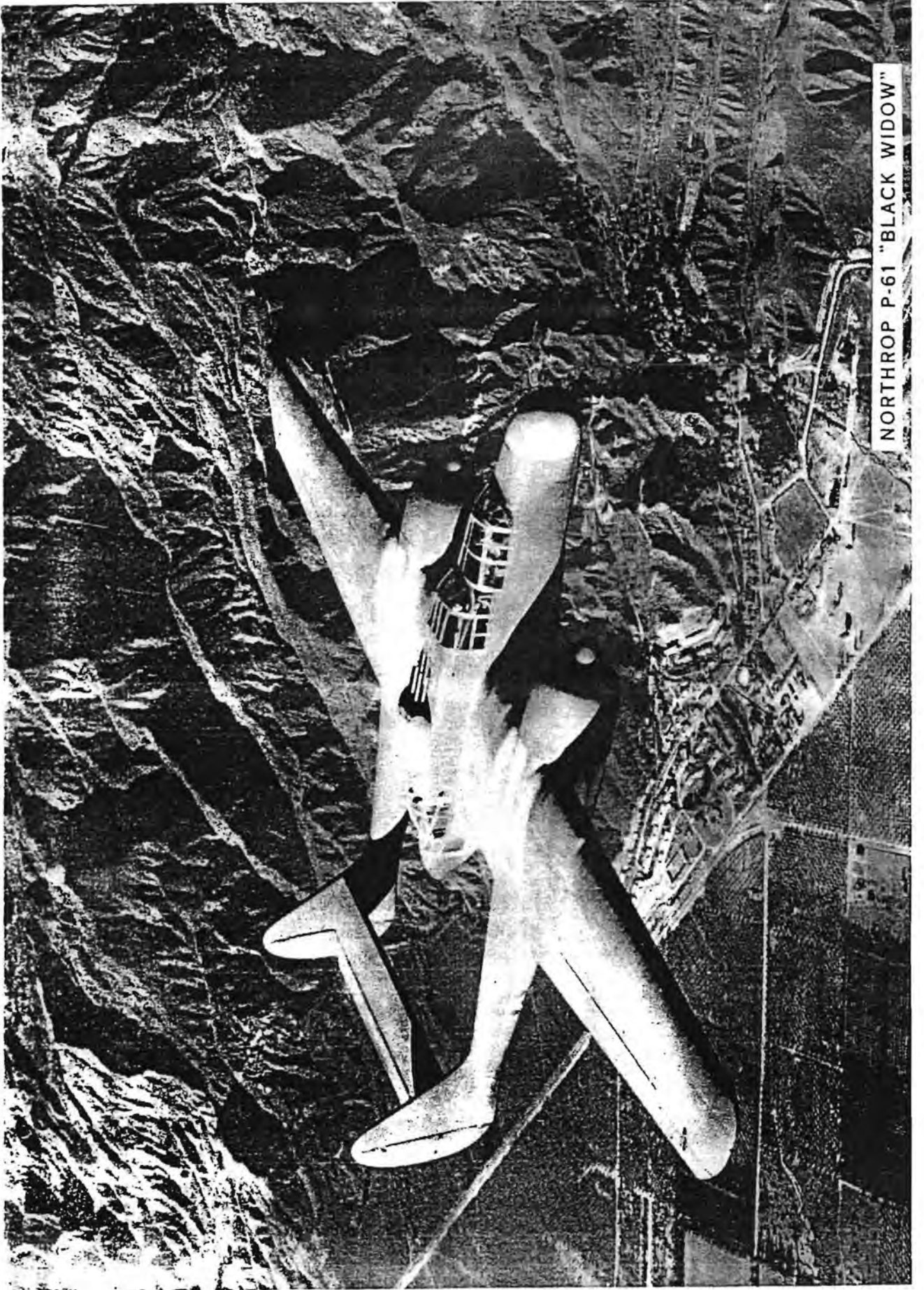
Though the AAF did not have a pressing need for an airborne radar designed for interception purposes, an improved model (SCR-720) which was capable of better discrimination between aircraft and chaff and offered increased detection range was developed in 1942. The British adopted this development as their Mark X airborne radar and ordered 2,900 sets from the United States. Two squadrons of the advanced Mosquito night-fighter had been fitted with Mark X by January 1944 and other RAF squadrons had it by the end of the war. The U. S. Black Widow also included SCR-720 as standard equipment. SCR-720, then, was the airborne radar immediately available to American air defense forces<sup>2</sup> in the post-war period.

#### IDENTIFICATION, FRIEND OR FOE (IFF)

Because the immutable laws of aerodynamics forced aircraft designers of all nations into similar channels, the aircraft of all countries had begun to look pretty much alike by World War II. Only the markings were different. Therefore, since all major belligerents had large numbers of aircraft, an electronic method of telling friend from foe became essential. The Watson-Watt group of British scientists began working on an IFF device in late 1937 and

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NORTHROP P-61 "BLACK WIDOW"





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by 1940 had produced airborne equipment which would give an automatic electronic response to a query from the Chain Home (CH) ground radar stations along the English coast. This was Mark I British IFF. Meanwhile, the U. S. Navy was developing an RR (radio response) device for a similar purpose, although the Air Corps did not believe it to be sophisticated enough for air-ground identification purposes.

The British Mark I IFF had limited utility, because it was keyed to the frequency used by the Chain Home stations. A more advanced model, which could be queried not only on the 10-15 meter wavelength used by the CH radars, but also on the 7 meter band used by mobile radars and the 3-5 meter band used by the gun-laying radars of the antiaircraft forces, was developed by the British in 1939-40 and went into service in 1941 as Mark II. This IFF radar was copied in the United States as SCR-535 and was the IFF set used by both the United States and Great Britain during the greater part of the first two years of the war.

Mark II/SCR-535 was not entirely satisfactory, however, because the expanding use of radar for various types of military operations made it increasingly difficult to provide an IFF set that could be tuned to the rapidly

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proliferating number of radar wavelengths. The obvious answer was an IFF set with a wavelength all its own. Parallel development of such IFF equipment occurred in both the United States and England during late 1940 and 1941. The IFF which resulted from British development became known as Mark III (SCR-595/695). The American type became Mark IV (SCR-515). It then became necessary to decide which of the two types the Allies would use, because inter-Allied use of a single type was necessary to permit joint operations. The Combined Chiefs of Staff came to the conclusion, in early 1942, that the British Mark III should be utilized, although the reasoning behind the decision is not clear. The U. S. Signal Corps contended that the British admitted American Mark IV was technically superior to the Mark III, but were "committed" to the Mark III and the CCS decision was made accordingly. Watson-Watt, however, made no such admission of Mark IV superiority and insisted that Mark III was chosen because it was clearly the best equipment.

Whatever the reason for the CCS decision in favor of the Mark III, that equipment was made available to Allied forces between February and December of 1943 and was in use throughout the remainder of the war. Mark IV/SCR-515

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was held in reserve in the event Mark III was compromised. Compromise was believed to have occurred in the Pacific in 1945, but the war was over before Mark IV could be installed in that area. Two versions of Mark III were produced in the United States during the war. SCR-595 was produced by Hazeltine Corporation, primarily for the Navy. SCR-695 was produced by Philco Corporation for the Army. There were only minor differences between the two sets. Approximately 150,000 Mark III sets were produced in the United States, about 18,500 of them the SCR-595 type.

#### ARMAMENT

American fighters in 1939 carried nothing heavier than .30-caliber and .50-caliber machine guns and it was with this armament primarily -- improved as the war went along -- that World War II was fought.

Cannon had been used in fighter aircraft in World War I and development of aircraft cannon continued between wars, but it was not until World War II was well along that the French-designed Hispano-Suiza 20-mm cannon became available in quantity. The P-61 interceptor, specially designed for air defense use, mounted four of these cannon. The P-61, however, did not see much service during the war.

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By 1942 the Army's Ordnance Department had developed a 4.5-inch rocket for aircraft use. but it was so slow that it could be used only against ground targets. The Air Force made no attempt to use these rockets against air-<sup>3</sup>borne targets.

The Air Force began work on an air-to-air guided missile in January 1945. It was essentially a 100-pound bomb with wings, a guidance system and a proximity fuze and was very cumbersome, weighing 625 pounds. Testing of this weapon (JB-3) did not commence until after the war was over. None of the first 10 missiles tested showed much promise. The Germans were somewhat more advanced in this field. By April 1945 they had developed a two-inch rocket (R4M) which could be mounted on the ME-262. Each aircraft carried 48 rockets, 24 to a bank. In a service test just before the end of the war, six ME-262 interceptors armed with the R4M rocket destroyed 14 B-17E bombers. The war ended, fortunately, before further tests<sup>4</sup> could be conducted.

Thus, World War II development resulted in the production of the first weapons system specially designed for air defense use -- the P-61 interceptor, equipped with

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ORGANIZATION

airborne radar, IFF and adequate armament. Because of the nature of World War II, the AAF made only infrequent use of the P-61 as an air defense weapon. At the end of the war, nevertheless, the AAF had an all-weather air defense capability it had not commanded when the war began.

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## CHAPTER TWO

### THE DROUTH YEARS -- 1946 - 1948

When the Army Air Force was reorganized in the spring of 1946, the combat element was shaped with classic symmetry. There was a strategic force, a tactical force and an air defense force. All the bases were thereby covered. The strategic force would strike to the military and economic vitals of the enemy, rendering him, in time, incapable of further war. The tactical force would support the ground forces. The air defense force would protect the United States from the operations of the enemy's strategic bombers.

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The organization was simple and direct. It was not until the matter of respective priorities for the various forces was reached that trouble brewed. Since the twenties the Army's air arm had followed the Douhet doctrine that the side with the most and best strategic bombers would ultimately win any war. This doctrine appeared to have been borne out in World War II, although it was amended with the proviso that long-range bomber strikes over heavily defended territory required fighter escort. Obviously, then, the first priority in the post-war Air Force would have to go to the strategic element, in this case the Strategic Air Command. As to the tactical force, the Air Force was obligated to provide assistance to Army Ground Forces. Something had to be assigned to Tactical Air Command. That left, at the end of the priority chain, the Air Defense Command. Although technically a co-equal member of the Air Force's combat triumvirate, it was unthinkable that ADC would have to do any fighting in the near future. In 1946 no possible enemy had a bomber capable of damaging the United States, unless bases on the North American continent were available. And the ground forces had the responsibility for making sure that no enemy obtained bases on this continent. As had been true for



generations, the United States was protected by wide oceans and friendly neighbors. Therefore, ADC would have to wait. And that is what ADC did for nearly three years following World War II -- wait.

#### PLANNING

When the Air Defense Command was created on 27 March 1946, its "interim" mission was to "organize and administer the integrated air defense system of the continental United States...exercise direct control of all active measures and coordinate all passive means of air defense." There was precious little to administer. ADC controlled the 414th Night Fighter Squadron at Bolling Field, a completely paper organization, and the 425th Night Fighter Squadron at March Field, a unit manned with one officer and two airmen. ADC had two bases -- Mitchel Field on the east coast and Hamilton Field on the west coast. The ADC headquarters was at Mitchel. The ADC commander was Lt. General George E. Stratemyer, fresh from war-time duty as air commander in the China-Burma-India theater.

But AAF, at this time, did not believe it essential that ADC have command control of the forces which it might be necessary to use to beat off an attack from the air.



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The semantical niceties of "operational control" as opposed to "command" were put into play. AAF enlarged upon the ADC mission in June 1946 to the extent of explaining that ADC would also be required to "coordinate within the...United States the means available from other services for air defense, such as naval or marine fighter units temporarily shore-based." <sup>7</sup> Although there was nowhere any indication that the Navy was agreeable to such a derogation of authority, it was the AAF opinion that this "coordination" could be achieved only "through the assignment of operational control of such units of other services to the Commanding General, Air Defense Command, <sup>8</sup> during periods of emergency." Because defense forces were to be made available to ADC through coordination with the Navy, and, by inference, other AAF commands, AAF did not believe it necessary to provide extensive "direct-command" forces for ADC. In other words, adequate air defense forces were being furnished, except that they be- <sup>9</sup> longed to somebody else.

Planning on the basis of the ground rules laid down by AAF proved to be an unprofitable exercise because of the many imponderables involved. Nobody could say how many Navy and Marine fighters would be ashore at any one

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time, where they would be located and what types of aircraft would be included. Neither did there seem to be much possibility of using Tactical Air Command aircraft in an emergency, a preliminary TAC-ADC conference of 10 August 1946 having revealed a broad difference of opinion as to ADC's "responsibilities for the provision of the air defense of the continental United States." <sup>10</sup> The ephemeral nature of an air defense weapons system built upon the shifting sands specified in the June directive was well known to AAF, so in October 1946, perhaps in a spirit of wishful thinking, ADC was asked what it would require in the way of regular AAF units in order to establish an active air defense organization. The ADC answer was prompt and specific. ADC figured it would need 18 day fighter squadrons (P-84 aircraft) and 18 all-weather fighter squadrons (P-87 aircraft) to protect the five most vital areas of the country. <sup>11</sup> At the time of writing, ADC controlled three fighter squadrons, only one of which had any aircraft -- a handful of P-61 night fighters.

Although AAF was in no position to do anything concrete about the ADC proposal, so long as air defense had third priority among the three combat elements of the Air Force, it could predict slightly better times to come

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when the 70-Group Air Force was realized. In a survey of 24 October 1946, AAF outlined a 70-Group Force in which 25 groups (75 squadrons) would contain fighter aircraft. Three of these fighter groups (nine squadrons) would have all-weather aircraft for air defense use. The unpleasant aspect of the 70-Group plan was that all 22 of the day fighter groups in the 70-Group Air Force were already active. ADC had only one of these and there was no mention of it being given any more. So, according to the October 1946 outline of AAF plans, ADC could look forward to having 12 squadrons of fighter aircraft at most. <sup>12</sup> This was exactly one-third of the number General Stratemeyer believed was necessary.

Despite the October indication of AAF thinking, ADC went ahead with a more detailed plan which also called for 36 squadrons of fighter aircraft, half of them all-weather interceptors. This plan, forwarded to AAF on 22 November 1946, spelled out the areas to be defended: (1) Washington-Philadelphia-New York-Boston; (2) San Francisco; (3) Chicago-Detroit; (4) Los Angeles; (5) Seattle-Pasco. It was obvious that ADC planned to give precedence to the population-industrial centers of the northeast, the northern border and the west coast. ADC also pointed out that the

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36-squadron force requested was only a minimum to be provided quickly (by July 1949 assuming AAF approval was received by the end of 1946) if ADC were to have the barest chance of blunting an offensive thrust at this country. Although details were not presented, it was strongly implied that the ultimate air defense force would be considerably greater.

Before it would be possible to determine what forces should be made available to ADC, however, it was necessary to decide just what ADC was expected to do. The interim mission, dated 12 March 1946, told ADC to organize and administer the integrated air defense system of the United States and exercise direct control of all active measures and coordinate all passive means of air defense. Either the earlier instructions had to be confirmed by a permanent directive or a new directive had to be provided. What made the decision difficult was a deep difference of opinion between ADC and AAF as to what the ADC mission should be. ADC preferred a strong positive statement to the effect that its mission was to "defend the continental United States from hostile air attack." AAF wanted something to the effect that ADC would plan the air defense of the continent in cooperation with SAC, TAC, Army Ground Forces and Navy and would organize, train and direct such portions of the national air defense forces as might be

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assigned to it from time to time. The difference, of course, was that ADC wanted sole responsibility for defense against hostile air attack and direct command of the forces necessary to meet that responsibility, while AAF, cognizant of the aspirations of the other armed services in this field, was satisfied with keeping a foot in the air defense door while jockeying for position within the national defense establishment. Besides, AAF simply did not feel it was possible to allocate 12 of its 55 existing groups to active air defense. Finally General Spaatz decided, in March 1947, that the matter had become hung on dead center. But, until money problems and the question of the unification of the armed services had been settled, there appeared to be nothing to be done. ADC would have to do the best it could with the interim mission of March 14 1946.

Meanwhile, ADC was readying a long-range plan which it hoped could be realized by 1955. This plan was predicated on AAF approval of the "in being" plan of November 1946, which would mean that 36 fighter squadrons would be in place and operational by the middle of 1949. The long-range plan carried on from that point. Only the defense of the five critical areas mentioned in the November plan



  
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were considered in the long-range plan, but the area around each was widened considerably. From any point of view, however, the long-range plan (submitted to AAF on 8 April 1947) was insupportably lavish. By 1955, the plan said, ADC should have 102 squadrons of all-weather interceptors and 249 squadrons of interceptor missiles, plus 325 battalions of anti-aircraft artillery and a radar network requiring 114 Aircraft Control and Warning Squadrons. This defense behemoth presumed the assignment of 700,000 men and 4,000 aircraft to ADC.<sup>15</sup>

None of the three ADC plans was ever approved or disapproved by AAF, because AAF frankly didn't know what sort of reply to make. Through the spring and summer of 1947 AAF was treading water, waiting for Congress to take action on the Unification Act which would set it free from the Army. Everything else had to wait until this issue was decided. The consummation devoutly to be wished was effected in September 1947 and the independent USAF confidently set about planning its future. The creation of an independent Air Force did not mean the fortunes of ADC were bound to improve, however. When Air Force resources were dispensed, ADC continued to stand third in line, behind SAC and TAC. This was made obvious to ADC in December

  
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1947 when USAF directed ADC to base future planning on the premise that the "Air National Guard [would] constitute [ADC's] major source of Air Defense Units." <sup>16</sup> This policy letter amounted to a rejection of ADC requests that it be provided with air defense forces in being. Only a token weapons complex was to be provided. If the Air Force was limited to 55 wings, ADC could expect three wings (nine squadrons) of fighters, two of them equipped with all-weather interceptors. If Congress approved a 70-wing Air Force, ADC would get 12 squadrons, half of them equipped with all-weather aircraft. The three wings to be allocated to ADC under the 55-wing program were already assigned, although two of these wings contained only two squadrons each for a total of seven manned and equipped squadrons. These operating units were located at Dow, Mitchel, Hamilton and McChord. In addition, the wing which would be added to the ADC complement if the 70-wing Air Force were approved had been activated, but had not been manned or equipped pending Congressional action. <sup>17</sup>

At the same time, USAF hammered out a mission directive for the Air Defense Command. Air defense was to be a cooperative venture. In time of emergency, ADC was to have operational control of all SAC and TAC aircraft

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possessing an air defense capability. The Air National Guard capability in the air defense field would be added as soon as it became available. ADC was adjured to inaugurate close and constant collaboration with SAC and TAC in order to make sure that everybody understood his air defense function in time of emergency.

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Although a command decision favoring a cooperative type of air defense had been made, events in early 1948 seemed to conspire to upset that decision. First, both the President's Air Policy (Finletter) Commission -- which reported in January -- and the Congressional Aviation Policy (Brewster) Board -- which reported in March -- recommended the 70-wing Air Force and the Finletter Commission heard considerable testimony to the effect that the nation's security rested on adequate air defense. General Spaatz testified that the Soviet Union was building replicas of the B-29 bomber. A further indication of the aggressive designs of the Russians came 24 February 1948 when the Communists seized control of Czechoslovakia.

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A continuation of international tension through March led USAF to order ADC on 27 March 1948, to do something about defending the Atomic Energy Commission plant at Hanford, Washington, from Russian attack. The attempt

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to create a semblance of active air defense in the Pacific Northwest in late March and early April 1948 was a complete failure so far as the weapons aspect was concerned. The 325th All-Weather Wing was marooned at Hamilton because only three radar observers were available to man the Wing's P-61 aircraft. The 27th Fighter Wing was borrowed from SAC and was moved from Kearney, Nebraska, to McChord. But the P-51 aircraft of the SAC unit were useless in the bad weather experienced in the Seattle-Tacoma area. Furthermore, the SAC aircrews were not trained in the techniques of ground-controlled interception and cooperation with ground radar units was poor.

ADC saw in the Northwest fiasco an opportunity to overturn the USAF mission directive of 17 December 1947. After hardly two weeks of ineffectual operations in that area, ADC, on 15 April 1948, described to USAF what had happened and recommended "that the Air Defense Command be given the means for effecting air defense and the authority to utilize the means as it sees fit." Lest there be any misunderstanding of what was intended, ADC called for an end to the "operational control" concept and for the direct assignment of air defense forces to ADC. This was followed, nine days later, by an ADC staff study which recommended

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prompt transfer of five wings of jet aircraft (15 squadrons) to ADC. Two of these wings were currently assigned to SAC, two to TAC and one to Caribbean Defense Command. Four had P-80 aircraft and one had P-84's. Failing actual transfer, ADC asked that the five wings be given a secondary mission of air defense, be moved to locations specified by ADC, and a portion of their flying time made available to ADC for air defense training.

But USAF was still not ready to provide ADC with an "in being" force of more than token proportions. Despite the debacle in the Northwest, ADC continued to claim third priority among the combat elements of USAF. For that reason, USAF could not accept the ADC recommendations because of the necessity for "meeting other air force missions." While managing to say "no" to the ADC request, USAF, in its May reply, admitted the need for an affirmative answer. ADC would be given the means for accomplishing active air defense and would be given the maximum possible freedom in utilizing these means, USAF said, but added the paralyzing qualification about "other missions." USAF recognized the "desirability" of directly assigning forces to ADC as opposed to "operational control," but again added the qualification that the matter was "under

consideration" and expressed the hope that "a mutually agreeable solution [could] be determined when the various factors...[were] evaluated."<sup>24</sup> A deeply discouraged ADC was coldly cynical about the USAF reply. "A typical staff officer's reply -- evasive, inconclusive and unsatisfactory"<sup>25</sup> concluded the ADC Deputy for Operations.

Thoroughly dissatisfied, ADC returned to the attack in early June 1948. After summarizing his various unfulfilled requests over the past two years, General Stratemeyer<sup>26</sup> sketched the unenviable position in which he found himself:

It would appear that the problems inherent to the establishment of an effective air defense system are not fully appreciated by the members of your staff who are empowered to act upon my recommendations. On two separate occasions diplomatic developments have brought into sharp focus the urgent need for an effective air defense. On each of these occasions frantic efforts have been directed by your headquarters in order to avert another 'Pearl Harbor'. However, the heightened interest in air defense quickly subsided with the lessening of diplomatic tension; and our subsequent attempts to correct the deficiencies, so clearly evident in our efforts to meet a possible emergency, produced no tangible results.

In the past it had been the habit of USAF to temporize with ADC requests, postponing answers where possible, providing "we realize your problem, but..." answers in other instances. This time, however, the USAF answer was blunt and laid all the cards, face up, on the table. ADC was not going to get

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more than it had, USAF said. because of a shortage of suitable aircraft for air defense use and a shortage of suitable bases. As to the ADC request for transfer of five wings of jet aircraft from SAC, TAC and the Caribbean, use of these 15 squadrons for air defense would preclude their use in the more important missions of bomber escort and ground support. The wing from the Caribbean was to be moved to Europe. Here again was evidence of the operation of the priority system. Air defense still ranked third. As to the earlier "in being" plans of November 1946 and April 1947, USAF gave them short shrift as being, in some ways, "in excess of the total capabilities of the Air Force." <sup>27</sup> The picture was not totally black, however, in that USAF promised that it would give SAC and TAC the additional mission of air defense and would instruct these two commands to train under the operational control of ADC in order to improve whatever air defense capability they might possess. The total effect of the USAF reply, nevertheless, was to dash any hopes ADC might have of enlarging, in the near future, its capacity to provide an active air defense system. <sup>28</sup>

Nevertheless, this capacity was significantly enlarged within the next six months, although ADC had to

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sacrifice its very existence in order to bring it about. On 1 December 1948, both ADC and TAC were dissolved as major air commands and a new command, Continental Air Command, (ConAC) was created. More significant, however, was the fact that three of SAC's fighter wings, instead of the two originally requested by ADC, were transferred to the new organization. The ostensible cause of the reorganization was an Executive Order (No. 10.007) of 15 October 1948 which directed increased attention to the training of the civilian components (Air National Guard and Air Reserve) of the Air Force. The more probable reason, however, was the Truman Administration's decision to limit the Air Force to 48 wings, despite congressional approval of a strength of 70 wings. By pooling the strength of ADC and TAC, USAF expected to obtain a respectable force of double-duty squadrons. Those squadrons with air defense as a primary mission had ground support as a secondary mission and those with ground support as a primary mission had air defense as a secondary mission. The SAC squadrons were made available to the new organization because of the growing realization that jet aircraft of the F-80 and F-84 type had insufficient range to permit them to

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escort long-range bombers. ADC and TAC were retained as "operational commands" within ConAC, but for all practical purposes they had disappeared with the creation of ConAC. Nevertheless, by a simple stroke of the pen, the air defense force (since the nine former SAC squadrons were given the primary mission of air defense) had doubled in strength. On 30 November 1948, ADC had seven manned and equipped fighter squadrons earmarked for air defense purposes. The following day 16 manned and equipped fighter squadrons were available for air defense use. The SAC squadrons also brought their bases with them, so the number of air defense bases increased from three (Dow, Mitchel, and Moses Lake) to six (Langley, Otis and Self-<sup>29</sup>ridge were added).

#### AIRCRAFT

When the Air Defense Command was created in March 1946 there was no debate as to which night-fighter aircraft would be used for air defense purposes. The only one available was the P-61 (Black Widow) which became available in quantity in the summer of 1944 and saw limited use in the later stages of World War II. It was hardly a match for B-29 and B-50 bombers, however, because it had a speed

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of only 360 miles an hour and a ceiling of 30,000 feet. Something better was needed and AAF hit upon the P-82 as a temporary solution until a really satisfactory night-fighter could be obtained. The P-82, essentially two P-51's joined by a center wing section (and therefore known as the "Double Mustang"), was originally designed as a long-range escort fighter to succeed the P-51. North American began development in January 1944.

The development effort was overtaken by the end of the war, however, and the first XP-82 aircraft were not accepted by AAF until late in 1945. With the war finished there did not seem to be any particular use for the P-82. After studying the problem, the AAF Operations Group recommended, in November 1945, that if the P-82 was to be procured in any quantity it should be utilized as an interim all-weather fighter. The Deputy Commander, AAF, agreed with the A-3 reasoning and on 29 November 1945 authorized procurement of the P-82 as an all-weather fighter, assuming that yet-to-be-held tests would show it to be adequate for that purpose.

A contract for 250 P-82 aircraft was formalized in February 1946, before the all-weather test was begun. One hundred were to be P-82E long-range escorts. The remaining 150 were to be P-82F and P-82G all-weather

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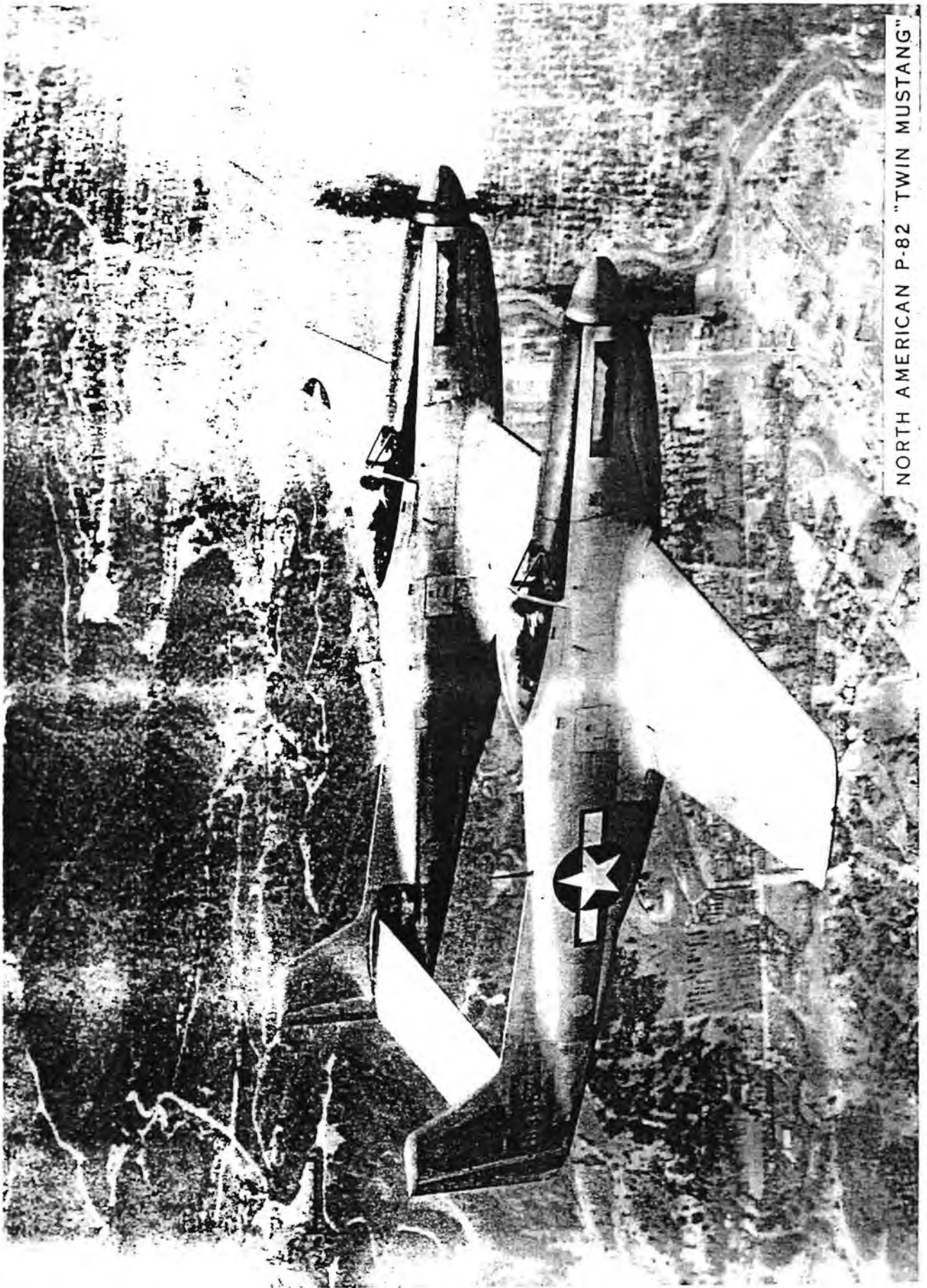
interceptors. In the spring of 1946 it was anticipated that production of P-82E aircraft would begin in April 1947 and that production of all-weather version would start when P-82E production was complete. <sup>31</sup>

For a brief period in the spring of 1947, AAF considered changing the P-82F/G back to day-fighter configuration because Eglin tests accused the aircraft of poor maneuverability, slow deceleration and poor pilot visibility. AMC pointed out, however, that if the P-82 was not put to night-fighter use there would be nothing beyond the P-61 until the P-87 or P-89 became available two years, or more, in the future. AAF reluctantly agreed that, whatever its shortcomings, it was the P-82 or nothing. <sup>32</sup>

The shortcomings of this interim night-fighter became more and more evident as the months rolled by. The Allison V-1710 engine was pretty much of a failure and although development work continued through 1947 and into 1948 it was never satisfactory. North American went ahead with the airframes and by the end of 1947 was storing 130, pending completion of engine development. Some of the airframes had been in storage since April 1947 and were deteriorating to the point where the Inspector General was becoming concerned. The engine situation was so

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NORTH AMERICAN P-82 "TWIN MUSTANG"



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desperate by January 1948 that it was suggested the Packard V-1650 engine be substituted for the Allison engine. This was an impossible alternative, however, because both the Packard and Continental engine plants had been dismantled and several months and considerable expense would be required to re-build either. Anyway, the Allison production line had been underway for months before the serious deficiencies of the Allison engine had come to light and 82 per cent of the 750 engines ordered had already been produced. As a practical matter, then, it was imperative that the Allison engine be made to work.

Because it was forced into a corner, AMC found it necessary to release the Allison engine for installation in the P-82 in March 1948, assuming that a long list of modifications would be made and the engines would be operated at a power rating considerably below the rating called for by the specifications. Meanwhile, because the P-61 had proven to be entirely unsuitable for the operations ADC had in mind, ADC was getting anxious for the P-82 with its 400-mile speed and 34,000-foot ceiling, even though it was to be equipped with an engine of dubious reliability and less power than had been expected. After the engine log-jam was broken it was possible to comply with the ADC

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request. All P-82F/G aircraft had been delivered by the  
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end of 1948.

At best, the F-82 was regarded only as a stop-gap all-weather fighter. Long-range dependence was to be placed on the aircraft which resulted from the design competition announced by AAF immediately after World War II. Three types of fighters were planned, a long-range "penetration" model, a short-range day fighter, and a large, heavily armed two-place all-weather interceptor. Six aircraft manufacturers entered the all-weather competition -- Bell, Consolidated, Curtiss, Douglas, Goodyear and Northrop. AAF originally had in mind a conventional aircraft, but since most of the six competitors submitted designs for a jet type, it soon became  
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obvious that the new all-weather interceptor would be a jet.

AAF was definitely seeking an advanced night-fighter since the specifications against which the competitors were asked to bid called for an aircraft capable of speed of 525 miles an hour at 35,000 feet, 550 miles an hour at sea level; ability to climb to 35,000 feet in 12 minutes and a combat radius of 600 miles. Provisions for launching air-to-air rockets were to be included. The aircraft was to be armed with a minimum of six machine guns or 20mm cannon. IFF and AI radar were to be included in the design. After studying the six proposals during the winter of 1945-46,

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AMC decided that the Northrop design was the most promising. Curtiss had already been given a contract to develop its entry, an aircraft subsequently known as the P-87. The Goodyear entry was rejected for poor tail design. Douglas proposed a fighter of such great weight that it was primarily a bomber. Bell suggested the use of four engines, two of one type and two of another, leading, AMC felt, to maintenance complications. Consolidated also proposed an aircraft of extreme weight and one which would probably have difficulty in spin recovery.

Northrop actually submitted four designs for the all-weather fighter competition. Two were more or less conventional fighters, one with two engines, one with three. The other two designs, however, were for radical tailless "flying wing" types. Northrop still had hopes that a flying wing fighter could be developed. This hope was natural, since Northrop had been working on a flying wing jet since the autumn of 1942. This was the ill-fated P-79 which, had it been successful, would have been the first American jet aircraft. Northrop was so busy with standard types of aircraft during 1942 and 1943, however, that development of the P-79 was turned over to a small subcontractor. The sub-contractor proved unable to do

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what Northrop wanted done and Northrop had to resume the project in its own shops in 1944. The only P-79 ever built was completed in 1945. Aside from its distinctive appearance, the P-79 was also unique in that the pilot was placed in a prone position. It was powered by a single Westinghouse jet engine and was designed to reach a speed of 630 miles an hour and an altitude of 45,000 feet. Unfortunately, the P-79 crashed and was destroyed during its first flight on 12 September 1945. Despite continuing Northrop confidence in the P-79 design, AMC chose a design which called for orthodox wing and tail surfaces.<sup>37</sup> AAF gave AMC permission, on 10 April 1946, to write Northrop a contract<sup>38</sup> for two XP-89 aircraft.

In September 1946, Northrop was ready for inspection of the mock-up version of the P-89, which by that time was seen as a twin-engine, two-place interceptor weighing 36,000 pounds and armed with four 20 mm. cannon. The power plant was to consist of General Electric J35-GE-3 engines. The first flight was expected to take place in November 1947. AMC was not favorably impressed with the mock-up presented by Northrop in September 1946, however, and asked that the contractor re-think the design in terms suggested by the AMC inspection team. The AMC people wanted

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the radar operator moved closer to the pilot, the canopy re-designed, aluminum substituted for magnesium in the wings and something done about unsatisfactory fuel and oil systems, plus numerous minor changes. Another mock-up session was held in December 1946 and this time AMC was satisfied. Northrop was free to proceed with construction of the first aircraft.

But progress was relatively slow on the P-89, because of continuing indecision as to the engines to be used. This was a time of much development activity in jet engines and newer and more powerful engines appeared in rapid succession. In addition to the J35-GE-3 engine mentioned in September 1946, attention was also given to the J35-A-9, J35-A-15 and J35-A-17 (all built by Allison) which came along later. Also, despite the earlier decision in favor of the P-89 as the first specially designed post-war all-weather interceptor, there were nagging doubts that the P-89 was really best for the purpose. There was recurring discussion of the Curtiss P-87, the Lockheed P-90 and the Douglas F-3D (a Navy type) as possibilities in the all-weather field. Because of the air of uncertainty that prevailed, it was not surprising that the first flight of the XP-89 did not occur in November 1947 as

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originally planned. It was not until 16 August 1948 that  
the XP-89 successfully got off the ground.<sup>40</sup>

With the successful experimental flight of the XP-89, it became apparent that a reasonably final decision would soon have to be made as to whether or not this aircraft was to be the first jet all-weather interceptor. As background for this decision, the F-87 and F-3D were flown by experienced night-fighter pilots and a special series of flight tests of the XF-89 were conducted during September 1948. The XF-89 was not too impressive, since the J35-A-9 engines could not be operated at full power because they generated excessive tail pipe temperatures. As a result the aircraft required an especially long take-off run (about 5,500 feet). The XF-89 managed to get to 30,000 feet in 14.7 minutes and attained a speed of 565 miles an hour at 20,000 feet and 523 miles an hour at 30,000 feet. The test pilot was of the opinion that acceleration in the XF-89 was slower than in other jets he had flown.<sup>41</sup>

In a sense, the decision had already been made, since Curtiss had been awarded a contract for 88 F-87 Blackhawks in June 1948. There was a body of opinion within the Air Force, however, that believed this action to have been hasty. To find a solution to what had become a major problem,

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therefore, USAF appointed a board of officers (Maj Gen K. B. Wolfe, AMC; Maj Gen F. O. Carroll, AMC; Brig Gen Carl A. Brandt, USAF; Col Bruce K. Holloway, ADC; and Col Albert Boyd, AMC, plus six relatively junior officers) to determine which of the competing aircraft had the best potential as an all-weather fighter. The Board met at Muroc on 7-8 October 1948. It was agreed by the conferees that none of the aircraft under discussion (F-87, F-89 and F-3D) was really satisfactory as an all-weather interceptor. On the question of which was the least unsatisfactory, none of the members voted in favor of the F-87 or the F-3D. Generals Wolfe and Carroll, Colonel Boyd (all from AMC) and four junior members voted to procure the F-89. General Brandt, Colonel Holloway and two junior members voted against procuring any of the three. In addition to the close vote in favor of the F-89, the Board also recommended that, because of the immediate need for an improved all-weather aircraft, the TF-80 be modified by addition of airborne radar to become a second interim all-weather interceptor to replace the F-82. The F-80 was the first operational jet fighter, which had recently been redesigned to permit addition of a second crew member (and thereby became known as TF-80). The training version



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of the F-80 subsequently became the T-33 and the interceptor version was designated F-94. Since every aircraft considered by the Board was at least partially unsatisfactory for air defense use, it was also recommended that USAF organize a new design competition for an all-weather interceptor with 1954 as the goal for operational use.<sup>42</sup>

The action recommended by the Board was taken almost immediately. On 14 October 1948, General Muir S. Fairchild, USAF Vice Chief of Staff, directed the USAF DCS/M to halt production of the F-87 and to put the F-89 and the all-weather version of the TF-80 (F-94) into production as soon as possible. This action was approved by Secretary of Defense Forrestal in November 1948 and funds for the purchase of 48 F-89's and 110 F-94's were released by President Truman in January 1949. Northrop was authorized to proceed with the construction of 48 F-89's on 10 January 1949. AMC anticipated that deliveries would begin in June 1950.<sup>43</sup>

Although production of the F-89 had been authorized, there remained the fact that it was not regarded as a satisfactory all-weather fighter. AMC, therefore, was faced with the job of making it as satisfactory as possible before it was actually put to active air defense use. To improve

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high-altitude performance, Northrop was ordered, in November 1948, to put the J35-A-17 engine in the second XF-89. At the same time, the contractor was directed to meet complaints that the F-89 would be a maintenance nightmare by modifying the airframe to the point where it would be possible for five men to change an engine within 30 minutes. Also, AMC wanted certain equipment removed in order to bring the weight down to a manageable 36,000 pounds. When these changes were made, Northrop estimated that the F-89 would be able to do 564 miles an hour at 35,000 feet, climb to 35,000 feet in 4.5 minutes and reach a ceiling of 48,000 feet. If this performance proved possible with the actual aircraft, the F-89 would be much superior to the all-weather fighter envisioned in the AAF specifications of August 1945.<sup>44</sup>

**AIRBORNE RADAR**

The first of the post-war interceptors, the F-82, was equipped with the same radar -- SCR-720 -- used by the war-time P-61. It was becoming obvious by the spring of 1948, however, that the F-89 interceptor would need something better. All that was readily available at the time was the AN/APG-3 radar being developed for the tail

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defense of the B-36. Hughes, therefore, was given a contract in June 1948 to adapt the AN/APG-3 for use in the F-89. This contract was amended in November 1948 to provide a similar airborne radar for the F-94. In the summer of 1948 Hughes also proposed to adapt the AN/APG-3 for use in a one-man interceptor, but after conferences with North American, builder of the F-86, it was decided that the F-89 and F-94 should have a single-seat counterpart and that the F-86 was the logical airframe to convert. The Hughes proposal to adapt the AN/APG-3 for single-seater use was revived. The modified AN/APG-3 for F-89 and F-94 aircraft was designated E-1, that for the F-86 was named E-2.

While the AN/APG-3 was a suitable place in which to start in development of an advanced airborne radar, AMC needed a much smaller unit which would be capable of displaying a B-29 at a range of 21,000 yards. Changes to the original AN/APG-3 were expected to be so radical that the interceptor version was re-named AN/APG-33. Hughes had begun to wrestle with the problem of adaptation by the end of 1948.

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IDENTIFICATION, FRIEND OR FOE (IFF)

Although U. S. electronic engineers had designed an improved version (Mark V) of the earlier Mark III IFF system by the end of World War II, the JCS decided, at the end of the war, that the Mark III system would be used by American military aircraft during the immediate post-war period. This decision was taken even though the Russians and U. S. commercial airlines had become familiar with Mark III and it was by no means a secure device. By October 1948, however, with East-West tension heightening, JCS was ready to junk the war-time Mark III and replace it with a more secure IFF, but no further action with respect to replacement of the Mark III had been taken by the end of the year.

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ARMAMENT

When the post-war Air Defense Command was created in March of 1946, interceptor aircraft were armed with machine guns and 20mm cannon. But there was talk of guided missiles for air-to-air use and Hughes Aircraft Company had actually developed such a missile by the end of World War II. The Hughes JB-3 was essentially a 100-pound bomb with wings, a guidance system and a proximity




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fuze. It was not very satisfactory, however, because it  
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was cumbersome and weighed 625 pounds.

The success of the German V-1 and V-2 missiles during the later stages of the war made it obvious that post-war armament development would be oriented in that direction. As a result, missile development contracts sprouted like spring flowers immediately after the war. Twenty-eight such contracts were in force at one time. Two of these were concerned with air-to-air missiles (AAM) for fighter aircraft. One was held by the Ryan Aircraft Company, the other by the M. W. Kellogg Company. The development plan called for creation, first, of a subsonic missile which would subsequently grow into a supersonic model. Hughes Aircraft Company and General Electric held  
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contracts for a similar missile intended for use by bombers.

In March of 1947, AMC was of the opinion that both Ryan and Kellogg were making excellent progress and test flights of the Ryan missile were expected later in the spring. The actual missiles being developed by the two contractors were similar, except for guidance systems. Ryan was developing a continuous wave radar seeker which used the same antenna for both sending and receiving, depending on a filter to keep the sending and receiving channels

  
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separated. Kellogg was working on a unique two-beam seeker. Although both contractors were considered to be progressing satisfactorily, a serious reduction (to 22 million) in the amount of development funds to be available in Fiscal 1948 made it necessary, in May 1947, to choose between the two. Ryan was chosen to continue, because it was believed to be somewhat further along the development trail, but Kellogg was not unhappy at the decision, since it had decided to cease attempts to develop completed missiles in favor of development of missile components. At the same time, Hughes was dropped from the bomber AAM program, on the ground that General Electric's engineering qualifications were better. Hughes, though, was to continue with the development of the promising radar seeker. The May 1947 reduction in missile development activity, coupled with an earlier cut of December 1946, reduced the number of active missile projects from 28 to 12, of which the Ryan and General Electric programs were two.

The promise of 1947 gradually gave way to the doubt of 1948 as the Air Force gained more experience with guided missiles. Although the target seeker proposed by Ryan was theoretically promising, USAF, by January 1948,

  
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was beginning to doubt that a filter capable of effectively separating the outgoing from the incoming radar signals could be made available within the time allotted for development of the Ryan missile. AMC began to hedge as regards the Ryan development. While continuing to recommend support of the Ryan seeker, AMC pointed out that Hughes and Bendix were also working on similar radar devices which could possibly be substituted for the Ryan seeker in the event of need.<sup>50</sup>

Despite decreasing enthusiasm for the Ryan missile, USAF took advantage of a November 1948 windfall of 16 million dollars from a Fiscal 1948 supplemental appropriation to direct AMC to buy 130 missiles from Ryan. At the end of the year, therefore, AMC was still speaking of the Ryan Firebird as a coming air-to-air missile. But there was some hedging here, too. While Hughes had been dropped in favor of General Electric as a prime contractor for the bomber AAM during the fund crisis of early 1947, continuing difficulty with General Electric over the patent clauses of the development contract led AMC to release General Electric from the missile program when the existing contract lapsed in June of 1948. Hughes, as a result, again entered the missile business with a bomber AAM called Falcon. By the

  
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end of 1948 the distinction between bomber-launched missiles and fighter-launched missiles had blurred to the point where the two were regarded as interchangeable. At the end of 1948, therefore, AMC was saying simply that it was monitoring the development of two air-to-air missiles -- the Ryan Firebird and the Hughes Falcon. Development was expected to be complete by 1952-1955.<sup>51</sup>

Meanwhile, the Army's Ordnance Department was proceeding with development of an unguided 2.75-inch spin-stabilized rocket expected to have a range of about 2,000 yards. This rocket was a refinement of the 2-inch R4M rocket developed by the Germans just before the end of World War II. It was a considerable improvement over the machine guns and cannon currently being used as fighter armament and served to bridge the gap between World War II weapons and the guided air-to-air missiles expected in 1952 or later.<sup>52</sup>

#### INTERCEPTOR MISSILES

The Air Force was an early starter in the race to develop a surface-to-air missile capable of destroying the fast, high-flying bombers known to be on the drawing boards of all the major nations of the world. World War II

  
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was still in progress when Boeing was asked to study the possibilities of building a ram-jet vehicle which would be able to reach 60,000 feet at a range of 35 miles and attain supersonic speed. Preliminary studies consumed most of 1945, but upon their conclusion Boeing was satisfied that the project (GAPA) was feasible and design studies and field tests were begun in February 1946. Because of the success of the Boeing studies, AAF launched a still more ambitious project in the spring of 1946. General Electric and the University of Michigan were asked to look into the chances of developing a missile capable of knocking down another supersonic missile. AAF had the German V-2 in mind, but the thinking encompassed more advanced missiles as well. The planners envisioned a large missile, 60 feet long and six feet in diameter, with a range of 550 miles. The ability to erase a target at altitudes between 60,000 feet and 500,000 feet was desired. The contract for the General Electric THUMPER project was written in March 1946, that for the University of Michigan WIZARD program the following month.

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Although it was anticipated that all three surface-to-air projects would eventually result in actual missiles, the fund crisis of Spring 1947 necessitated a change in plans.

  
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GAPA was further along (31 test missiles had been launched by March 1947) and was allowed to continue as before. The THUMPER and WIZARD projects, however, were well ahead of the times. It would be five to ten years, AMC estimated, before the necessary long-range ground radar, long-range and highly accurate guidance systems and long-range radar seekers could be developed for the test support of any anti-missile missile devised by General Electric or the University of Michigan. Because of this situation, it was considered wise to reduce these programs to a long-term study basis, with General Electric to be given \$500,000 a year for this purpose, the University of Michigan a million dollars a year.

In the summer of 1947, the AAF Director of Research and Development, Lt. General Curtis E. LeMay, expressed a need for acceleration of the THUMPER and WIZARD projects, but AMC was unable to take action because of a shortage of funds. Money could have been transferred from one of the other seven current missile development projects, but each of these carried a priority equal to or higher than those of THUMPER and WIZARD. Meanwhile, GAPA appeared to be making great strides. In October 1947 USAF felt enough confidence about GAPA that it could answer a question

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from the President's Air Policy Commission to the effect that GAPA should be operational by the middle fifties. The probable range of the GAPA was reduced from 35 to 30 miles in the report to the Commission, however.<sup>55</sup>

By the end of 1947, too, USAF was reasonably sure of what it expected of surface-to-air missiles. First, USAF anticipated a "50-mile" missile (GAPA) capable of destroying a target flying as fast as .9 Mach at altitudes up to 70,000 feet. This missile would be used as part of the "interim" air defense system. Later would come advanced missiles (the products of THUMPER and WIZARD studies) with the ability to kill (1) high velocity missiles with high altitude ballistic trajectories, (2) high velocity missiles or aircraft flying in the lower atmosphere -- up to 70,000 feet, and (3) high velocity missiles flying at low altitudes. USAF was also considering development of a short-range, highly mobile, inexpensive surface-to-air missile for the protection of troops and forward military installations, but had not yet secured Army agreement.<sup>56</sup>

The same difficulty with guidance equipment that threatened to delay the THUMPER-WIZARD program cropped up with regard to GAPA in early 1948. While development had progressed to the point where USAF was ready to buy complete GAPA missiles for test and training purposes, guidance

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components were not available. For that reason, USAF suggested that the similar Navy LARK be purchased instead. The Navy agreed to make the LARK available. When the supplemental Fiscal 1948 funds became available in November 1948, however, the guidance problem with respect to the GAPA had improved enough that AMC was instructed to buy 50 GAPA and 50 LARK missiles.<sup>57</sup>

Although the financial crisis of 1947 had not affected GAPA, the crisis of 1948 was a different story. In July 1948, AMC discovered that instead of the 21 million dollars it had requested for missile research and development in Fiscal 1949 it was to get slightly more than half of that amount, or 11 million. Instead of the 5.5 million it had planned to spend on the furtherance of GAPA development, only three million would be available. This was particularly disappointing, because AMC felt that rapid progress was being made. Seventy-five test vehicles had been fired at Holloman Air Force Base and much of value had been learned about components and sub-systems. Also, a ramjet engine capable of producing a speed of Mach 3 was nearing completion. This was an especially bad time to reduce development expenditures, but there was no alternative.<sup>58</sup>

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Therefore, at the end of 1948, the Air Force was engaged in the development of two types of interceptor missiles. The short-range Boeing GAPA had progressed far enough that contracts for completed missiles were being written. The long-range anti-missile missile was still in the study stage, because it was unknown when the state of the missile art would reach the point where the necessary radar sub-systems could be provided. Both General Electric (THUMPER) and the University of Michigan (WIZARD) were still actively engaged in this project, however.

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### CHAPTER THREE

#### THE CONAC PERIOD: 1949 - 1950

The problem of how to create an air defense force of respectable size, while at the same time assuring the ground forces of effective support, was "solved" in December 1948 by merging ADC and TAC into a composite organization known as Continental Air Command (ConAC). At the same time, most of the fighter units formerly controlled by Strategic Air Command were transferred to the new organization, because it was becoming apparent that it was not possible to provide fighter escort for the very long-range bombers being provided for SAC. In this shuffle, the number of active fighter squadrons

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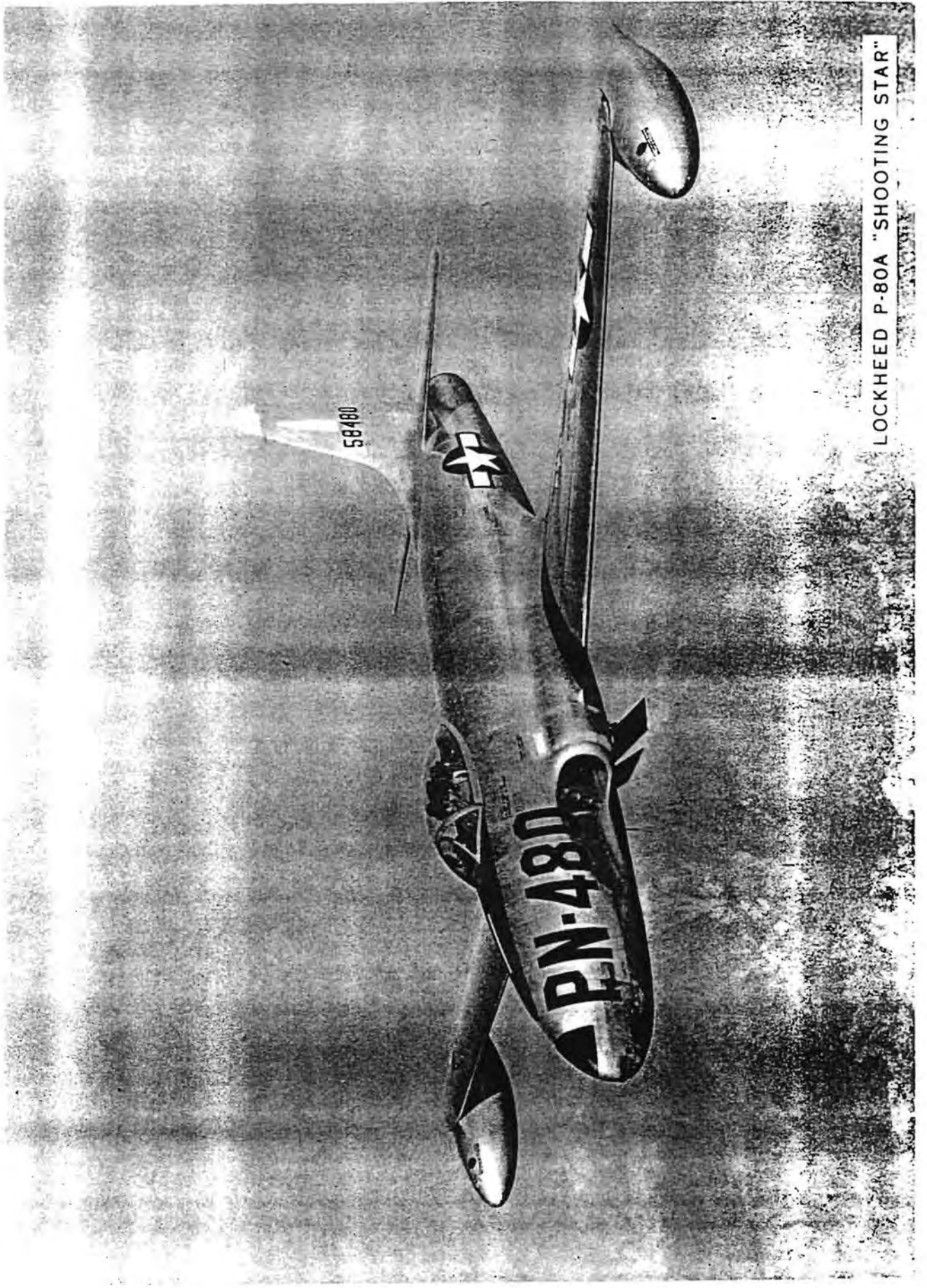
available for air defense purposes was increased from seven to 16, but was still 20 short of the 36 squadrons ADC had believed necessary as a stop-gap, or "interim", force. Besides, the expanded air defense force was heavily weighted with day fighter aircraft of marginal use at night or in bad weather. In addition, the night-fighter portion of this force was still supplied with World War II aircraft and equipment. It was in no sense capable of dealing with bombers of the B-29 type.

#### PLANNING

Two events of late 1948 and early 1949 effectively prevented ConAC from seeking additional air defense weapons strength. The decision of the Truman administration, announced in December 1948, to limit the strength of the Air Force to 48 wings made it clear that air defense could expect no gains and, in all likelihood, would be lucky to hold what it had. The April 1949 decision of Louis A. Johnson, newly-appointed Secretary of Defense, to halt construction of a Navy supercarrier touched off the "Revolt of the Admirals", during which it was charged that the B-36 was an inefficient strategic weapon. The resulting congressional investigation consumed the summer of 1949 and

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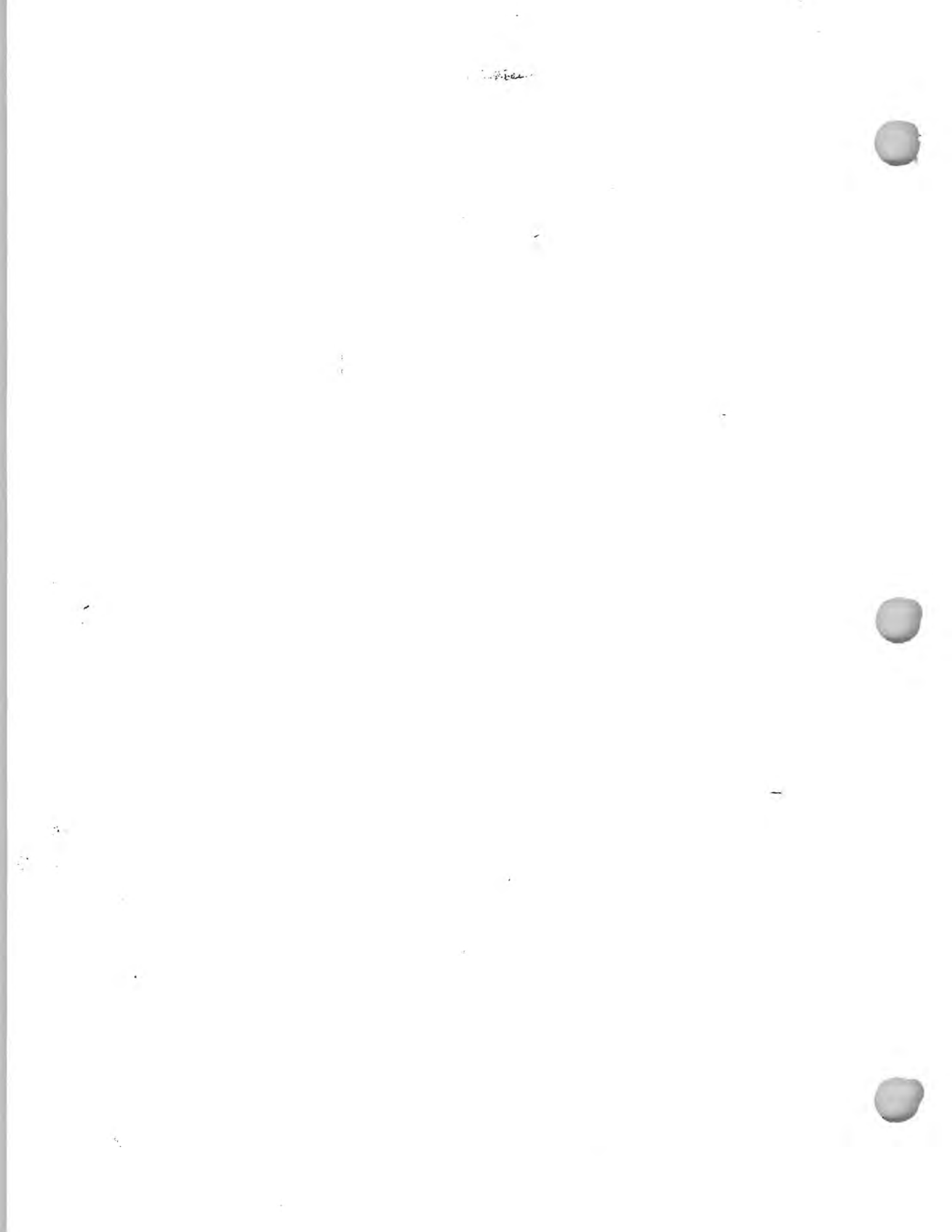


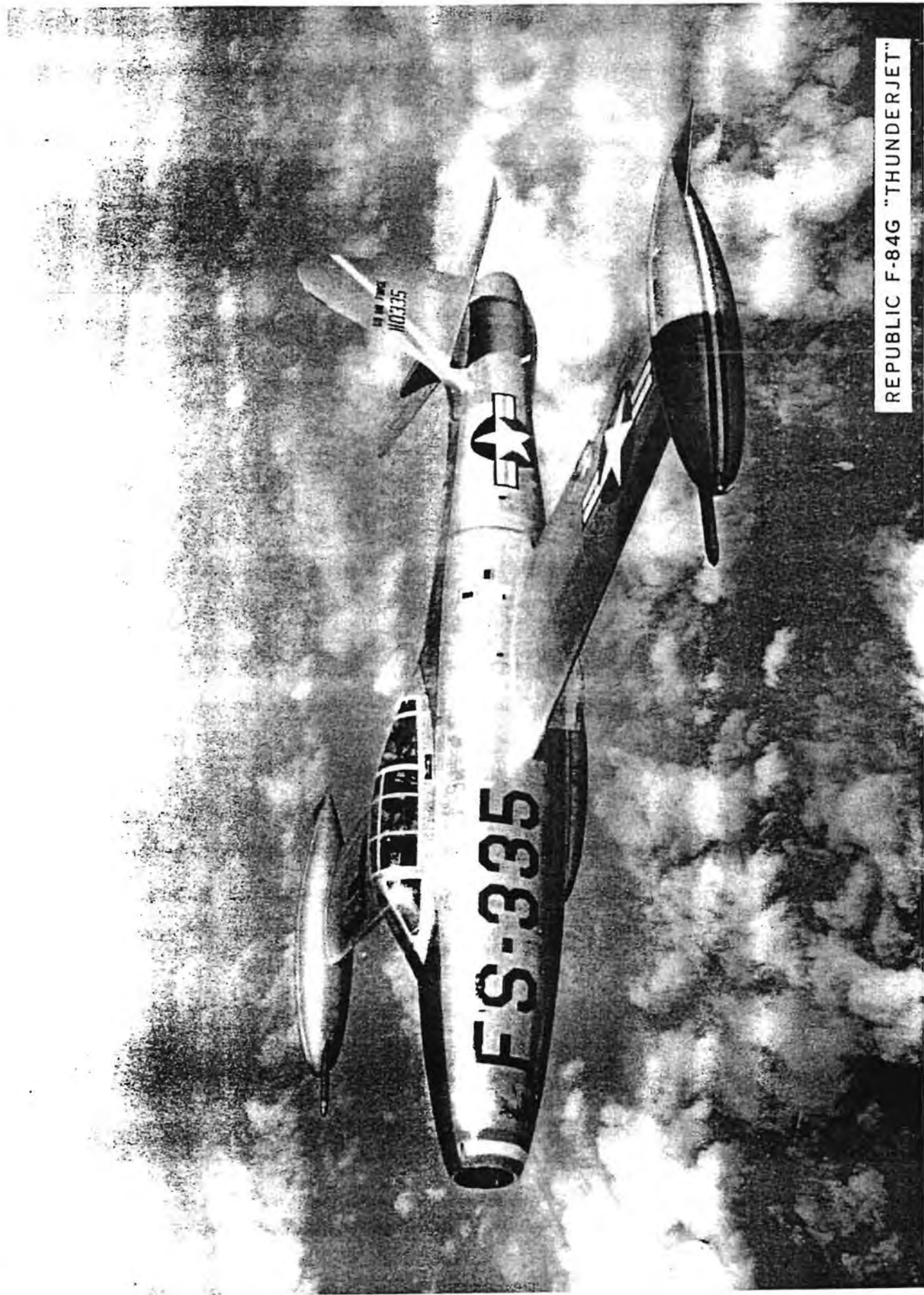


LOCKHEED P-80A "SHOOTING STAR"

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REPUBLIC F-84G "THUNDERJET"

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had the effect of slowing down all defense planning activity. Slow progress was made, however, in fleshing out with equipment and aircrews four squadrons which had had only paper existence. At the end of 1949, therefore, ConAC controlled 20 manned and equipped interceptor squadrons dedicated to air defense. Only five of these squadrons had night fighters -- the "interim" and unloved F-82. The other 15 squadrons were equipped with day jets of the F-80, F-84 and F-86 types. Even so, a 20-squadron force (23 squadrons had actually been activated, but only 20 had been manned and equipped) was considerably larger than ADC had been led to expect in the pre-ConAC days. In December 1947, ADC had been told it would get nine fighter squadrons in a 55-group Air Force and 12 squadrons in a 70-group Air Force. And what was especially significant, the air defense force was untouched when it became necessary, because of the likelihood of serious reductions in the Air Force budget for Fiscal 1949, to cut the size of the planned Air Force from 70 groups to 48 groups. The need for a respectable "in-being" air defense weapons force had been recognized even before the occurrence of two worrisome international events.

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The first was the explosion, in August 1949, of the first Soviet atomic device. Although authorities

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differed, it had been generally agreed that the Russians were not likely to have an atomic weapon until 1952. As though this were not enough to indicate the intentions of the Soviet bloc, South Korea was invaded by Communist North Korea on 25 June 1950. Shortly after the announcement of the existence of a Soviet atomic bomb, the USAF Chief of Staff, General Hoyt S. Vandenberg, noted "a desperate need for a vastly more effective air defense."<sup>61</sup>

In this instance, the planning groundwork for an increased air defense weapons system was laid in Washington, although ConAC was kept informed of progress. As the months wore on, however, Lt. General Ennis C. Whitehead, who had assumed command of ConAC on 15 April 1949, became anxious for action with regard to the plans developed in late 1949 and early 1950. On 1 March 1950 he pressed USAF to obtain JCS approval of the 61-squadron air defense force recommended by the "package plan" USAF had been preparing. Perhaps anticipating General Whitehead's anxiety, USAF had presented the plan to JCS on 2 March 1950, before General Whitehead's request arrived. The "package plan" was actually three plans. If the Air Force was permitted 58 wings, ConAC would get a total of 35 air defense squadrons (as opposed to the 23 squadrons active at the time the plan was presented). If

  
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a 69-wing Air Force was authorized. 47 air defense squadrons would be formed. In a 95-wing Air Force, ConAC would have 61 air defense squadrons. It was to the 95-wing plan that General Whitehead was referring in his request of 1 March 1950.

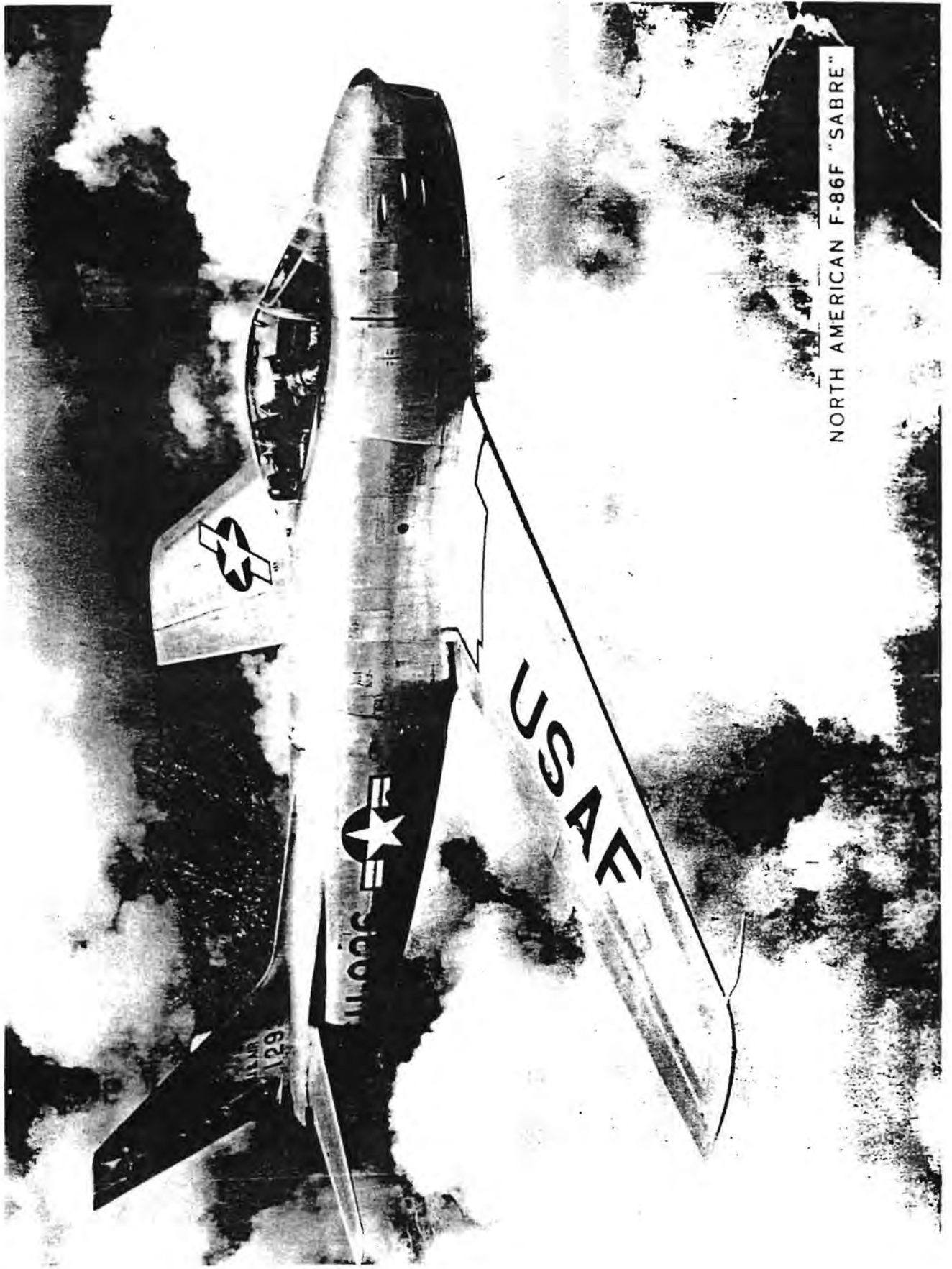
JCS approval of the USAF "package plan" was not immediately forthcoming and in April 1950, USAF was forced to tell General Whitehead that no additional air defense squadrons -- beyond the 23 already allocated -- could be made available to him. But then came hostilities in Korea. Because of this situation, Congress, on 30 June 1950, authorized the President to call reserve forces to active duty without further reference to Congress. This congressional action indicated to ConAC a new, and previously untried, way in which air defense weapons strength might be increased. On 15 July 1950, ConAC recommended that 20 fighter squadrons of the Air National Guard be called to federal service to buttress the air defense system. USAF was not ready to be stampeded into precipitate action, however. The ConAC request was disapproved on 1 August 1950 because USAF believed ConAC would be kept fully occupied in dispersing its 23 squadrons to 14 bases (an action recently approved). Also, USAF was

hopeful that the JCS would soon approve the first phase of the "package plan", in which case ConAC would be authorized 12 additional regular Air Force squadrons, for a total of 63 35.

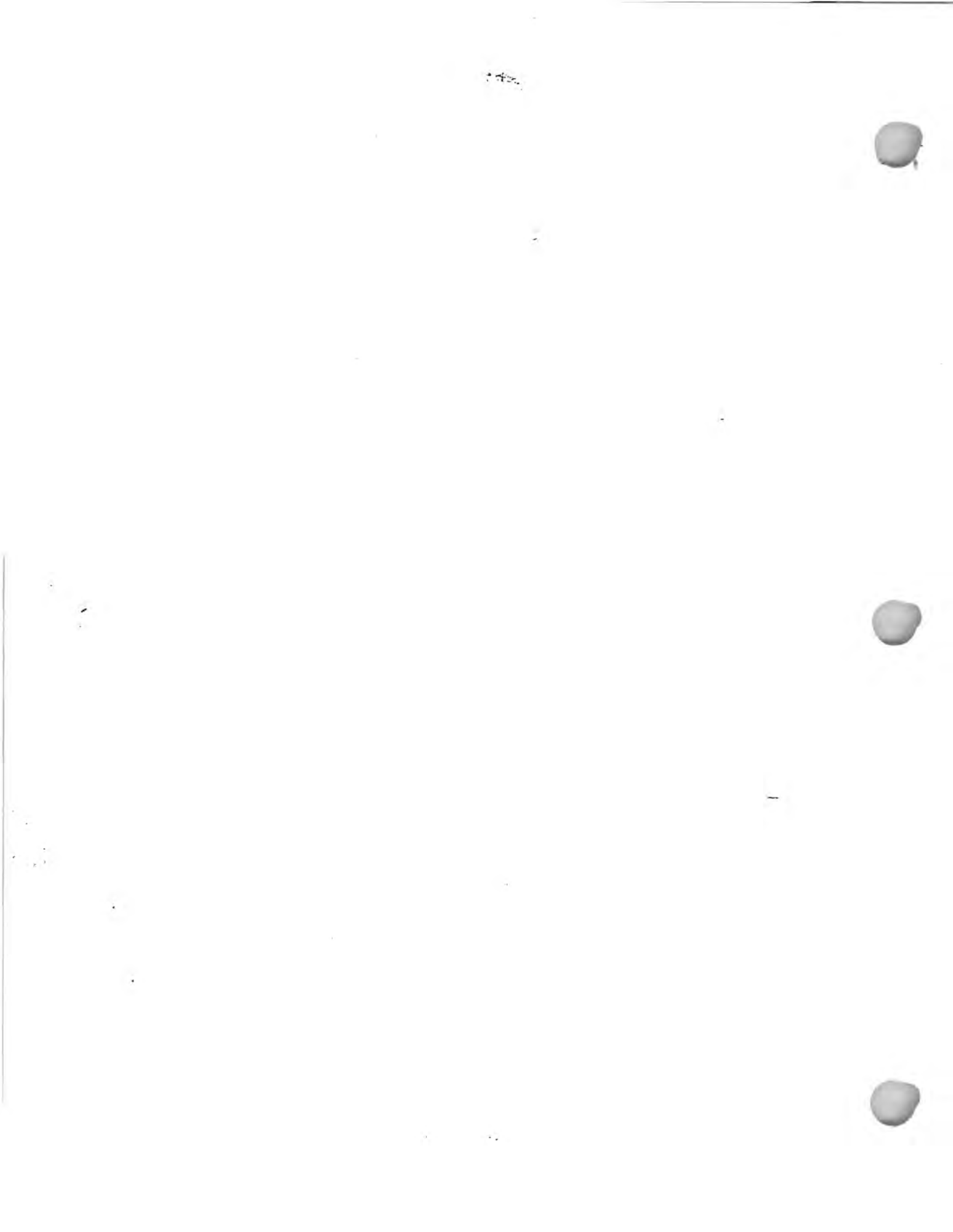
Since JCS approval of the first increment of the "package plan" was obtained shortly thereafter, ConAC did not immediately press the matter of ANG federalization, but concerned itself with the manning and equipping of the 12 additional squadrons it was authorized by the end of Fiscal 1951. The matter of the ANG arose again in late 1950 when the Chinese Communists entered the Korean fighting and it appeared, for a time, that the United States might soon be at war with both Communist China and the Soviet Union. Therefore, on 6 December 1950, ConAC asked for authority to call to federal service 15 ANG squadrons, with 23 additional ANG squadrons to be placed in "on-call" status for possible later use. The verbal approval of USAF had been obtained before the letter was written, although formal written approval was not received until 22 January 1951. One of the first major tasks of the revived Air Defense Command (reconstituted 1 January 1951), therefore, was the 64 federalization of a portion of the ANG.

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NORTH AMERICAN F-86F "SABRE"



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Until the nine SAC squadrons were added to the air defense force in December 1948, dispersal of the interceptor units was no problem. But in 1949 it became obvious that there was patent imbalance in having 20 squadrons tied to seven operating locations. JCS attacked the problem in its 1949 Short Range Emergency War Plan by directing that air defense weapons units be dispersed to better tactical locations on M-Day. In a corollary study, JCS listed locations that might be suitable for operations by fighter squadrons. ConAC agreed that dispersal was wise, but argued that air defense units required so much ground support that dispersal prior to M-Day was necessary. A plan for bringing this about was submitted to USAF on 20 August 1949 and approved by USAF on 7 November 1949.<sup>65</sup>

To give practical effect to the dispersal plan, USAF, on 30 January 1950, supplemented the earlier JCS study by providing for ConAC comment a list of 53 bases it thought could be used for fighter operations. Forty-four were felt to be usable within the near future, while nine were recommended for the further dispersal which would take place on M-Day. Thirty-two were currently active or inactive Air Force bases in the United States, 17 were civilian airports, two were naval air stations and



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two were in Alaska. USAF intended to provide information on bases as part of the "package plan" subsequently submitted to JCS on 2 March 1950. With minor exceptions, ConAC agreed that any of the bases named by USAF could be used for air defense purposes.

By May 1950, ConAC was ready to specify exactly which bases it wanted, at least for the dispersal of the 23 interceptor squadrons it controlled at the time. In addition to the eight bases currently being used (McChord had been added to Langley, Otis, McGuire, Selfridge, Hamilton, Kirtland and Moses Lake in early 1950), ConAC wanted Paine (Washington), Oxnard and Victorville (California), O'Hare (Illinois), McGhee-Tyson (Tennessee), Greater Pittsburgh (Pennsylvania), Buffalo and Suffolk County (New York), Reno (Nevada), Westover (Massachusetts), New Castle (Delaware) and Andrews (Maryland).

Because JCS had not approved the "package plan", USAF did not feel it had the authority to approve the ConAC plan for dispersal at that time. However, when ConAC again asked for dispersal approval on 6 July 1950, 11 days after the commencement of hostilities in Korea, USAF approval was granted in another 11 days -- on 17 July 1950. Although JCS had still not approved the "package plan", USAF believed the international situation made it necessary to give

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"interim" approval for dispersal of the 23 squadrons currently comprising the air defense weapons force. A subsequent study in USAF recommended that ConAC be permitted to move its air defense fighters into Westover, Andrews, Dover (Delaware), New Castle, O'Hare, Griffiss (New York) and George (previously known as Victorville) in addition to the seven bases already in use (Langley had been removed from the original group of eight). This was considerably different from the list submitted by ConAC in May 1950, but nevertheless acceptable. By the end of 1950, the ConAC interceptor force had spread out into the 14 bases authorized, although Oscoda (Michigan), Greater Pittsburgh and Wright-Patterson had been substituted for Andrews, Dover and New Castle in the list of authorized bases provided by USAF in August 1950. Although dispersal had been accomplished and a large increase in strength (to 35 squadrons) had been authorized, the interceptor force, in 1950, showed only a net gain of one squadron over the 20 squadrons available at the end of 1949. ADC acquired the 1st Fighter Wing (three squadrons) and the 97th FIS -- first of the 12 additional squadrons under the 58-Wing Plan -- during the year, but lost three squadrons when the 4th Fighter Wing was ordered to the Far East.

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In general, the dispersal of the interceptor force followed the wishes of ConAC and the resulting deployment was designed to provide protection for the population centers of the United States, plus the production facilities of the Atomic Energy Commission. This had been air defense policy since 1946, when ADC proposed to concentrate on the defense of the (1) Washington-Philadelphia-New York-Boston, (2) San Francisco, (3) Chicago-Detroit, (4) Los Angeles and (5) Seattle-Pasco areas. In May of 1950, however, the newly appointed Secretary of the Air Force, Thomas K. Finletter, wondered why this should be so. The Secretary was apparently surprised to discover that the atomic retaliatory force, Strategic Air Command, was not being given defense priority. The reason for giving population-industrial areas priority, General Whitehead explained to the Secretary on 17 May 1950, lay in the nature of the Soviet bomber force. General Whitehead reasoned that SAC bases (except the one at Rapid City, South Dakota) were virtually invulnerable to Soviet attack because (1) most of them were in the interior of the United States and should receive enough warning to permit evacuation and (2) most were located at the extreme one-way range of the Soviet TU-4 bomber. Besides, General Whitehead did not believe the Soviet bombardiers were sufficiently skilled to knock out 20 SAC bases in

  
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a single strike. Further, he doubted that the Russians would have enough atomic bombs within the next two or three years to mount such an effort. At the same time, he pictured the disorganization and chaos which would result should an atomic bomb be dropped on a major city, an operation fully within the current capabilities of the Soviet bomber force in General Whitehead's opinion. The time to shift defense emphasis to SAC would be when Russia had developed vastly improved bombers and had manufactured a sizable stock pile of nuclear weapons. That time General Whitehead believed to be at least three years away.

#### AIRCRAFT

The F-82. The "interim" F-82 conventional interceptor was delivered to ADC early in 1949 and by the middle of the year five squadrons had been equipped with it. This stop-gap night-fighter was almost more trouble than it was worth, ADC units experiencing continual maintenance difficulty. Spare parts were difficult to obtain, the engine was never completely satisfactory and performance was never adequate. For all these reasons, a USAF board of officers decided, in December 1949, that the F-82

  
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was a second-line interceptor and it was replaced by the F-94 as soon as this modified F-80 became available. By the end of 1950 only 26 F-82's remained in air defense units. The life of the F-82 was a short, unhappy one. <sup>70</sup>

The F-89. Although the XF-89 had made a successful maiden flight in August 1948, a USAF board of officers had chosen the F-89 over the F-87 in October 1949, and President Truman had released the necessary funds for the purchase of 48 F-89's in January 1949, none of these aircraft had been furnished to air defense units by the end of 1950. Why this was so is a case history in the frustrations of aerodynamics. The USAF board of officers had been aware of the serious deficiencies of the F-89, and several of the members had advocated buying none of the alternatives offered, but the majority had decided to proceed with the F-89 as the best of a not-too-promising lot. By early February 1949 the reservations of the board gained added point. Continued testing of the XF-89 (the first experimental model) had revealed such a degree of tail flutter and general instability that it was found necessary to reduce the allowable speed in the aircraft to 400 miles an hour. Nevertheless, Northrop had been ordered to proceed with production of the first 48 aircraft. To meet an

  
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objection that the F-89 was underpowered, AMC recommended that the second F-89 prototype (YF-89) include Allison J35-A-17 engines rather than the J35-A-9 engines of the XF-89.  
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Northrop worked to strengthen the tail, but the problem was one which apparently went deeper than mere strength of structural members. A minor accident from this cause occurred 20 May 1949. Then on 27 June 1949, vibration during a test flight became so severe that it was necessary to crash land the XF-89 on Muroc Dry Lake, causing major damage to the aircraft. Despite this setback, AMC, in August 1949, hopefully established a production schedule which called for receipt of the first production model F-89 in July 1950. In addition, Northrop was given a contract for 64 additional F-89's in October 1949 and January 1950, for a total of 112. Test flying of the repaired XF-89 was resumed in the autumn of 1949.  
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All hopes for a prompt and easy solution to the tail flutter problem were dashed 22 February 1950 when, during a demonstration flight before a gathering of AMC officials, the XF-89 disintegrated in air. The Northrop test pilot was seriously injured and the engineer flying



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in the radar operator's position was killed. There was obviously something radically wrong with the design or construction of the F-89. And it was obviously something that could not be solved in time for production of the combat-ready interceptor in July 1950. By April 1950, AMC had laid out a test program that called for (1) installation of strain gages on elevator torque tubes, (2) complete testing of the hydraulic dampers Northrop proposed to install in the tail, (3) a long series of flight tests of the balance weights Northrop proposed to place in the aircraft, (5) wind tunnel tests of the tail by which the aero-dynamic balance of the tail would be determined, and (6) detailed tests of the hydraulic dampers proposed for rudder and elevators. Meanwhile, production of the F-89 was suspended.

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No really acceptable "fix" for the tail flutter in the F-89 had been discovered by the end of 1950 and testing continued into 1951. It had been decided by the end of the year that the first 18 production airplanes, in which flutter was artificially controlled by judicious placement of balance weights, would be the only ones designated F-89A. Subsequent aircraft, in which flutter would be controlled by improved design, would be known as F-89B's.

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The Northrop production line was to halt after completion of the 18th item until an aerodynamically acceptable tail was devised. An accelerated service test was conducted by AMC and the Air Proving Ground Command was preparing to begin operational and suitability testing. But by early November 1950 only eight F-89 aircraft had been produced.  
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Even if production schedules for the F-89 had not been disrupted by design difficulties, the inability of Allison to deliver acceptable engines for the aircraft would have precluded meeting the July 1950 date for initial acceptance of completed interceptors. While the XF-89 was powered with the Allison J35-A-9 engine, it was decided in the summer of 1949 to use the more advanced Allison J35-A-21 engine in subsequent models. Allison, however, had considerable difficulty producing the required engines. Although four of the new engines had been promised by January 1950, only two had been made available by that time and neither was satisfactory for flight. Engine development dragged unsuccessfully through 1950 and when engines began to arrive in some quantity in the autumn of that year, it was discovered that blades had a tendency to come off turbine wheels. Northrop found it necessary,



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in October 1950, to ground all F-89's until this problem could be solved. The F-89's were still on the ground at the end of the year.<sup>75</sup>

Meanwhile, there was talk of using still more powerful engines in the F-89. In June 1950, USAF asked AMC to consider using either Allison J35-A-23 or General Electric J47-GE-21 engines in later models of the F-89. The J-47 was already under development for the B-47 bomber and adaptation sounded feasible and, above all, desirable, since the J-47 developed a thrust of 9,100 pounds without afterburner, while the J35-A-21 was rated at only 6,800 pounds even when an afterburner was used. Tests of the J-47 in the F-89 airframe were underway at the end of 1950.<sup>76</sup>

The F-94. Delays in the development of the F-89 had led the Board of USAF Senior Officers which met at Muroc in October 1948 to recommend conversion of the two-place version of the F-80 to all-weather interceptor configuration. This was strictly an interim measure, since the F-80 was the first operational jet aircraft and was sure to be superseded by improved jets in the foreseeable future. But the F-80 was available and a two-place model had proved feasible. This makeshift interceptor was dubbed F-94. The version which did not contain radar or armament became known

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as the T-33 jet trainer. The recommendations of the Board were approved by Secretary of Defense Forrestal in November 1948 and funds for the purchase of 111 F-94 interceptors were released by President Truman in January 1949. By that time the Board had met again (29 December 1948 - 6 January 1949) and had recommended, despite reduction in the authorized size of the Air Force from 70 to 48 groups, procurement of an additional 178 F-94's. AMC predicted, in late January 1949, that delivery of F-94 aircraft would begin in December of that year and reach a production rate of 20 a month by July 1950.<sup>77</sup>

Although it was also a two-place all-weather interceptor, the F-94 was to be a smaller and much less complicated aircraft than the F-89. While the F-89 weighed in the neighborhood of 17,000 pounds, the F-94 would weigh only 6,200 pounds. It was planned to use the Allison J33-A-23 engine in the F-94.<sup>78</sup>

Receipt of evidence that the Russians had succeeded in detonating an atomic device in the late summer of 1949 forced attention to the state of United States defenses against air attack. The Board of USAF Senior Officers which met 24 October 1949 discussed the need for rapid modernization of the defense forces, but postponed a

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decision because the matter appeared to require further study. The Board met again 14 December 1949 and because "foreign possession of the atomic bomb necessitates acceleration of the USAF program to modernize its interceptor and all-weather fighter force at the earliest possible time", it was recommended that the total number of F-94 aircraft to be procured be raised to 368, as against the previously authorized total of 288.<sup>79</sup>

The need for haste in the provision of some sort of jet interceptor for the air defense forces impelled division of the F-94 program into three segments, based on the availability of the various elements of the weapons system.

According to plans laid in January 1950, the first version -- the F-94A -- would be essentially a two-place F-80 equipped with a low-power E-1 fire control system and armed with machine guns. Then would come the F-94B, which would have an instrument approach system, automatic pilot, increased cabin pressurization, complete internal and external purging of the fuel system, a radar with power output of 250 kilowatts, a zero reader, a rocket nose and collision course sight, and thermal anti-icing equipment. Finally would come the F-94C to include a thinner wing (to increase speed from .8 Mach to .9 Mach) and a larger power plant. The Allison

  
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J33-A-29 and the British Nene (J-48) were suggested as possible engines.  
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Further technical study of the F-94 production plan, however, indicated a need for changes. The engineers decided that it would be possible to include only the instrument approach system, the zero reader, increased cockpit pressure and windshield de-icing in the F-94B. The other items mentioned by USAF would have to wait for the F-94C, or later, since deliveries of the F-94B were scheduled to begin in November 1950, with the first F-94C's to follow in the spring of 1951. An attempt would be made to use the J-48 engine and thin wing in the F-94C, although there was doubt that either would be fully developed by the time they were needed. The automatic approach system would not be ready. The same situation applied to the 250 kilowatt radar and the rocket nose and collision course sight, since neither would be ready for testing until 1951. The automatic pilot was too large for the F-94 and could not be used. An advanced fuel purging system would be used if the contractor's development program made sufficient progress.  
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The F-94A did not reach air defense units during the latter part of 1949 as originally scheduled, but did begin to arrive in interceptor squadrons in the spring of 1950. By the end of 1950 ConAC had 60 of these aircraft

  
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against a revised production total of 92. No F-94B's had  
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been made available to the air defense forces.

The F-86D. The same delay in development of the F-89 which prompted the decision to procure the F-94 also led to procurement of the F-86D, another interim interceptor created by conversion of an existing airframe. In point of time, however, the F-86D post-dated the F-94. The Board of Senior Officers which met at Muroc in October 1948 provided the recommendation which eventually resulted in the F-94. It was not until the next meeting of the Board -- 29 December 1948 to 6 January 1949 -- that immediate development of a single-seat all-weather interceptor was recommended. The choice of the F-86 as the basic vehicle was almost automatic, since it was the best of current day fighters. By March 1949 tentative specifications for an interceptor version of the F-86 had been drawn up. The following month North American began to modify two F-86A aircraft for use as interceptors. When the Board of Senior Officers met again on 16-17 May 1949 it was ready to accept the recommendation of Major General Gordon P. Saville, commander of ConAC's somewhat ephemeral Air Defense Command, that the F-86D be designated the single-seat interceptor

  
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the Board had had in mind when it made the January  
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recommendation.

The decision to produce a single-seat all-weather interceptor set a precedent, since all previous night fighters -- F-61, F-82, F-89 and F-94 -- had been two-place aircraft. There was considerable doubt among night-fighter crews that it could be done, that one man could monitor the radar equipment and fly the aircraft at the same time. But the Board of Senior Officers was convinced that the effort should be made. To make a one-man interceptor possible, the Board pointed out, it would be necessary to develop a high-speed automatic pilot and a "single presentation" radar for the F-86. The Board also wanted the F-86D armed with twenty-four 2.75-inch folding fin rockets (FFAR) being developed by the Army's  
84  
Ordnance Department.


The recommendations of the Board were approved by the Secretary of the Air Force and on 19 July 1949 AMC was authorized to spend seven million dollars on conversion of the F-86 to interceptor configuration. After an engineering inspection of August 1949 proved favorable, 79 million was made available the following month for the purchase of 124 F-86D's. The first flight of the experimental F-86D occurred in September 1949. In October the

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Board of Senior Officers met again, this time to consider what action should be taken in view of the intelligence that Russia had exploded a nuclear device. Because there was insufficient information available on which to base a recommendation as regards air defense aircraft, action was deferred until December. At that time the Board recommended that the number of F-86D's to be purchased with Fiscal 1950 money be increased from 124 to 155. It had been decided earlier to buy 250 of these aircraft with Fiscal 1951 money.  
85

Despite difficulties with the General Electric J-47 engine and the E-4 fire control system, development of the F-86D proceeded generally according to plan during 1950. AMC anticipated that the first F-86D off the production line would become available in January 1951. The F-86D looked so promising, in fact, that the number to be bought in Fiscal 1951 was increased from 250 to 356. The proposed Fiscal 1952 budget called for 394 F-86D's. As of the end of 1950, plans called for procurement of approximately 900 F-86D's during Fiscal 1950-51-52, which made it apparent that major dependence was going to be placed on the F-86D in the near future.  
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The 1954 Interceptor. When the decision to proceed with the F-89 was taken in October 1948, the Board of Senior Officers agreed that the F-89 was the best of a sorry lot and that something should be done to organize a design competition that would produce a truly advanced all-weather interceptor by 1954. At its meeting at the end of 1948, the Board reiterated its stand on the advanced interceptor, but added a specific recommendation that the design competition should be held in 1950. USAF 87 went along with this recommendation in February 1949.

Three months later, in May 1949, General Muir S. Fairchild, USAF Vice Chief of Staff, called the leaders of the aircraft and electronics industries together to discuss the proposed new interceptor and a new approach to the development of aircraft. In the past, General Fairchild explained, experts within the Air Force had conferred on aircraft requirements and had presented the industry with a rigid set of military specifications with which the contractor was expected to comply. This was a narrow, parochial approach to the problem, in General Fairchild's estimation, which made no use of the great reservoir of engineering talent controlled by industry. Therefore, General Fairchild proposed to prepare for the 1954 interceptor by briefing the industry representatives



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on the air defense problem and encouraging industry proposals for coping with it. Not merely an advanced airframe was involved, but a complete weapons system including armament, electronic controls and communications. General Saville presented the briefing, outlining the ground electronics environment and describing the actions necessary to detect and destroy hostile bombers. At the end of the conference, General Fairchild urged the industry representatives to go home and meditate on these matters and let him know their reactions.

88

The results of this unique approach, unfortunately, were negligible. The habits of competition were apparently ingrained, because none of the industry representatives responded with the wide-ranging, thoughtful replies General Fairchild had anticipated. Some saw an opportunity to establish themselves on the ground-floor of air defense and offered to serve as prime contractors for the entire air defense system, including the ground environment. Others responded with "selling" letters, pushing the company's particular product. Still others, mostly smaller companies, wanted to change the existing procurement system only to the extent of selling their products directly to the government instead of acting as sub-contractors to prime contractors.

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Although the industry replies were disappointing, the concept of developing weapons as entities, rather than collections of independently developed components, caught hold. While AMC was somewhat cautious and recommended that the radical new "weapons system" method of development be implemented with care,<sup>90</sup> USAF decided, in November 1949, that the weapons system method would be used in developing the 1954 interceptor. First, a suitable electronic fire control system would be designed. Then an airframe compatible with the electronic equipment would be developed.<sup>91</sup>

Consequently, AMC, in January 1950, invited 50 firms to submit their terms for developing the fire control system for the new interceptor, and Hughes was eventually declared winner of the competition. While the fire control proposals were being evaluated, competition for the airframe contract was organized. USAF furnished the military characteristics to AMC on 18 August 1950. Less than two weeks later, on 1 September 1950, 19 possible contractors were invited to submit bids. <sup>\*</sup> Deadline

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\* The following aircraft manufacturers were invited to submit proposals:

Boeing  
Douglas  
Republic

Lockheed  
Northrop  
North American





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for proposals was originally the end of 1950, but this was later extended to 31 January 1951. More than a simple airframe was involved in the proposals, since the winner would have to assume responsibility for the "satisfactory  
92 functioning of the airplane as a weapon."

The prospective development contractors were also instructed to work closely with Hughes to make sure the airframe would be compatible with the electronic equipment. Because an advanced airframe design was obviously desired, several of the competitors sought research assistance from  
93 the National Advisory Committee for Aeronautics (NACA).

At the deadline for the airframe competition, six prospects had submitted nine proposals. Republic submitted three bids, North American two. Single proposals were submitted by Chance-Vought, Lockheed, Douglas and  
94 Convair.

By the end of 1950, then, the outline of the air defense weapons force for the next five years was well established. Converted F-80's, known as F-94's, had begun to arrive. A modification of the F-86, known as F-86D, was expected in 1951. The F-89, culmination of a design

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\*(Cont'd)

Convair	Chase	Bell
Ryan	Chance-Vought	United Aircraft
Glenn L. Martin	McDonnell	Fairchild
Grumman	Curtiss-Wright	Hughes
Goodyear Aircraft		

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competition held in 1945, would become available as soon as various airframe and engine problems were solved. The result would be an air defense force composed of about two-thirds F-86D's, with the remainder consisting of F-94's and F-89's. The force at that time would be made up of nominally all-weather jet interceptors. This force would be modernized in the mid-fifties, if all went well, by acquisition of what was still known at the end of 1950 as the "1954 interceptor."

#### FIRE CONTROL SYSTEMS

Adaptation of the B-36 tail radar (APG-3) for use in interceptors made relatively rapid progress during 1949 and 1950. The interceptor adaptation was designated APG-33 and became the basic component of the E-1 fire control system for the F-89 and F-94. AMC specified that the power output of the radar be increased from 40 to 250 kilowatts and the diameter of the antenna be increased from 12 inches to 25-30 inches, but Hughes did not find it possible to comply. All that was feasible was to increase the power supply to 50 kilowatts and antenna size to 18 inches. The first APG-33 prototype was tested in an F-94 in May 1949 and the results were encouraging. By



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July 1949 Hughes was able to report that the radar could detect a B-25 at 11 miles and was capable of lock-on at four miles. Prospects were good, Hughes thought, for still better performance as development continued. On the basis of these favorable reports, production of the E-1 system was directed and the first production model was installed in an F-94A in October 1949. By February 1950, 25 E-1 systems had been completed. The operational suitability test of the E-1 was begun by Air Proving Ground in September 1950. As a result of this test, 10 minor changes (such as the location of various switches) were recommended and subsequently accomplished by retrofit action. Tests of the E-1 in the F-89 and F-94B had also begun by the end of 1950. Although ADC experienced considerable early difficulty in maintaining the E-1 system, the problem was primarily a shortage of skilled maintenance personnel. The result of this development action was that ADC had been partially relieved of total dependence on the World War II SCR-720 by the end of 1950. It had 60 F-94A interceptors equipped with the advanced E-1 fire control system.

The E-2 "single-presentation" radar for the F-86D differed from the E-1 only in that smaller components were used in order that the radar might be fitted into the small

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space available. The radar synchronizer and indicator circuits were linked and the controls were changed so that the pilot could perform the lock-on operation with his left hand. Also, to avoid the use of the hood required with the E-1, a cathode ray tube was added which would allow longer persistence of the "blip" on the radar scope. The first prototype E-2 system was installed in an F-94A in December 1949. No serious defects were discovered and production was initiated in 1950. The E-2 system was undergoing operational suitability tests at the end of the year.<sup>96</sup>


The E-2 system, however, was designed for use with 20mm guns, so that when it was decided that the F-86D would be armed with 2.75 FFAR rockets, it was necessary to develop an appropriate fire control system. This was done, to over-simplify, by grafting a rocket-firing computer to the E-2. The composite system was designated E-3. Hughes delivered a prototype E-3 to North American for testing on 26 May 1950, but the results were discouraging. North American found the E-3 "entirely unsatisfactory" and recommended thorough-going redesign. This system was later installed in the second YF-86D and after further testing was completed in October 1950 the

  
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E-3 was returned to Hughes for evaluation and engineering changes. The deficiencies of the E-3 were still under study at the end of 1950.<sup>97</sup>

Although AMC had expressed a need for 250-kilowatt radar when the E-1 was first discussed, the state of the radar art had not been far enough advanced at that time to make it possible. But by early 1950, Hughes was ready to attempt design of the more powerful set. Because the 250-kilowatt radar was considerably different from the original APG-33, it was renamed APG-37. The E-3 fire control system, when equipped with the more powerful radar, became known as E-4. Hughes had managed to assemble a prototype E-4 by November 1950, but testing had not begun by the end of the year.<sup>98</sup>

Aside from the E-series of fire control systems, which represented normal growth in the development of the art, USAF also wanted a much advanced fire control system for use with the 1954 interceptor. In fact, the heart of the 1954 interceptor was to be the fire control system, with the airframe to serve primarily as a vehicle to carry that system. That was why USAF directed, in late 1949, that competition for development of the fire control system be held before that for the airframe.<sup>99</sup>

  
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Therefore, in January 1950, AMC invited 50 firms to submit their terms for developing a fire control system for the new interceptor. Eighteen responded with proposals. That the Air Force was venturing into virtually uncharted development territory was indicated by the wide variance in the bids. Emerson Electric Company was confident it could do the job for \$1,680,000. Northrop felt that development would cost \$14,250,000. General Electric foresaw no insurmountable problems and estimated development could be completed in 27 months. Westinghouse, on the other hand, pessimistically predicted a development period of 63 months. AMC analyzed the bids on the basis of price, past performance and other factors and by early May 1950 thought it could recognize six potential winners. From a technical standpoint, North American, Sperry Gyroscope and Hughes appeared to be the best qualified. From the logistics standpoint (supply and promptness of delivery of spare parts), Westinghouse, Bendix and General Electric<sup>100</sup> looked best.

Discussions regarding a development contractor moved to the Pentagon at this point. A group charged with evaluating the proposals as to operational suitability recommended acceptance of the Hughes bid if the

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Hughes proposals could be amended to include portions of the Westinghouse plan. Meanwhile, USAF had appointed an ad hoc board to determine which of the proposals had the most merit. This board was headed by General Saville, who had become USAF Deputy Chief of Staff for Development since briefing the assembled industry representatives on the air defense problem in May of 1949. General Saville in turn appointed a special Air Defense Engineering Committee, headed by Dr. George E. Valley, to assist him in technical evaluation of the various proposals. The Valley committee recommended that the award be made from a group of bidders which included Glenn L. Martin, Sperry and North American. After sifting the conflicting recommendations, the Saville board narrowed the competitors down to Hughes and North American. The board visited the West Coast in early June 1950 and not only toured both plants but also interviewed officials of both firms. <sup>101</sup>

Members of the Valley committee saw enough during this visit that they recommended accepting the North American offer, although the ideal situation, the committee felt, would be to award development contracts to both. The full board did not agree with the Valley group, however, and, in July 1950, declared Hughes the winner of the competition. The North American radar scanner, inertial automatic

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navigator and radar power package were to be developed separately to fit the basic Hughes system. Contract discussions were opened with Hughes in late July 1950, but because of various disagreements over costs the final contract was not approved by AMC until 2 October 1950. The development of the advanced fire control system (known at that time as Project MX-1179) had not progressed beyond the study stage at the end of 1950.

#### IDENTIFICATION, FRIEND OR FOE (IFF)

Because the Mark III IFF used in World War II had been hopelessly compromised, the Joint Chiefs of Staff decided, in October 1948, that a better, more secure, system was needed, especially in view of the increase in international tensions. The basis for a better system was immediately at hand -- the Mark V IFF developed between 1943 and 1945 at the Naval Research Laboratory by a Combined Research Group which included representatives of the Navy Research Laboratory, the Army Signal Corps, the United Kingdom and several manufacturers. Mark V was never used in World War II, but the Mark X which Watson Laboratories began to develop in December 1948 was based, in part, on the techniques evolved in connection with the Mark V. Because Mark V provided a

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platform from which to build, the required Mark X antennas, receiver-transmitters and simple coding equipment were developed rapidly and were tested on ConAC aircraft at Langley between July and November 1949. Although ConAC discovered that the Mark X beacon was of little help in tracking interceptors beyond the range of ground radars,<sup>103</sup> it was apparently adequate as an IFF system.

Since the JCS timetable called for all U. S. military services to have the Mark X system in operation by 1 July 1952, USAF pressed ahead with plans for installation of the equipment. Beginning in June 1950, all new aircraft were to have Mark X installed on the production line. Existing tactical aircraft were to be retrofitted with the Mark X during the year beginning 1 June 1950. AMC proposed to do even better than required by USAF, promising that all fighter units would be fitted with the AN/APX-6 IFF transponder by the end of 1950. The retrofit program began in September 1950, but was nowhere close<sup>104</sup> to completion by the end of the year.

But it really didn't matter that the installation of airborne transponders failed to meet the schedule, because the supply of the ground elements of the Mark X system was still further behind schedule. ConAC noted this problem as early as March 1950 and repeatedly called

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it to the attention of AMC and USAF throughout the remainder of the year, but to no avail. At the end of the year there were only eight of the interrogator-responsor units installed at radar sites and these were not production models, but prototypes suitable only for testing purposes. The Mark X system could only be effective when both ground and airborne equipment was installed and working. 105

Development and installation of the AN/APX-6 and its associated ground equipment was only Phase I of the Mark X project, however. The second phase was the addition of a more complex coding and decoding technique by which individual aircraft could be recognized. This was first known as the Short Interval Identification System (SIIS), but was later called the Security Identity Feature or Selective Identification Feature (SIF). Development of SIF had barely begun at the end of 1950. 106

#### ARMAMENT


The movement away from the airborne machine guns and cannons of World War II continued during the ConAC period of ADC history, although all interceptors were still armed with machine guns and cannons at the end of 1950. When ConAC was created in December 1948, three

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advanced types of armament were under development. Two were air-to-air guided missiles -- the Ryan Firebird and Hughes Falcon. The third was a 2.75-inch rocket intended to increase interceptor firepower until the guided missiles were ready.

The Ryan development was soon to fall by the way-side, however, since there was no point in developing two missiles to do the same job and the Firebird suffered in comparison with the Falcon. Initial procurement of Ryan missiles was directed September 1947, when AMC was instructed to obtain 150 for service test. This directive was rescinded in October 1947 because of a shortage of funds, but was reinstated in May 1948. The number to be procured was cut to eight in September 1948, but was increased to 138 in November of that year. This changing of minds ended in April 1949, when the whole Ryan program was cancelled, never again to be revived.

Of the many proposals regarding an air-to-air missile during the hectic days of the early post-war period, only the Hughes Falcon survived. After the choice between the Falcon and Firebird was made in April 1949, all funds and energy could be devoted to the Falcon. There appeared to be plenty of energy available, but funding was a problem.

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At one point in 1949, \$200,000 had to be provided from an emergency fund in order to keep development work going. But, one way or another, funds were made available and in 1950 it was estimated that the service test of the missiles would be completed by December 1953, with missiles being made available to operational squadrons beginning in June 1954.  
108

Meanwhile, the Army's Ordnance Department was apparently making satisfactory progress in the development of the "interim" 2.75-inch folding-fin rocket (FFAR), because USAF continued to plan for its use as armament for the F-89D and F-86D. The rockets, of course, would not be used until the aircraft designed to carry them were on hand. And the only jet interceptors available by the end of 1950 were 60 F-94A aircraft. This model of the F-94 did not carry the 2.75-inch rocket.

#### INTERCEPTOR MISSILES


As was the case with air-to-air missiles, there were three active interceptor missile projects at the end of 1948. One, the Boeing GAPA, involved a short-range missile intended to knock down a subsonic target at a height of 60,000 feet and a range of 35 miles. At the end

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of 1948, development of GAPA had progressed to the point where AMC had been instructed to buy 70 test missiles. The other two interceptor missile projects -- the General Electric THUMPER and University of Michigan WIZARD were "far out" study efforts aimed at creation of a missile which would be effective between 60,000 and 500,000 feet, would intercept a target moving at 4,000 miles an hour and would have a range of several hundred miles.

In 1949, however, a re-shuffle of missions in the air defense field eliminated GAPA as a factor in air defense. The Joint Chiefs of Staff decided that short-range air defense missiles would thereafter fall within the purview of the Army, thereby preparing the way for what eventually emerged as the NIKE antiaircraft missile. Boeing, however, had acquired a considerable body of experience with missiles that the Air Force was loath to release. The result was a combination of the Boeing and University of Michigan projects into a new program for development of a compromise missile to be named BOMARC. The General Electric THUMPER project was allowed to lapse on 30 June 1949, because it, in many ways, duplicated the University of Michigan effort.

Boeing and the University of Michigan collaborated, in early 1950, on a study intended to determine the feasibility of developing, within a reasonable period of time,

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an interceptor missile capable of intercepting a super-sonic target at a range in excess of 100 miles and at altitudes up to 90,000 feet. This was a goal somewhere between those for GAPA and WIZARD. The preliminary conclusions of this study, announced in June 1950, were that a missile which would be effective between 10,000 and 80,000 feet, would have a range of 250 miles and would intercept targets at velocities between 400 and 2,000 miles an hour could be made ready for service test in 1956. AMC concurred as to the technical feasibility of the project in the late summer of 1950. USAF approved the development shortly thereafter and in December 1950 the Research and Development Board of the Department of Defense indicated similar approval. The way was clear, assuming availability of funds, for development of

109

BOMARC.

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## CHAPTER FOUR

## FEDERALIZATION OF THE AIR NATIONAL GUARD - 1951

To prove how swiftly events could move in time of emergency, the size of the interceptor force more than doubled between the end of 1950 and early March 1951. Fifteen Air National Guard squadrons were called to federal service on 10 February 1951. Six more were called on 2 March 1951. In addition, two regular Air Force squadrons were activated at Presque Isle on 12 January 1951. Therefore, while ADC controlled 21 squadrons on 14 bases when it was re-activated on 1 January 1951, it had 44 squadrons on 34 bases two months later. It took nearly five



laborious years to accumulate the first 21 squadrons.  
 The next 23 were acquired in two months. <sup>110</sup>

This large-scale enrollment of the ANG resulted in a considerable increase in aircraft, aircrews and air bases. But the immediate increase in combat capability was not great, because the aircraft were mostly obsolete P-47's and P-51's, the aircrews were relatively inexperienced and the air bases lacked many necessary facilities. The immediate problem then, was digestion of this mass of potential combat capability. This was the first major effort of the reconstituted Air Defense Command and required the better part of two years. Almost half of the home bases of the ANG squadrons were undesirable from a full-time air defense standpoint and changes were required. <sup>111</sup> Ten squadrons were moved as follows:

<u>From</u>	<u>To</u>
Reading (Pennsylvania)	Dover
Stout Field (Indiana)	Scott -
Kellogg Field (Michigan)	Selfridge
General Mitchell Field (Wisconsin)	Truax
Bradley Field (Connecticut)	Suffolk
Holman Field (Minnesota)	Wold-Chamberlain
Kirtland (New Mexico)	Long Beach
Sioux Falls (South Dakota)	Ellsworth
Baer Field (Indiana)	Sioux City
Berry Field (Tennessee)	McGhee-Tyson

The squadron at Long Beach was subsequently transferred to Oxnard.



  
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Since the federalized ANG squadrons brought their aircraft with them, the number of tactical aircraft controlled by ADC more than doubled in early 1951, increasing from 365 at the end of 1950 to 813 at the middle of 1951. A third of these, however, were obsolete World War II F-47 Thunderbolts and F-51 Mustangs. While the proportion of F-47's and F-51's remained at about one-third during the succeeding year, the numbers of early model all-weather interceptors (F-94A/B and F-89B/C) gradually increased. While there were 86 such aircraft in the ADC inventory in mid-1951, the number had increased to 168 a year later. At the middle of 1952 the ADC weapons force consisted of about one-third early-model all-weather jet interceptors, one-third day jet fighters (F-84 and F-86) and one-third  
112  
obsolete World War II fighters.

While ADC had ambitious plans for improving the training of the recently acquired ANG aircrews, this training was not as thorough as it might have been, because of the shortage of gunnery ranges and the general lack of training facilities. With the weapons force doubled in size (and considerable numbers of ANG aircrews requiring specialized air defense training), the need for a weapons training center became increasingly apparent. Advanced

  
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flying training was merely a matter of aircraft and instructors and could be accomplished at the home base. Weapons training, however, required an adequate range, suitable targets and sufficient maintenance support. Western Air Defense Force (WADF) approached this problem by arranging with Air Training Command, in the spring of 1951, for use of the Williams Bombing and Gunnery Range in Arizona. ATC agreed to let ADC use the western half of the range, but could not agree to base ADC units at Luke Air Force Base during their training periods because Luke was fully occupied with ATC activities. WADF therefore arranged to have its squadrons based at Yuma County Airport, a former Army air base returned to the county at the end of World War II. WADF units, based at Yuma, began gunnery training in September 1951.

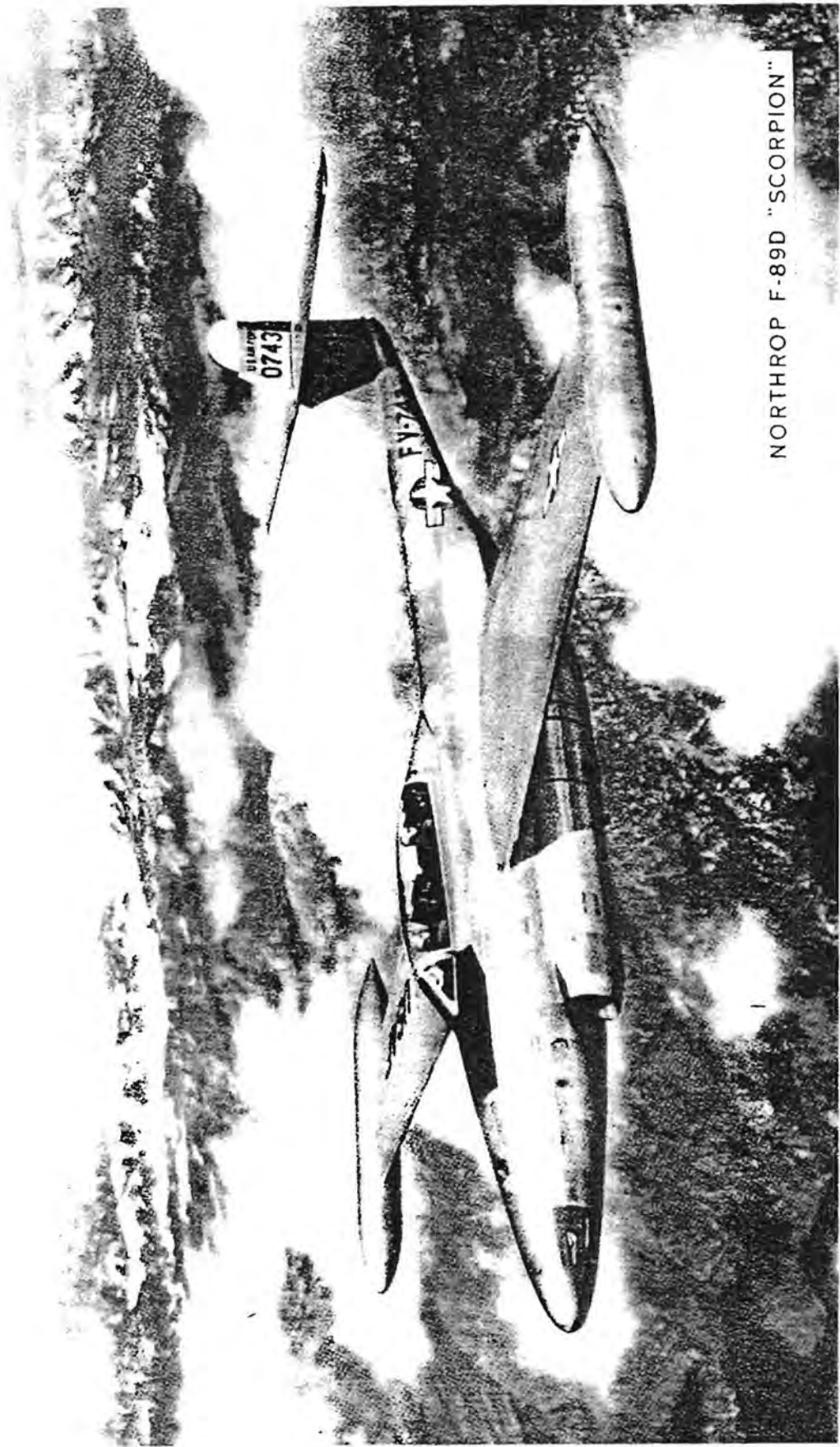
The solution reached by WADF appealed to ADC as a possible solution for the gunnery training problem of the entire command. In early 1952 ADC prepared a plan which called for improving the facilities at Yuma until it would be possible to support 100 aircraft there, making it possible to provide weapons training for three squadrons simultaneously, although it was not anticipated that this level of training would be reached until 1954. USAF saw

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the logic of the ADC request and by the middle of 1952  
114  
had tentatively approved the ADC proposal.

The federalization of a portion of the Air National Guard, then, was a mixed blessing. While it provided a major increase in the size of the interceptor force, it also created major problems with regard to bases, aircraft, maintenance and training. But, in sum, advantages outweighed the disadvantages, because when the ANG squadrons completed their 20 months of federal service in November and December of 1952, only the numerical designations of the squadrons were returned to the states. The aircraft and crews remained with ADC (regular Air Force personnel were fed into these squadrons during the summer and autumn of 1952). As a result, 20 of the 21 squadrons federalized in early 1951 were a net gain to the air defense force, as constituted at the end of 1952. One ANG  
115  
squadron was moved overseas and thereby lost to ADC.

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NORTHROP F-89D "SCORPION"



## CHAPTER FIVE

## TOWARD A HIGHER PLATEAU, 1951-1954


## THE PLANNING

Although the size of the weapons force doubled in the early months of 1951, interceptor strength was still below that proposed in the USAF "package" plan of early 1950. This plan foresaw an air defense weapons force of 35 squadrons in an Air Force of 58 wings; 47 squadrons in an Air Force of 69 wings; 61 squadrons in an Air Force of 95 wings. ADC nearly reached the second plateau in the spring of 1951, but it was to take time to reach the higher goal. Meanwhile, the size of the ADC cut of the

  
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total Air Force pie was substantially reduced. Where the 1950 USAF plan had allocated ADC 61 squadrons in an Air Force of 95 wings, a similar 1951 plan called for 61 air defense squadrons in an Air Force of 138 wings. In other words, 21 per cent of total Air Force combat strength was to be devoted to air defense in the 1950 plan, while only 15 per cent was so earmarked in the 1951 plan. When, later in 1951, the size of the 1953 Air Force was decreased from 138 to 126 wings, the air defense allocation was accordingly reduced from 61 squadrons to 57 squadrons. This was the 1953 goal toward which the ADC planners were working following the federalization, and integration, of 21 squadrons of ANG fighters.<sup>116</sup>

But further increases were not experienced for many months. In fact, things got worse before they got better, because of the need for fighter units overseas. The 81st Fighter Wing (91st and 92nd FIS from Larson and the 116th FIS from Geiger) was moved to England in the late summer of 1951. In March 1952 the 319th FIS transferred from Larson to the Far East, leaving an air defense force of 40 squadrons. ADC was displeased at these "raids" on air defense capability, but realized that USAF had to take cognizance of world-wide requirements and was not wilfully

  
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reducing the Zone of Interior weapons force. It was even thought possible, in late 1951, that the Korean fighting might require a reduction to 31 squadrons. This did not prove necessary, however. Strength was reduced to 39 squadrons in October 1952 when the 59th FIS was shifted from Otis to Goose AFB in Labrador, but no further reductions were made.

A plan to reach the 57-squadron level almost immediately by calling to federal service the 16 ANG squadrons not previously federalized was dropped because the 20 squadrons returned to state control in late 1952 had no aircraft. It was thought wiser to distribute the aircraft held by the 16 non-federal squadrons among the denuded squadrons and build the ADC force through activation of regular units. Later in 1952, in response to a query from USAF, ADC forecast an "ultimate" air defense weapons force of 151 squadrons of interceptor aircraft plus 3,000 BOMARC missiles (30 squadrons). ADC was aware that it was extremely unlikely that the budget would ever permit realization of a force of that size,<sup>118</sup> but USAF had asked the question and ADC had answered.

The requirement for 151 interceptor squadrons was apparently not taken seriously by USAF, since it was never

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reflected in any program issued by that headquarters. Progress toward the 57-squadron level was fairly rapid, however, after the Air National Guard was released from federal service in late 1952. Four new regular squadrons were activated in November 1952 and fourteen others were organized during the spring of 1953. This raised the total to 57 squadrons, but was not pure gain, because six squadrons were transferred overseas during the same period. The gain in combat strength was still less, since five squadrons possessed neither men nor aircraft. Although there had been much activity on paper, ADC controlled 46 manned and equipped squadrons at mid-1953, seven more than were available at the end of 1952.

ADC worked toward the 57-squadron goal until December 1953, when USAF announced that Congress had authorized an increase in the size of the total Air Force from 120 wings to 127 wings and that more than half of this increase (12 squadrons) had been allocated to air defense. This raised the ADC authorization to 69 squadrons, to be attained by mid-1957. ADC was thankful for this addition to its combat strength, but suggested that this was only an interim figure since Congress, in a still more recent action, had approved a 137-wing Air Force and that ADC would thereby

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be authorized 75 squadrons. For the long pull (this being figured as the period ending in 1960), ADC estimated it would need 113 squadrons of manned interceptors -- scaled down from the 1952 figure of 151 squadrons, plus 53<sup>120</sup> squadrons of BOMARC -- increased from 30 squadrons.

USAF did not immediately disabuse ADC of the 75-squadron notion (a "programming" figure not to be confused with the "requirement" figure of 113 squadrons), and ADC planning through 1954 assumed that one day in the not too distant future 75 squadrons (and possibly 77) would be allocated to air defense. In January 1955, though, USAF settled the matter by stating flatly that ADC would get only 69 squadrons.<sup>121</sup>

While the planners talked of 69 (and 75 and 113) squadrons, actual ADC strength, at the end of 1954, was approaching the 57-squadron goal originally authorized for 1953. The 57 squadrons were on hand at that time, but two had not yet been manned and equipped. The interceptor force was deployed to 42 bases. This was a reasonable approximation of the "package plan" for 61 squadrons<sup>122</sup> on 52 bases which USAF presented to JCS on 2 March 1950.

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## AIRCRAFT

Just as the interceptor force reached respectable size during the 1951-54 period, it was equipped, for the first time, with all-weather jet aircraft. The federalization of the Air National Guard in early 1951 brought considerable numbers of aircraft into the air defense system, but these were primarily day fighters left over from World War II. More than one-third of the total on 30 June 1951 were P-47 and P-51 veterans of the war that ended in 1945. Slightly less than half were post-war jets of the F-80, F-84 and F-86 types. Less than 100 could possibly be called all-weather interceptors. There were 82 F-94A/B aircraft, a makeshift interceptor version of the F-80. Because of a lack of anti-icing equipment it was perhaps erroneous to regard these aircraft as all-weather interceptors. The true all-weather version of this aircraft, the F-94C, had not become available. Also, early versions of the F-89 were beginning to appear, four F-89B interceptors having been delivered.

By the end of 1954, the situation was vastly different. Of the approximately 1,100 tactical aircraft possessed by ADC, more than two-thirds (about 800) were modern F-86D all-weather interceptors. Although plans to make the F-86D

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initially available in January 1951 proved hopelessly optimistic, a flood of these aircraft descended on ADC in 1953, more than 600 being provided during that year. Of the remainder, about 200 were F-94C all-weather craft and about 100 were F-89D's. The only day fighters in active air defense use at that time were 37 F-86's.

The F-89D. While the F-94C and F-86D were interim interceptors created through modification of existing fighter aircraft, the F-89 was an original development - - USAF's first attempt to design a jet aircraft specifically for interceptor use. Even though the design competition was announced in 1945, an operational aircraft was still not available by the end of 1950. A persistent tail flutter had not been solved at that time, nor had a reliable engine been developed.

Although 25 F-89B aircraft had reached ADC squadrons by the end of 1951, the F-89 was still not ready. -In early 1952, three F-89's disintegrated in air in fairly rapid succession. Also, the low-slung engine of the F-89 earned a reputation as the "world's largest vacuum cleaner" by picking up litter from the runway. A vagrant piece of metal, on several occasions, was sucked into engine inlets, causing disintegration of the compressor rotor



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blades. Pieces of the compressor then destroyed the remainder of the engine. Inlet screens were an answer of sorts, although it was discovered that at extremely high altitudes the inlet screen could become completely clogged with ice. The main problem was encountered at low altitudes, however, where the major accidents had occurred. <sup>123</sup>

Wright Air Development Center (WADC) was of the opinion that the jet wake fairings on the F-89 were primarily at fault. It was argued that the existing fairings, intended to decrease the vibration caused by the wake from the jet engines, actually transmitted severe stress to the entire airframe. At any rate, AMC, in June 1952, limited the F-89 to a speed of 350 knots at altitudes below 15,000 feet until something could be done about the structural weaknesses of the aircraft. At the same time, USAF refused to accept 65 completed F-89's until Northrop could come up with an answer. Meanwhile, the 74th FIS at Presque Isle AFB, Maine, received the first F-89C aircraft in January 1952. Because of the lack of structural reliability, however, deliveries were halted in March 1952 when the 74th had received only 19 aircraft. The chances of making an acceptable interceptor of the F-89 were so bleak by the middle of 1952 that W. L. Campbell of the Aircraft

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Production Board made a public recommendation that the  
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F-89 be scrapped.

Although Mr. Campbell's suggestion was not followed, the situation with regard to the F-89 got worse before it got better. Four more F-89's (all F-89C models) disintegrated in air in the summer of 1952, one at the national air show in Detroit in late August. In every instance the aircraft was being flown at a speed in excess of 350 knots and at an altitude less than 15,000 feet. Following the accident of 22 September 1952, all F-89's were grounded until the obvious structural faults were remedied. Close and detailed study of the F-89 structure during the late summer and early autumn of 1952 made it appear that the failures resulted from the stresses imposed by maneuvers, low stability resulting from a center of gravity too far  
125  
aft on the aircraft and possible structural fatigue.

The blame for this situation apparently lay in an assumption by design engineers that the straight wing was a rigid structure which would experience only negligible aerolastic effects. This assumption was proved wrong when the F-89 began to fly, but ARDC was not inclined to reproach Northrop design engineers for this mistake. ARDC pointed out that "most structures designers" agreed with




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the Northrop assumption at the time the design was prepared and that "what happened to air during transonic flow over a wing" was simply not known at that time. Tests in subsequently available wind tunnels had shown that the design was in error. All that could be done at that point was redesign the 189 F-89's already produced (at a cost of approximately 17 million dollars) and apply the new knowledge to aircraft yet to be produced. Northrop began to redesign the airframe, expressing the hope, in November 1952, that the modifications could be introduced into the production line by April 1953.

The design improvements directed in late 1952 found their way into the Northrop production line, as advertised, in April 1953. By the middle of 1953 ADC had 31 of the modified F-89's available. The number had doubled by the end of 1953. But the F-89 was still a relatively unreliable aircraft. There was another rash of F-89 accidents during the last half of 1953, many of them laid to control system failures. Vibration was still noticeable at low altitudes, but was not considered serious enough to justify further redesign. Anyway, the F-89 had been in development for so many years that it was becoming obsolescent before it became operational to a significant degree. In addition to

  
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other problems, it was discovered that the engines in the F-89 (J35-A-21, -33 and -35) were susceptible to a "power droop" of as much as 10 per cent at altitudes above 20,000 feet.

Finally, after nearly eight years of development, the first F-89D reached ADC on 7 January 1954. The first unit to receive the "ultimate" result of F-89 development was the 18th FIS at Minneapolis-St. Paul. Development was presumably complete, although the ARDC Weapons System Project Office, in February 1954, asked AMC to placard all F-89D's with a warning never to exceed a speed of 425 knots at an altitude of less than 20,000 feet. Subsequent improvements to the rudder and automatic pilot, however, improved the maneuver capability of the aircraft. As to the undesirable "power droop" in the J-35 engine, shielding of the temperature sensing element of the engine power control proved to be the answer and this problem disappeared. At the end of 1954, ADC had 118 F-89D aircraft. The F-89B and F-89C disappeared in early 1954.


Almost as soon as it was decided that the Falcon air-to-air missile being developed by Hughes would be used by interceptors rather than bombers, it was also decided that the F-89 would be the initial carrier. When the idea

  
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of arming the F-89 with the Falcon was first broached in 1951, an operational date of 1 January 1954 was suggested. But, as was often the case with proposed operational dates, this prediction was optimistic. By August 1952, the operational date had slipped to 1 October 1954.<sup>129</sup>

The most difficult problem in modifying the F-89D for use as a Falcon carrier was the fire control system. The E-9 system of what came to be known as the F-89H had twice as many components as the E-6 used in the F-89D. What with the missiles and electronic equipment to be placed in pods on the wing tips of the aircraft, it amounted, in the words of a WADC spokesman, to suspending an F-84 fuselage on each wing tip of the F-89. Also, there was the possibility that the F-89H would be so heavy that it would be necessary to use the advanced J-71 engine as a power plant, thus creating further delays.<sup>130</sup>

These problems were eventually solved, but each solution required time. The first airborne test of the E-9 fire control system occurred 3 August 1953. Falcons were successfully fired from a modified F-89D on 21 October 1953, but the missile pod showed a tendency to collapse after firing and redesign was necessary. Progress was being made, but not quickly enough to meet the operational date of

  
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1 October 1954. By the end of 1953 that date had receded to August 1955. A year later, it was hoped that the F-89H would be available in 1956.<sup>131</sup>

The F-94. Although the F-94A was not, strictly speaking, an all-weather interceptor because it did not include adequate anti-icing equipment, it was, nevertheless, the first of the jet fighters specifically modified for air defense use. Sixty of these aircraft were available for air defense operations at the end of 1950. The second model in this series (F-94B) began to appear in April 1951, with the 61st FIS at Selfridge AFB, Michigan, being the first air defense unit so equipped. The F-94B differed from the F-94A in that it included a zero reader to permit more accurate landings in bad weather, a high-pressure oxygen system, an improved hydraulic system and external fuel tanks mounted along the center line of the aircraft instead of suspended from the wings. Since the F-94A and F-94B were essentially jet night fighters and not all-weather interceptors, the need for an effective jet all-weather interceptor remained. ADC, nevertheless, was pleased to receive the early models of


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the F-94, because they were an improvement over aircraft  
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currently on hand.

Development of an F-94C that was an appreciable improvement over the F-94A and F-94B proved a matter of some difficulty. After flying test aircraft in late 1951 and the first half of 1952, representatives of ADC came to the conclusion that because of low speed (about 40 knots slower than the F-89) and poor maneuverability, the F-94C was unacceptable to the command. After sober second thought, however, ADC added the cautionary postscript that if nothing better was available, the F-94C would be accepted  
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if all deficiencies were corrected.

Because of ADC objections to the F-94C, representatives of USAF, ARDC, APGC and ADC met in August 1952 to discuss the deficiencies of the aircraft. It was finally agreed that five improvements would make the aircraft acceptable for air defense use. These included variable position dive brakes, aileron spoilers, an improved drag chute, improved armament (which meant substituting rockets for machine guns) and improved engine reliability. The first three modifications were relatively simple and by the middle of December 1952 Lockheed had arranged for their installation in the field. The armament problem was somewhat complicated, in that the engine flamed out when the

  
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full load of 24 2.75-inch rockets (carried in the nose) was salvoed at altitudes above 25,000 feet. This phenomenon could be avoided by firing only half the rockets, but even this tactic produced a near flame-out that seriously reduced the speed of the interceptor. The answer was to mount the rockets in wing pods, 24 rockets to a pod, but this solution required development and was not likely to be available until the 163rd F-94C was on the production line.  
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The F-94C was finally made available to, and accepted by, ADC in March 1953. The first ADC unit to receive the aircraft was the 437th FIS at Otis AFB, Massachusetts. Since the F-94C was not expected to destroy a bomber any more advanced than the Russian TU-4 (a copy of the B-29), it was about two years late. Intended as a "quick-fix" interim all-weather interceptor to plug the air defense gap until the F-89 was ready, 1949 planning had anticipated an operational F-94C in 1951. Since it was not ready at that time, enthusiasm for the F-94C waned and two of the four contracts calling for production of the converted F-80 were cancelled in late 1952, reducing total production from 617 to 387. By the middle of 1954, ADC had 265 F-94C's -- the high



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point of F-94 usage. At the end of the year there were 201 F-94C's in service. The last F-94A/B aircraft had disappeared during the first half of 1954.<sup>135</sup>

The F-86D. The second "interim" interceptor authorized in 1948, when it appeared that the F-89 was going to be seriously delayed, was the F-86D modification of the F-86. The F-86 was the best fighter available at the time, so its selection for air defense use was almost automatic. It was unique, however, in that it was the first single-place interceptor. The first flight of the experimental F-86D occurred in September 1949 and was so promising that by the end of 1950 approximately 900 had been ordered, indicating that the F-86D would form the backbone of the interceptor force until the "1954 interceptor" (F-102/106) arrived.

In 1951 there was hope that ADC would get the F-86D in the spring of 1952, but this hope was not realized because of continuing difficulty with the General Electric J47-GE-17 turbojet engine and the Hughes E-4 fire control system. Most of the engine problems appeared to stem from the engine control system. If the system worked as planned, the pilot controlled the engine, variable nozzle area and afterburner from a single lever. The control system

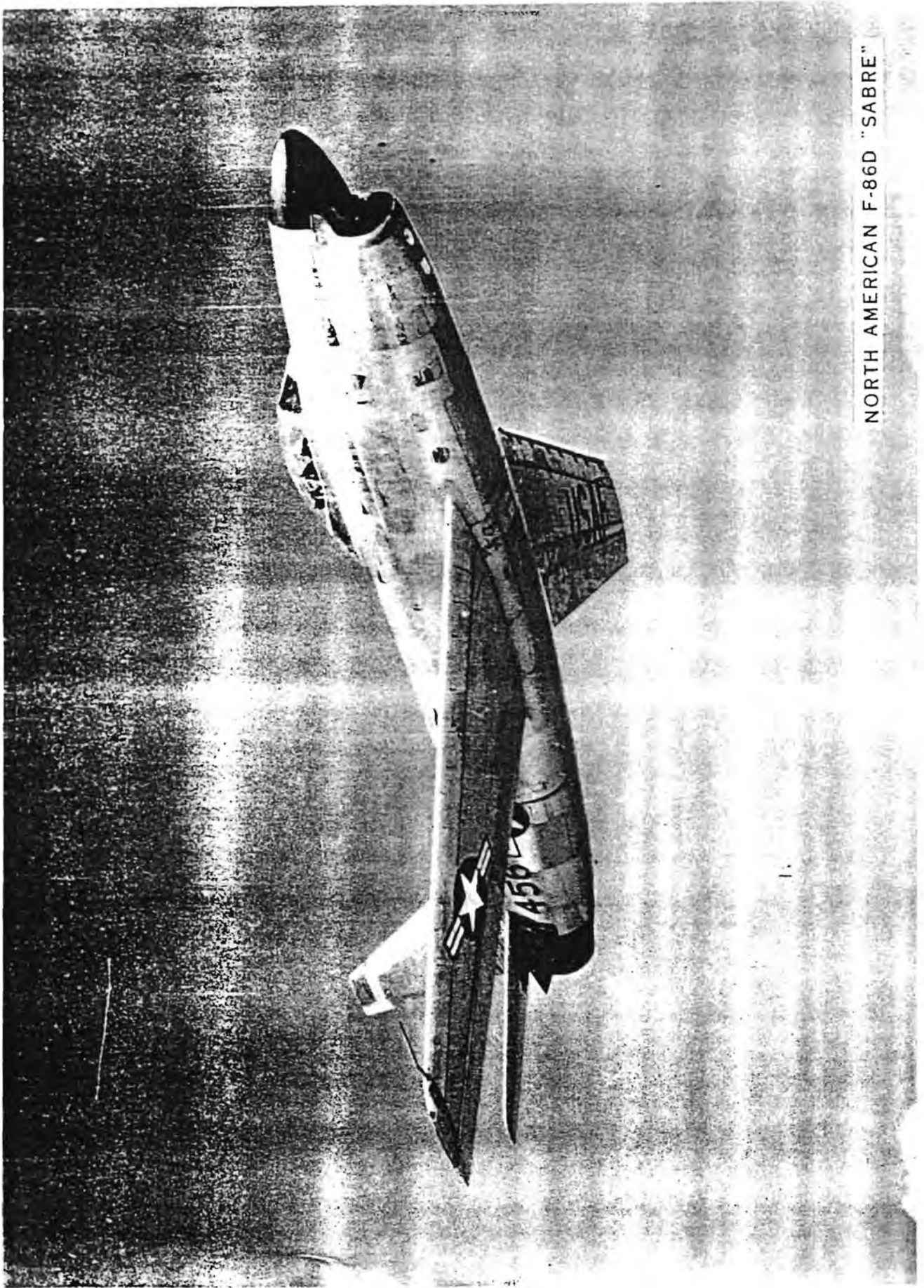
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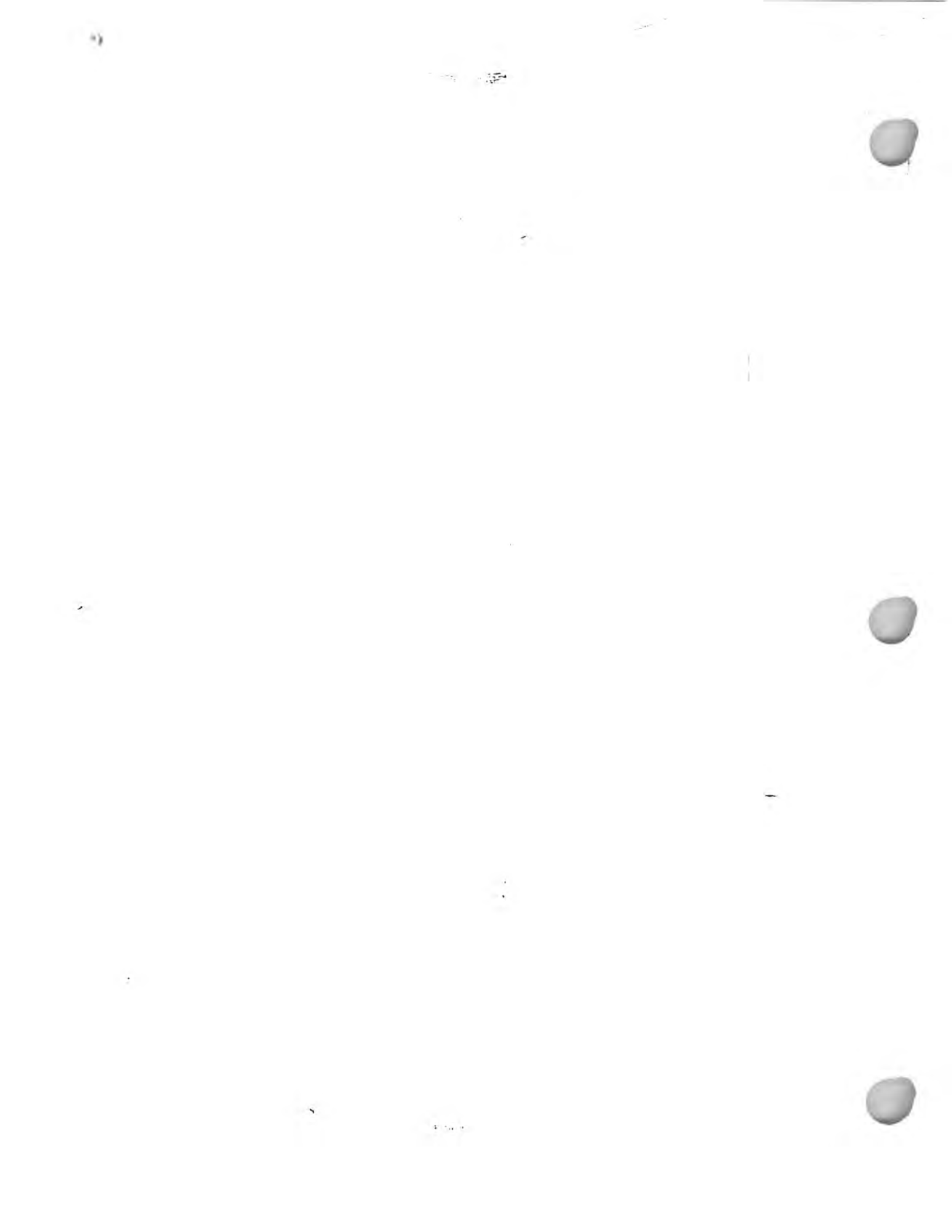


LOCKHEED F-94C "STARFIRE"





NORTH AMERICAN F-86D "SABRE"



synchronized such variables as engine speed, fuel-air ratio and exhaust temperature. The trouble was that it simply did not work. Because the control system was subject to frequent malfunction, there were violent fluctuations in revolutions-per-minute, fuel pressure and exhaust gas temperature. As a result, General Electric had fallen 18 months behind in engine deliveries in early 1952. Since airframes were beginning to pile up around the North American plant, AMC asked that General Electric be permitted to ship engines even though ARDC did not consider the engines qualified for use. The AMC view prevailed and 250 engines were shipped. Happily, General Electric developed, in mid-1952, a modified control system which promised to remedy many of the engine difficulties. The J47-GE-17 engine had passed its 150-hour qualification test by the end of that year.

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The fact that the F-86D was highly complicated because of the need to adapt the interceptor's electronic equipment to one-man operation, plus the fact that frustrating engine and fire control problems were encountered, made it impossible to deliver the F-86D to ADC by the spring of 1952, nor by the revised date of November 1952. When the F-86D's were declared ready, however, they

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descended on ADC in a flood. Several ADC squadrons received the F-86D in April 1953. By the end of the year ADC had 600 of these interim interceptors. But development of the F-86D was not complete, although a production rate of better than a hundred aircraft a month was attained in 1953. Even though it was introduced into the air defense system nearly two years behind schedule, it was still not ready. This was made clear in the autumn of 1953. Between 13 September and 16 December 1953, thirteen F-86D's were destroyed by engine fires and explosions. On the latter date all F-86D's were grounded until the suspect fuel system could be made safe. Hastily formed teams of technicians were sent into the field by North American and General Electric and most of the F-86D's were released for flight by the end of February 1954. But this was merely a stop-gap measure and thoroughgoing modification was indicated. This led to a tremendous, and costly, modification program known as "Project Pullout" which involved approximately 300 individual modifications to about 1,200 F-86D aircraft. Work began in March 1954 and was about half

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complete by the end of the year. When "Pullout" was finished, ADC had a modern all-weather interceptor. At the same time, "Pullout" was a vivid demonstration of the cost of imperfect development.

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The F-102. Beyond the F-89 and the interim interceptors -- F-94 and F-86D -- USAF planners saw an advanced, specially designed interceptor they called the "1954 interceptor" for the year it was expected to become operational. Experience with the F-89 should have given them pause, since it provided ample evidence that there is likely to be a wide divergence between plans and reality, but when airframe bids were requested in September 1950 the 1954 operational date was mentioned. Later events proved the 1954 date to be almost impossibly optimistic. When the bidding closed in January 1951, six contractors had submitted nine proposals. Republic submitted three bids, North American two. Single proposals were made by Chance-Vought, Lockheed, Douglas and Convair. By the end of March 1951, AMC had rated the proposals with respect to technical and logistical considerations. Then a board of general officers appointed by the USAF Director of Requirements examined the proposals from the standpoint of operational suitability. The decision,



  
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announced by USAF on 2 July 1951, was surprising in that three winners were named. Convair, Republic and Lockheed were all to proceed with development through the mock-up stage. At that time the firm providing the most promising design would be awarded a production contract. The decision was further surprising because all three winners ranked comparatively low in the technical and logistical rankings. The Lockheed entry, a more-or-less conventional straight-wing aircraft intended to fly at Mach 2, ranked fourth in the technical ratings and fifth on the basis of logistical supportability. Republic's winning proposal involved a complicated turbojet-ramjet power plant in a delta-wing, delta-tail aircraft which tied for the lowest rating as to logistics and finished eighth in the technical standings. Convair submitted a plan for an aircraft that was essentially a refinement of the delta-wing F-92 it had been developing in the late forties. The F-92 had proceeded to the point where it was successfully flown in September 1948, before the development contract was cancelled on the grounds of excessive cost. At any rate, AMC rated Convair's 1951 proposal dead last on the basis of technical feasibility, but <sup>138</sup> third in terms of logistical support.

The plan for a three-pronged development of the 1954 interceptor (Project MX-1554) died a quick death, however.

  
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Although each of the three winners was notified of his good luck and the procurement wheels were turning in AMC in July and August of 1951, the plan was buried in September when Roswell L. Gilpatric, Under Secretary of the Air Force, decided it was unwise to finance three concurrent Phase I development programs. Mr. Gilpatric therefore ordered that Lockheed be dropped, that the Republic program be supported through the mock-up stage and that Convair be given a contract for a prototype <sup>139</sup> interceptor. This action, in effect, declared Convair the undisputed winner of the design competition for the 1954 interceptor.

In the fall of 1951, while the matter of an airframe contractor was being settled, it was becoming painfully evident that the "1954 interceptor" was not going to be ready in 1954. There were doubts that it would be ready by 1956. But intelligence estimates of the 1954 threat indicated a pressing need for a modern all-weather interceptor at that time. Consideration of another "interim" interceptor, such as the F-86D and F-94C were regarded, was begun. After assessing the Navy F4D, the F-91 (a Republic development based on the design competition of 1945 which led to selection of the Northrop F-89), and

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the North American Sabre-45 (an improvement of the F-86 which ultimately became the F-100), USAF decided that a partially developed MX-1554 was most promising.<sup>140</sup>

The 1951 planning foresaw an interim interceptor that would be identical to the "ultimate" 1954 interceptor, except for the engine. The J-57 engine planned for the interim interceptor was believed capable of producing aircraft speed of about 850 knots. The J-67 engine for the ultimate interceptor was expected to provide speed of nearly 1,200 knots. Because of this considerable difference in performance, it was the original intention to hold production of the interim model to a minimum, putting primary emphasis on development of the ultimate version. But as 1952 wore along and the difficulties involved in developing the ultimate interceptor became more and more evident, it became apparent that the period between the obsolescence of the F-86D and the appearance of the ultimate 1954 interceptor was likely to be a long one. Therefore, by almost imperceptible steps, the interim model assumed greater importance and the quantities discussed grew larger. More emphasis on the interim model meant less emphasis on the ultimate model and did violence to the weapons system concept outlined by General Fairchild in 1949. The realities

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of the development situation, however, dictated this un-  
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desirable trend.

The difference between the interim 1954 inter-  
ceptor (by this time known as the F-102A) and the ulti-  
mate model (known as F-102B at this time, but later desig-  
nated as F-106) was further widened in late 1952 when it  
was determined that the MX-1179 fire control system being  
developed by Hughes would not be ready in time for the  
F-102A. USAF was forced to the conclusion that the  
F-102A would have to be equipped with either the E-4 or  
E-9 fire control system, "whichever was closer to reali-  
zation." The E-4 was programmed for use in the F-86D,  
the E-9 for use in the F-89D. Neither was as sophisti-  
cated as the MX-1179, for which Hughes had been given a  
development contract in October 1950. On the basis of a  
WADC recommendation, the E-9 was subsequently chosen as  
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the fire control system for the F-102A.

Although it was fairly well known by November 1952  
that the F-102A would be much less of a weapons system  
than was planned in 1949, the F-102 mock-up inspection  
held at that time was conducted in an aura of wishful  
thinking. The model was packed with representations of  
"black boxes" that were expected to be available for the


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ultimate interceptor, but were obviously too advanced for the F-102A. Even so, Air Force inspectors were reasonably well satisfied with the general arrangement presented by Convair and the contractor was free to proceed with de-  
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velopment.

At this point the great configuration debate began. Although there were no delta-wing aircraft currently available to the USAF, the idea was not new. Convair's experimental XF-92A was a delta-wing aircraft and the British had been contending for several years that the delta wing was ideal for high-speed aircraft. The principal advantages were that the delta wing was aerodynamically thin but structurally thick while at the same time being much easier to build than a straight thin wing. The straight thin wing required special heavy machinery. The delta wing  
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could be built with standard tooling.

But the designers who prepared the original Convair proposal failed to make proper allowance for the aerodynamic drag produced by a delta-wing aircraft. While Convair had predicted a maximum altitude of 57,600 feet and a combat radius of 350 miles for the F-102A, wind tunnel tests conducted by the NACA in late 1952 and early 1953 indicated that the probable maximum altitude of the aircraft would

  
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be 52,400 feet and the combat radius 200 miles. The problem, simply stated, was that the aircraft was so bulky amidships that an undesirable drag was produced. The solution was to indent the fuselage to a "coke bottle" configuration, but this answer was not arrived at overnight. Convair had to be shown where its original design was in error, and it was not until August 1953 that Convair accepted the implications of the "NACA ideal body theory" and joined in the recommendations that the design of the F-102A be changed to meet the requirements of that theory. These changes were many. It was necessary to lengthen the fuselage by seven feet and move the wings and tail rearward in order to accommodate the indented fuselage. The wings were provided with a cambered leading edge and "warped" tips in order to eliminate the drag encountered when the elevons were deflected to maintain the appropriate angle of attack during the cruise and climb phases of flight.

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Meanwhile, Convair was working to build early test models of the F-102. Production had already begun when the "coke-bottle" decision was reached, so it was decided to accept 10 straight-fuselage aircraft before re-orienting the production line toward the "coke-bottle" model. After

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the coke-bottle discussion, not much was expected of these first 10 aircraft, although some aspects of delta-wing performance could be checked.<sup>146</sup>

The first flight took place at Edwards on 24 October 1953. On this occasion, R. L. Johnson, chief Convair engineering test pilot, took the aircraft to an altitude of 14,000 feet and reached a speed of 270 miles an hour. Five additional flights took place during the next week, the YF-102 reaching an altitude of 35,000 feet and a speed of .9 Mach. While stability was relatively good and control was not overly difficult, the general performance of the aircraft was not satisfactory. The fuel system operated erratically and the engine did not develop its full power. The pilot complained of fumes in the cockpit and a mild buffeting at speeds approaching .9 Mach. The main landing gear would not satisfactorily retract. The suspicions that the F-102 was not yet ready for flight testing were borne out on 2 November when the test aircraft appeared to wallow through the air immediately after takeoff, never rising more than 20 feet from the runway. The subsequent wheels-up landing damaged the underside of the aircraft so badly that it was eliminated from the test program. Test Pilot Johnson was seriously injured. The actual villain

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was later determined to be the Bendix fuel control which had failed to function properly on any of the six

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flights.

Flying in the second YF-102 began 11 January 1954, with E. D. Shannon, chief Convair experimental pilot, at the controls. Shannon made a number of flights in the YF-102, noting buffeting, an occasional tendency to yaw and increased difficulty of control at speeds approaching .9 Mach. By early April 1954 Johnson had recovered sufficiently to resume his testing duties. He pushed the YF-102 to 47,000 feet, but the effort was so great that he placed the practical ceiling of the aircraft at 40,000 feet. He was also able to reach a speed of 1.24 Mach by assuming a 30-degree dive angle. Subsequent to this test, the second YF-102 was modified by extending the tail cone, cambering the wings, adding new speed brakes and adding 592 pounds of ballast. These modifications were improvements, because Johnson was then (14 April 1954) able to reach an altitude of 47,500 feet without the struggle he had experienced earlier. There was a notable

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improvement in stability and control.

Primarily because the modified YF-102 showed improved performance, ARDC pressed for an accelerated Phase II



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test (use of military pilots). Convair had insisted earlier that Phase II flying could not possibly begin before June 1954. ARDC won the argument, however, and on 28 April 1954 Maj Gen Albert Boyd, WADC Commander, became the first military pilot to fly the YF-102. By 1 June 1954. ARDC pilots had completed 56 hours of test flying in the aircraft. Military pilots tended to verify Johnson's test reports. Mili-  
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But testing in the YF-102 was not the main show. Since the YF-102 was the straight-fuselage model and USAF had decided that the coke-bottle design was to be the combat configuration. Really significant testing had to await coke-bottle aircraft. To permit testing to begin as soon as possible, Convair pushed a coke-bottle airframe through the production line, not bothering with many of the refinements which would be included in the tactical aircraft. By this forced-draft method, the first coke-bottle aircraft, designated YF-102A, or "Hot Rod," to distinguish it from the straight-fuselage models, was ready in December 1954. Johnson made the first flight on 19 December. Advantages of the straight-fuselage model were immediately apparent. The Hot Rod used less runway for takeoff than did the YF-102. It attained a speed of Mach 1.2 in level flight and was still climbing strongly at an altitude of 51,600 feet. Thus, at the end of the year when the "1954 interceptor" was expected

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to be operationally ready, only one stripped-down test model of the interim version was available. And it had made only one test flight. A significantly improved jet interceptor was in the works, but it was not going to be as improved, or ready as quickly, as the Board of Senior Officers had anticipated in 1949.<sup>150</sup>


The F-103. The same design competition that produced the F-102 (and eventually the F-106) was responsible for the F-103. As originally announced in July 1951, there were three winners of the competition -- Convair, Lockheed and Republic. In September 1951, Lockheed was dropped, Convair was given a contract for a prototype interceptor and Republic was requested to continue development through the mock-up stage. The Republic development was the F-103. The F-103, like the F-102, was a delta-wing design. It was to use the MX-1179 fire control system and the J-67 engine of the F-102. It was expected to offer Mach 3 speed and a ceiling of 80,000 feet. The F-103 differed from the F-102 in that it was to have an alternate ramjet engine for high speed at extreme altitudes. The use of titanium alloys rather than aluminum or magnesium was also anticipated.

The F-103 program, unfortunately, was perpetually on the brink of financial starvation. By the middle of 1953

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the estimated cost of developing the F-103 had risen to \$41,000,000, leading USAF to give up the earlier plan of financing development to the point where a prototype interceptor would be built. USAF, instead, began to see the F-103 as purely an experimental aircraft, used to expedite advancement in the state of the aircraft art. Republic, in June 1953, was given a contract for the construction of a single experimental aircraft. The first flight was scheduled for March 1957, a significant change from the development contract awarded Republic in 1951, which called for initial flight in 1955. Progress with the F-103 was slow, though, because of the continuing shortage of funds. In early 1954, ARDC asked for \$13.3 millions of F-103 money for Fiscal 1955, but USAF would not agree, suggesting instead a stretched-out development program funded at the rate of about five million dollars a year. WADC countered by preparing a program which called for \$6.2 million in Fiscal 1955, \$8.9 million in Fiscal 1956 and \$5.6 million in Fiscal 1957. If this level of funding could not be provided, WADC added, it would be better to cancel development. WADC won a partial victory in this instance. The necessary funds for continued development were provided, but only after reductions were made in funds set aside for development of other aircraft.

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Revitalized by the promise of money, the F-103 program took on new life. Republic was awarded a Phase II development contract in June 1954 and plans were made for the construction of three experimental aircraft. The first was scheduled to fly in February 1957 and was to explore aerodynamic conditions at 75,000-foot altitudes and Mach 3 speed. The second was to test the operational capability of the combination turbojet-ramjet engine and was to begin flying in June 1957. The third was to fly in December 1957. It was to be equipped with a fire control system and armament and was to be used to develop operational tactics for interceptor aircraft.

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The F-104. The same 1951 design competition which resulted in the F-102 and F-103 also resulted, in a sense, in the F-104. Although Lockheed was removed from consideration as regards F-102 development in September 1951, USAF, in early 1952, directed ARDC to negotiate with Lockheed for the development of a very advanced day fighter. Negotiations were long and complicated, however, because of continuing confusion as to the type of aircraft Lockheed was to develop and because of legal difficulties. With regard to the aircraft itself, the Air Force was originally

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interested in a relatively heavy delta-wing fighter (the Lockheed entry in the "1954 interceptor" competition was a straight-wing type), but Lockheed muddied the waters by also offering a "featherweight" straight-wing model. As 1952 merged into 1953 the merits of the delta-wing model versus the featherweight model were debated within USAF and the planned production date of 1956 became more and more unrealistic. Finally, in January 1953, USAF decided to proceed with development of the lightweight model. Lockheed was given a contract in March 1953.

The legal problems concerned the handling of patent rights. Lockheed balked at accepting a contract which forfeited all F-104 patent rights to the government and would thereby make it possible for USAF to assign a production contract to a firm other than the original designer. The same problem had occurred in dealings with North American (F-100), Convair (F-102) and McDonnell (F-101) and the government had given ground. But the AMC Judge Advocate had come to the conclusion that the Lockheed contract was a good one on which to stand firm, before too many precedents were established. As a consequence, contract negotiations dragged along for several months until General Boyd, WADC commander, insisted in June 1952 that the deadlock be broken. So, when the matter of the lightweight

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aircraft was settled. there was no legal barrier to the prompt negotiation of a contract with Lockheed. The government again retreated on the patent issue. <sup>155</sup>

The F-104 was not intended as an interceptor. It was designed as a light, fast, relatively inexpensive air superiority fighter. The designers hoped it would reach a speed of nearly Mach 2, possess a combat ceiling of 53,000 feet and climb at a rate of 49,000 feet a minute, beginning at sea level. It was the smallest of the post-war combat aircraft, with short, straight, extremely thin wings. It was not, strictly speaking, a new development, deriving much from the Douglas X-3 experimental craft and the F-90 developed by Lockheed in the late forties. The Douglas aircraft had not been successful because of the failure of the engine contractor to produce a suitable engine. So, in order to recoup its losses on the X-3 program, USAF directed Douglas, over strong Douglas objections, to deliver the X-3 plans to Lockheed. Many of the X-3 ideas went into the F-104. <sup>156</sup>

Perhaps because of its derivation from earlier developments, the F-104 was unique in that it experienced few serious problems during development. A satisfactory mock-up inspection was held 30 April - 1 May 1953, barely

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weeks after the development contract was signed by Lockheed. At that time the first flight was scheduled for March 1954. And, surprisingly enough, the first flight was made according to schedule, occurring on 5 March 1954. Although the Wright J-65 engine used in the initial aircraft was not equipped with an afterburner, the XF-104 managed to reach a speed of Mach .98 at 30,000 feet by the middle of April 1954. By this time, use of the J-65 engine was regarded as only a temporary measure, because the General Electric J-79 engine (developed for use in the B-58) had come along and promised much better performance than the J-65.<sup>157</sup>

ARDC was highly pleased with the progress and performance of the test models of the F-104, but was faced with the ironic fact that, as of mid-1954, neither TAC nor ADC had ever filed a requirement for such an aircraft. Lockheed could not be given a contract for volume production of the F-104 until such a requirement had been placed. Because of the advanced performance of the tiny craft, however, ARDC was confident that either one or both of the possible users would be happy to have it when they learned<sup>158</sup> of its potentialities.

  
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ADC was caught unaware by the proposal to use the F-104 as an interceptor. Its initial reaction (September 1954) was generally negative, however, in that it did not "appear that this aircraft could be expected to meet the performance and electronic criteria established for all-weather interceptors without seriously jeopardizing its...performance." <sup>159</sup> At the same time, ADC was looking for an interim interceptor to help fill the gap between the F-102 and the F-106. It was willing to consider the F-104, or any other fighter aircraft. So, during late 1954, ADC watched F-104 development and <sup>160</sup> debated its possible use in air defense.

The F-101B. Like the F-89, the F-101B was the result of the design competition held immediately after World War II. But the process was long and complicated. One of the winners of the 1945 competition was McDonnell, which proposed to build a long-range "penetration" fighter ultimately designated F-88. McDonnell made excellent development progress with the F-88 and managed first flight on 20 October 1948. This swept-wing aircraft, equipped with two J-34 engines rated at 3,150 pounds of thrust each, reached a speed of 700 miles an hour. Because of this highly respectable performance, it was

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planned to begin production in 1949, but the economy wave of that year engulfed the F-88 and production plans were scrapped. Then, in June 1950, USAF ordered a competitive evaluation of the F-88, the Lockheed F-90 and the North American F-93 in another attempt to determine the best penetration fighter. The F-88 won this competition, but the evaluation board decided that it did not have sufficient range and endurance to be an adequate penetration fighter. The F-88 went back on the shelf. Finally, in 1951, McDonnell produced a revised version of the F-88 which was so different from the original that it was re-christened F-101. It was expected, in 1951, that it would be capable of 918 knots at 35,000 feet, with a combat radius of 800 miles. Whether it would be a bomber escort, a penetration fighter or a fighter-bomber was a moot question during 1952, but in early 1953 USAF decided it could be used for all three  
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purposes.

USAF did not mention that ADC was also interested in the possibility of using the F-101 as an interceptor, because USAF had rejected a tentative ADC suggestion (first expressed to WADC in October 1952) that this aircraft be modified to interceptor configuration. It was the WADC opinion that ADC had been rebuffed in this matter because

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of the high cost of the F-101. Besides, McDonnell production facilities were limited and production of an interceptor version of the F-101 would probably require construction of another plant. USAF had decided to solve the interceptor problem by increasing the numbers of F-86D's and "putting the heat on" the F-102.<sup>162</sup>

ADC regarded this initial refusal as merely temporary, however, and in April 1953 again approached USAF with a proposal to use the long-range F-101 as an interceptor on the perimeter of the United States and in areas where ground radar was scarce. USAF did not disapprove the ADC request, but replied vaguely that the F-101 would be considered, along with other fighters, in providing an interceptor to help fill the gap between the F-89 and F-106.<sup>163</sup>

WADC was of the opinion that of the two fighters (F-100 and F-101) as yet uncommitted for interceptor modification, the F-101 was the most promising. The F-100 was essentially an improved version of the F-86 and would probably contain many of the drawbacks of the F-86. Furthermore, the F-100 had a much shorter range than the F-101. Even the F-101 did not offer the 60,000-foot ceiling and 1,000-mile radius of action mentioned by USAF when the study of the two fighters was requested. WADC

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estimated that the F-101 would have a ceiling of about 50,000 feet and a maximum radius of about 750 miles. It was further estimated (late 1953) that 20 months would be required to produce a prototype aircraft and 44 months would be required to develop a suitable fire control system. 164

By early 1954 there appeared to be three aircraft that might meet the ADC requirement -- an advanced F-89 and interceptor versions of the F-100 and F-101. In June 1954, ADC announced that it considered the F-101 the best of the three, (subject to USAF approval, which had not been obtained by the end of 1954). After some initial confusion, it was decided that the interceptor version (subsequently titled F-101B) would include the MG-3 fire control system of the F-102A and would carry Falcon missiles. The first flight of the basic F-101 occurred on 29 September 1954. The test aircraft climbed smoothly at Mach .9 and leveled off at 35,000 feet. In less than a month, McDonnell test pilots had reached a speed of Mach 1.4 in the aircraft. At that speed, however, there was a distinct "rumble" which indicated a need of re-design of the engine air intake duct. Also, almost every flight experienced compressor stall. Although Pratt and Whitney engineers were confident that the compressor stall problem in the J-57 engine could be solved, no solution was immediately evolved. At the end

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of 1954, WADC was ready to predict that the F-101B, equipped with the advanced J-67 engine (only early models would have the J-57), would be ready to fly by the middle of 1956, that production could begin in 1957 and that aircraft could be made available to active interceptor squadrons in early 1958.<sup>165</sup>

The F-106. The essential difference between the F-102 and the F-106 lay in the engine and fire control system. The primary reason for establishing two-phase development of the "1954 interceptor" was the realization that the J-67 engine and the MX-1179 fire control system would not be ready for several years. Since some sort of advanced interceptor was needed as soon as possible, development of the F-102 and a much less sophisticated fire control system was decided upon in 1952. The unfortunate consequence of this decision was that components for the F-102 could be financed from production funds, while development of the J-67 engine and MX-1179 fire control system had to be financed from much less plentiful research funds. A two-year delay in the development of the MX-1179 was anticipated. There was apparently little to be done about this situation, however, until development of the F-102 was completed.<sup>166</sup>

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In spite of the funding problem, however, ARDC was hopeful in 1952 that a test version of the F-106 would begin flying in late 1954. This hope proved, in view of subsequent events, naive. The J-67 engine was an American version of the British Olympus engine. Although it showed early promise, by August 1953 Wright (the American licensee) was nearly a year behind schedule in adapting the J-67 to the F-106. In October 1953, therefore, USAF authorized ARDC to proceed with the engineering work necessary to make the Pratt and Whitney J-75 engine compatible with the F-106. This was a form of insurance, in the event Wright difficulties with the J-67 proved insuperable. The J-75 was an advanced version of the J-57 engine used in the F-102. Also in the late summer of 1953, it was recognized that development of the fire control system for the F-106 (first known as MX-1179 and subsequently titled MA-1) was slipping badly and the test program was extended a year. The proposed date for the first flight of the F-106 was <sup>167</sup> consequently pushed back to February 1955.

By early 1954, Hughes progress with the MA-1 fire control system was so disappointing that Major General C. S. Irvine, Deputy Commander for Production, AMC, recommended bringing the Bell Telephone System into the development

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effort in order to guard against Hughes failure. Bell, however, was not interested in merely backstopping Hughes, but wanted to plunge into an entirely new line of development. Everybody concerned agreed that any Bell development would probably be completed some time after the MA-1 was ready, so the idea of using Bell was dropped. Also, it was becoming obvious that development of the Pratt and Whitney J-75 engine was progressing at a much more rapid rate than development of the Wright J-67 and it appeared likely that the J-75 would be the engine used in the F-106, although at the end of 1954 the J-67 was still mentioned officially as the F-106 engine.

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The Advanced Medium Range Interceptor (MRIX). Years before the F-102 and F-106 became operationally ready, ADC began to think ahead toward the day when something better than the "1954 interceptor" would be necessary. Because intelligence estimates prepared during the later stages of the Korean fighting indicated that by 1958 the USSR would have a large fleet of high-speed bombers, ADC asked, on 7 January 1953, that it be provided with an interceptor of speed and altitude capability considerably in excess of those being designed into the F-102/106. ADC had in mind an aircraft that would be able to climb at




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Mach 2.5 and cruise at Mach 3. ADC also wanted a combat radius of 525 miles and a fire control system with a lock-on range of 50 miles. Altitude capability was not specified, being given simply as "very high." ADC thought it possible that the F-103 might meet the requirements. <sup>169</sup>

USAF agreed, citing approval of the Joint Chiefs of Staff, that an advanced interceptor of the type advocated by ADC was required. USAF added, however, that the new interceptor was not required until October 1959. Also, USAF pointed out that the F-103 was primarily a research vehicle and that it was probably not appropriate for the air defense mission. In view of experience with the F-102 program, USAF stressed the need for prompt development of detailed requirements if a new aircraft was to be made available by October 1959. <sup>170</sup>

But there was no prompt development of detailed specifications, apparently because what ADC proposed would require great advances in metallurgy and in aircraft and engine design. There was no noticeable action in connection with the ADC requirement for nearly two years. ADC repeatedly brought this matter to the attention of USAF and ARDC, but it was not until November 1954 that USAF presented to ADC a draft General Operational Requirement

  
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(GOR) for comment. ADC was not particularly impressed with the USAF proposal, commenting that what was needed was an interceptor which could cope with a cruise missile similar to the U. S. "Navaho." This, at the time, was believed to be the ultimate in air-breathing airborne threats. The Navaho was designed to fly at a speed of Mach 3.25 and attain an altitude between 80,000 and 88,000 feet. It was at this inconclusive point that matters stood at the end of 1954.<sup>171</sup>

The Advanced Long Range Interceptor (LRIX). In addition to the MRIX, ADC also wanted a long range interceptor to operate on the far fringes of the ground environment and conduct the air battle as far from the target area as possible. No counterpart of the proposed interceptor existed, since even the F-89, longest-legged of the 1953-54 interceptors, had a combat radius of about 400 miles. The ADC requirement, submitted 7 April 1953, called for an aircraft with a thousand-mile radius of action, a combat altitude of 60,000 feet and speed between Mach 1.5 and Mach 2. ADC saw this aircraft as a multi-engine type with a two-man crew. Not much happened immediately, however, since the aircraft required was somewhat in advance of the art. But in October 1953 USAF



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asked for further justification of a long-range interceptor. The ADC justification was that augmentation of the radar network would ultimately provide radar coverage 250 to 500 miles beyond the borders of the United States and that an interceptor was needed which would exploit the advantages gained by this extended radar coverage. Also, since the long-range interceptor would carry atomic armament, it was felt necessary to intercept enemy bombers as far from the domestic borders as possible.

USAF agreed that the ADC request was a valid requirement and in January 1954 the Aircraft and Weapons Board decided that an industry-wide competition should be held with regard to the LRIX. At the same time, USAF took the position that the ADC requirement that the aircraft be available for evaluation in 1956-57 was unrealistic and that 1960 was a more likely date. This extension of the evaluation date, however, caused ADC to revise its requirements. If the LRIX was not to be available until 1960, ADC wanted an aircraft which would fly at Mach 3, have a combat altitude of 70,000 feet, carry three atomic missiles as armament, have a fire control system with a lock-on range of 50 miles and a completely integrated electronic system. As to range, ADC now wanted an LRIX which could proceed to

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a control point 600 miles away, loiter for three hours, then proceed at Mach 2.5 to an intercept point as much as 200 miles away and still have enough fuel remaining to reach a re-service base as much as 300 miles away. ADC had also changed its mind about the size of the crew, now requesting a one-man, rather than two-man crew.<sup>173</sup>

Even though there was general agreement that such an aircraft should be developed, the administrative wheels moved slowly. In February 1954, ARDC learned that it was to be directed to hold a design competition, but it was not until May that the directive was actually received. Fifteen potential manufacturers were contacted and 13 expressed interest. When interested contractors were asked to attend a meeting on 28 May, 11 responded by sending representatives.<sup>174</sup>

A relatively short deadline date -- 15 July 1954 -- was originally established for the submission of proposals, but this proved too short and was later moved back to 16 August 1954. Further, the competition was divided -- as had been the competition for the "1954 interceptor" -- into two phases, one for the airframe and engines and the other for the fire control system. This division left the airframe competitors pretty much in the dark, since they



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could not know what the fire control system would be like and could not make adequate provisions for it in designing the airframe. Too, the military characteristics against which the contractors were asked to design were considerably different from the requirements ADC outlined in January. The manufacturers were asked to design an aircraft which could reach a speed of Mach 1.7 at 40,000 feet, cruise at an altitude of 60,000 feet and offered a thousand-mile radius of action. Two types of armament were specified. One armament configuration included 48 2.75-inch FFAR rockets plus eight GAR-1 Falcons. The alternative was three atomic rockets of the MB-1 type. The aircraft was to have at least two engines and was to carry a two-man crew. The fire control system was to be capable of detecting a target the size of a B-47 at a range of 100 miles.<sup>175</sup>

By 16 August 1954, the closing date of the airframe and engine competition, WADC had received 15,000 pounds of paper and 24 aircraft models from the eight contractors who had participated -- Boeing, North American, Lockheed, Douglas, Northrop, McDonnell, Martin and Republic. The designs varied immensely in detail, although most proposed using the J-67 engine. Every contractor projected the use of at least two engines, although McDonnell

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suggested using three and Martin and Douglas proposed using four. All proposals envisioned large aircraft -- from the 59,000-pound model proposed by Douglas to the 120,000-pound behemoth suggested by Martin. The average weight was about 75,000 pounds. The job of evaluating the various proposals was difficult enough when WADC proposed checking only those prepared with close attention to the military characteristics provided in advance. But each contractor also submitted "alternative" proposals which often made little reference to the stated LRIX characteristics. USAF made evaluation especially difficult by insisting, over ARDC objections, that all proposals be evaluated on the theory that promising "alternative" suggestions should not be allowed to escape. After three-and-one-half months of wrestling with this mound of paper, WADC concluded, 30 November 1954, that none of the proposals met the military specifications. 176

The only possibility of providing a reasonably satisfactory aircraft by 1959, WADC believed, would require adoption of a design calling for a 100,000-pound model and then the chance of satisfying the requirement for a 60,000-foot ceiling would be marginal unless range requirements were relaxed. Acquisition of a B-47 target

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on the airborne radar at a range of 100 miles was simply not feasible. WADC felt that the MX-1179 (the Hughes fire control being developed for the F-106) with a 40-inch radar dish and increased power would do as well as any of the 30-odd fire control systems proposed during the competition. At any rate, ARDC presented the facts to ADC in December 1954 and awaited ADC reactions.<sup>177</sup>

The ADC response was one of exasperated frustration. In the first place an interceptor was useless if it could not counter the expected threat, so ADC recommended that none of the proposals be developed. Furthermore, ADC recommended giving selected airframe manufacturers contracts for general design studies which would eventually lead to the sort of LRIX ADC had in mind. Meanwhile, ADC recommended that an interceptor version of the F-101 be procured in order to provide interim long range capability until the LRIX was ready.<sup>178</sup>

#### FIRE CONTROL SYSTEM

The first post-war interceptor fire control system was the E-1 system provided for F-89B/C and F-94A/B aircraft. The heart of this unit was the APG-33 airborne radar, an adaptation of the radar originally developed for use in

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the tail of the B-36. The first production model was installed in an F-94A in October 1949 and by the time production ceased in early 1952 approximately 600 sets had been built.

The E-2 system was similar to the E-1 system, except that it contained smaller components to permit installation in the one-man F-86D. The E-2, however, was designed to control the firing of 20mm guns and it had been decided, before development of the E-2 was complete, that 2.75-inch FFAR rockets would be used as armament for the F-86D. Then, to oversimplify a complicated matter, a computer which would aid in the firing of rockets was grafted to the E-2 to produce a fire control system which became known as E-3.

The E-3 fire control system was tested in the summer of 1950, but was branded as "entirely unsatisfactory" in October 1950 and returned to the Hughes Aircraft Company for re-evaluation. Meanwhile, the E-3 had been by-passed by technological progress and was never installed in any operational air defense aircraft. Hughes had developed a 250-watt radar (APG-37) to replace the 50-watt radar (APG-33) of the E-1/2/3. The E-3, equipped with the APG-37 radar, became the E-4 fire control system which

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was eventually installed in great numbers of F-86D interceptors.

The first prototype of the E-4 was assembled in November 1950, but no F-86D was available for test purposes, so it was installed in a B-25. The original E-4 was far from being everything the Air Force wanted, since many deficiencies appeared as the test program proceeded. The power output of the set was too low, the error dot wandered erratically across the scope, the pressurization system sprung leaks and the vertical gyroscope drifted to an excessive degree. In numerous instances extraneous spare parts rattled around inside the various black boxes of the total system. Much of the trouble was traceable to a lack of effective quality control at the Hughes plant. By May 1952 the situation was so bad that all E-4 systems at the North American plant (where the F-86D was assembled) were returned to Hughes for re-work and delivery of F-86D's was halted. AMC took a more active hand in the game at this point and demanded that Hughes and North American develop procedures whereby usable fire control systems could be installed in F-86D interceptors. This blunt warning had the desired effect and by September 1952 the most serious

  
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problems had been overcome and North American again began installing the E-4 system in F-86D aircraft. <sup>179</sup>

Once the initial deficiencies were worked out of the E-4, improvements were made continually, each being added to the E-4 as it moved along the Hughes production line. By the end of 1953, so many changes had been made to the E-4 that USAF believed it necessary to approve a massive modification program designed to improve early model E-4 systems to the point where they would be equivalent to late model systems. The most important additions were a tunable magnetron and a new common synchronizer. Both additions were intended to improve the E-4's ability to cope with the electronic counter-measures likely to be employed by enemy bombers. The modification program, known as Project Pull Out, got under way in March 1954. It involved 300 changes (to the airframe and engine as well as the fire control system) to each aircraft. During the height of Pull Out operations as many as 225 ADC aircraft were involved at one time. Pull Out was <sup>180</sup> continuing at the end of 1954.

The E-5 and E-6 fire control systems were essentially E-4 sets modified for two-man operation in the F-94C and F-89D, respectively. The E-5 was developed later than the

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E-4 and thereby suffered fewer difficulties than the E-4. As a consequence, Project Hop Up for modernization of the E-5 was a much less extensive modification program than Pull Out. Also, fewer aircraft were involved. The E-6 system for the F-89D came along still later and did not require a modification project.

Although provision of a data link device (one which would provide automatic directions to the airborne interceptor through data presentation on a scope rather than through voice communication by means of radio) became imperative when approval of the SAGE system was announced in 1953, work on such a device began much earlier. On 30 June 1951, WADC officially established a project for development of data link (AN/ARR-39). By that time Hughes and North American had already completed advanced engineering planning and General Electric was studying modulation problems and circuit details. The project continued in the study phase, with no production of actual hardware contemplated, until the SAGE announcement of May 1953. It became obvious, at that point, that hardware would ultimately be required. By October 1953, WADC and ARDC had prepared a tentative schedule for the installation of data link equipment. In early 1954 USAF was just as tentatively

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thinking of requiring data link for all operational interceptors, although the prospect that such a modification program would involve the expenditure of hundreds of millions of dollars tended to delay the rendering of a hard-and-fast decision. In June 1954, however, USAF took the first step in that direction by authorizing the procurement of 200 sets of AN/ARR-39 equipment. At about the same time, WADC engineers threw cold water on the project by revealing that the AN/ARR-39 data link would actually fill a space 1,000 cubic inches greater than the estimate provided by WADC in October 1953. WADC therefore recommended withholding engineering approval of the data link proposal until North American could devise some method of fitting the AN/ARR-39 into the space available in the F-86D.

But USAF was not prepared to accept further delay and in August 1954 approved a schedule which called for deliveries of data link equipment to begin in the fall of 1955. WADC protests that such a delivery schedule was premature were not heeded. When AMC added that deliveries of some related equipment would extend into 1958, however, USAF decided to re-examine the whole data link program.

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Data link was therefore in an uncertain "study" status at  
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the end of 1954.

The Second Generation of Fire Control. Systems E-1 through E-6 were, generally speaking, modifications of one system, the E-1, which evolved from the B-36 tail radar. Something much better was needed, however, since it was evident that the speed of both bombers and interceptors would increase as engines improved. A high degree of automation was imperative in advanced fire control systems. This need was recognized in 1949 when the Board of Senior Officers decided that the "1954 interceptor" would be built around the electronic control system. Automation was imperfectly understood at the time and automation techniques were just beginning to be applied to industrial processes. But the Board realized that a fast, sure, automatic method of controlling the interceptor from takeoff through the interception, attack and recovery phases was necessary. Such a system was what the Air Force had in mind when it awarded Hughes a contract for development of the MX-1179 fire control system in October 1950.

By September 1951, however, both the contractor and USAF agreed that the MX-1179 system would not be ready by

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1954. This decision led to development of a series of "interim" fire control systems intended to bridge the gap between the E-1/E-6 series and the ultimate MX-1179.

The first of these was the E-9<sup>\*</sup>. Although it was intended solely for the testing of the Falcon missile, the E-9 received consideration for tactical use when, in November 1952, it became apparent that the "1954 interceptor" would not be ready by 1954 and that an "interim" aircraft would have to be developed. It was decided that this "interim" interceptor (F-102) would have an "interim" J-57 engine (rather than the ultimate J-67) and an "interim" E-9 fire control system (rather than the ultimate MX-1179).  
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What made the E-9 different from the E-6 being developed for the F-89D was addition of a universal computer, an analog device which by electrical and mechanical means performed the arithmetical calculations required to solve the fire control equation. The E-9 program was

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\*Note: There were also E-7, E-8 and E-10 systems, but none was used by ADC. The E-7 was a proposal by North American that was never accepted by WADC. The E-8 was developed by RCA for the F-91 aircraft. The fire control system was cancelled when the aircraft was cancelled. The E-10 was developed by Hughes for use by the Navy. It was based on the E-4.

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slow in starting and the first experimental model was not delivered until May 1953. This set was installed in an F-89D and testing began in August 1953. A more completely automatic experimental model was first flown in March 1954. By this time, USAF had decided that the basic E-9 was not sufficiently sophisticated for the F-102. Instead, the E-9 was to be used in a modified F-89D equipped with Falcon missiles and known as F-89H. A pre-production model of the E-9 was installed in an F-89D in December 1954 and testing was underway at the end of the year. 184

So many changes were necessary in adapting the E-9 (a fire control system originally designed for two-man operation, since it was in turn an adaptation of the E-6 system used in the F-89D) to the one-man F-102 that a new designation -- MG-3 -- was given the system intended for the F-102. But more than a fire control system was wanted for the F-102. In addition, an automatic flight control system, an integrated power supply, a semi-automatic armament selection device and data link were desired. Development of such an electronic package (to be known as an Aircraft and Weapons Control System rather than a fire control system) was proposed by AMC in March 1953 and approved by USAF the following month. But USAF approval of what came to be

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known as the MG-10 had no immediate effect on development, because the essential elements of the design of the basic MG-3 fire control system were not completed until January 1954. The first development test model of the MG-3 had not been completed by the end of the year. Meanwhile, Hughes had the AMC proposal for the MG-10 and agreed that development of such an electronic package was possible. 185

Development of two other interim fire control systems also began during the 1951-54 period. One was the MG-12 for the F-89J and the MG-13 for the F-101B. The MG-12 was essentially the E-9, modified to permit use with MB-1 atomic rockets. Actually, the MG-12 was a simpler design, because the auxiliary equipment needed for the MB-1 was not nearly so complicated as the missile auxiliaries for the Falcon missile. The initial intent was to use a modified E-6 in controlling the MB-1, but by the end of 1954 it had been decided to modify the E-9 for that purpose. Because neither the F-89J aircraft nor the MB-1 rocket were yet ready, there was no particular hurry about development of the fire control system. For that reason, not much work had been done on the MG-12 by 186 the end of 1954. No serious problems were expected.



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What became known as the MG-13 became necessary when it was decided, in late 1954, that an interceptor version of the McDonnell F-101 would be provided to ADC. The possibility of fitting the F-101B with the MX-1179 fire control system was first considered, then dropped because of the slow progress being made with the MX-1179. Then it was decided to adapt the MG-3 (the fire control element of the MG-10 electronic package being developed for the F-102) for use in the F-101B. The F-101B was to carry both the MB-1 and Falcon missiles and therefore required a somewhat different fire control device (since the F-102 would not carry the MB-1). The resulting modification was the MG-13. It was still in the discussion stage at the end of 1954.

Repeated decisions to develop interim fire control systems affected the degree of progress attained in developing the ultimate MX-1179 system. Also, experience with the development of electronic controls led USAF to lengthen the prescribed time between the beginning of flight testing and the beginning of quantity production. In 1950 this period was estimated at eight months. By December 1952 this estimate had been raised to 18 months. At any rate, early in the MX-1179 development program it was estimated that the first developmental model of the MX-1179 would be

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available for testing in December 1954. A month before that date -- in November 1954 -- Hughes figured that the development program was 32 months behind the original schedule. The reason was simple. Hughes had been so busy developing interim systems that it just hadn't been able to find time to carry forward MX-1179 development at the rate originally scheduled.  
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#### IDENTIFICATION, FRIEND OR FOE (IFF)

Because the Mark III IFF of World War II had been hopelessly compromised, a new IFF system was required when international comity began to prove something of a myth in the late forties. In October 1948, the JCS decided that the new system -- a Mark X IFF developed by Watson Laboratories -- should be in full operation by all military services by 1 July 1952. AMC promised to improve this timetable by having the airborne transponder (AN/APX-6) installed in all ADC interceptors by the end of 1950. This promise was not fulfilled, however, because of the inability of manufacturers to meet schedules for the production of sub-systems and because of the unreliability of some of these sub-systems. As a result, it was not




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until late 1952 that all ADC interceptors were fitted with  
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AN/APX-6 transponder.

The AN/APX-6 transponder and its associated ground equipment was only Phase I of the total Mark X program, however. The second phase was the addition of a complex coding device by which individual aircraft could be recognized. This was the Selective Identification Feature (SIF). Full-scale development and production of SIF required a decision by the JCS, since the Navy was working on a similar device called PTC (Pulse Train Coding). SIF finally won the competition in early 1952, but the delay in reaching a decision made it impossible to begin production until the autumn of 1953. In September of that year, Eastern Air Defense Force was chosen to make a massive test of SIF in which 200 aircraft and 28 ground stations were to be involved. Installation of the SIF equipment consumed all of 1954. By the end of the year sufficient progress had been made that it was anticipated the test could begin  
190  
in early 1955.

#### ARMAMENT

At the outbreak of the Korean fighting, ADC interceptors were armed with machine guns. There were, however,

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plans for arming ADC aircraft with more lethal armament. First to arrive would be the 2.75-inch folding fin air rockets (FFAR), a development controlled by the Army's Ordnance Corps. At the same time, Hughes was beginning the development of a radar-guided air-to-air missile which came to be known as Falcon. At the end of 1950, it was anticipated that the service test of the Falcon would be completed by December 1953 and that tactical missiles would be available by June 1954.

Modernization of interceptor armament did not move at quite that swift a pace, however. By the end of 1954, the 2.75-inch FFAR was available on F-86D, F-94C and F-89D interceptors, but the Falcon was far from ready. Falcon missiles were successfully fired from an F-89D test aircraft on 21 October 1953, but the missile pod showed a tendency to collapse after firing and re-design was necessary. Progress was being made, but not enough to meet the operational date of 1 October 1954 (slipped in 1952 from the original date of June 1954). By the end of 1954 the operational date had receded to August 1955.

Meanwhile, ADC began to think about adding a nuclear punch to its armament. Following discussions within the headquarters during the last half of 1951, ADC was ready



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to state a formal requirement on 31 January 1952. At that time, ADC pointed out that it regarded existing and programmed armament as deficient. Therefore, in order to assure a high degree of kill probability against targets using electronic countermeasures or evasive action, ADC requested development of nuclear air-to-air missiles which would cut a wide swath of destruction through a formation of enemy bombers.  
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USAF was now receptive to the idea of using nuclear warheads in air-to-air missiles, although it had previously considered such use inappropriate because all nuclear materials were required for SAC bombs. Before air-to-air missiles could be provided with nuclear warheads, however, USAF thought it would be necessary to determine whether the idea was technically feasible, whether sufficient nuclear materials were available and what operational use would be made of such atomic weapons. Preparation of the operational plan fell to ADC. This request caught ADC unprepared, since it was not experienced with atomic weapons. ADC's first move, therefore, was to ask ARDC, in May 1952, a long series of questions about the size and characteristics of possible atomic missiles. At about the same time, USAF asked ARDC to make a feasibility study along

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similar lines. The F-89 had meanwhile been nominated as a potential carrier for the atomic missile. <sup>193</sup>

ARDC (specifically the Air Force Special Weapons Center) was not very encouraging as to prospects for immediate development of atomic armament for interceptors, since current atomic warheads were much too large for use in interceptor missiles. It was acknowledged that a small warhead could probably be developed, but that it would entail a long-range development project. To underline its point, AFSWC pointed out that the Shrike, the smallest atomic weapon currently under development, was 23 feet long and weighed 5,225 pounds. <sup>194</sup>

But this was far from the end of the story. The Joint Air Defense Board, a JCS organization charged with monitoring air defense activities, also made a study of nuclear armament for interceptors and in a report dated 14 January 1953 came to the conclusion that atomic weapons should be developed for air defense use. The JADB recommended concentration on small inexpensive warheads in the 2-4 kiloton range and extended wargaming to determine how they should be used. Because of the implied JCS support contained in the JADB report, ADC reopened the matter. On 23 March 1953, ADC repeated to USAF that "a requirement



  
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exists in ADC for lightweight atomic warheads of lowest possible cost with yields within the range of 1-20 KT." <sup>195</sup>

USAF was again receptive to the idea, but explained that the Terrow rocket mentioned by ADC as a possible recipient of a nuclear warhead was too small for inclusion of an implosion-type warhead. USAF added, however, that the problem was being attacked in two directions. Attempts were being made to fit the existing XW-7 and XW-12 warheads into a rocket suitable for mounting on an interceptor. Also, the Atomic Energy Commission believed it possible to design a warhead which would fit into a smaller case. USAF agreed that the F-89 could probably be modified to serve as a carrier for the atomic air-to-air missile. AFSWC reversed its position of a year before and reported in June 1957 that it appeared theoretically possible to develop an air-to-air <sup>196</sup> missile containing an atomic warhead.

While the concept of atomic armament for interceptors had been accepted by USAF, ARDC and ADC, actual development of an atomic warhead for such employment could not proceed until the approval of the Joint Chiefs of Staff had been obtained and that approval was not immediately forthcoming. Meanwhile, AFSWC had determined that a warhead diameter of from 12 1/2 to 15 inches would be most feasible for use in an air-to-air missile. There still remained much uncertainty

  
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regarding the weight and explosive yield of such a warhead, although ADC wanted a warhead which would produce a yield somewhere between [ ] kilotons. Impetus for development of such a warhead was provided 2 April 1954 when the JCS approved the use of atomic warheads in air-to-air rockets.

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Gradually, following the JCS approval, the nature of the atomic armament for interceptors began to emerge. To encourage speed of development, the atomic warhead was to be placed, initially, in an unguided rocket. Use in a guided missile was to come later. It was anticipated that the atomic rocket (named DING DONG in early 1954) would have a diameter of 17 inches and a yield

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b(3)

With the general characteristics of the airborne atomic rocket established by late 1954, one of the next problems to be overcome was testing of the warhead when it had reached that point in development where test was possible. This matter assumed the status of a major problem, because the testing of an atomic device was not something to be undertaken lightly.

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## INTERCEPTOR MISSILES

Development of a long-range interceptor missile to be known as BOMARC was approved by the Research and Development Board of the Department of Defense in December 1950. The missile foreseen was one which would be effective at altitudes between 10,000 and 80,000 feet, would have a range of 250 miles and would intercept targets flying at speeds of from 400 to 2,000 miles an hour. The first missiles were to be operational in 1956. The BOMARC was a compromise between the short-range GAPA missile partially developed by Boeing and the extra-long-range WIZARD being studied by the University of Michigan.

On 12 January 1951, Boeing was designated as prime contractor for the weapon which it was anticipated would "first augment then replace the manned interceptor." During the first half of 1951, Marquardt Aircraft Company was chosen to provide the ramjet engines the BOMARC would use to produce high speed during the cruise phase of flight. Aerojet Engineering Corporation was selected to develop the liquid-propellant rocket booster required to lift the missile off the ground. Westinghouse Electric Company agreed to furnish the necessary target seeker. The BOMARC development-production team had been formed.

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The optimism of 1950 gave way to the frustration of succeeding years as it proved to be exceedingly difficult to translate success in development of the short-range GAPA into success with the long-range BOMARC. The airframe itself presented no particularly difficult problems, however, since the airframe of 1954 was essentially the airframe designed in 1950. It grew somewhat during development (the length increased from 35 feet to 41.2 feet, the wingspan grew from 14 feet to 18.1 feet and the weight at launching rose from 8,000 pounds to 12,250 pounds), but the missile looked pretty much the same. <sup>201</sup>

At the same time, subcontractors for vital components of the BOMARC were facing problems that tended to push far into the future the operational date of the missile. Aerojet had provided boost rockets for the Boeing GAPA missile and Boeing was confident that it could also develop boost rockets for the much larger BOMARC. But Aerojet was not immediately able to guarantee combustion stability in a rocket which was expected to generate 35,000 pounds of thrust. Through 1952 Aerojet worked to perfect the faulty gas pressurization system and thought that the answer had been found by the end of the year. But satisfactory firings in February and March of 1953

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ended in a major explosion in April. The following month Aerojet appeared to have found a solution in the "staggered start" in which pressure was raised in the oxidizer tank before the gas generator was started. The promise of May, however, led to the discouragements of August and September, when three successive malfunctions badly damaged the test stand, made a shambles of the test missile and destroyed the thrust chamber.

Aerojet was having such difficulty in developing a satisfactory booster that, despite ARDC's distaste for "duplication of costly components," Reaction Motors, Inc., was brought into the booster program in the spring of 1953 in order to provide a "hedge" in the event Aerojet's problems finally proved insoluble. The Reaction Motors booster had been previously used as a test bed for new booster fuels, but now changed into a full-fledged alternate for the Aerojet development. What was especially interesting was the possibility that the Reaction Motors booster could ultimately provide 50,000 pounds of thrust. At the end of 1953, Aerojet was working to increase the reliability of its product (which used a combination of red fuming nitric acid and JP-4 jet fuel plus a starting compound composed of 30 per cent aniline alcohol and 70 per cent furfuryl alcohol), while Reaction

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Motors experimented with a booster using a mixture of  
203  
liquid flourine and ammonia.

The Reaction Motors' threat to Aerojet disappeared in 1954, however. Although another Aerojet rocket motor exploded during a test held in February 1954, enough progress in solving earlier problems had been made by July 1954 that ARDC authorized a flight test. Meanwhile, none of the dozen motors tested by Reaction Motors during the first half of 1954 was successful and it was apparent that Aerojet was significantly ahead in motor development. By the end of 1954, then, Aerojet was making sufficient progress that the need for a high-thrust test stand was evident. ARDC was seeking a location for such a test  
204  
stand as the year ended.

Marquardt had similar problems with its ramjets. Test firings in 1951 and 1952 were not encouraging, although one ramjet did burn for 10 seconds. There were various explanations for the continued failures, but explanations did not provide the BOMARC with a useable ramjet. These failures were difficult to understand, because ramjet investigations had begun in 1944 and the Navy had flown supersonic ramjets as early as 1947. Nevertheless, Marquardt was hopeful that use of Lockheed's X-7 test vehicle for flight testing of the ramjet would




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point the way to solutions. The first 28-inch ramjet (the size required for BOMARC) was flown on the X-7 on 17 December 1952 and burned, as mentioned above, for 10 seconds. It was not until the 10th flight, on 8 April 1953, that the ramjet burned for as long as 20 seconds. On this occasion the X-7 had reached an altitude of 59,000 feet and a speed of Mach 2.6 when the fuel control failed and thrust decayed. A flight of 12 September 1953 was equally promising, but a December failure produced discouragement again. Boeing was definitely dissatisfied with ramjet performance and at the end of 1953 ordered continuance of the test program.

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There was no immediate improvement in ramjet performance. A test firing of 24 February 1954 was also unsuccessful when the diffuser wall collapsed after only nine seconds of operation. But continued work brought results when a successful test was conducted on 17 June 1954. On this occasion the X-7 test vehicle was dropped from a B-29 at 28,000 feet and boosted to a speed of Mach 2.2 with a solid rocket. At this point the ramjet took over and pushed the speed of the X-7 to Mach 3.21. The ramjet burned for 100 seconds. Two other successful tests (of seven conducted) were noted during the last half of


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1954. In one test the ramjet remained lighted for 153  
206  
seconds, the longest burning period yet achieved.

Westinghouse appeared to be making progress in the development of a BOMARC target seeker, but intensive testing had not begun by the end of 1953, so nobody was quite sure whether the Westinghouse development would be satisfactory or not. Westinghouse divided the development process in two parts. First came a "Model A" seeker, of which three had been built by the end of 1953, then a smaller, lighter "Model B". The original proposal to test the target seeker in actual missiles was soon discarded in favor of a plan to conduct tests in an aircraft. An F-94B interceptor was fitted with a special nose in which  
207  
the experimental seeker would fit.

When laboratory tests of the Westinghouse seeker indicated that it would have limited capability at low altitudes because of ground clutter and would be susceptible to jamming, Boeing began development of a coherent pulse-doppler seeker which would avoid ground clutter through a technique described as "velocity gating." By September 1953, research had proceeded to the point where Boeing was ready to subcontract with Radio Corporation of America for further development. Attempts to provide a  
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pulse-doppler seeker were continuing at the end of 1954.

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Although none of the major components were close to the completion of development, BOMARC flight testing got off to a shaky start on 10 September 1952 when the first missile was launched from the Florida test center that later became known as Cape Canaveral. The test crew was successful in igniting the booster and the missile rose 500 feet before the gimbaling controls failed. The missile then performed several loops "and other unorthodox gyrations" before it crashed and exploded.

Four months passed before a second launch attempt was made on 23 January 1953. Again, the missile was successfully launched, but the booster failed after 1.5 seconds of flight. As a consequence, the BOMARC rose only eight feet in the air, then settled back to the ground and exploded.

The third test missile, launched 10 June 1953, met a somewhat more encouraging fate. The booster performed satisfactorily and the ramjets ignited, but after 23 seconds a low-order explosion (apparently in the rocket chamber) abruptly ended the flight at about 10,000 feet and Mach 1.6.

The two remaining BOMARC test flights in 1953 -- 27 July and 4 September -- followed the pattern of the third flight. There were about 20 seconds of successful flight

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to an altitude of 10,000 feet, or slightly above, and a speed of about Mach 1.5, followed by disintegration of the missile. There was such a disturbing similarity to the last three flights that "major problems in design and reliability of components" were indicated and further flight testing was delayed nearly a year in order to give Boeing and its subcontractors an opportunity to study the malfunctions that had occurred.

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Flight testing was resumed in August 1954, but it quickly became apparent that many problems remained. The sixth launching, 5 August 1954, showed many of the characteristics of the last three test attempts of 1953. The BOMARC got off the pad successfully, but flew only 15 seconds before the elevator control malfunctioned and caused violent flight maneuvers which tore the missile apart.

Because of this unbroken string of test failures, it was decided to limit the scope of the test program. Hence, when the seventh test missile was launched 25 October 1954, no ramjets were included. Only the rocket motor and guidance components were tested. Perhaps it was only coincidence, but the first test flight in which the ramjets were deleted turned out to be the first




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successful flight of the missile. The BOMARC rose to an altitude of 44,000 feet, reached a speed of Mach 2.45 and covered about 34 miles in eight minutes of flight.

A second successful flight (eighth launching) occurred on 24 November 1954 when a similar missile also reached an altitude of 44,000 feet. On this occasion a speed of only Mach 2.2 was attained, although the missile covered 48 miles in nine minutes of flight. Ramjets were not used. At the end of 1954, therefore, there could be some comfort in the realization that the missile could be made to fly. All that remained to do was increase the range and improve reliability -- major tasks as subsequent events proved.

At the end of 1954, after having wrestled with the realities of BOMARC development for four years, USAF no longer talked easily of having the BOMARC ready for operational use in 1956. The first move toward recognition of the inevitable was division of BOMARC development into two phases. First would come BOMARC I with a range of 125 miles, altitude capability of 60,000 feet and speed of Mach 2.5. Then would come the "ultimate" missile, BOMARC II, with range of 250 miles, altitude capability of 80,000 feet and speed of Mach 2.7. The original development program, published 31 December 1950, called for BOMARC I in

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1954. with the ultimate missile to be available in 1956. In April 1951, October 1954 was established as the completion date for BOMARC testing. Slightly more than a year later, in July 1952, the test completion date had slipped to August 1955. At the end of 1953 that date was being given as June 1956. A quarterly review of missile progress at the end of June 1954 estimated that testing would be finished in June 1957. In this relatively short period of about four years, the BOMARC development program had slipped approximately three years. The operational date, it was obvious to operations planners, had slipped from 1956 to 1959.

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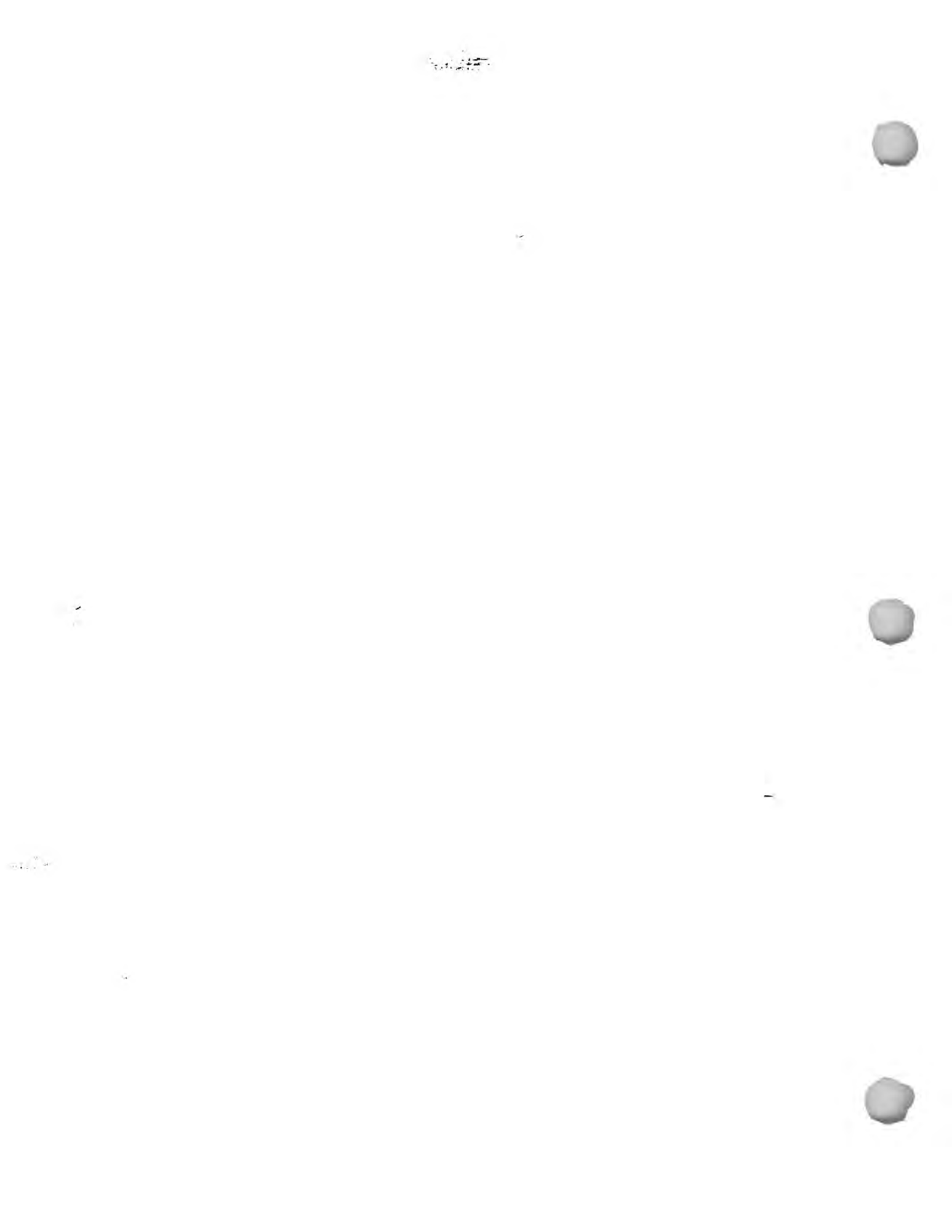




PART TWO

THE WEAPONS FORCE REACHES MATURITY

1955 - 1962



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## CHAPTER SIX

### WEAPONS FORCE PLANNING

Progress toward a force which would be adequate to contend with the offensive threat posed by Soviet long-range bombers was evident at the end of 1954. Fifty-five squadrons of interceptors were manned, equipped and in place at that time. Growth to a force of 69 squadrons was approved.

#### INTERCEPTOR MISSILES.

New factors, however, began to enter ADC planning. One was BOMARC, the interceptor missile. This long-range

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missile had been under development for some time, and ADC knew that, eventually, it would be assigned to the air defense force. Since planning is necessarily hazy in the early stages of weapon development, ADC characteristically thought big. Planning in the 1952-54 period mentioned deployment of 53 BOMARC squadrons. In the light of subsequent cost estimates, this figure seemed fantastically large, but at the time, with only the threat in mind, the requirement was both sound and logical. By 1955, however, planning was beginning to take the shape of the more precise programming and USAF appeared inclined to establish 40 squadrons as the probable size of the BOMARC force. At about the same time, programming for the shorter-range TALOS missiles began to be taken seriously. TALOS was a Navy development originally designed for shipboard use. It was therefore expected to be effective at altitudes of 60,000 feet and at ranges of 50-150 miles. It therefore fell somewhere between the Army's NIKE and ADC's BOMARC. On 7 June 1955 USAF was designated as the service responsible for land-based TALOS. USAF was inclined to prepare for the deployment of eight TALOS squadrons, each with four detachments, although ADC was thinking in terms of as many as 53 squadrons in early 1955.

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Since TALOS had a relatively short range, ADC first planned a chain of 32 detachments which generally supported SAC and AEC installations. As a beginning, ADC asked, early in 1956, that funds be provided for TALOS sites at Lockbourne AFB, Ohio; Bunker Hill AFB, Indiana; Peoria, Illinois and Kirksville, Missouri. USAF approved this request and included it in the Military Construction Program (MCP) for Fiscal 1957 which it presented to Congress. Meanwhile, ADC had decided that the "chain" concept of TALOS deployment was not the proper one and that TALOS should be sited in more direct support of SAC. It was therefore recommended, in March 1956, that the first four TALOS sites be located on four major SAC bases -- Offutt, Barksdale, March and Castle. Unfortunately, however, the 1957 MCP had already been presented to Congress and changing the sites at that juncture would have been embarrassing. The matter was compromised by leaving the sites presented to Congress as the first four, with the sites subsequently recommended by ADC as the second four. By the end of May 1956, ADC TALOS siting teams were ready to take the field, but their departure was delayed when a controversy erupted over the relative efficiency of the Air Force TALOS and the Army NIKE. Since it appeared that some sort of

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competitive test between the two air defense missiles would  
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be required, siting was deferred indefinitely.

TALOS, as it turned out, proved to be a short-lived addition to the ADC arsenal. Secretary of Defense Charles E. Wilson settled the Army-Air Force controversy in November 1956 by issuing a decree which awarded all missiles having a range of less than 200 miles to the Army. TALOS  
214  
fell within this category.

While TALOS was coming and going, ADC also busied itself with further planning for BOMARC. Since USAF appeared willing, in 1955, to support a program which called for 40 squadrons of BOMARC (120 missiles to a squadron for a total of 4,800 missiles), ADC reached a decision on the location of these 40 squadrons and suggested operational dates for each. The plan was as follows:

<u>Site</u>	<u>Operational Date (Qtr/FY)</u>
1. McGuire	1/60
2. Suffolk	2/60
3. Otis	3/60
4. Dow	4/60
5. Niagara Falls	1/61
6. Plattsburg	1/61
7. Kinross	2/61
8. K. I. Sawyer	2/61
9. Langley	2/61
10. Truax	3/61
11. Paine	3/61
12. Portland	3/61

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<u>Site</u>	<u>Operational Date (Qtr/FY)</u>
13. Hamilton	4/61
14. Oxnard	4/61
15. San Diego	4/61
16. Fort Ord	1/62
17. Bunker Hill	1/62
18. Greater Pittsburgh	1/62
19. Duluth	2/62
20. Sioux City	2/62
21. Grand Forks	2/62
22. Cut Bank	3/62
23. Opheim	3/62
24. Minot	3/62
25. Klamath Falls	4/62
26. Geiger	4/62
27. McConnell	4/62
28. Ardmore	1/63
29. Amarillo	1/63
30. Reese	1/63
31. Biggs	2/63
32. Laughlin	2/63
33. Williams	2/63
34. Ellington	3/63
35. New Orleans	3/63
36. Fort Campbell	3/63
37. Pinecastle	4/63
38. Tyndall	4/63
39. Charleston	4/63
40. Seymour-Johnson	1/64

As it was organizing siting teams for TALOS in the late spring of 1956, ADC was also thinking about establishing definite sites for the first 24 BOMARC units. USAF felt that this activity was premature, however, since no funds for BOMARC construction were included in the MCP for Fiscal 1957. During this waiting period, ADC recast its BOMARC plan to call for the initial




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placement of two flights (half a squadron) at each site. Later each location would support a full squadron of four flights (120 missiles).<sup>215</sup>

Although it had appeared in 1955 that USAF was ready to support a force of 40 BOMARC squadrons, such was not the case in 1956. When the ADC plan for deployment of 40 squadrons was presented in September 1956, it was bluntly rejected by USAF as being far too costly. ADC, being concerned with defense and not cost, had blithely ignored the fact that 4,800 BOMARC missiles at 3.3 million dollars per missile would require an outlay in excess of 15 billion dollars, exclusive of the cost of building the shelters. USAF then proposed an alternative plan which would provide 22 squadrons with a total of 70 flights, or less than half of the 160 flights provided in the ADC plan. The deployment proposed by USAF placed BOMARC squadrons around the perimeter of the United States and limited those in Montana and North Dakota, along the southern border and in the southeast to two flights per squadron.<sup>216</sup>

ADC made vigorous rebuttal to the USAF proposal, pointing out that even the 40 BOMARC squadrons contained in the ADC plan would provide only minimum defense coverage so far as ADC was concerned. Any reduction, therefore, was

  
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fraught with risks ADC did not want to accept. After more inconclusive discussion in late 1956, the matter of BOMARC deployment was taken out of ADC's hands. In December, USAF asked that the ADC plan be submitted to CONAD for approval and subsequent submission to the Joint Chiefs of Staff. Meanwhile, site surveys for 14 BOMARC installations were underway.

CONAD took a position somewhere between ADC and USAF. The joint command recommended, in January 1957, that 40 squadrons of BOMARC be deployed, but that each should have only two flights for a total of 80 flights. This compromise solution was accepted, at least temporarily, by both USAF and ADC. Other measures were also invoked in order to cut the immense cost of the BOMARC system. Siting was temporarily halted in April 1957 until USAF could be assured that all BOMARC units would be located on existing bases and would not require the purchase of additional land. Also, launchers were re-  
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designed to permit more "austere" construction.

Actual construction of the first BOMARC sites began in late 1957. ADC was allocated 43 million dollars in the Fiscal 1958 MCP with which to build half-bases of 56 launchers (reduced from the earlier figure of 60

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launchers) at McGuire, Suffolk, Otis and Dow. Initial effort was concentrated at McGuire, since it was scheduled to become operational 1 September 1959. From the beginning it was evident that the 43 million dollars was not going to be sufficient to build all four bases, since preliminary engineering estimates placed the cost of the McGuire and Suffolk sites at 38.5 million, leaving only 4.5 million for Otis and Dow. There was also an unexpected delay at McGuire when it required intervention by the Secretary of Defense to obtain Army permission (McGuire AFB is located on Fort Dix, an Army installation) for construction of BOMARC launchers.<sup>219</sup>

Because of the great cost of the full BOMARC program, USAF continued to cast around for safe methods of reducing it. In December 1957, USAF wondered if the increased range of the IM-99B (over 400 miles as opposed to the approximately 200-mile range of the IM-99A) and a proposed advanced BOMARC known only as IM-X might not make it possible to reduce the number of proposed BOMARC sites. The scope of the proposed reduction was not given. ADC could not agree that any reduction was feasible, on the theory that the improved range of the advanced missiles would merely offer improved air defense coverage where it

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was vitally needed. ADC countered this proposal by recommending that BOMARC deployment be expedited rather than reduced. It was suggested that USAF seek a supplemental Fiscal 1958 appropriation to permit the construction of nine BOMARC bases, rather than the four presumably financed in the regular 1958 MCP. In addition, ADC recommended that each of these nine bases be equipped with 112 launchers instead of the 56 launchers authorized for the first four bases -- a recommendation which ran counter to the CONAD-USAF-ADC BOMARC compromise reached early in 1957. Looking ahead, ADC also asked for funds for construction of 11 BOMARC sites in the Fiscal 1959 MCP. If this request was approved, a total of 20 BOMARC bases would be provided by 1958-59 Military Construction Programs. <sup>220</sup>

The ADC request (subsequently supported by CONAD) hung fire through the spring of 1958, but eventually came to naught. Not only was the request for acceleration denied, but the BOMARC program for Fiscal 1959 was also cut. It was becoming painfully obvious that ADC was not going to get the 40 squadrons of BOMARC (112 launchers and 120 missiles to a base) as planned in 1955. It was also becoming evident that the 40 half-squadron compromise reached in early 1957 was a dead letter. In June 1958,



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USAF let it be known that it was prepared to ask Congress for only 31 BOMARC bases. Two of these were to have 56 launchers and the remainder 28 launchers, which added up to a total program of 924 launchers and approximately 1,000 missiles. Construction of 10 additional bases was authorized for Fiscal 1959, for a total of 14.<sup>221</sup>

As to the four bases financed with Fiscal 1958 funds, it was found possible to squeeze construction costs within the 43 million dollars appropriated by cutting the number of launchers at Otis and Dow from 56 to 28 and substituting less massive launchers for those originally specified.<sup>222</sup>

By late 1958 it was time to think about the budget for Fiscal 1960 and the BOMARC construction it would buy. ADC/CONAD asked that 15 additional bases be constructed with 1960 money, bringing the 1958/59/60 total to 29 bases. The preliminary USAF reaction, stated in November 1958, was that no more than 12 bases could be worked into the budget. At the same time, there arose a difference of opinion between ADC and CONAD as to where the BOMARC bases should be located. CONAD believed that two bases should be located in Canada. ADC did not object to these proposed bases at North Bay and Ottawa, so long as they were merely added to the bases programmed for the United States. CONAD, however,

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suggested substituting the Canadian bases for those previously programmed for Bunker Hill and Youngstown (initially  
223  
sited at Greater Pittsburgh).


Late 1958 was also the time for settling the problem of which bases should have the early-model IM-99A and which should have the fully developed IM-99B. Discussions of the matter in 1956 found ARDC holding the position that the first 12 bases should have IM-99A, the remainder IM-99B. ADC wanted the change made after the 10th base. As missile development proceeded and the years rolled by, the number of bases to receive the IM-99A grew smaller, because base construction was slower than missile development. In June 1958, USAF reduced the number of IM-99A bases to eight. The following September NORAD asked that the IM-99A bases be reduced to six and JCS and USAF concurred. Then in December 1958 a reduction to five IM-99A bases was directed by USAF. No further reductions were made, although three of the five IM-99A bases were to be supplemented with IM-99B missiles. Only the bases at McGuire and Suffolk were to be limited to  
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the IM-99A model.

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At the end of 1958, ADC plans called for construction  
225  
of the following BOMARC bases in the following order:

- |                   |                     |
|-------------------|---------------------|
| 1. McGuire        | 16. Malmstrom       |
| 2. Suffolk        | 17. Grand Forks     |
| 3. Otis           | 18. Minot           |
| 4. Dow            | 19. Youngstown      |
| 5. Langley        | 20. Seymour-Johnson |
| 6. Truax          | 21. Bunker Hill     |
| 7. Kinross        | 22. Sioux Falls     |
| 8. Duluth         | 23. Charleston      |
| 9. Ethan Allen    | 24. McConnell       |
| 10. Niagara Falls | 25. Holloman        |
| 11. Paine         | 26. McCoy           |
| 12. Adair         | 27. Amarillo        |
| 13. Travis        | 28. Barksdale       |
| 14. Vandenberg    | 29. Williams        |
| 15. San Diego     |                     |

But even this program proved optimistic. The value of the BOMARC as an air defense weapon was seriously questioned during congressional debate over the relative merits of the BOMARC and NIKE-HERCULES in the late spring of 1959. Actually, the debate was unrealistic, because the weapons were complementary rather than competitive. The NIKE-HERCULES was a point defense weapon of relatively short range, while BOMARC was a long-range area defense weapon. Nevertheless, the House voted to withhold all funds from BOMARC while the Senate took similar action with regard to NIKE-HERCULES. Its "feet held to the fire" by this striking difference of opinion within the Congress, the Department of Defense produced, in June 1959, a compromise Master Air Defense Plan. As a result, the BOMARC

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program was reduced to 18 sites, two of them in Canada, each site to have 56 launchers and 60 missiles, for a total of 1,080 missiles. This congressional action rendered academic discussion of such matters as the exact location of the BOMARC site in the Sioux City area. There just was not going to be a BOMARC squadron in the Sioux City area.

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After going through the congressional wringer the ADC BOMARC program at the middle of 1959 was as follows:

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<u>Priority Number</u>	<u>Site</u>	<u>Activation Date</u>	<u>Operational Date</u>
1	McGuire	Jan 1959	Sep 1959
2	Suffolk	Feb 1959	Dec 1959
3	Otis	Mar 1959	Mar 1960
4	Dow	Jun 1959	Jun 1960
5	Langley	Sep 1959	Sep 1960
6	Kinross	Mar 1960	Mar 1961
7	Duluth	Apr 1960	Apr 1961
8	Niagara Falls	May 1960	May 1961
9	Paine	Jul 1960	Jul 1961
10	Adair	Aug 1960	Aug 1961
11	Travis	Sep 1960	Sep 1961
12	Vandenberg	Oct 1960	Oct 1961
13	Malmstrom	Jan 1961	Jan 1962
14	Glasgow	Apr 1961	Apr 1962
15	Minot	May 1961	May 1962
16	Charleston	Jul 1962	Jul 1963
17	La Macaza (Canada)	Feb 1961	Feb 1962
18	North Bay (Canada)	Mar 1961	Mar 1962

The new program amounted to the first 18 sites of the old program, with three exceptions. The sites at Truax (No. 6), Ethan Allen (No. 9) and San Diego (No. 15) were replaced by Charleston and the two Canadian sites. The new program

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would provide only a perimeter of BOMARC defenses, from Charleston on the South Atlantic coast north through Langley, McGuire, Suffolk, Otis and Dow; then along the northern border of the nation at La Macaza, Niagara Falls, North Bay, Kinross, Duluth, Minot, Glasgow and Malmstrom. The west coast would be protected by four BOMARC locations running from Paine in Washington through Adair and Travis to Vandenberg in Southern California.

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Although no funds were provided for additional BOMARC construction in the budget for Fiscal 1960, money for 14 sites had been provided in the 1958 and 1959 budgets, so there was no immediate shortage of construction funds. Since the Ethan Allen and Truax sites had been removed from the program, however, construction at these locations was halted.

The 18-site BOMARC program remained in effect through the early weeks of 1960 and was implicit in Air Force testimony before the House Appropriations Committee in January 1960. At that time, USAF asked that 421.5 millions be provided in the Fiscal 1961 budget for continued procurement of IM-99B missiles. USAF testimony also included the statement that a decision would be made by December 1960 as to whether or not additional funds would be required in future budgets. This was a cautious approach to the financing of the complete

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BOMARC program, but it was evidence that USAF intended to  
229  
proceed.

All this was changed on 24 March 1960, however, when USAF returned to Congress to ask that the budget request of January be drastically revised. Among the changes requested was a cut in IM-99B procurement from 421.5 million to 40 million, plus an emphatic statement that this would be the end of all BOMARC procurement. ADC had learned of this change of attitude as regards the IM-99B only the previous day, 23 March, when USAF announced that the IM-99B would be limited to seven sites -- Kincheloe, Duluth, Niagara Falls, Langley, Otis, La Macaza and North Bay. Each site was to be limited to 28 missiles, except where additional missiles could be recouped from the testing and training programs. All told, no more than 337 IM-99B missiles were to be bought, a far cry from the 4,800 missiles ADC had programmed in the mid-fifties and even from the 1,470 missiles (including 210 IM-99A missiles)  
230  
contained in the current ADC program.


The reasons given by USAF for curtailment of the IM-99B were various. Increasing Soviet emphasis on intercontinental ballistic missiles, against which the BOMARC was impotent, was mentioned in the hearings of 24 March. Nagging technical difficulties which had continued to delay operational use of BOMARC were also given as a reason.

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The necessity of diverting BOMARC production funds to projects of higher priority (such as the Atlas and Titan ICBM's) was underscored. The general impression left by USAF and Defense Department testimony was that BOMARC had been outdistanced in the technology race, but that it could be put to good use in defending the northeast United States against the still-potent Soviet bomber fleet.

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It was the obvious ADC position, in view of the size of the BOMARC force currently programmed, that the reduction to seven IM-99B squadrons would result in totally inadequate deployment. At the same time that it announced the decision to limit the IM-99B to seven sites, USAF also pointed out that total cancellation of the IM-99B program would release approximately 255 millions allocated to the IM-99B in previous fiscal years, sufficient funds to buy three squadrons of F-106A interceptors or four squadrons of F-101B aircraft. Would ADC consider these aircraft an adequate substitute for the lost IM-99B missiles? The ADC answer was in the negative. In a 23 March reply that provoked considerable discussion in the committee hearings the following day, ADC contended that to provide the same coverage offered by the IM-99B, manned interceptors would have to replace the interceptor missiles on a one-for-one basis. Although General Thomas D. White, Air Force Chief

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of Staff, strongly supported the ADC position as the considered judgement of experts in the air defense field, members of the subcommittee were frankly skeptical. <sup>232</sup>

As a result of this skepticism, no more money was provided for BOMARC. Therefore, when BOMARC deployment was completed in 1962, only 10 sites in the northeastern United States and the adjoining area in Canada were equipped with the missiles. Three sites -- McGuire, Otis and Langley -- had both IM-99A and IM-99B missiles. Two sites -- Suffolk and Dow -- offered only IM-99A weapons and three others -- Niagara, Kincheloe and Duluth -- were equipped exclusively with the IM-99B. The Canadian sites -- North Bay and La Macaza -- were not operationally ready because of the continuing reluctance of the Canadian government to permit the storage of nuclear warheads in Canada. Ten sites and approximately 500 missiles, then, was the final extent of a program that once called, hopefully, for 40 sites and 4,800 missiles. Again, as in <sup>233</sup> other instances, reality fell painfully short of plan.

#### DEPLOYMENT TO PROTECT SAC

Another new factor in ADC planning was a shift in deployment in order to afford a greater degree of protection

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for SAC, the nation's capacity for retaliation. The question of "what do we defend" had been raised at the time ADC was created. Then the answer was given as "population centers and atomic energy plants" and the answer was acceptable to levels of authority above ADC. But when Thomas K. Finletter was inducted as Secretary of the Air Force on 24 April 1950, Mr. Finletter raised the question again. He wanted to know why air defense priority was not afforded to SAC bases. General Whitehead, ConAC commander, explained the situation to Mr. Finletter in May 1950. SAC bases were relatively invulnerable, General Whitehead explained, because most were deep in the interior of the country and would benefit from the early warning provided by the defense forces stationed on the periphery. Besides, the majority of SAC bases were located at the extreme one-way range of the TU-4 bombers of the Russians. Also, General Whitehead did not believe the Russians were sufficiently skilled in handling long-range bombers to mount a simultaneous strike against all SAC bases. There was far greater danger, General Whitehead believed, that the Russians would strike population centers because they were much easier to hit and because the Russians could exploit to their advantage the chaos which would be created by an

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atomic attack on a major U. S. city. At the same time, General Whitehead acknowledged that the time would come "in two or three years" when the Russians would have the necessary equipment and know-how to aim a serious blow at SAC. When that time approached, General Whitehead felt the air defense weapons force should be repositioned to counter it.

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Although the JCS emergency war plans in effect during subsequent years mentioned the importance of defending SAC bases, no actual shift of interceptor deployment for this purpose was suggested until late 1955, when ADC brought up the subject again. The matter arose in connection with a discussion over the use of F-104 day fighters in the air defense system. When it was first suggested, in February 1955, that F-104's might be put to use in air defense, ADC declined the offer of four wings for the perfectly logical reason that day fighters were not much use to an organization that would probably have to fight at night. By June 1955, however, ADC had decided that it could use the proffered four wings (12 squadrons) of F-104 aircraft if the F-104 was not considered a substitute for an interceptor. In other words, ADC would accept the F-104 if the resulting fighter program would call for 81 squadrons instead of 69 squadrons as currently




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programmed. In October 1955, General Earle E. Partridge, who had assumed command of ADC the previous July, repeated the June request and mentioned, as justification, the increased dispersal of SAC units. ADC planners took up the idea and in mid-November 1955 presented to USAF a plan for shifting 10 squadrons of interceptors from the north and northeast to the south-central area in order to provide additional protection for SAC. The units removed from the north and east were to be replaced by F-104 squadrons. The ADC plan was not immediately approved by USAF, but CONAD anticipated approval by asking SAC, in late December 1955, to list its priority locations in order that ADC might have a solid basis on which to plan redeployment.<sup>235</sup>

USAF approval came in April 1956, but involved only half the 10 squadrons of F-104 aircraft ADC had requested. A sixth squadron of F-104's was allocated to air defense, but was assigned to Alaska.<sup>236</sup>

ADC originally intended to implement the shift in deployment by placing interceptor squadrons at Biggs, Webb and Bryan Air Force Bases in Texas, Pinecastle AFB in Florida and Andrews AFB in Maryland. F-86D's from Stewart, Selfridge and Larson were to go to the Texas bases. F-104's were to be placed at Pinecastle and Andrews. By June 1956

  
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the plan had been changed to provide somewhat more protection for SAC. A squadron intended for activation at McGhee-Tyson in Tennessee was shifted to Lake Charles, Louisiana. Also, it was decided that the F-86D, rather than the F-104, would be stationed at all bases in the network protecting SAC. The F-104 would be located only at bases where there was also an interceptor squadron. In no place was the responsibility for air defense to rest solely with F-104 aircraft.


The campaign to provide additional protection for SAC received still more impetus in June 1956 when USAF decided to award 12 more interceptor squadrons to ADC as part of the drive to reach a USAF strength of 137 wings by the end of Fiscal 1957. Five squadrons of this additional force were to be applied to the protection of SAC, making again, a total of 10 squadrons to be redeployed for that purpose. In addition to the six bases mentioned above, USAF suggested use of Walker in New Mexico, Minot and Grand Forks in North Dakota and Glasgow in Montana. Walker was an operating SAC base and could presumably accommodate a squadron of interceptors, but the three bases on the northern border were in the early stages of construction and it was obvious to ADC that none of the three would be ready in time.



  
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Although the campaign for "137 wings in Fiscal 1957" foundered on financial rocks in late 1956, the 10-squadron shift in the direction of increased protection for SAC was retained. The list of bases to be involved, however, changed as circumstances changed. By early 1957, Biggs and Bryan in Texas, Andrews in Maryland and Lake Charles in Louisiana had been dropped from consideration. Substituted were Loring and Dow in Maine, Schilling in Kansas and Amarillo in Texas. It was further proposed that a Greater Pittsburgh unit be moved first to Randolph, then to Glasgow, because Greater Pittsburgh would have to be evacuated before Glasgow was ready. Also, the time schedule for this major redeployment was liberalized. Instead of a requirement to accomplish the necessary moves in Fiscal 1957, USAF substituted a schedule that would spread the movement over a two-year period extending from October 1957 through September 1959.

There was constant reprogramming of the interceptor force in late 1957 as the era of expansion ended and USAF groped for the proper level of retrenchment. The plan for deployment of 10 squadrons to provide a greater level of protection for SAC was untouched, however. The move of a squadron from Presque Isle to Pinecastle (later renamed

  
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McCoy), the first projected, was accomplished on schedule in late 1957. At the same time, substantial changes were made in the remainder of the redeployment program. Plans for the use of Webb, Schilling, Amarillo and Randolph (for subsequent re-transfer to Glasgow) were dropped. Randolph was not usable because of a shortage of family housing and Amarillo was not acceptable because it was impossible to site the fighter squadron at a logical location on the base. As substitutes for these four bases, ADC listed Bergstrom in Texas and Altus in Oklahoma as well as re-instating Lake Charles and Glasgow. By the end of 1957 it was also obvious that it was going to take longer to get some of these redeployment bases ready for a fighter squadron than had previously been thought necessary. The move to Minot, for example, was delayed a full year. Most of the other redeployments had slipped six months. As a consequence it was not expected that the shift of deployment for the protection of SAC would be completed before the spring of 1960.

By the middle of 1960, deployment for the greater protection of SAC, conceived in 1955, was complete. Nine squadrons were actually moved, but their ultimate locations were considerably different from what was originally

  
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planned. One squadron was placed at McCoy (Pinecastle) in Florida in order to provide improved defense cover for SAC units in the southeastern United States. In the south and southwest, interceptor squadrons were shifted to England in Louisiana, Webb in Texas and Walker in New Mexico. Along the northern rim of the Great Plains, ADC fighter units were placed at Glasgow in Montana and Minot and Grand Forks in North Dakota. In the critical northeast area, interceptor squadrons were redeployed to Dow and Loring in Maine. Although redeployment for the improved protection of SAC took five years to accomplish it was carried through virtually as planned in the beginning, despite much vigorous reprogramming of the interceptor force as a whole.

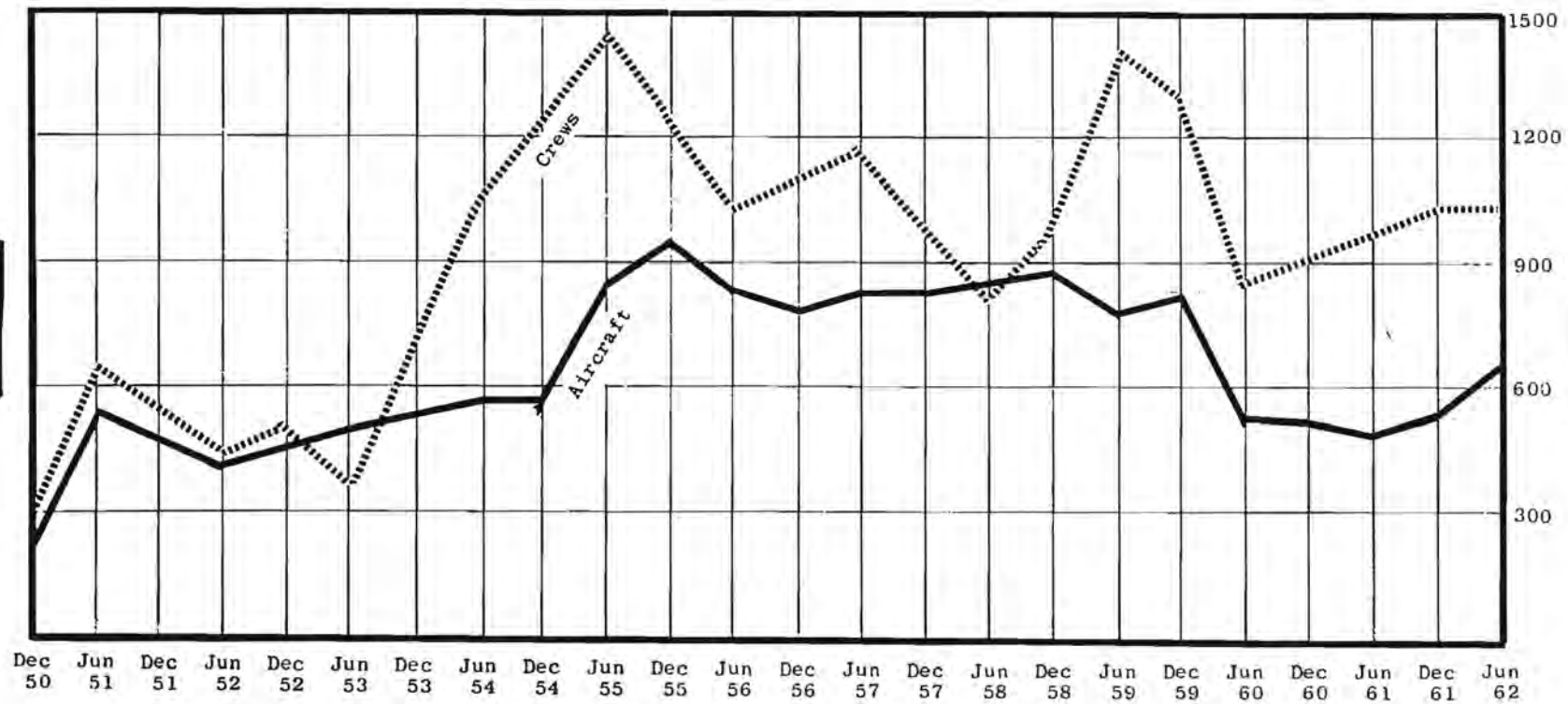
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#### BLUEPRINT FOR GROWTH -- AND RETRENCHMENT

In late June 1956, still another new planning factor emerged to complicate ADC programming. At that time, USAF decided that the total 137-wing Air Force would have to be operational by the end of Fiscal 1957. One-hundred-twenty-nine wings were currently in operation, which meant that eight wings would have to be activated during the coming year. The ADC portion of this increase amounted to 12

  
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squadrons. At mid-1956, ADC possessed 64 operating interceptor squadrons, plus four that had been activated but had not been manned nor equipped. The new USAF plan meant, then, that ADC would have to man and equip 16 squadrons during the succeeding 12 months. Implementation of the new USAF plan would give ADC 80 squadrons at mid-<sup>242</sup> 1957.

However, because of the straitened financial circumstances of USAF, there was an aura of unreality about the "137 wings in Fiscal 1957" plan from the beginning. This did not prevent ADC from engaging in a great deal of planning activity. The necessary base surveys were conducted during July 1956 and ADC, in cooperation with USAF, decided where the squadrons were to be activated. The ADC plan of 25 July 1956 entailed temporary assignment of three squadrons to both McChord and McGhee-Tyson, but this undesirable situation could not be avoided. The squadron intended for Minot was to be activated at Randolph and moved when Minot was ready. As for Glasgow, the interceptor unit for that base was to be activated at Grandview and moved later. The Grand Forks unit was to be organized at Kirtland in January 1957, moved to Clinton-Sherman in early 1958 and finally shifted to Grand Forks when that <sup>243</sup> base was ready.

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This "solid" program was in effect less than two weeks. In the middle of August USAF decided that three of the planned interceptor squadrons would not be activated and that the drive for "137 wings in Fiscal 1957" was no longer underway. About two weeks later, however, USAF reversed itself again and proclaimed "137 wings in Fiscal 1957" as dogma. but with a difference. ADC was to activate the 12 new squadrons in Fiscal 1957, but many would not be <sup>244</sup> manned and equipped until Fiscal 1958.

This was the high point in ADC 1946-1962 programming, because before the program of 1 September 1956 was barely a month old, ADC was receiving "firm indications" that the "137 wings in Fiscal 1957" plan had been scrapped and that ADC would be limited to the 68 squadrons enrolled on 30 June 1956, rather than the 80 squadrons indicated in the official program. No official instructions were immediately forthcoming from USAF, however, and ADC went ahead with the activation of the 398th FIS at Hamilton, the first of the 12 additional squadrons programmed. Therefore, at the end of 1956 ADC had 65 manned and equipped interceptor squadrons, plus four that were neither manned nor equipped, for a total of 69. The official confirmation of the October rumors came in January 1957 when USAF informed ADC that it

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would be limited to 70 squadrons, a position to be reached by 30 June 1957. According to the new USAF plan, gradual attrition of the interceptor force would begin in Fiscal 1958, with the force being reduced to 66 squadrons at the end of Fiscal 1961. While there was disappointment that the 80-squadron level was no longer authorized, there was a sense of relief that ADC would still be permitted 66 squadrons at the end of Fiscal 1961. Early planning had predicted rapid attrition after 1960, some estimates reducing the interceptor force as low as 27 squadrons by 1963.<sup>245</sup>

After the heady days of summer 1956, when 80 squadrons of interceptors were planned for ADC, subsequent planning involved ever more modest figures. The ADC program of 11 February 1957 foresaw a force of 66 squadrons on board at the end of Fiscal 1957, three squadrons fewer than were active at the end of 1956. The upper limit on future expansion was set at 68 squadrons. Actual strength on 30 June 1957, however, was 71 squadrons, including three (at Thule, Goose and Ernest Harmon) received 1 April 1957 when the Northeast Air Command was disbanded. Only 69 of these squadrons were manned and equipped. This increase in responsibility was recognized in the program of 15 July


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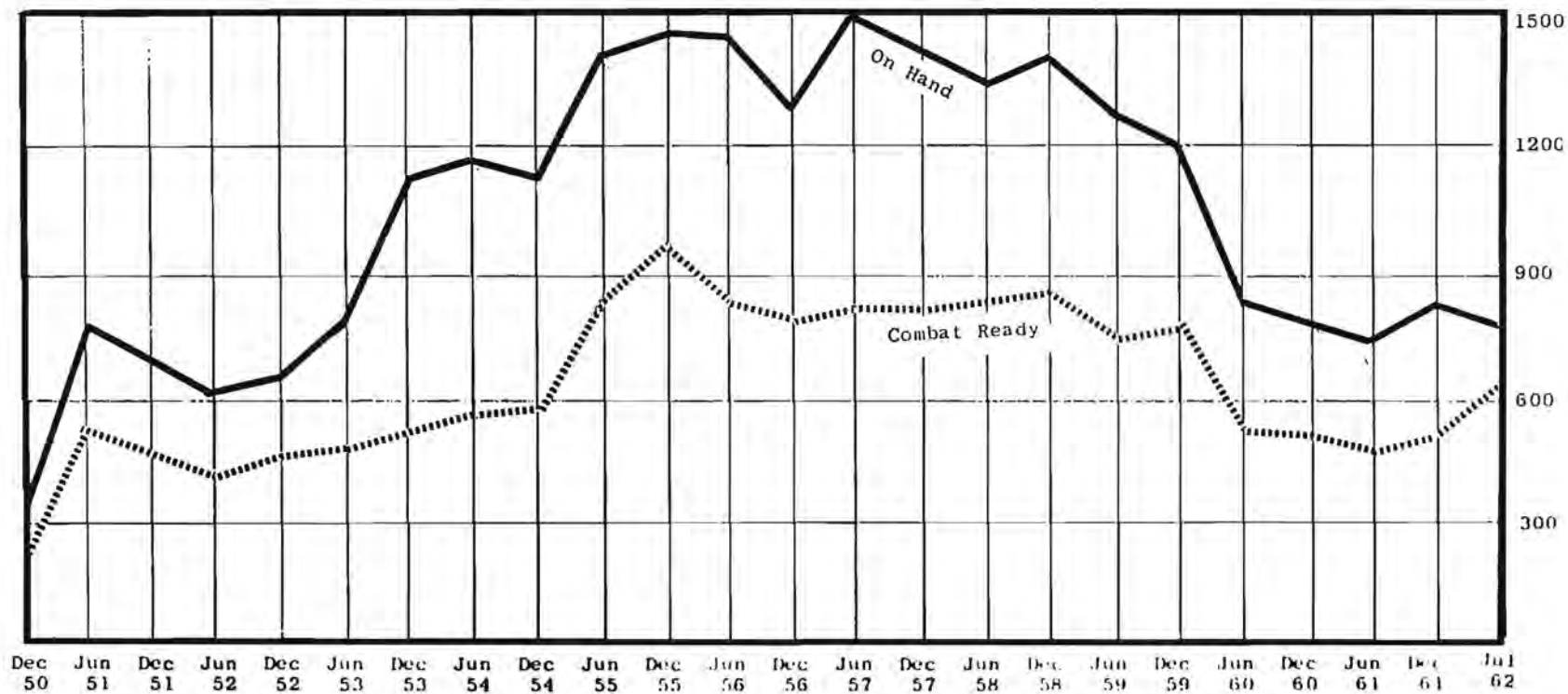
  
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1957 when the upper limit of expansion, to be reached in  
Fiscal 1960, was set at 71 squadrons.<sup>246</sup>

Later in 1957, a further reduction in the fighter force became necessary when it became obvious to USAF that funds would not be available for the 40 squadrons of F-106 aircraft previously programmed. Also, to spread the cost over a longer period, the period of conversion to the F-106 was lengthened. While fighter programming in the first half of 1957 anticipated the receipt of 40 squadrons of F-106 interceptors by the end of Fiscal 1961, similar programs in the last half of the year called for provision of 26 squadrons of the advanced interceptor by the end of Fiscal 1962. As a consequence, the size of the total interceptor force was also reduced. While the program of 15 July 1957 foresaw a force of 67 squadrons at the end of Fiscal 1958 and a force of 71 squadrons at the end of Fiscal 1961, the five fighter programs produced between October 1957 and February 1958 (indicating the degree of uncertainty which existed during this period) called for an end-1958 force of between 57 and 61 squadrons and an end-1962 force of between 46 and 49 squadrons. The final position (as "final" as any program can ever be), reached 15 February 1958, called for 59 squadrons at the end of Fiscal 1958 and

  
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48 at the end of Fiscal 1962. At the end of 1957, there were still 71 active squadrons on the ADC roster, although the number manned and equipped dropped from 69 at mid-year to 63 at the end of the year. Wholesale inactivations and transfers overseas in early 1958 cut the number of active squadrons to 63 by 30 June, four more than authorized by the program of 15 February 1958, although only 58 squadrons<sup>247</sup> were manned and equipped.

Further reductions in the number of F-106 aircraft to be purchased were announced in July and September 1958. In July USAF informed ADC that not 26, but only 16 squadrons of F-106 interceptors would be available to ADC at the end of Fiscal 1962. In September the extent of the reduction was deepened with the further decision that each F-106 squadron would have 18 rather than the normal 25 aircraft. Only 341 F-106 aircraft (at 4.4 million dollars each) were to be bought, in contrast to the approximately 1,000 required to equip the 40 squadrons originally required by ADC. Even though the cut in the number of F-106's was drastic, there was a sense of relief that the advanced interceptor was to be purchased at all. There were recurrent rumors in early 1958 that the entire F-106 program was to be cancelled. This new

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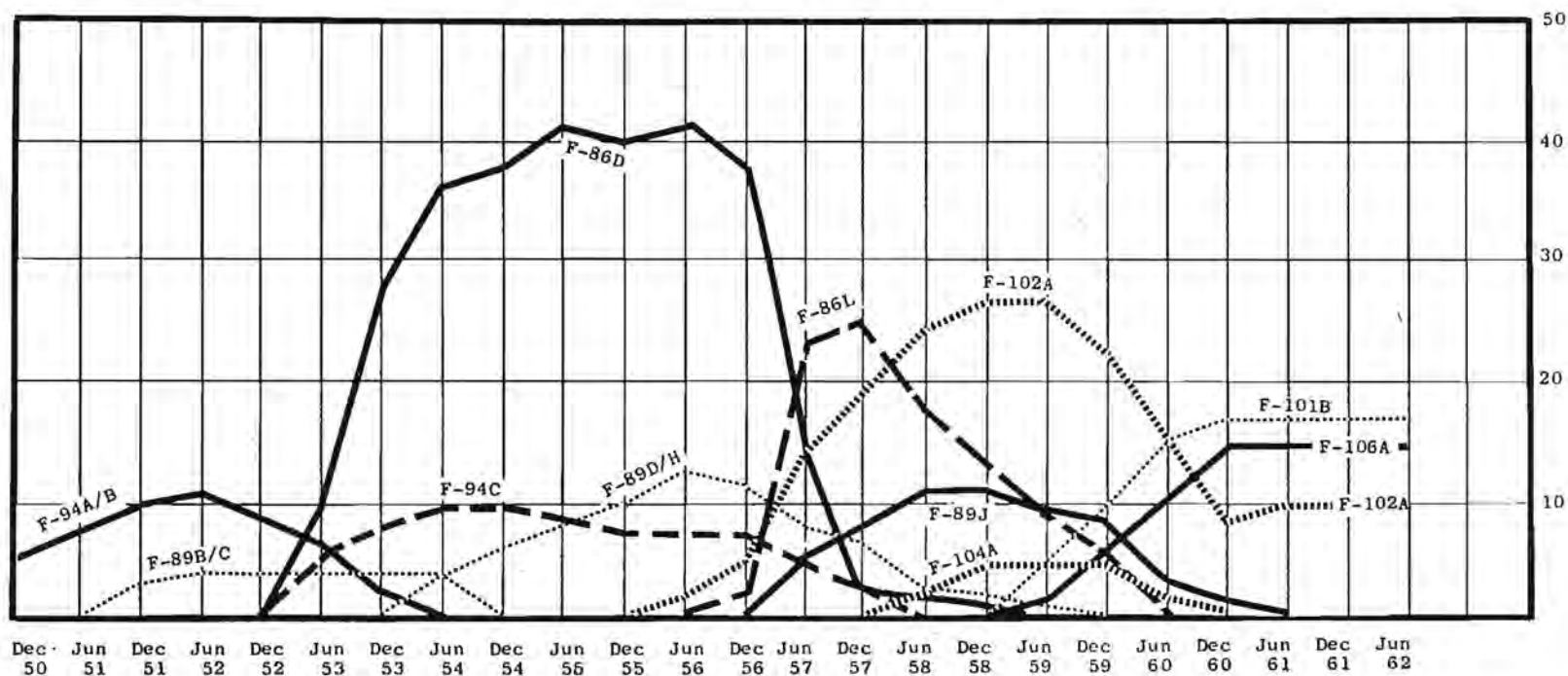
reduction in F-106 squadrons did not immediately require a reduction in the total interceptor force, however. Interceptor programs published through the remainder of 1958 and most of 1959 still called for 60 squadrons at the end of Fiscal 1959, 55 squadrons at the end of Fiscal 1960, 52 squadrons at the end of Fiscal 1961, 47 squadrons at the end of Fiscal 1962 and 41 squadrons at the end of Fiscal 1963. What this meant was that obsolescent aircraft would be retained in the air defense system longer than had been anticipated in earlier plans. In terms of actual squadrons on board, ADC had 60 at the end of 1958 (58 manned and equipped) and 57 at the middle of 1959 (55 manned and equipped).  
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The next major slash in the interceptor force came in the autumn of 1959, when USAF began to wrestle with the budget for Fiscal 1961. It soon became apparent that reduction toward the goal of 41 squadrons at the end of Fiscal 1963 would have to be made at a much more rapid rate than currently programmed. The fighter program of 3 August 1959 called for a force of 55 squadrons at the end of Fiscal 1960. The succeeding program of 11 December 1959 authorized only 49 squadrons. Both programs, however, came almost together when discussing Fiscal 1963. The

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## Fighter-Interceptor Squadrons by A/c Type



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3 August program saw 41 squadrons at the end of Fiscal 1963. The 11 December program listed 40. A special feature of the interceptor force reductions impelled by the 1961 budget was the decision to eliminate the F-104A as a factor in air defense. Although it offered advanced performance as an aircraft, the F-104A was not compatible with SAGE and in time of austerity was a luxury which could not be financed. Programming in 1960 generally followed the guidance laid down in late 1959. The strength figure for the end of Fiscal 1961 dropped slightly -- from 43 to 41 squadrons -- but beyond that point a reasonably stable force was anticipated. The program of 9 September 1960 also scheduled 41 squadrons for the end of Fiscal 1962. A drop of only one squadron -- to 40 -- was expected at the end of Fiscal 1963. Another squadron was to be dropped on Fiscal 1964, with the total standing at 39 at the end of that year. Only a slight reduction in fighter strength was experienced during the last half of 1959, the total declining only from 57 squadrons to 56, all of which were manned and equipped.

Retrenchment was at least temporarily completed during 1960 when 15 squadrons -- more than one-quarter of the 1959 interceptor force -- were lost. No further reductions (below 41 squadrons) were made in 1961 or the

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first half of 1962. This force was increased to 42 squadrons on 1 July 1962 when ADC received from MATS the 57th FIS at Keflavik, Iceland. The interceptor program in effect in the summer of 1962 anticipated that ADC would still have 41 interceptor squadrons at the close of Fiscal 1966. Only the unit at Thule was scheduled for inactivation. Since no more interceptors were being produced, the number of aircraft assigned to each squadron would inevitably decline as the years wore along. At the end of Fiscal 1962, ADC had four squadrons with 24 F-106A aircraft and 10 with 18 such aircraft; one squadron with 24 F-101B aircraft and 16 squadrons with 18 F-101B aircraft experienced serious attrition during Fiscal 1962 when 66 aircraft were given to Canada. At the end of Fiscal 1966, although there would be little change in the total number of squadrons, it was expected that 15 of the 17 F-101B squadrons would have 18 aircraft and one would be down to 12 aircraft. Of the eight F-102A squadrons previously mentioned, five would still have 26 aircraft while three would be reduced to 20 aircraft. The 1966 force would obviously be somewhat slimmer than the 1962 force. The rate of attrition would be tied to the rate of major accidents involving combat aircraft, since a lost aircraft could not be replaced.

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CHAPTER SEVEN  
AIRCRAFT FOR THE MATURE FORCE

The shape of the ADC interceptor force of 1962 was determined, generally, by actions taken by the end of 1954. The interceptors in use in 1962 were all under development in 1954, which is merely another indication that aircraft development is a long process. At the same time, the interceptors being used in 1962 were vastly different from those which comprised the weapons force in 1954. By 1954 the first generation of jet all-weather interceptors -- F-89D, F-86D and F-94C -- were available in quantity. Six years later, these aircraft, and their various mutations, were

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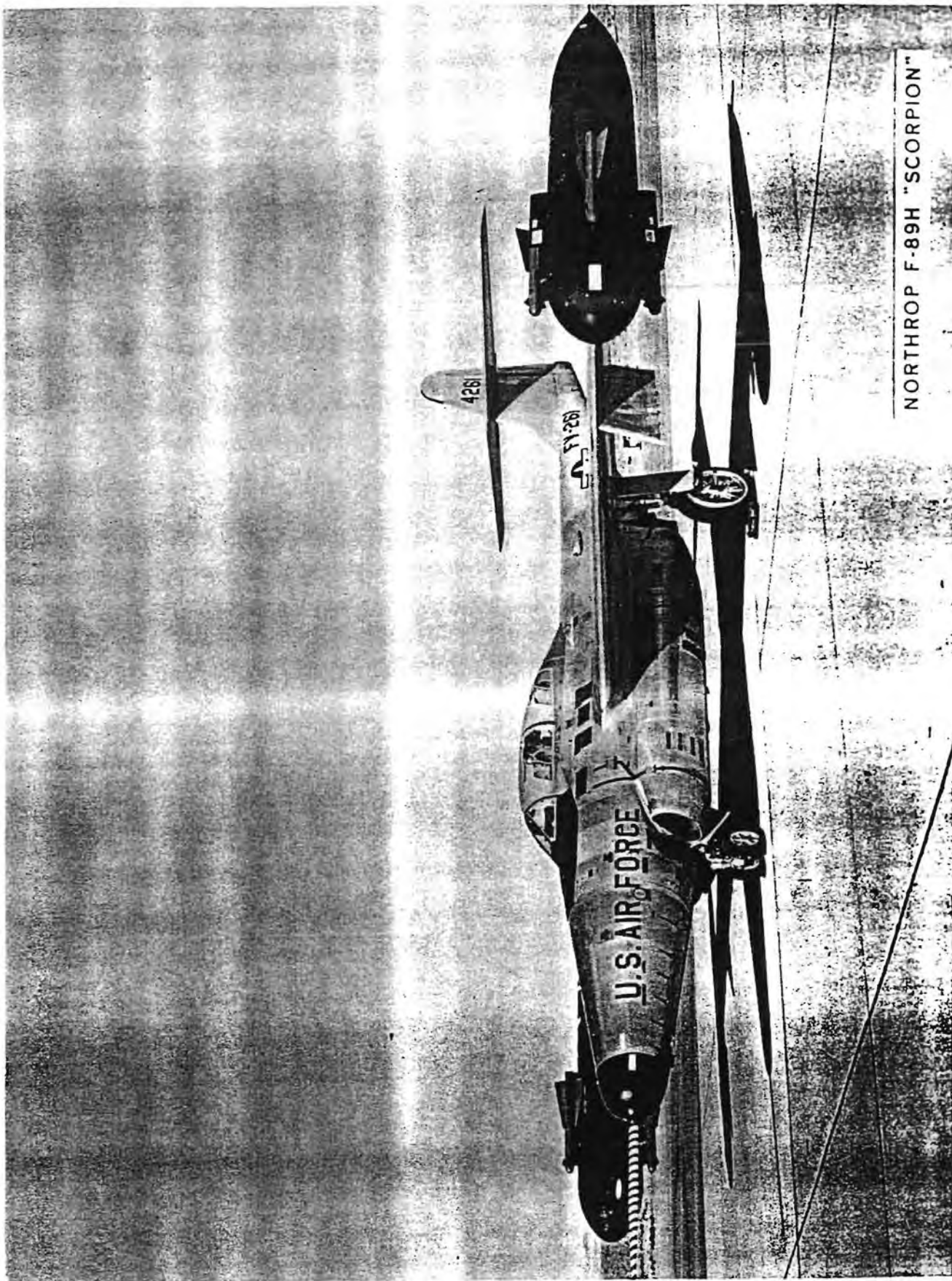
gone. In their places were second-generation jet all-weather interceptors -- F-102A, F-101B and F-106A. Beyond the second generation, as of 1962, there was nothing under development. All proposals for a third generation of manned interceptors had thus far been beaten down in the general rush to embrace guided missiles and space satellites as primary weapons of both offense and defense. As of late 1962, however, an ADC proposal for an Improved Manned Interceptor (IMI) was being considered in the Pentagon. But whatever the future might hold, the 1955-1960 period was one of considerable activity in interceptor development.

#### THE F-89

While nearly eight years of development were required to place an operational F-89D interceptor at the disposal of ADC in January 1954, development was still not complete. It had been decided in 1951 that the F-89 would be the first ADC interceptor to be armed with the Falcon air-to-air missile then being developed by Hughes. In 1951 it was hoped that a Falcon-firing F-89 would be available in January 1954. This date, as subsequent events proved, was unrealistic inasmuch as the basic F-89D aircraft itself was not operationally ready until that time.

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NORTHROP F-89H "SCORPION"



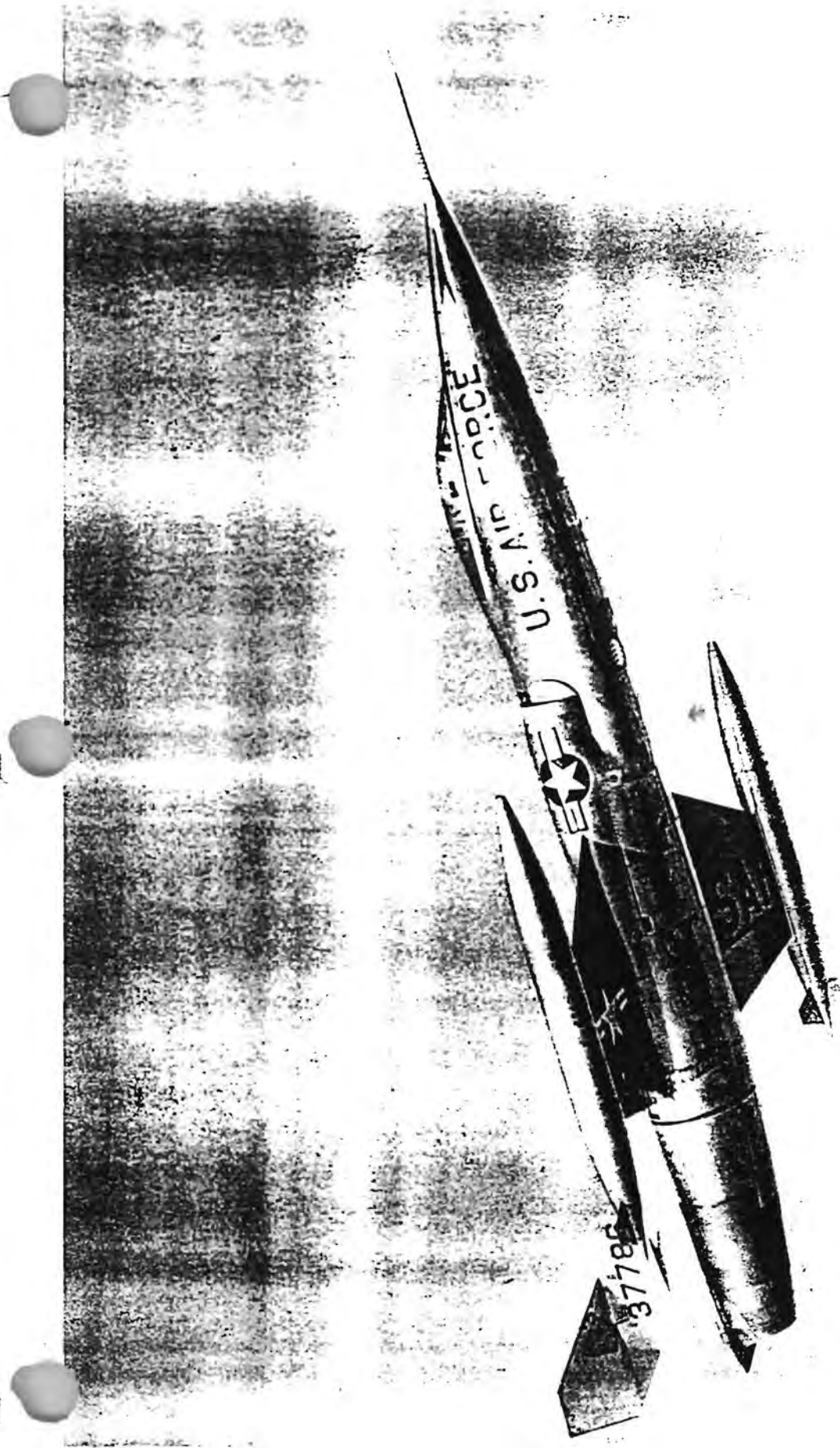
The most difficult problem in modifying the F-89D for use as a Falcon carrier (the modified interceptor was designated F-89H) was the fire control system. The E-9 system of the F-89H had twice as many components as the E-6 used in the F-89D. For a while there were fears that the added weight of the missiles and electronic equipment would make it necessary to use the advanced J-71 engine on the F-89D, but later tests indicated that the J-35 engine of the F-89D would be adequate. The first airborne test of the E-9 fire control system occurred on 3 August 1953 and Falcon missiles were successfully fired from a modified F-89D on 21 October 1953, but early testing dictated so much redesign of the fire control system that Hughes was not able to deliver the first production model of the E-9 until 1 May 1955. Testing of the complete weapons system consumed the remainder of 1955 and the early months of 1956. The first operational F-89H was delivered to the 445th FIS at Wurtsmith AFB, Michigan, in March 1956, more than two years after the date originally set for operational employment of the Falcon-equipped F-89. The delay in converting the F-89 to missile armament doomed the F-89H to short operational life, because the F-102A, which also mounted Falcon missiles and offered performance superior to that

  
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of the F-89H, was nearly ready by the time the F-89H became available. At the high point of F-89H use only 112 were included in the ADC inventory. Twenty-one remained by the following September. The basic F-89D aircraft was used by ADC until mid-1958, but it returned briefly in July 1962 when the 57th FIS, Keflavik, Iceland, was transferred to ADC. The 57th was to receive F-102A aircraft in the autumn of 1962.

The F-89 was also destined to serve as the first carrier of an atomic rocket intended for air defense purposes. ADC began to consider the use of atomic weapons in conjunction with interceptors as early as 1951, but the concept gained few immediate converts because of the immense difficulty of developing an atomic rocket that could be carried by an interceptor. Various possibilities were considered, such as adaptation of existing atomic bombs, but progress was negligible. The result of this 1951-52-53 activity was a conclusion that atomic armament for interceptors was just not possible until the Atomic Energy Commission could design a small warhead in the 1-20 kiloton category. The AEC accepted this task. Meanwhile, ARDC and ADC agreed that the F-89D was the most likely carrier for the atomic weapon.

  
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LOCKHEED F-104A "STARFIGHTER"



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Since the feasibility of atomic armament for interceptors hinged on development of a suitable warhead, there was little Air Force action in this regard, aside from planning, through 1954. By early 1955, however, there began to be solid evidence that production of the necessary warhead was possible. On 9 March 1955, therefore, USAF instructed ARDC to institute a "crash" project to convert the F-89D into a carrier for what was then known as the DING DONG (subsequently MB-1) rocket. By direction of the National Security Council, ADC was to have atomic capability by 1 January 1957. There was no particular difficulty encountered in modifying the F-89D, since the fire control system was a relatively simple modification of the E-9 known as MG-12. The limiting factor continued to be the rocket and warhead. The first F-89J (as the atomic carrier was designated) was delivered to the 84th FIS at Hamilton AFB, California, in December 1956. An F-89J, equipped with an MB-1 rocket, was available at Hamilton on 1 January 1957, thereby meeting the deadline established in March of 1955.

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From January 1957 until the F-101B became available in January 1959, the F-89J was the only ADC interceptor to carry an atomic punch. Because the F-101B and

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and F-106A did not immediately become available in large quantities, the F-89J remained in the inventory until the end of 1960. From a peak inventory of 268 (30 June 1958), 207 were still filling an operational role at the end of 1959. The last F-89J was removed from ADC in December 1960.  
253

#### THE F-94C

Since the F-94C was an adaptation of the F-80, the Air Force's first jet fighter, it did not have the growth potential of the F-89 and F-86 and no further modifications were made to it. Even so, it was remarkably long lived as an active, first-line interceptor. its lifetime with ADC stretching from March 1953 to February 1959.  
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#### THE F-86D

At the end of 1954 the F-86D was the backbone of the interceptor force. Seventy-eight of every 100 aircraft in the ADC tactical inventory at that time were F-86D's. A year later ADC controlled more than 1,000 of the first one-man all-weather jet interceptor. The F-86D was adequate in performance and plentiful, but its service life promised

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to be short unless it could be fitted with data link equipment to make it compatible with the GPA-37, electronic heart of an advanced system of ground controlled interception which immediately preceded SAGE, and with SAGE itself. To prolong the useful life of the F-86D, USAF announced, in the fall of 1955, another massive modification program intended to make the F-86D compatible with advanced ground environment systems. It was the original USAF intention to modify 1,240 F-86D's, but the number actually reworked amounted to about half that number. This modification program, designated Project Follow-On, began in May 1956 and was accomplished by Sacramento Air Materiel Area and the North American plants at Inglewood and Fresno, California. The modernized F-86D became known as the F-86L.

The first F-86L was received by the 49th FIS at L. G. Hanscom Field, Massachusetts, in October 1956. Output from Project Follow-On accelerated rapidly during late 1956 and 1957 until ADC had 576 F-86L aircraft at the end of 1957. With the advent of SAGE-compatible, data-link-equipped interceptors of the F-101B and F-106A type the need for the F-86L declined. Nevertheless, the F-86D/L aircraft had a long air defense life which stretched from April 1953 to June 1960.

  
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## THE F-102A

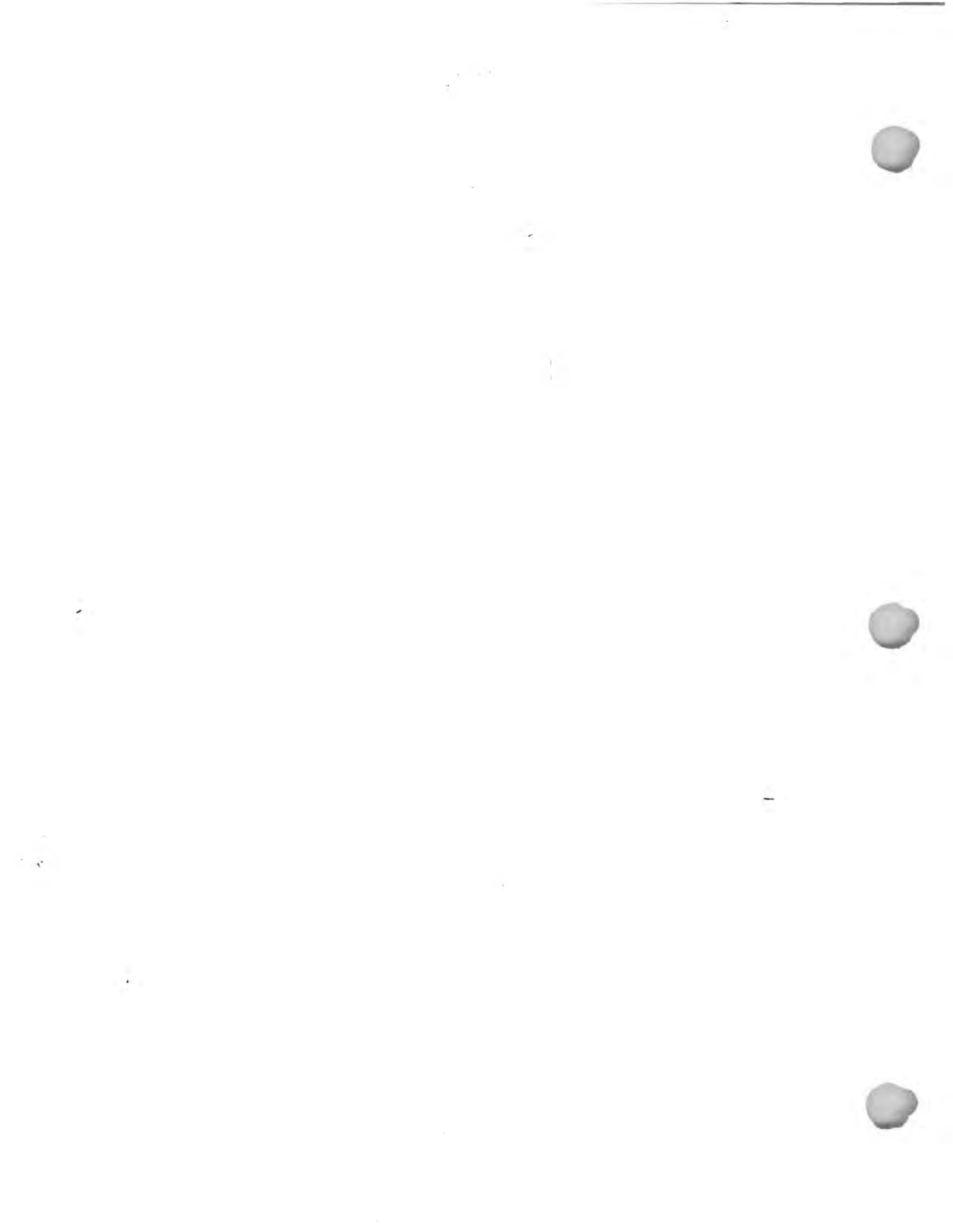
With the first successful flight of the "Hot Rod" F-102 on 19 December 1954, basic development of the successor to the F-86D was complete. The Hot Rod was the first experimental model of the F-102 to include the "coke bottle" fuselage designed to correct the aerodynamic flaws of the earlier straight-fuselage model. Thus, at the end of 1954, the Air Force had one experimental model of an interim version of what in 1948 had hopefully been called the "1954 interceptor." This was more evidence to support the truism that interceptor development is a lengthy process.

One swallow does not make a summer and one flight, unfortunately, does not make a test program. Flight testing continued through 1955 and early 1956, but no serious flaws were discovered and the F-102A was released for tactical use. The 327th FIS at George AFB, California, received ADC's first tactical F-102A's in April 1956. The F-102A replaced the F-86D as the most numerous interceptor and by the end of 1958 they numbered 627, or about half the total number of interceptors controlled by ADC. The F-102A began to leave the air defense system with the receipt of the F-101B and F-106A, but at the middle of 1961 there were still 221 of these aircraft available within ADC.

  
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CONVAIR F-102A "DELTA DAGGER"





And an end to the usefulness of the F-102A was not in sight. After modernization by addition of data link, an improved fire control system and atomic missiles (GAR-11), ADC anticipated, in late 1962, that 10 squadrons would still be included in the air defense network in late 1967.<sup>257</sup>

#### THE F-103

Although development of the F-103 had moved slowly during the early fifties because of a continuing shortage of funds, a transfusion of development money in the spring of 1954 promised to add impetus to this program. Republic was awarded a Phase II development contract in June 1954 and plans were made for the construction of three experimental aircraft.<sup>258</sup>

The bloom of health exhibited by the F-103 program in late 1954 was misleading, however. The F-103 concept was far ahead of the state of the art and what had been hopefully planned in 1951 proved impossible of accomplishment at least at the scale of funding allocated to this development. The heart of the F-103 proposal was a plan to mate a turbojet engine with a ramjet engine in order to produce the high altitude (80,000 feet) Mach 3


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performance desired in this advanced interceptor. It was planned that the RJ-55 ramjet engine would act as an afterburner for the J-67 turbojet engine to 40,000 feet and Mach 2.1. Then the ramjet was to begin operation, pushing the F-103 to 80,000 feet and Mach 3. But the theory was never tested, because the F-103 never got off the ground. The theory that titanium alloys would withstand the 500-degree heat generated by the Mach 3 speed of the F-103 also remained a theory, despite years of testing on the ground, because the F-103 never flew. Other advanced ideas suffered a similar fate. F-103 development proceeded through 1955 and 1956, but was cancelled in September 1957 when USAF decided that it was not making sufficient progress to justify the expense. If this starved offshoot of the "1954 interceptor" proved anything, it proved, again, that there were thousands of unseen pitfalls along the path from design proposal to operational hardware.

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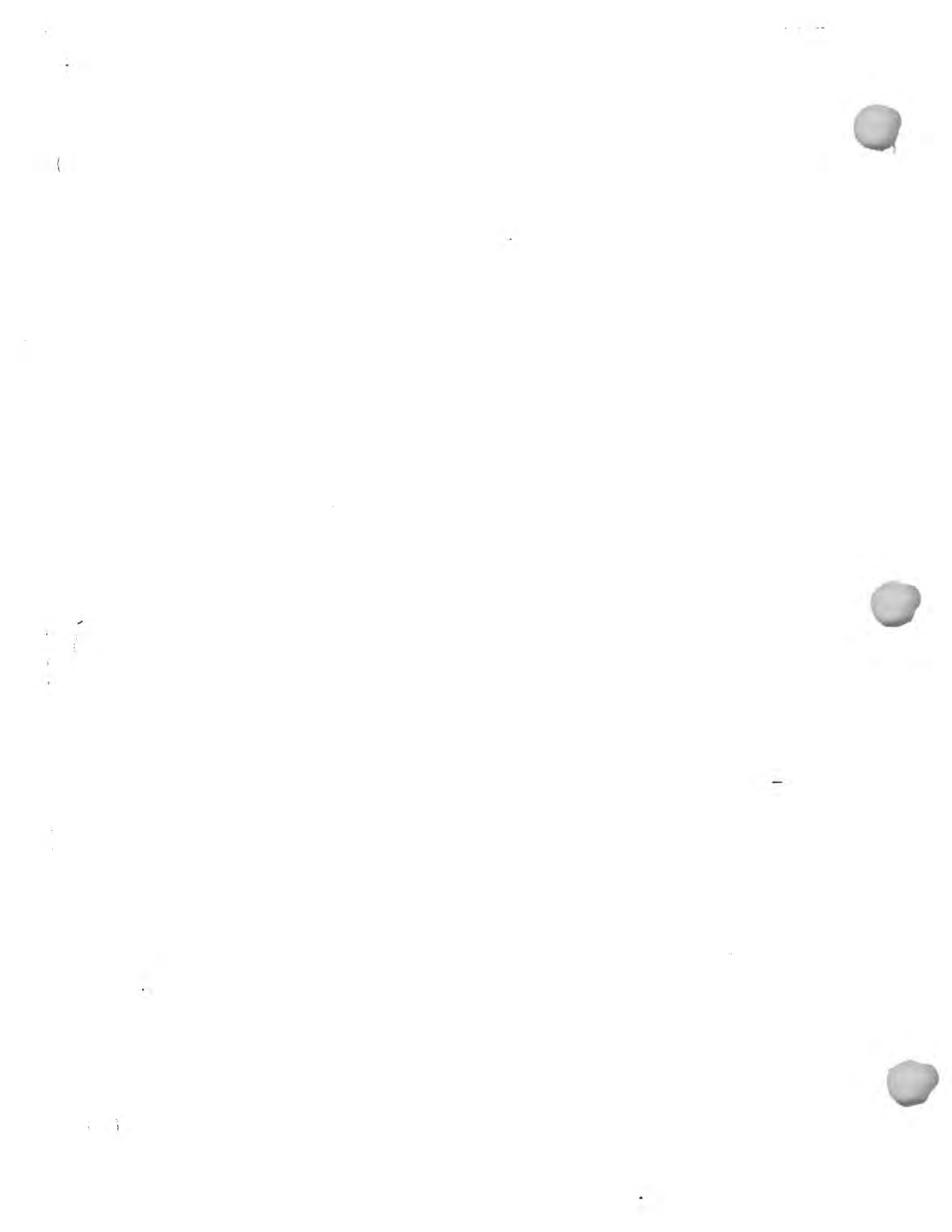
#### THE F-104

The small, fast F-104 was never intended as an interceptor. It was an air superiority fighter. For that reason, ADC did not pay particular attention to it during the early stages of development. ADC, therefore, was taken unawares

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CONVAIR F-106A "DELTA DART"



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when, in the late summer of 1954, ARDC suggested that the F-104 might be used as an interceptor. The initial ADC reaction (September 1954) was generally negative, but at the same time, ADC was looking for an interim interceptor to help fill the gap between the F-102 and the F-106. It was willing to consider the F-104, or any other fighter aircraft.<sup>260</sup> So, during late 1954 and the early months of 1955, ADC watched F-104 development and debated its possible use in air defense. The aircraft was certainly impressive in terms of performance. On 23 March 1955, a test model of the aircraft flew Mach 1.9 and reached an altitude of 60,000 feet. This was especially noteworthy, since the test aircraft was powered by the J-65 engine instead of the advanced J-79 engine to be used in production models. By the middle of 1955, ADC was half-way convinced that it wanted the F-104 and asked USAF to have ARDC carefully study the aircraft with air defense requirements in mind.<sup>261</sup>

Oddly enough, while ARDC at one time had been in the position of "selling" the F-104 to the using commands, its study of late 1955 was not favorable to the use of this aircraft for air defense purposes. This stand was based generally on the lack of satisfactory airborne radar



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in the F-104. The radar developed by WADC's Armament Laboratory could track a target at a range of 10 miles or less, but had no search capability. The fire control system could fire infrared missiles (Sidewinder -- GAR-8), but not radar-controlled missiles. It was not sophisticated enough to direct the interceptor on a lead-collision course. It could not direct the interceptor on a snap-up maneuver. For all these reasons, ARDC could not recommend use of the "limited capability interceptor" (F-104).<sup>262</sup>

But now the positions were reversed and ADC had decided that it would like to have the F-104, whatever its shortcomings as to electronic equipment, as an interceptor. USAF agreed and in April 1956 awarded ADC six squadrons of F-104's for air defense use. It was anticipated that ADC would receive its first F-104's in early 1957.<sup>263</sup>

With the decision taken to provide the F-104 to ADC, the development honeymoon with regard to this aircraft ended abruptly. The early stages of F-104 development had been unprecedented, in that development progress was rapid and performance of the aircraft had been better than expected. But when testing for operational suitability began, deficiencies appeared. The F-104A demonstrated an undesirable tendency to "pitch-up" at high speeds and was

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subject to such a tail flutter at high speed and low altitude that it was restricted to 575 knots at 20,000 feet and below. It was also doubtful that the airframe could withstand the 7.33 "G" forces the F-104 might encounter in high speed turns. Finally, the J-79 engine was almost impossible to re-light when it flamed out at altitudes above 30,000 feet. Because ADC continued to insist that it could not accept an unproved aircraft, the F-104 did not find its way into the ADC tactical inventory in early 1957 and the test program was slowed by the loss of four aircraft during April and May 1957. But progress was made. The tail and airframe were strengthened and the reliability of the engine was improved. By the end of 1957 ADC was reasonably well satisfied that it was getting a usable aircraft, although it was a day fighter and not an interceptor. The first F-104 in ADC was received by the 83rd FIS at Hamilton AFB, California, on <sup>264</sup> 26 January 1958.

Because of financial pressures, USAF purchased fewer F-104A aircraft than had been originally planned and ADC was given four squadrons instead of the six initially programmed. At the end of 1958 ADC had 100 of the tiny fighters. But the F-104 was short-lived as a factor in



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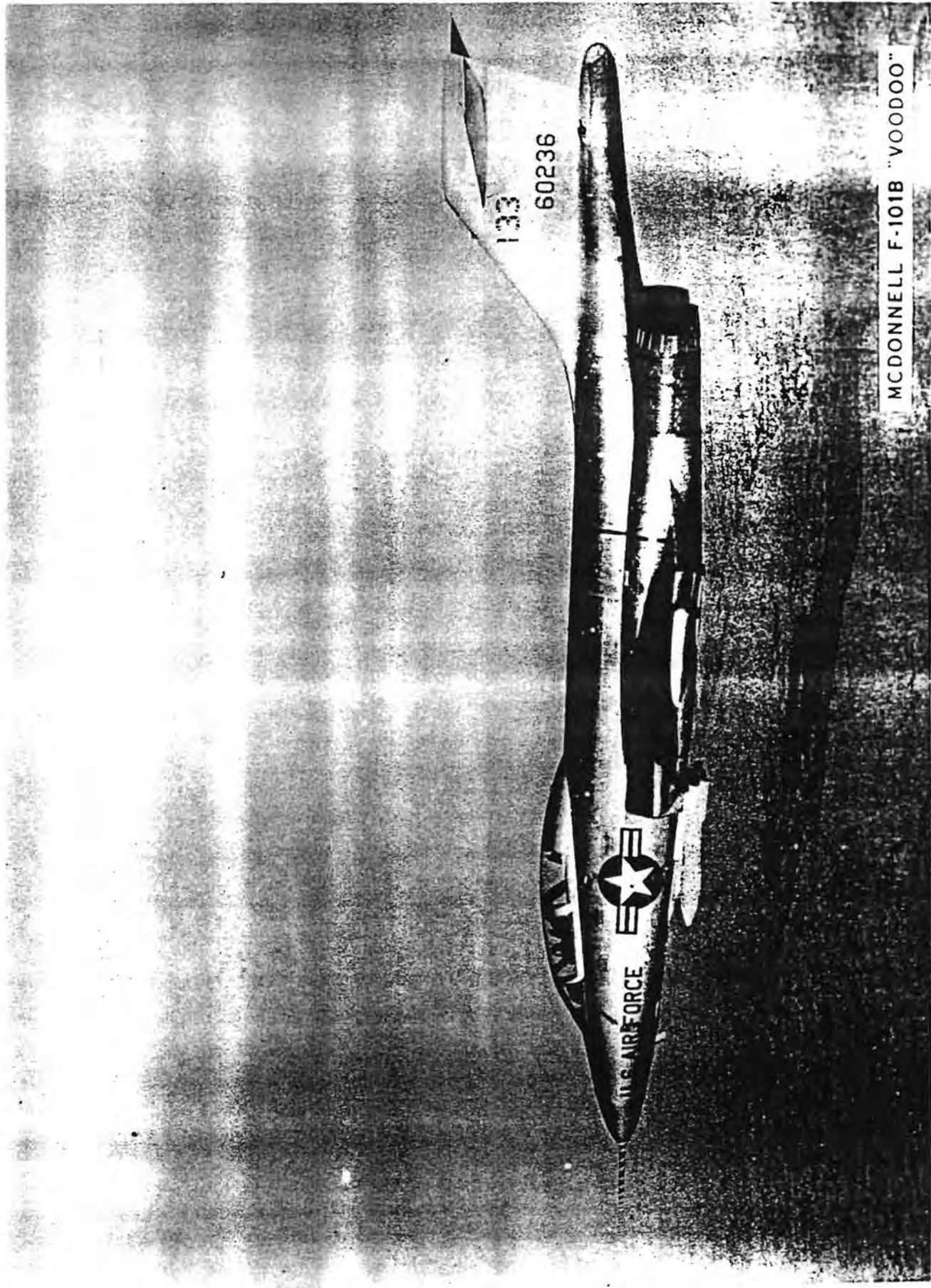
air defense. Since it could not be fitted with data link equipment, the F-104 could not be used in the SAGE environment. The last F-104 disappeared from the ADC combat inventory in September 1960.  
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#### THE F-101B

The first flight of the McDonnell F-101 occurred on 29 September 1954, before ADC had received USAF approval for its use as an interceptor. ADC had announced in June 1954 that it considered the F-101 the best of three possibilities (advanced F-89, F-100 and F-101), but USAF approval of what became known as the F-101B did not come until February 1955. At that time, active development of the interceptor version of the F-101 began. A short time earlier WADC had predicted that the F-101B, equipped with the advanced J-67 engine, would be ready to fly by the middle of 1956, that production could begin in 1957 and that the aircraft could be made available to active interceptor squadrons in early 1958.  
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Shortly after the receipt of USAF approval for the development of an interceptor version of the F-101, it was decided to use the J-57 engine rather than the J-67 or J-75, because the advanced engines had not completed development.

  
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MCDONNELL F-101B "VOODOO"



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Major problems, if they developed, were likely to involve the compatibility of the fire control system, the flight control system and the airframe. No difficulty was anticipated in adding a second man (radar observer) to the crew.

As such estimates generally were, the 1954 prediction that the first flight of the F-101B would occur in mid-1956 proved to be optimistic. It was not until 27 March 1957 that the F-101B made its maiden flight. Although it gave indications that it would be able to conduct a snap-up attack on a target at 65,000 feet (the interceptor itself would be at a somewhat lower altitude) and attain a speed of Mach 1.72, there were still problems in connection with this aircraft. Pratt and Whitney had solved a compressor stall problem in connection with the engine, but the F-101B continued to display a tendency to "pitch-up" when the nose was raised slightly. This was correctible through use of a mechanical device, but it was the consensus among WADC engineers that the correction of the aeronautical flaw that made it possible would be a better solution. The F-101B was also addicted to spins that were a definite hazard to inexperienced pilots.

The need to remedy these deficiencies and ADC's insistence on a thoroughly tested, effective interceptor

  
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upon delivery served to delay receipt of tactical F-101B aircraft within ADC. The ADC stand was based on experience with the F-102A, which had been delivered before testing was complete and had proved to be a source of continual trouble. As late as April 1958, however, USAF was still insisting that ADC would receive combat aircraft the coming July, as previously scheduled, but AMC broke the bad news shortly thereafter. McDonnell had failed to deliver test aircraft on schedule and quantity production was being held up until enough test flying had been done to make sure that ADC would get a usable aircraft. As a consequence, ADC did not receive its first F-101B until 5 January 1959. The 60th FIS at Otis AFB, Massachusetts, was the first ADC unit to be so equipped.

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The F-101B received by ADC was a well-tested aircraft which offered advanced performance. It had, from the ADC standpoint, only two serious flaws. In the first place, ADC thought that the radar observer's cockpit had been badly designed, but there was little that could be done except to request minor changes. More important, the MG-13 fire control system was not nearly as advanced as the airframe in which it was placed. The MG-13 was merely a refinement of the E-6 fire control system of the F-89D and

  
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was not sufficiently sophisticated to control the weapons of an interceptor as fast as the F-101B. ADC therefore asked permission to replace the MG-13 with the MA-1 system of the F-106. On cost grounds, however, USAF denied the request. The only alternative was to attempt improvements to the Central Air Data Computer that was the heart of the MG-13 system.<sup>270</sup>

ADC had 289 F-101B aircraft (17 squadrons) in its combat inventory at the middle of 1962. Into the indefinite future, the F-101B was to be the major element in the ADC interceptor force.<sup>271</sup>

#### THE F-106

The seed that was planted by the USAF Board of Senior Officers in October 1948 eventually flowered in 1959 when the first F-106 aircraft was received by ADC. What the Board wanted by 1954 simply could not be had by that time. Because of the state of the art, the "1954 interceptor" mentioned in 1948 was developed in two steps. First came the "interim" model (F-102A), which became available in 1956. Development of the ultimate F-106 was agonizingly slow because concentration on the F-102 in the

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1952-56 period lessened the attention which could be given to the F-106.

As a result, the F-106 had not flown by the end of 1954. There was still no agreement as to which engine the ultimate "1954 interceptor" would use. Although it was originally planned to use the Wright J-67 engine (the American version of the British "Olympus" engine), Wright had so much trouble adapting it to the F-106 that the Pratt and Whitney J-75 engine (an advanced model of the J-57 engine used in the F-102) began to gain favor. The decision to substitute the J-75 for the J-67 was taken in early 1955.  
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Although the J-75 engine had been chosen over the J-67 because of more rapid development in 1954 and 1955, the J-75, in turn, also became a source of delay in the F-106 program. Continuing problems in the development of the engine, not to mention the fire control system, made it impossible to make the initial flight in the F-106 until January 1957. At that time, Convair began testing the flight characteristics of the aircraft. The first USAF test flight took place at Edwards AFB, California, on 29 April 1957. The F-106 reached a speed of Mach 1.9 and an altitude of 57,000 feet.  
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This should have been a time of rejoicing, but it was not. Because neither the J-75 engine nor the MA-1 fire control system was as reliable as either USAF or ADC would have liked, because ADC was going to insist on a thoroughgoing test program before accepting the F-106 and because money was tight, USAF was getting to the point, in the spring of 1957, where it was willing to throw in the sponge on the F-106. A possible alternative was re-design of the F-106 as a long-range interceptor. Also, because of an acute shortage of funds, USAF raised the possibility that the F-101B might have to be dropped if the F-106 was retained.

None of these alternatives was palatable to ADC, "short of clear recognition that the F-106/MA-1 [program]... has failed." Redesign as a long-range interceptor would take so long, in the ADC view, that such a decision would mean the end of the F-106. If it were necessary to reduce the total numbers of F-101B/F-106 aircraft procured, ADC favored applying the reductions equally to each type since they were complementary in that the F-106 had a relatively short range when compared with the F-101B.

USAF saw ADC's point at the conclusion of this discussion and the F-106 was retained, with the first F-106 reaching ADC in late May of 1959. The 498th FIS

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at Geiger AFB (Spokane International Airport), Washington, was the first interceptor squadron to convert to the "ultimate" version of the "1954 interceptor." ADC was not sure it was being presented with a combat-ready weapons system, but bowed to affirmative opinions on the part of ARDC, AMC and USAF and accepted the F-106. Experience in late 1959 and early 1960, however, tended to substantiate the ADC doubts. Development and testing were obviously not complete at the time ADC began to receive aircraft for tactical use, because continual production line changes were made to both the airframe and fire control system. This practice was so common that by 1960 ADC possessed so many divergent configurations that maintenance support was almost impossible. In February 1960, ADC could list 63 changes in the fire control system and 67 changes in the airframe that would be necessary to give early model F-106's the same configuration as the most recent aircraft off the production line. And even assuming that all production line changes were advantageous, ADC still did not have a combat-ready aircraft. <sup>277</sup>

It was obvious that a major retrofit program was needed with respect to the F-106. By the middle of 1960, AMC had determined that about 800,000 manhours (involving 130 changes) would be required to bring the F-106 fleet to

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the point where it would be a valuable adjunct to the air defense system. Part of the work (Project Broad Jump) was accomplished by Sacramento Air Materiel Area. The remainder (Project Wild Goose) was done at ADC bases by roving AMC field assistance teams supported by ADC maintenance personnel. Wild Goose-Broad Jump required about a year, beginning in September 1960.<sup>278</sup>

At mid-1962, ADC had 251 F-106 interceptors allocated to 14 squadrons. Since the F-106 was the last of the manned interceptors (as of autumn 1962), it would be a major factor in the air defense system far into the ill-defined future.<sup>279</sup>

#### THE ADVANCED MEDIUM RANGE INTERCEPTOR (MRIX)

Long before the second generation of jet all-weather interceptors (F-102, F-101B and F-106) became operational, ADC began to think about a third generation of jet interceptors. On 7 January 1953, ADC asked that it be furnished an interceptor of speed and altitude capability considerably in excess of that being designed into the F-102/F-106. ADC had in mind an aircraft that would be able to climb at Mach 2.5 and cruise at Mach 3. ADC also wanted a combat radius of 525 miles and a fire control system

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with a lock-on range of 50 miles. Altitude capability was not specified, being given simply as "very high." ADC thought it possible that the F-103 might meet the requirements. An operational date of 1958 was mentioned. <sup>280</sup>

USAF agreed, citing JCS approval, that such an interceptor was required, but added that the F-103 was primarily a research vehicle and was probably not appropriate for the air defense mission. USAF also pushed the operational date for this new aircraft back to October 1959. Because of experience with the F-102, USAF stressed the need for prompt development of detailed requirements. But the preparation of detailed specifications lagged, apparently because what ADC proposed would require great advances in metallurgy and in aircraft and engine design. It was not until November 1954 that USAF presented to ADC a draft General Operational Requirement (GOR) for comments. ADC was not particularly impressed with the USAF proposal, commenting that what was needed was an interceptor which could cope with a cruise missile similar to the U. S. "Navaho." This, at the time, was believed to be the ultimate in airbreathing airborne threats. The Navaho was designed to fly at a speed of Mach 3.25 and attain an altitude between 80,000 and 88,000 feet. <sup>281</sup>

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Following this exchange of views there was, happily, a near meeting of minds on what had become known as the Medium Range Interceptor (MRIX) and was intended to eventually replace the F-102/F-106. The F-101B was characterized as a long-range interceptor. In May of 1955, USAF forwarded to ARDC a revised GOR that was acceptable to ADC. But again nothing much happened. Instead, USAF and ARDC began talking of the F-103 as a possible MRIX. This, as in the case of the F-104, was a direct reversal of position. Now, in late 1955, USAF was suggesting the use of the F-103 as an MRIX, while ADC  
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demurred:

The F-103 involves a dual cycle engine system involving the J-67 engine which was discontinued some three months ago. Speaking very broadly, the Republic proposal was to combine the characteristics of the jet engine with those of the liquid powered ramjet, through the utilization of a ducting arrangement. This Rube Goldberg device has yet to be tried and, in fact, study of the F-103 proposal uncovers a multiplicity of problems and a great need to relegate to basic research many of the physiological, aerodynamic and power plant problems operating in the Mach 3.0 and 80,000 foot altitude region.

ADC recommended, instead, that the aircraft industry be asked to develop an MRIX which would make use of the Allison J-79, the Pratt and Whitney JT-9 or a similar

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high performance turbo-jet engine. So anxious was ADC to obtain an MRIX that it proposed in early 1956 that the LRIX (advanced long-range interceptor) be dropped in favor of the MRIX when it became apparent there would be insufficient funds to finance both.<sup>283</sup>

The results of the LRIX competition, announced in the spring of 1956, temporarily, and indirectly, strengthened the ADC hand. Although North American was announced as the winner of the LRIX contest, neither USAF nor ADC was satisfied that the 107,000-pound aircraft was the LRIX desired. ADC then proposed an attempt to convert the unsatisfactory LRIX into a much lighter MRIX capable of a speed of Mach 2.5, a combat altitude of 70,000 feet and a range of 300-350 miles.<sup>284</sup>

The MRIX was dead, however, although ADC refused to attend the funeral. In November 1956, USAF announced that the LRIX would be the only third-generation jet interceptor developed, because of the primary need for an aircraft with a wide radius of action, long endurance and the ability to accomplish more than one firing pass at a target. ADC protested the decision, but the protests were ineffective. The MRIX had ceased to be a topic for discussion by early 1957.<sup>285</sup>

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## THE ADVANCED LONG RANGE INTERCEPTOR (LRIX)

Shortly after it requested development of the MRIX (January 1953), ADC asked, 7 April 1953, for development of an advanced long range interceptor (LRIX). No counterpart of this aircraft existed in the current ADC inventory since the F-89, the 1953 interceptor with the longest range, had a combat radius of about 400 miles. In LRIX, however, ADC wanted an aircraft with a 1,000-mile radius of action, a combat altitude of 60,000 feet and speed between Mach 1.5 and Mach 2. ADC saw this advanced interceptor as a multi-engine type with a two-man crew. The remainder of 1953 was spent in justifying the LRIX, but by the end of the year USAF agreed that the LRIX was a valid requirement. In January 1954 the USAF Aircraft and Weapons Board decided that an industry-wide competition should be held with regard to the LRIX.

While USAF approved the development of an LRIX, it regarded the ADC request that the aircraft be available for evaluation in 1956-57 as unrealistic and suggested that 1960 would be a more logical date. This lengthening of the development period caused ADC to revise its requirements. If the LRIX was not going to be available until 1960, ADC wanted an aircraft that would fly at

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Mach 3. have a combat altitude of 70,000 feet, carry three atomic missiles as armament, have a fire control system with a lock-on range of 50 miles and a completely integrated electronic system. As to range, ADC wanted capability to proceed to a control point 600 miles away, loiter for three hours, then dash at Mach 2.5 to an interception point as far as 200 miles away and still have enough fuel remaining to reach a re-service base as much as 300 miles away. Also, ADC now preferred a one-man crew to a two-man crew.

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The prescribed competition was held in the summer of 1954. At a preliminary meeting of 28 May 1954 there were 11 possible contractors in attendance. The specifications presented to the contractors were not exactly those ADC had prescribed. The prospective contractors were asked to bid on an aircraft which could reach a speed of Mach 1.7 at 40,000 feet, cruise at 60,000 feet and offer a radius of action of a thousand miles. Two armament configurations were specified. One included 48 2.75-inch FFAR rockets plus 8 GAR-1 Falcons. The alternative was three atomic rockets of the MB-1 type. At least two engines and a two-man crew were also specified. The fire control system was to be capable of detecting a target the size of a B-47 at a range of 100 miles.

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When the airframe and engine competition closed on 16 August 1954 (there was a separate competition for the fire control system), eight contractors -- Boeing, North American, Lockheed, Douglas, Northrop, McDonnell, Martin and Republic -- had submitted plans and models. The designs varied immensely in detail, although most proposed using the J-67 engine. After three and one-half months of sifting the various proposals, WADC concluded on 30 November 1954, that none of the proposals met the military specifications. <sup>289</sup>

The only possibility of providing a reasonably satisfactory aircraft by 1959. WADC believed, would require adoption of a design calling for a 100,000-pound model and then the chance of satisfying the requirement for a 60,000-foot ceiling would be marginal unless range requirements were relaxed. Acquisition of a B-47 target on the airborne radar at a range of 100 miles was simply not feasible. WADC felt that the MX-1179 (the Hughes fire control being developed for the F-106) with a 40-inch radar dish and increased power would do as well as any of the 30-odd fire control systems presented during the competition. At any rate, ARDC presented the facts to ADC in <sup>290</sup> December 1954 and awaited ADC reactions.



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ADC was inclined to accept the WADC ARDC conclusions. Since a weapon was useless if it could not be expected to counter the threat, ADC recommended that none of the proposals be accepted. Instead, ADC suggested that selected airframe manufacturers be given contracts for design studies which might eventually lead to the sort of LRIX ADC had in mind. To provide protection while the LRIX was being developed, ADC recommended that an interceptor version of the F-101 be procured.<sup>291</sup>

This position was held by ADC only briefly, however. By February 1955, ADC was arrayed against the idea of additional design studies, recommending instead that competitive development contracts be immediately awarded to two contractors. Since it was apparently not possible to build the aircraft ADC wanted, ADC was willing to compromise to the point where it would accept an LRIX that would have a radius of action of 500 miles, plus the ability to loiter for an hour at 500 miles, plus the ability to make a supersonic dash of 100 miles and engage in five minutes of combat at that point. ADC continued to fight this battle through early 1955, taking repeated exception to the proposal of the USAF Aircraft and Weapons Board to get on with the LRIX program by asking two contractors to

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make further design studies. In late April 1955, ADC was recommending that these two contractors each be authorized to build six aircraft for competitive test, with the production contract to be awarded to the winner. There were other far-out solutions proposed. The 28th Air Division, for example, wanted to modify B-47 bombers for use as long range interceptors. ARDC proposed doing the same thing with the B-58. All three proposals wilted when exposed to detailed examination.

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Following the hiatus of early 1955, the LRIX program began to move again in the latter part of the year with the writing of a new General Operational Requirement in July. Peculiarly, in view of the failure of the design competition of 1954, the requirements contained in the new document were more stringent than those included in the earlier GOR. A minimum combat ceiling of 75,000 feet was mentioned (with a ceiling of 88,000 feet desired). Combat speed of Mach 2.5 was required (with Mach 3.25 desired). A thousand-mile radius of action was prescribed. ADC naturally concurred with the GOR, since it contained everything ADC wanted in an LRIX. As to combat time, however, ADC now

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decided that it wanted 10 minutes instead of the five minutes mentioned earlier. The operational date of the LRIX was given as 1963.<sup>293</sup>

The formal GOR was presented to ARDC in October 1955, but ARDC had already taken action to put its provisions into effect. Northrop, Lockheed and North American had been authorized to begin parallel development of the airframe. This procedure represented a victory for ADC, which had inveighed against an LRIX program limited to design studies.<sup>294</sup>

At the end of 1955 a new factor -- the budget -- began to interfere with LRIX progress. USAF had approved development of two types of advanced interceptors -- MRIX as well as LRIX. Budget pressures were so severe, however, that USAF proposed to designate the F-103 as the MRIX, thereby combining the two projects and saving money. ADC felt this to be undesirable and recommended, instead, that development of the LRIX be halted in order to provide funds for the development of the MRIX. In short, ADC had decided that the MRIX held a higher priority than the LRIX.<sup>295</sup>

The LRIX was not cancelled, however, although the LRIX competition of 1955-56 was as indecisive as the competition of 1954. There was a nominal winner in 1956 -- North American -- but the theoretical performance of the winning

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model was far short of that needed to counter the threat expected in 1960-65. Besides, the North American design envisioned an interceptor that would weigh 107,000 pounds -- nearly as much as the B-47. Neither USAF nor ADC was satisfied that the North American aircraft was the LRIX desired. ADC was convinced that it was "impossible to use a bomber to catch another bomber." ADC proposed, therefore, to sit down with North American and try to convert the winning design into something much lighter in weight that could achieve a speed of Mach 2.5, a combat altitude of 70,000 feet and a range of 300-350 miles. Because ADC was willing to sacrifice range for speed and altitude, the conversations with North American were intended, in effect, to create an acceptable MRIX from an unsatisfactory LRIX.

USAF, however, would not recede from the long-range concept. Although ADC protested (in reversal of a former position) that range in excess of the control capability of the ground environment offered no advantage and that the value of "loitering" had never been demonstrated, USAF was still convinced that an LRIX had more to recommend it than did an MRIX, even though the LRIX now imagined by USAF had somewhat less capability than that required by

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earlier specifications. USAF changed the General Operational Requirement, on 30 November 1956, to call for an aircraft with a speed of Mach 2.5 and a ceiling of 60,000 feet. ADC continued to hold out, if it was necessary to develop an LRIX, for an aircraft capable of Mach 3 speed and a ceiling of 70,000 feet.

Because of ADC's repeated objections to the LRIX, USAF hesitated to make a unilateral decision and in February 1957 appointed a Board of General Officers to study the situation and make recommendations. Members were Maj. Gen. Kenneth P. Bergquist, Director of Operations, DCS/O, USAF; Maj. Gen. James Ferguson, Director of Requirements, DCS/D, USAF; Dr. Courtland Perkins, USAF Chief Scientist and Maj. Gen. Hugh A. Parker, DCS/O, ADC. The result of the Board's deliberations was a compromise between the USAF and ADC points of view. The Board recommended development of an LRIX that would (1) be capable of Mach 3 speed within a 350-mile radius and offer 10 minutes of combat at 70,000 feet; (2) offer a thousand-mile radius at a speed of Mach .9, plus five minutes of combat at Mach 3; (3) include airborne radar capable of detecting a target the size of a B-47 at 100 miles; (4) carry as armament three nuclear missiles with a range of 15-25 miles; (5) be capable of

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attack on a target with an altitude differential of 40,000 feet (up to 100,000 feet); (6) offer all this performance without the use of external fuel tanks. North American, which had "won" the 1956 LRIX competition, was to build the airframe to meet these requirements. ARDC was directed, 11 April 1957, to proceed with development of the re-  
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oriented LRIX.

The LRIX program achieved recognition of a sort in mid-1957 when the aircraft to be developed acquired a name -- F-108. Otherwise, the latter part of 1957 was spent in studying the problem. North American produced four design studies which ARDC outlined to USAF in October 1957. USAF was not particularly happy with any of the four, since in each case the most recent military specifications were compromised. USAF then reiterated that it would be necessary for the F-108 to carry three 95-pound nuclear Falcons (designated GAR-9) which would be so designed as to be effective at an altitude of 100,000 feet, ARDC contended that increasing the effective altitude of the missile to 100,000 feet would require a larger wingspan on the missile and recommended that the requirement be lowered to 90,000 feet. As to range, USAF insisted on a radius of action of a thousand miles, though



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ARDC recommended accepting a design which offered something less and acquiring the thousand-mile range through "growth."<sup>299</sup>

With obvious reluctance, ARDC agreed to push forward in the direction indicated by USAF. At the same time, ARDC felt constrained to add the cautionary note that "schedule advances and design emphasis shifts definitely move this program into the realm of high risk."<sup>300</sup>

The F-108 was also in the high risk area as regards funding. To a suggestion that it might be necessary to cancel F-108 development for lack of funds, ADC replied, in January 1958, that development of an advanced manned interceptor had to be pursued until the intentions of the USSR in the manned bomber field were more fully known and until the operational capabilities of interceptor missiles were proven. ADC believed the F-108 as then conceived was a significant advance over the F-106 and would make an important contribution to the store of knowledge concerning high-speed, high-altitude flight.<sup>301</sup>

But this did not end the money problems of the F-108. Although development appeared to progress normally during 1958, the threat of death by financial starvation hung over the F-108 at all times. As USAF began, in November 1958, to prepare the budget for Fiscal 1960, it appeared that the

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F-108 program would suffer from fiscal malnutrition to the extent that the operational date of the advanced long-range interceptor would slip from 1963 to 1964. ADC replied that this delay was totally unacceptable, but USAF was in no position to obtain the financing needed to support the development program on the scale previously planned. At the end of 1958, USAF forecast the future of the F-108: (1) Every effort would be made to achieve the first flight of the F-108 in February 1961; (2) the operational date would be delayed from 1963 to 1964; (3) the number of test aircraft would be reduced from 31 to 20, <sup>302</sup> thereby lengthening the development period.

Whatever financing problems might arise, the characteristics of the F-108 began to take firmer shape during 1958. USAF continued to hold fast to a requirement for a highly sophisticated control system which would provide automatic operation of the F-108 from a point just after takeoff to a point just before touch-down. USAF also asked that the F-108 be capable of assessing damage, identifying and rejecting decoys, and detecting nuclear weapon carriers. ADC at first (August 1958) objected to inclusion of these characteristics, but on sober second thought decided to go along on the theory that any improvement in the capability of an interceptor was desirable, no matter how unlikely

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the chances of achieving it might seem. Although ADC could see no need for it from an air defense point of view, USAF was unwavering in a requirement for in-flight refueling. As to the engine, it appeared that the General Electric J-93 would be chosen, although the Pratt and Whitney J-58 showed early promise. By the end of 1958 General Electric had been given a contract for six prototype engines and three had been established in test cells. The possibility that it might be necessary to pre-heat the J-93 before starting it at temperatures below -20 degrees was a matter of some concern to ADC. No method for avoiding this procedure was immediately available.

While development of the F-108 proceeded during early 1959, the negative financial pressures which seemed to indicate that development would never be completed continued to mount. In July 1959 USAF asked ADC if there were any development programs that might be cancelled to provide funds for the F-108. The ADC reply was negative, because the F-108 was so expensive that major programs (such as BOMARC or frequency diversity radar) would have to be junked in order to provide enough money for development of the F-108. And this ADC did not want to do. It was the ADC conclusion

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that the F-108 would have to be funded by direct, and  
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additional, appropriations.

A month later, on 21 August 1959, USAF directed the strictest sort of austerity in the development of the F-108, ordering the deletion of various refinements in the control and communications system. But this action amounted to whistling up-wind, because on 28 September 1959, USAF found it necessary to call a halt to development. At the same time, development of the ASG-18 pulse doppler fire control system and the GAR-9 nuclear Falcon missile  
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was to continue at an annual rate of 10 million dollars.

Although the F-108 was virtually dead from the USAF standpoint, ADC and NORAD, for a while, preferred to believe it was only sleeping. NORAD continued to include the F-108 among its requirements and when, in December 1959, ARDC proposed fitting the ASG-18 and GAR-9 to existing interceptors, ADC took the view that the only satisfactory vehicle for the ASG-18/GAR-9 combination was the F-108. USAF helped keep hopes alive by asking Congress to increase the amount spent on ASG-18/GAR-9 development from nine million dollars in Fiscal 1960 to 15 million in Fiscal 1961. Since USAF asked for no F-108 development funds for Fiscal 1961, ADC became more receptive to the

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idea that a long-range interceptor might be created by adding the ASG-18/GAR-9 combination to something besides the F-108. In May 1960, ADC asked ARDC to check into the possibility of using as an LRIX a North American airframe, (designated A3J -- a Navy type), powered by the Pratt and Whitney J-58 engine, and equipped with the ASG-18/GAR-9. North American delved into the possibilities of such an LRIX, but the theoretical probability that the A3J would have only 37 per cent of the kill capability of the F-108 caused ADC enthusiasm for the A3J to dissipate in the autumn of 1960.

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Following disillusionment with the F-108, ADC began, in October 1960, to work on the specifications for another advanced long-range manned interceptor (involving what ADC described as a "quantum jump" in interceptor performance) designed to cope with a new family of threats that not even the F-108 could be expected to handle. These new threats included air-launched ballistic missiles (ALBM), submarine-launched ballistic missiles (SLBM), Boost Glide Vehicles and Intercontinental Cruise Missiles (ICCM). This advanced interceptor was initially known as LRAPIS, for Long Range Advanced Piloted Interceptor System. The ADC Plans organization estimated that this aircraft would have to be

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capable of a speed of Mach 5 and an altitude of 200 miles. Asked for an unofficial opinion on such a vehicle, WADD agreed that development of the LRAPIS was technically feasible, but that the difficulties would be great. In the first place, WADD didn't believe it could be developed by the target date of 1966, but that 1970-72 would be more logical. Furthermore, it would have to be extremely large (about the size of a B-70), which would probably limit its use as a fast-reaction interceptor. Finally, the cost was likely to be astronomical. Despite this somewhat negative response, ADC continued to feel a need for a long-range manned interceptor beyond the F-101B. As of the summer of 1962, the LRAPIS had evolved into the Improved Manned Interceptor (IMI). USAF and DOD had expressed interest in such a vehicle, but approval for development had not yet been received.

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## CHAPTER EIGHT

### SOPHISTICATED FIRE CONTROL SYSTEMS

Three radar-based fire control systems were in regular operation within ADC at the end of 1954. The E-4 was used in the F-86D, the E-5 in the F-94C and the E-6 in the F-89D. All three were essentially refinements of the tail radar of the B-36. Possibly the most significant refinement was the substitution of the more powerful 250-watt radar (AN/APG-37) for the earlier 50-watt version. The next significant step beyond the E-4/5/6 was the E-9, intended to make it possible for the F-89D to fire the guided Falcon missile. Flight testing of the E-9 began in late 1954. Beyond the E-9 were the MG-10 for the F-102A, the MG-12 for

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the F-89J and the MG-13 for the F-101B. Still further in the future, although development began in 1949, was the MX-1179 system originally intended for the "1954 interceptor." Progress with this system was slow, however, and created the need for the "MG" interim systems. Thus a vicious circle was created, because concentration on interim fire control further delayed development of the ultimate MX-1179 system. As a result, Hughes estimated, in November 1954, that development of the MX-1179 was 32 months behind schedule. At that rate, the first development model of this system would be ready in August 1957, rather than in December 1954 as previously planned. Data link, the automated control system through which SAGE would direct the movements of interceptors, was in an uncertain "study" status at the end of 1954, because the data link equipment proposed for the F-86D was 1,000 cubic inches larger than the space allocated for it in the aircraft.

#### THE E-9 SYSTEM

Essentially a system representing growth of the earlier E-6, the E-9 involved one important difference. It included a universal computer, an analog device which,

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by electrical and mechanical means, performed the arithmetical calculations required to solve the fire control equation. The computer used continuous data on range to the target, closing rate, the target's angular motion with respect to the interceptor and the missile's time of flight in planning the flight path for the interceptor. The E-9 was originally intended for the testing of Falcon missiles, but later it was decided that the "interim" 1954 interceptor (F-102) would have an "interim" fire control system (E-9). Still later, however, it was decided that the E-9 would be used with the F-89H, the first ADC aircraft to be armed with the Falcon missile.

After successful flight tests in early 1955, Hughes began production of the tactical version of the E-9 in May of that year. Two F-89H aircraft (including the E-9) were delivered to the Air Force in November 1955, and four more in December. Acceptance flights in late 1955 revealed so many discrepancies in the E-9 system, however, that acceptances were halted in December 1955. The matters which most urgently required correction were the extreme sensitivity of the steering dot, the tendency of the antenna to oscillate during "beacon" operations, and a shortage of power in the missile batteries which prevented aborted

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missiles from retracting within the missile pod. These problems were solved by the time the last of the 156 E-9 sets under contract were completed at the end of 1956. The last 25 sets were modified on the production line. 308 The others were improved through retrofit action.

#### THE MG-12 SYSTEM

When it came time to provide a fire control system for the F-89J, the member of the F-89 family that carried the atomic rocket, it was logical that consideration be given to the E-9 system of the F-89H. And the MG-12 system of the F-89J was basically that, except that computer and other sub-assemblies were re-adjusted to supervise the firing of the large, unguided MB-1 rather than the guided Falcon missiles. Actually, the design of the MG-12 came along after the E-9 only because development began later. A pre-production model of the MG-12 was installed in a test aircraft in May 1956 and flight testing started. Aside from early difficulties with the snap-up maneuver, testing proceeded pretty much according to plan and the MG-12 was ready when the F-89J and the MB-1 were ready at the end of 1956. At that time, Hughes had

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produced 75 satisfactory MG-12 sets, which was far ahead  
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of airframe production.

#### THE MG-10 SYSTEM

The fire control system for the F-102A was another outgrowth, and presumed improvement, of the E-9. In this case, Hughes had to adapt the basic E-9 system for one-man operation, the changes proving so extensive that the resulting system was re-named MG-3. Where there were about 5,000 parts in the E-9, there were 7,000 in the MG-3 (and 2,000 in the E-4/5/6). The complete package of controls for the F-102A, however, was much more than a modified E-9. It also included an automatic flight control system, an integrated power supply, a semi-automatic armament selection device and data link. The total system became known as MG-10.

The first developmental model of the MG-3 element of the MG-10 was available in February 1955. Testing of an F-102A with an MG-3 unit aboard began in February 1956. By that time, Hughes had put together 16 test models of the complete MG-10, less flight control and data link equipment and was in the midst of extensive in-house testing.

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Despite Hughes experience with fire control systems, deficiencies recurred during testing. The missile auxiliaries and the computer, for example, introduced false signals into the system. Besides, the beacon navigation element failed to work properly, there were large steering dot errors at the time of lock-on, the system was slow to warm up and the filter in the pilot's radar scope required frequent replacement.

The Air Force was in such a hurry to bring the F-102A into the tactical inventory, though, that it began accepting F-102A aircraft in January 1956, before airborne testing of the MG-10 had even begun. As a consequence, hundreds of F-102A's were delivered without a complete MG-10 system. None of the 384 fire control systems Hughes had delivered by the end of 1956 included altitude barometric controllers. The automatic attack and navigational and landing features were missing from the flight control element. The J-4 compass had not been made compatible with the remainder of the MG-10. Data link was not available.

Because of this situation, it was necessary, in 1957, to prepare an extensive modification program in order to bring the fire control systems to the level of

  
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competence offered by the 459th F-102A off the production line. So comprehensive was the retrofit program that it required four months of work on each aircraft to bring early-model F-102A's (the first 353 aircraft produced) to "459" configuration. Later models (354 through 458) required about three months of work. This modification program began in January 1958 and continued through most of the year.

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After the MG-10 was brought up to a reasonably standard configuration throughout ADC's F-102A fleet, there were other modifications which ADC felt were imperative. The efficiency of the F-102A as a weapons system would be improved, ADC was sure, if the range of the radar in the fire control set could be lengthened. Experience with the electronic jammers carried by SAC bombers also convinced ADC that a means of countering electronic countermeasures (ECCM) was highly necessary. Finally, ADC wanted an infrared search and track capability built into the F-102A in order to permit the interceptor to operate more efficiently at low altitudes where radar was likely to be affected by ground clutter. This was a period, however, when modification funds were scarce and many desirable changes were either cancelled or forced to wait in a long, tiresome line for money. The three proposed changes to the

  
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MG-10 were in the latter category. Although all three were requested in early 1959 and all three were still being discussed in early 1961, only one was underway at that time. Beginning in October 1960, AMC began modifying the fire control systems of approximately 275 F-102A aircraft in order to improve their capability against electronic counter-measures. Installation of this complex equipment permitted the MG-10 to be tuned automatically, change frequencies at random, rapidly re-establish a broken "lock" on a target and otherwise combat electronic jamming. At the same time, the MG-10 was also modified to permit it to control the firing of the atomic Falcon (GAR-11) which was becoming available to F-102A squadrons. What came to be known as the Fig 7/GAR-11 modification of the F-102A was completed in the autumn of 1961. Testing of the proposed Infra-red Search and Track System was underway in late 1961 and early 1962, while the proposal for lengthening the range of the MG-10 was still being held in abeyance.


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#### THE MG-13 SYSTEM

The fire control system for the F-101B (MG-13) was still another variation of the E-9, although it was

  
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somewhat different from the MG-10, since the F-101B carried a two-man crew and was armed with both the MB-1 and Falcon missiles. In addition, the MG-13 contained a "combined indicator" which was an integrated optical sight and pilot radar scope. It also included an improved computer known as the Central Air Data Computer (CADC) in order to avoid confusion with the computer of the MG-10. Although flight testing of the MG-13 began in 1957 and progress was more or less normal, ADC was not satisfied with the fire control system it was scheduled to receive in the F-101B, contending in the spring of 1958 that the MG-13 had been outmoded by the speed and performance of this new interceptor. ADC recommended that the MG-13 be replaced by the MA-1 (MX-1179) intended for the F-106A. While ADC recognized that such a decision would entail a massive retrofit program, since production of the F-101B was well underway, ADC was convinced that the deficiencies of the MG-13 were sufficiently serious to justify such action. USAF would not agree to such a substitution, however, so ADC was forced to do the next best thing and seek improvement in the CADC, which supplied information to several control systems within the MG-13. By the end of 1958, ADC had submitted eight specific engineering change proposals in connection with the CADC.<sup>314</sup>

  
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Meanwhile, even though the F-101B was not yet operational within ADC, USAF was also thinking of modernizing the fire control system. Since the F-101B was likely to be in the active air defense inventory through 1965 and beyond, but would not be procured after Fiscal 1959, USAF thought it wise to plan for improvement of the MG-13 through modification. Particularly, USAF wanted to substitute the 23-inch radar dish and provide related improvements in ECCM capability. USAF had in mind a modification program that would begin in 1961 and end in 1963 and asked that ADC, AMC and ARDC get together to work up a plan of attack.

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From the ADC point of view, the most important of the proposals aired in early 1959 was one to increase the range of the fire control radar. ADC was also interested in improvement in ECCM capability, multiple antenna switching devices and infrared search and track equipment. Finally, ADC again asked for substitution of the MA-1 for the MG-13, but was again refused by USAF, this time on grounds that scarce modification funds could more profitably be spent on projects of higher priority. AMC estimated in April 1959 that installation of the ECCM features could begin in the July-September 1960 period and could be completed in a year.

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More than a year later, however, USAF had still not approved any modifications to the MG-13. In June 1960, AMC and ARDC again studied plans for modification and proposed a program involving infrared search and track and ECCM features at a cost of 77 million dollars. AMC/ARDC, at the same time, recommended that none of these modifications be undertaken until engineering and flight tests had definitely proven that each individual modification (six separate modification projects were included in the total package) would accomplish what was claimed for it. Meanwhile, AMC/ARDC recommended that the existing MG-13 sets be up-dated to the point where they had the same configuration as the Block 115 group of F-101B interceptors. A modification program similar to that which brought all MG-10 fire control systems to the capability of that installed in the 459th F-102A was envisioned. The recommendations of AMC/ARDC were generally followed in Project "Kitty Car," which also applied ECCM modifications to the MG-13. "Kitty Car" began in July 1961 and was virtually complete at the end of the year. Other modifications to the MG-13 were being tested in early 1962, but would not be ready for installation, assuming funds were available, until 1963.

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## THE MA-1

The Aircraft and Weapons Control System for the F-106A was much more than a fire control device. The MA-1 was designed to control the weapons system from just after takeoff to just before touch-down. During the flight, the principal function of the pilot was to monitor the operation of the various elements of the system. The calculating function within the MA-1 was done by a digital computer, a major advancement over the analog computer used in the E-9, MG-10, MG-12 and MG-13. Development of the MA-1 (known originally as MX-1179) began in 1949, at the same time that development of the "1954 interceptor" (ultimately known as the F-106) began.

But just as development of the "ultimate" aircraft was delayed by development of "interim" models (F-102 and F-101B), development of the MA-1 was delayed by periodic concentration on "MG" fire control systems. Early progress in what was essentially uncharted development territory was fairly rapid, however. By early 1952 the first experimental laboratory model of the digital computer had been completed. Its functions were limited, but it did serve to prove that a digital computer could be built into an airborne electronic system. At the same time, extensive



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radar design studies were underway. By the middle of 1952, the development of the MA-1 had advanced to the point where a model could be constructed in the nose section of an F-102.

At this point the first major delay in development of the MA-1 occurred. Although the first computer was completed in early 1952, it was not until late 1953 that the second became available. Meanwhile, work on the fabrication of experimental components for flight test purposes proceeded, though slowly. The radar, computer, simulated F-102 cockpit, tie-in equipment and test instrumentation were installed in a T-29 aircraft near the end of 1953 and flight testing began. Flight testing of the navigational components of the MA-1 began in early 1955.

In early 1956 it was planned that flight testing of the complete MA-1 system in an F-102 would begin in July of that year. The test vehicle was available at that time, but continuing difficulties with the power supply delayed completion of the stable platform within the F-102. It was not until the Christmas season of 1956 that the first flight of the MA-1 system occurred. Limited environmental and radar performance data was obtained, but no picture  
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appeared on the pilot's scope.

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Although development activity continued through 1957 and 1958, development of the MA-1 was still not complete when ADC received its first F-106A aircraft in May 1959. It was soon discovered that one component, the Tactical Situation Display, was so unreliable that it was disconnected. The generators in the MA-1 system experienced such a high failure rate that maintenance was very difficult. Also, transient voltages and random noise had an annoying habit of causing mis-alignment of the fire control portion of the MA-1 system. By February 1960 ADC was able to list 63 changes it believed were necessary in the MA-1 system. At the same time, the MA-1 was becoming a maintenance nightmare, since changes implied by continued development resulted in continuing modifications to the MA-1 equipment provided to the F-106A production line. As a result the MA-1 systems provided to ADC involved many different configurations and made the life of ADC maintenance crews increasingly difficult. The communications, navigation and landing systems of the MA-1 were so unreliable, because of an unpredictable power supply, that in December 1959 ADC found it necessary to restrict IFR flying in the F-106A to instances where the cloud ceiling was above 2,500 feet and there was visibility of

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at least three miles. In March 1960, the restrictions were increased to require a ceiling of 5,000 feet and visibility of five miles.  
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It was readily apparent that a major retrofit program was required in order to improve and standardize the MA-1 aircraft and weapon control system. It was estimated in mid-1960 that 800,000 manhours would be required to accomplish this job, although that total included retrofit work on systems other than the MA-1. This immense task, made necessary because development of the MA-1 was not complete before it was released for tactical use, began in September 1960 and continued through 1961 and into 1962. A portion (Project Broad Jump) was being accomplished by Sacramento Air Materiel Area and was expected to be complete in early 1963. Another portion (Project Wild Goose) was done at ADC bases by roving AMC field assistance teams supported by ADC maintenance personnel and was completed in September 1961. A third portion of this modification program (Project Dart Board) began in August 1961 and continued into 1962.  
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#### THE ASG-18

When it was decided, in the summer of 1954, to hold a design competition for an advanced long range interceptor

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(LRIX), it was understood that an advanced AWCS would be included. The specifications called for a fine control system that would detect a target the size of a B-47 at a range of 100 miles. Prospective contractors submitted 30-odd proposals for an advanced AWCS, but in November 1954, after all proposals had been evaluated by WADC, it was recommended that the MA-1 with a 40-inch radar dish and increased power be used in the LRIX. ARDC commented at that time that acquisition of a B-47 at a range of 100 miles was simply not feasible. <sup>321</sup>

The idea of an advanced AWCS was not dropped, however. In March 1955, Sperry and Hughes from the group of original bidders were asked to make a nine-month study of the problem. The two proposals which resulted were somewhat similar, although Sperry suggested the use of lower frequency radar. Of the two, WADC felt the Sperry proposal was the most advanced and seemed the most promising for future development. <sup>322</sup>

Nothing more was done immediately, while USAF and ADC wrestled with the question of just what was wanted in an LRIX. The whole matter was turned over to a Board of General Officers on 1 February 1957. By the end of the month, the Board recommended that, as to the AWCS, Hughes and Radio Corporation of America (rather than Sperry)

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conduct parallel and competitive development. Further studies conducted in 1957 again convinced ARDC that the state of the radar art would not permit development of airborne radar with 100-mile range. A probable upper limit of 60-70 miles was mentioned. USAF, however, was adamant in requiring that the aircraft and weapons control system for the LRIX contain a radar capable of reaching out 80 to 100 miles.

Because it had been decided to use the Hughes GAR-9 atomic Falcon as armament for what had become known as the F-108, Hughes thereby won the competition for the AWCS, since it was necessary that the AWCS be designed with the armament in mind. By late 1958 Hughes was working on a highly sophisticated control system that would use pulsed doppler radar and would not only provide automatic operation of the F-108 from a point just after takeoff to a point just before touch-down, but would also be capable of assessing damage, identifying and rejecting decoys and detecting nuclear weapons carriers. ADC at first (August 1958) objected to inclusion of these latter, far-out characteristics, since development along these lines might seriously delay completion. Later, however, ADC decided to go along on the premise that any improvement in the capability of an

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interceptor was desirable, no matter how unlikely the chances of achieving it might seem. The AWCS of the F-108 was likely to be so complex that the title of the second member of the crew was changed from radar operator to fire control officer.  
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While the F-108 as a weapons system succumbed to financial pressures in September 1959, development of the ASG-18 continued. USAF set an annual spending level of 10 million dollars for development of the ASG-18 and its associated armament, the GAR-9 missile. When the budget for Fiscal 1961 was being considered by Congress in March of 1960, USAF recommended that the level of development spending on the ASG-18/GAR-9 combination be raised to 15 million a year, although no airframe was mentioned in connection with this control system. Congress approved  
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this expenditure.

Meanwhile, development of the ASG-18 continued. One serious problem was the inability of the ASG-18 to provide range information while in the search mode. Multiplexing was suggested as a means of overcoming this difficulty, but involved such added complexity and introduced such uncertain state-of-the-art methodology that ARDC was reluctant to ask Hughes to attempt it. Also,



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there was no means of indicating to the fire control officer the range of a target beyond 150 miles. Any target beyond 150 miles was shown at that range until it came within 150 miles. Hughes, in this instance, thought it both possible and desirable to offer ranges up to 500 miles in connection with the ASG-18. Beginning in early 1960, with the F-108 gone, the ASG-18 development program was simply that. There was to be no engineering work in connection with the actual production of the system. No ground support equipment was to be bought. The current design, involving a three kilowatt power plant, was frozen.

Test flying of the ASG-18 in a B-58 test bed began in March 1960. During five test flights in July 1960, the ASG-18 recorded detection ranges of 93, 76, 63, 56 and 48 miles against a B-57 supplemented with 600 square feet of radar augmentation. Ever improved results were obtained in test flights during the subsequent two years. By the summer of 1962 the ASG-18 was capable of detecting a B-57 supplemented with 900 square feet of radar augmentation at a range of 170 miles. Automatic tracking at ranges up to 110 miles had been accomplished. The USAF demand for airborne radar capable of 100-mile detection range had been met.

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## DATA LINK


Although data link (presentation of data on a scope rather than through voice communication by means of radio) had been under development since 1951, it was in uncertain "study" status at the end of 1954. In June 1954, USAF had authorized the procurement of an early device known as AN/ARR-39, but was given pause when WADC revealed that the AN/ARR-39 would occupy 1,000 cubic inches more space in the F-86D than had previously been allotted to it. The plan for early realization of data link capability suffered another setback later in 1954 when AMC pointed out that deliveries of some related items of equipment could not begin until 1958. At that point USAF decided to re-study the question of data link for ADC interceptors.

The AN/ARR-39 itself was no particular problem as soon as the matter of space had been solved. The principal bottleneck was the coupler needed to pass the ground signals to the airborne system. In February 1955, General Electric estimated that the coupler would be available in the following month. In actuality, however, the coupler did not become available in quantity until 15 months later -- May 1956. At that time Hughes was able to proceed with production of an improved signal data converter which included data link capability. The F-86D was provided

  
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with data link equipment as a part of a modification project known as "Follow On" which began in the summer of 1956 and stretched into 1957. The F-86D with data link capability became known as F-86L.  
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Following installation of AN/ARR-39 in the F-86L, the next aircraft to receive data link was the F-102A. A considerable number of F-102As had been produced, however, by the time development of the Phase I AN/ARR-44 equipment was completed in 1957 ARDC reported that 220 of the Phase I AN/ARR-44 were available, but that the initial version of the AN/ARR-44 was likely to give erroneous information if frequencies were changed when the temperature of the receiver was below -30 degrees. The initial ADC reaction was to oppose the AN/ARR-44 as thereby unacceptable because ADC planned to use the F-102A to the limit of its capabilities and did not want to use data link with known deficiencies. This rigid opposition to the Phase I equipment had been modified by December 1957, however, and ADC decided to accept it, beginning with the 671st F-102A off the production line. The 671st F-102A was delivered in February 1958. The agreement among ADC, ARDC and AMC meant that 205 F-102A interceptors would be fitted with Phase I AN/ARR-44 data link. All F-102A aircraft beyond the 354th unit included provisions for data

  
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link, but no F-102A's in service were retrofitted with the Phase I set. Since development of the Phase II version was essentially complete by the end of 1957, installation of this type of data link began in 1958. <sup>330</sup>

The AN/ARR-39 and AN/ARR-44 were primitive types of data link which used the frequency division principle whereby 25 radio frequencies were utilized in maintaining contact between the ground station and the interceptor. A more sophisticated type, time division data link (TDDL), which used only a single communications channel and contacted the various interceptors and missiles within range of the ground station in timed sequence, was under development while FDDL equipment was being fitted. The AN/ARR-60 TDDL set was scheduled for the F-102A and F-101B. The AN/ARR-61 set was designed for the F-106A and in late 1958 it was anticipated that it would be built into the last 60 F-106A aircraft off the production line. It was to be made available to the remainder of the F-106A fleet on a retrofit basis. As of late 1958 it was expected that the first production models of TDDL data link would reach ADC tactical units in late 1960. <sup>331</sup>

FDDL had been installed in all ADC F-86L, F-102A and F-101B aircraft by the middle of 1959, but was so unreliable that the 26th Air Division, the first operational

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SAGE division, often had to revert to voice control of interceptors. ADC recognized, however, that data link was relatively new equipment and would probably become more reliable as time went along. For that reason, General Atkinson, reporting to General LeMay on the operational capability of the 26th Air Division in May 1959, revealed that he was not insisting that an interceptor with malfunctioning data link be declared operationally unready until the development agencies had had an opportunity to improve the reliability of the equipment. Actually, the situation was steadily improving at the time General Atkinson reported. While only 32 per cent of data link sorties in the 26th Air Division had been successful in January 1959, the percentage had risen to 68 in April 1959.

While no insurmountable problems were encountered during development of the AN/ARR-60 and AN/ARR-61, there were financial obstacles in the way of supplying TDDL sets to all F-101B, F-106A and those F-102A interceptors scheduled for armament with GAR-11 atomic missiles. The budget for Fiscal 1959 provided funds for 168 AN/ARR-60 models (half for the F-101B and half for F-102A) and 134 AN/ARR-61 sets. Fiscal 1960 funding provided money for 130 TDDL receivers for the F-102A, 168 for the F-101B and 12 for the F-106A. On the basis of the future aircraft

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inventory, as programmed in late 1959, this left a shortage of 78 receivers for the F-101B, 10 for the F-102A and 134 for the F-106A. Such a distribution of TDDL equipment seemed to ADC a perversion of priorities, since the F-101B and F-106A were more valuable to the air defense system than the F-102A. ADC proposed that the procurement of AN/ARR-60 for the F-102A be cancelled in order to provide complete coverage for the F-101B and F-106A, but  
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USAF would not accept the ADC argument.

This deficit in TDDL equipment was made up by means of Fiscal 1961 procurement, but the programmed dates for operational readiness of TDDL within the air defense system slipped appreciably between late 1958 and late 1960. In 1958 there was hope that TDDL would be operationally ready before the end of 1960, but this proved optimistic, since installation of the AN/ARR-60 and AN/ARR-61 did not begin until 1961. Sault Ste. Marie was the first SAGE sector to become operational with TDDL, an event which occurred in April 1961. The last sector was not completely  
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equipped with TDDL until the autumn of 1962.

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## CHAPTER NINE

### IDENTIFICATION, FRIEND OR FOE

The compromised Mark III IFF system used during World War II had been replaced with the improved Mark X system by the end of 1954. Before the Mark X could be put to use in the air defense system, however, it was necessary that a coding device be incorporated into it. This device, the Selective Identification Feature (SIF), was developed in the late forties and early fifties. Two types of SIF were under consideration -- a manual type which required response by the interceptor pilot and an automatic type which required no action by the pilot. Phase I testing of SIF began in 1952 and was not completed until June 1955.

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The test results were not reassuring, since they appeared to prove that automatic SIF was not feasible for positive identification. The equipment was difficult to maintain and presented operational problems that could not be accepted in a tactical situation. The slight increase in security it offered did not justify the cost, in the USAF view. Furthermore, the Army, Navy and Canada objected to joint use of the device. The manual SIF fared somewhat better in Phase I testing. It showed enough promise that Phase II testing proceeded. But the Phase II test was not the massive operation previously planned, in which the entire Eastern Air Defense Force was to participate. Instead, a limited test involving only six radar squadrons and three interceptor squadrons of the 30th Air Division was conducted. Although the Phase II test was not conclusive, tentative plans were made to install the manual version of SIF in ADC inter-  
335  
ceptor aircraft by the end of 1956.

SIF, however, was not ready by the end of 1956 and additional problems arose as development proceeded. By late 1957 it had been discovered that Mark X IFF when supplemented with SIF was incompatible with the FST-2 Coordinate Data Transmitter. Plans were made to modify the FST-2 to

  
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accommodate SIF and it was hoped at that time that a compatible air-ground system could be made operational in 1959. Even if this were possible, however, it was recognized that many technical problems would remain for solution before optimum performance could be expected. Improvements to ground and airborne antennas would have to be made, a better method of operational control of ground transponders would have to be devised and some means of screening out unwanted replies would be necessary.

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Meanwhile, since the Joint Chiefs of Staff was still anxious to achieve development of an air-to-air identification system that could be used by all U. S. armed services, USAF proposed to put to use an interim x-band system (AN/APX-26B and AN/APX-27B). Although it was not convinced that this interim equipment was adequate, ADC, in January 1958, asked that it be installed on all F-102A, F-101B and F-106A aircraft which would be in service after 1963. The plan to make the SIF feature of the Mark X operational 1 - January 1959 ran afoul of component shortages and a lack of skilled manpower. It became necessary to postpone the SIF "turn-on" date to 1 February 1959.

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Although the Mark X (SIF) was operational in early 1959, its usefulness was limited because it was susceptible

  
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to compromise. ADC considered it "the most vulnerable  
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electronic subsystem in the Air Defense System."

Something better was in the offing, however, in the shape of a cryptographic identification feature. This involved the cryptographic coding of interrogations and responses and the daily change of code key relationships between these functions. Since several billion code combinations were possible, this feature was calculated to cause enemy code experts unending puzzlement. When the cryptographic identification feature was added to the existing Mark X (SIF), the resulting IFF system was known as Mark XII. ADC unreservedly favored rapid development  
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and production of the Mark XII.

So far as ADC was concerned, however, development of the Mark XII was proceeding at a pace that was much too leisurely, since the operational date was given as 1966, or later. The Department of Defense agreed with the ADC estimate of the situation and in the spring of 1959 directed that at least two years be chopped off the testing process. The Department of Defense wanted an initial operational capability in 1961, with full operation in 1963. This meant that an accelerated service

  
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test would have to be conducted between July 1960 and July 1961. This also meant that ADC suddenly became involved in Mark XII testing, because ARDC was unable to provide the large numbers of fighter aircraft (possibly as many as 25 at a time) needed in testing the IFF device. By the middle of 1959 it was agreed that two squadrons of ADC interceptors would be fitted with experimental models of the Mark XII in preparation for the year of testing that was to begin in July 1960.<sup>340</sup>

As the time for the accelerated testing of the Mark XII came nearer, difficult problems began to appear. The money problem was present in all conversion programs, but it seemed especially nagging with regard to the Mark XII. The testing outlay alone was expected to be in the neighborhood of 26 million dollars. Provision of Mark XII for all aircraft of the Army, Navy and Air Force was likely to require a half-billion dollars. Funds in this amount were not easily come by in the austere budget implied in the Master Air Defense Plan which the Department of Defense drew up in the summer of 1959. There were practical difficulties, too. ADC had chosen F-101B squadrons at Otis and Suffolk

  
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as the units which were to be involved in the test program, but detailed study of the aircraft and the Mark XII equipment revealed that the F-101B did not have sufficient space for the Mark XII until the rotary power supply for the MG-13 fire control system was replaced with the static power supply being developed by Hughes. Even after this change was effected, Ogden Air Materiel Area estimated that an additional 1,500 manhours would be required to install the Mark XII in each aircraft.

Plans for volume production of the Mark XII were at least temporarily shelved in January 1960 when the Department of Defense decided there was no place for it in the pared-down budget for Fiscal 1961. The test program was unchanged, however, on the theory that production plans might be reinstated at some future time. <sup>341</sup>


When months passed and it appeared increasingly unlikely that funds would ever become available for complete conversion to Mark XII IFF, USAF enthusiasm for this advanced equipment waned. Although it continued to acknowledge responsibility for the testing of Mark XII, USAF began to search for ways in which the cost of the test program might be reduced. In the late spring of 1960, USAF announced a sharp reduction in the scope of testing to the end that only minimum testing and evaluation would



  
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be conducted. It was also announced that testing would be-  
gin in March 1961 rather than in July 1960.<sup>342</sup>

Despite the dim outlook for Mark XII as operational equipment, NORAD continued to press for at least minimum production of this highly desirable device. In April and again in August of 1960, NORAD sponsored demonstrations by the Hazeltine Corporation (the Mark XII contractor) that purported to show how sufficient equipment for significant use could be bought for 69 million dollars. Neither presentation elicited a favorable response from USAF. But NORAD was not dissuaded. It continued to press for implementation of Mark XII at least to the point where NORAD could be assured of maintaining secure contact with the SAC strike force. In February 1961, the Joint Chiefs of Staff asked USAF to comment on this proposal. The preliminary USAF reaction was again negative on the grounds that (1) the necessary money was needed for projects of higher priority, (2) SAC would still be exposed to friendly weapons while over Canada, naval units and NATO territory, (3) if Mark XII was to be implemented at all, it should be applied to all aircraft, not just those assigned to SAC, (4) the solution to the safe passage problem lay in better use of flight corridors and better correlation of SIF codes, rather  
than in partial implementation of Mark XII.<sup>343</sup>

  
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Despite repeated USAF insistence that insufficient money was available for procurement of the Mark XII for operational use, the testing of this equipment proceeded and was completed in the spring and summer of 1961. ADC repeated its requirement for the Mark XII as late as March 1962, but the USAF answer was the same: Mark XII was undoubtedly desirable and probably necessary, but equipment of higher priority was absorbing all available funds. <sup>343a</sup>

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## CHAPTER TEN

### MODERN ARMAMENT

At the end of 1954, ADC interceptors were armed with 2.75-inch FFAR rockets, but air-to-air missiles guided by radar or the infra-red emanations from the target (known officially as Guided Air Rockets -- GAR -- and popularly as Falcons) and unguided missiles equipped with nuclear warheads were under development.

#### MISSILES WITH CONVENTIONAL WARHEADS

The initial radar version of the Falcon -- GAR-1 -- was successfully fired from an aircraft on 21 October 1953,

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but the missile pod showed a tendency to collapse and re-design was necessary. As a result, the operational date slipped from June 1954 to October 1954 and, by the end of 1954, to August 1955. This latter date also proved optimistic, because of doubt as to the ability of the rocket motor to withstand extremes of temperature. When ARDC was finally satisfied that the motor of the GAR-1 could be fired at zero degrees and stored at -40 degrees, the missile was released for production. Delivery to ADC began in November 1955 and the first ADC squadron to receive the GAR-1 (and the F-89H to carry it) became operational at Wurtsmith in March 1956, nearly two years after the date originally established.

The GAR-1 delivered to ADC in late 1955 and early 1956 was merely the first in a series of Falcon missiles. In the early phases of the Falcon development program, four types of missiles, all with conventional high-explosive warheads, were planned. The GAR-1 was a radar-guided missile that could be fired from an interceptor flying at Mach 1.2. Behind the GAR-1 was the GAR-2, a version of the GAR-1 which employed infra-red guidance. Progress in the state of the art was to be represented by the GAR-3, an advanced GAR-1 which could be fired from an interceptor

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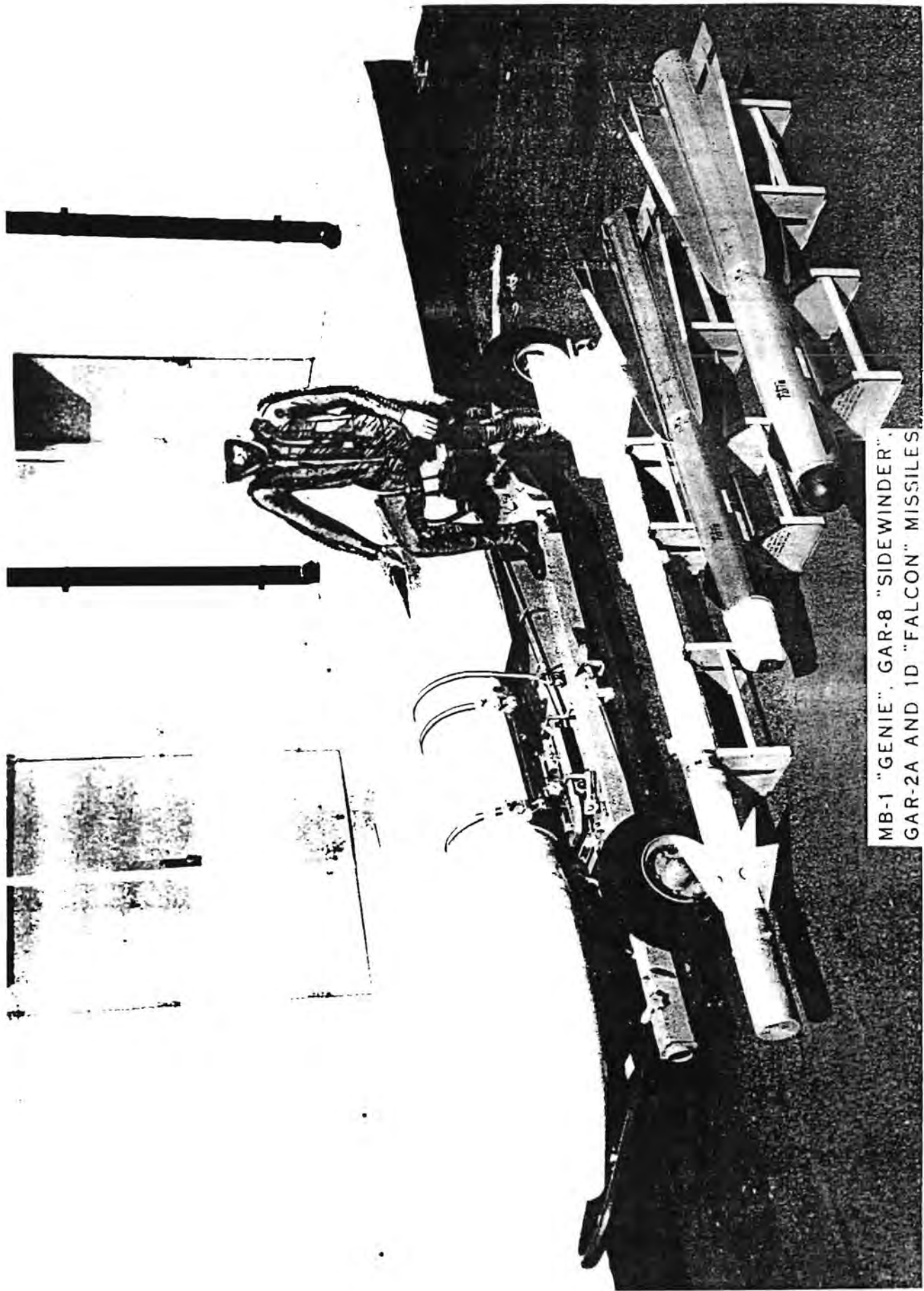
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flying at Mach 2 and would be guided by radar. GAR-4 was intended as the infra-red version of the GAR-3. Hughes Aircraft Company was the developer of all four early models of the Falcon.

The GAR-1 had a relatively short life as primary armament, because it was not effective at altitudes above 50,000 feet. It was replaced by the GAR-1D, effective to 60,000 feet and available shortly after the basic GAR-1 was delivered.<sup>345</sup>

Although the F-89H and F-102A and the GAR-1D missiles which were their primary armament were available to ADC in appreciable quantities by the end of 1956, the missiles were not usable at that time. While the fire control systems (E-9 and MG-10) designed for use in connection with the Falcon missile were far from reliable, the missiles themselves also failed to live up to expectations. The Weapons Center at Vincent (Yuma, Arizona), preparing for F-89H weapons training, discovered that 37.5 per cent of the Falcons in storage failed to meet operational standards upon initial inspection. A later check showed another 16.5 per cent to be unfit for use. Firing tests resulted in a large proportion of near misses even when the fire control system was operating normally. Hughes contended that the

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MB-1 "GENIE", GAR-8 "SIDEWINDER",  
GAR-2A AND 1D "FALCON" MISSILES





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situation was the result of a number of small deficiencies rather than any major flaw in the design of the missile. Hughes felt that the promised performance could be delivered if the circuit board was changed, some etched circuits were replaced with standard wiring, the sensitivity to voltage changes was reduced, factory testing and field testing procedures were standardized and the battery was modified. At any rate, the lack of reliability in the missile, and the lack of a self-destruction feature to preclude the classified missile from falling where its security might be compromised, caused ADC, in early January 1957, to order discontinuance of all missile firing at Vincent until further notice.

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The problems of the GAR-1D were somewhat more serious than Hughes was first willing to admit, however, and Hughes, on its own volition, stopped offering missiles for acceptance by the Air Force until changes which promised greater reliability could be made. This action was also taken in January 1957. A general restriction against the firing of the GAR-1/1D was lifted in April 1957, but use of the initial Falcon for weapons training was not immediately permitted. Instead, ADC inaugurated Project "Fast Draw" at Vincent in May 1957, a "confidence firing" test

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of the GAR-1D to determine whether or not the earlier deficiencies of the missile had been corrected. The first series of Fast Draw tests was inconclusive, so a second series was conducted in July 1957. Meanwhile, ADC was sufficiently convinced that the tests of the GAR-1D would prove favorable that it took steps to return 1,400 GAR-1 to AMC for indefinite storage. This advance action was supported by the results of the Fast Draw tests in July 1957. At that time it was concluded that the GAR-1D was accurate and reliable and a valuable addition to interceptor armament.

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Development of the GAR-2 was initiated in November 1951 and the first airborne firing occurred in September 1954. The GAR-2 was essentially the GAR-1D except that a passive infra-red seeker was substituted for the active radar seeker of the GAR-1D. The principal difficulty, and the main cause of development delays, was inability to integrate the infra-red equipment into the remainder of the control system of the GAR-1D. For this reason, it was not possible to mount a successful test firing of the GAR-2 until 9 August 1956. On that date, at Holloman, the missile was fired from an F-100C aircraft at an altitude of 52,600 feet and scored a direct hit on a flare balloon

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at 63,500 feet. In five subsequent test firings, Hughes reported that the GAR-2 scored direct hits on three occasions, a close miss on another. The fifth missile did not appear to guide properly and a wide miss resulted. By this time Hughes was also developing a GAR-2A, which differed from the basic GAR-2 only to the extent that the temperature limitation on the missile was reduced from zero to -50 degrees.<sup>348</sup>

While the deficiencies of the GAR-1D were largely corrected in 1957, this was not true with respect to the GAR-2. The reliability of this member of the Falcon family remained in question. During the ground phase of the Air Proving Ground Command (APGC) test a failure rate of 92 per cent was recorded. More than half the failures were attributed to "parameter drift," meaning that the missiles did not test within the limits established on the test console. These limits could be adjusted by the console operator and led Hughes to argue that the limits set by the test console were too narrow and that the GAR-2 was not nearly as unreliable as the tests would indicate. ARDC was inclined to agree with Hughes and recommended that production of the GAR-2 continue, despite an ADC recommendation (based on the APGC report) that

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production be halted until the reliability of the missile was improved. APGC hedged, finding merit in both points of view, and made the obvious recommendation that failure criteria for the GAR-2 be improved. Until this was done, it was difficult to determine, short of intensive test firing, whether the GAR-2 was really reliable or not. <sup>349</sup>

Actual firing of the GAR-2, however, was no more encouraging than the ground tests had been. During the Fast Draw II tests of August 1957, interceptors had no trouble firing the missiles, but each of the first five missiles fired was so obviously inaccurate that ADC recommended that GAR-2 test firing be discontinued until Hughes produced a missile that could offer performance that approached specifications. In August 1957 ADC directed its interceptor squadrons not to load alert aircraft with GAR-2 missiles until further notice. Major changes were necessary in the GAR-2, because the missile appeared to be affected by such extraneous sources of heat as cities and <sup>350</sup> the sun.

Improving the GAR-2 (or 2A) to the point where it was suitable for operational use proved to be a task of considerable proportions. Although "Follow On" tests in 1958 managed successful firing of the infra-red missiles, test

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pilots had to be careful to use a snap-up maneuver against a background of blue sky, avoiding the sun, the horizon and the ground. While ADC was pleased to note that the GAR-2 could probably be used at high altitudes (if an adverse background was avoided) when the fire control system was inoperative, it did not feel that the missile would be really useful until adequate performance at low altitudes was proven. The ban against the use of GAR-2 missiles on alert interceptors was therefore continued through 1958.

Low-altitude tests of the GAR-2A, conducted at Tyndall in early 1959 as part of the Fast Draw III series of Falcon tests, were an almost complete failure. When fired at a low altitude over the Gulf of Mexico, the missiles either failed to achieve guidance and followed a ballistic course into the water, or turned toward the sun instead of the target. The one ray of hope in the whole series of tests occurred 20 February 1959, when a GAR-2A was fired at a QF-80 target flying at 1,000 feet. The missile guided correctly and scored a close miss. This single success after universal failure raised hopes that something might, after all, be done to make the GAR-2A useful at low altitudes.



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Development, in 1959, of an improved guidance unit for the GAR-2A solved the problem of low-altitude guidance and permitted ADC to relax the restrictions on the use of this missile. By early 1961 the GAR-2A was in routine use within ADC as primary armament on the F-102A (pending installation of the nuclear GAR-11) and as secondary armament on the F-101B (backing up the nuclear MB-1).

The GAR-3 was intended for use with the F-106 interceptor, since the earlier models of the Falcon could not be fired at the Mach 2 speed offered by the F-106. Development of the GAR-3 was initiated in 1952 and the first successful airborne firing occurred in July 1955. In early 1956, Hughes claimed an experimental model of the GAR-3 made a direct hit on a parachute target. Another experimental model was launched, this time from an F-102A, in October 1956, but the test was inconclusive because the power source of the launch aircraft failed shortly after firing and the fire control radar stopped operating.

Testing of the GAR-3 continued through 1957 and into 1958 and, although minor successes were achieved, it had become apparent by mid-1958 that the GAR-3, as then constituted, would not meet the specifications established in 1952. Several components, including the motor, were unsatisfactory and the Air Force refused to accept the GAR-3

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for tactical use. ADC, however, agreed to accept about 200 of the unsatisfactory missiles for training purposes. Hughes thereupon began work on an improved model to be known as GAR-3A. Because of the difficulties experienced with GAR-3, Hughes did not expect, as of August 1958, to be able to furnish an adequate missile until August 1959.<sup>354</sup>

Development of the GAR-3A proceeded with few difficulties, the deficiencies of the GAR-3 apparently having been satisfactorily corrected. There was a brief flurry of concern, in early 1959, over the possibility that the GAR-3A might not be compatible with the F-106A, but continued testing dissipated this worry. The complete testing cycle was delayed because it was thought desirable to test the GAR-3A and GAR-4A together and development of the GAR-4A was slowed of a need to first eradicate the<sup>355</sup> shortcomings of the GAR-2.

The last of the Hughes series of conventional Falcons was the GAR-4. This missile employed an infra-red seeker and therefore was an advanced version of the GAR-2. At the same time, it was similar to the GAR-3, except for the difference in seekers. Development of the GAR-3 and GAR-4, in general, followed parallel paths. Development of the

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GAR-4 began in March 1954 and had reached the point in late 1955 where it was possible to hold a mock-up inspection. <sup>356</sup>

A year later, in September 1956, the first test firings of the GAR-4 were attempted. On this occasion, two missiles were launched from an F-102A at an altitude of 50,000 feet and a range of 15,000 feet. One missile knocked a flare from the flare balloon, but the second failed to achieve guidance. This modest success, however, did not signify a successful development trend. The deficiencies of the GAR-2 were also the deficiencies of the GAR-4 and by early 1958 ADC had determined that the GAR-4, in its current state of development, was not acceptable. USAF thereupon cancelled plans to purchase GAR-4 Falcons with 1958 funds. <sup>357</sup>

Since the GAR-4 was sub-standard, ARDC was asked to canvass possible improvements. ARDC determined that the only substantial improvement in view was incorporation of a cooled detector operating at liquid nitrogen temperatures and on a longer wavelength. This modification would require about two years to complete, ARDC believed, and would introduce a logistical complication by requiring armament specialists to deal with liquid nitrogen. The improvements outlined by ARDC were satisfactory to ADC and

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USAF and development along this line began, although ADC was hopeful that the two-year development cycle could be shortened. Experiments with indium antimonide substituted for lead selenide in the GAR-4 detector also showed promise.

Although late-fifties development of the GAR-4 (or GAR-4A as the improved missile was designated) was delayed by corresponding delays in the development of the GAR-2, sufficient progress had been made by 1960 that formal testing of the GAR-4A could begin. Category III testing of the GAR-3A and GAR-4A was completed in August 1961 and the missiles had been provided to operational squadrons in quantity by the end of the year.

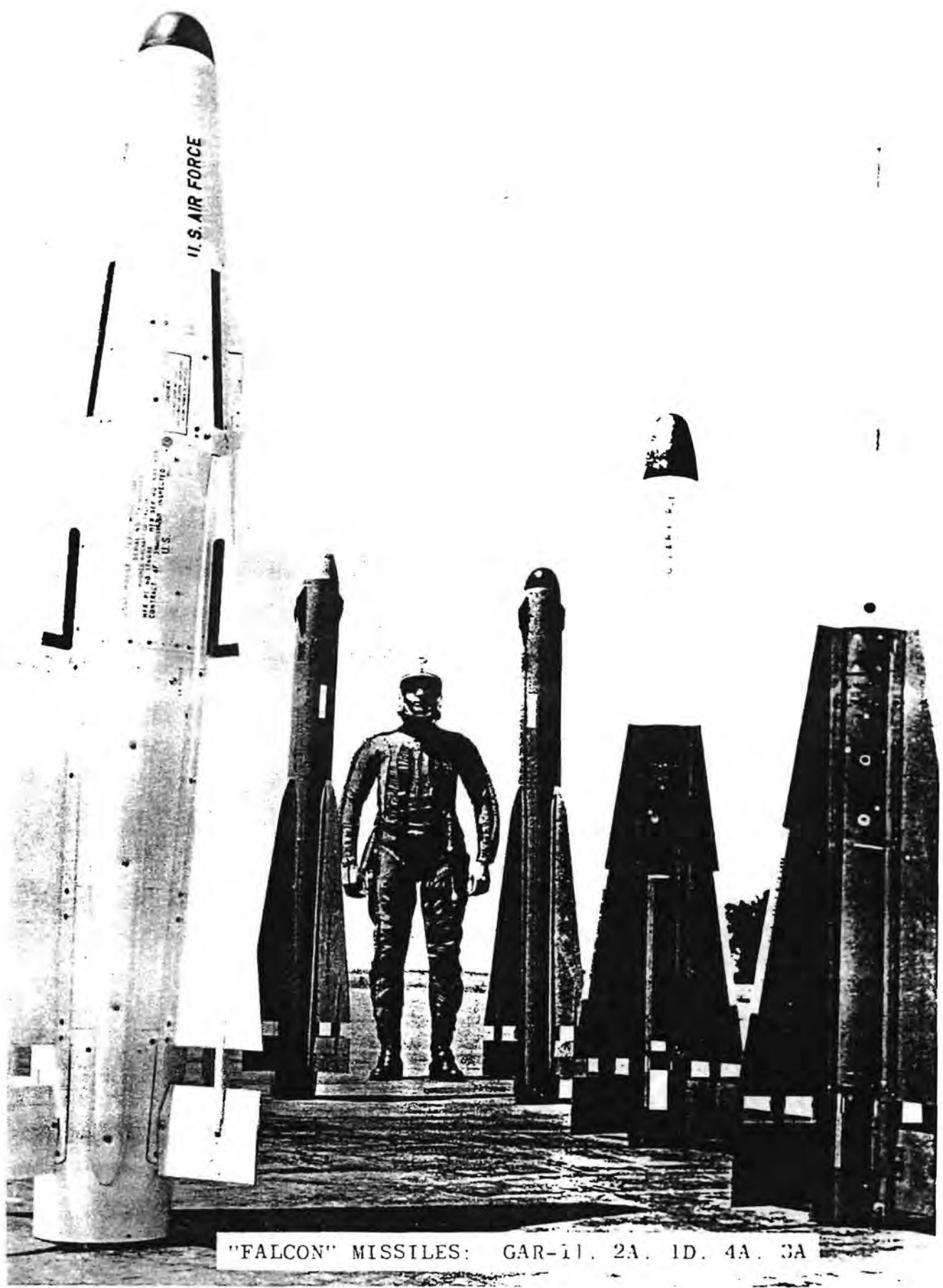
The Sidewinder (GAR-8) was a Navy development dating back to 1947. It also (like the GAR-2 and GAR-4) made use of an infra-red seeker. Since the seeker could detect only the rays emanating from engine exhaust systems, it was limited to tail cone attacks. This disadvantage, however, was offset by the fact that it could be adapted to use by fighter aircraft without provision of additional fire control equipment. The Sidewinder was of interest to ADC only briefly, since it came with the F-104 and left the command when the F-104 was phased out.

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The first problem with respect to the Sidewinder was whether ADC should accept an early model of the missile (Sidewinder I), available in the late spring of 1957 at the time the first F-104 aircraft was expected, or whether it should wait for the improved version (Sidewinder IA) due in late 1957. The Navy was willing to provide 450 Sidewinder I missiles immediately if ADC would replace them with Model IA when they became available. ADC wanted to accept the Navy offer, although USAF and ARDC were reluctant, because the Sidewinder I was only a developmental model. The ADC desire to obtain early combat capability with the F-104 proved the stronger argument in this instance, however, and the Navy offer was accepted. <sup>361</sup>

Although hindsight showed that this initial problem need not have been a problem, since the F-104 was not actually provided to ADC until early 1958, other problems arose when the GAR-8 went into operational use. While the Sidewinder had been more than 10 years in development, serious deficiencies appeared when ADC began to work with it. The first fault ADC found in it was the lack of reliability of influence fuzes at altitudes above 35,000 feet. Since the primary value of the F-104 to ADC, in view of its lack of adequate airborne radar, was its ability to reach extremely high altitudes, this shortcoming in

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"FALCON" MISSILES: GAR-11, 2A, 1D, 4A, 3A





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Sidewinder fuzes was serious. Also of major importance was the susceptibility of the Sidewinder to damage from moisture. Even after the Navy had taken action to improve the fuze, the GAR-8 was still unreliable at altitudes above 40,000 feet. The Navy was continually cooperative in attempting to improve the performance of the Sidewinder and in November 1959 ARDC was preparing to test the high altitude capabilities of what was purportedly a still better model (GAR-8B) when USAF announced that F-104 aircraft would be removed from the ADC inventory in 1960. At that point ADC lost interest in the Sidewinder.

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#### NUCLEAR ARMAMENT

The first statement of a need for atomic armament in air defense came on 31 January 1952 when ADC forwarded a formal requirement to USAF. The Pentagon was receptive, but ARDC was not encouraging, since existing atomic warheads were much too large for use in rockets which could be carried by interceptors. At mid-1952 the smallest atomic weapon currently under development was the Shrike -- 23 feet long and weighing 5,225 pounds. Despite this discouraging report, the Joint Air Defense Board, a JCS organization charged with monitoring air defense activities, continued a study of atomic armament for interceptors. In

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a report dated 14 January 1953, the JADB concluded that it was both feasible and desirable to build small, inexpensive warheads in the 2-4 kiloton range. Encouraged by implied JCS support, ADC re-opened with USAF the matter of atomic armament. On 23 March 1953, ADC repeated that "a requirement exists in ADC for lightweight atomic warheads of lowest possible cost with yields within the range of 1-20  
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KT."

This time around, ARDC (represented by the Air Force Special Weapons Center) reversed its position and reported in June 1953 that it appeared theoretically possible to develop an air-to-air missile containing an atomic warhead. The Atomic Energy Commission agreed to attempt to fit existing warheads into a rocket suitable for mounting on an interceptor. The AEC also believed it was possible to design a new warhead which would fit into a smaller case. While the concept of atomic armament for interceptors had been accepted by USAF, ARDC and AEC by mid-1953, official approval for development of a nuclear air-to-air rocket was not received from the Joint Chiefs of Staff until 2 April  
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1954.

Meanwhile, ARDC had been at work on the characteristics of such a weapon. By the end of 1954 it was fairly well established that the first atomic armament for interceptors

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would be an unguided rocket with a diameter of 17 inches and a warhead offering  
 Adaptation of an atomic warhead for guided missiles was to come later. With this matter settled, the question of testing arose, since testing of an atomic weapon was something that could not be undertaken without considerable advance planning. At the end of 1954, however, ADC was hopeful that a proof test of what had become known as the DING DONG rocket could be included in the DIXIE series of tests the AEC had tentatively scheduled for the Nevada Proving Ground in the autumn of 1955. There was general agreement that the F-89 would be the first interceptor to be supplied with atomic armament.

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Although ADC was disappointed when it did not prove possible to test the complete DING DONG (also subsequently known as High Card and Thunderbird and ultimately as MB-1 or Genie) during 1955, or, in fact, at any time prior to operational use, development of the unguided atomic rocket proceeded with reasonable rapidity once the decision had been taken to develop it. There was some early concern about the reliability of the rocket motor and about the stability of the rocket itself, but component testing appeared to indicate that everything was satisfactory.

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By the end of 1955, three successful test rounds (less the nuclear warhead) had been fired at Holloman and chances of meeting the 1 January 1957 operational date established by the JCS in 1954 appeared excellent. <sup>366</sup>

A more serious shortcoming of the MB-1, in the eyes of ADC, was its slavish dependence on the interceptor's fire control system for a firing signal and exclusive use of a time fuze. Being unguided, the rocket itself was impervious to electronic countermeasures (ECM), but the fire control system could be victimized by ECM and the MB-1 thereby neutralized. The possible use of an infra-red sighting system was suggested. Also, a proximity fuze was much more valuable in an ECM environment than a time fuze. ARDC acknowledged the desirability of these changes, but was unable to take any immediate action, because of the pressing need to meet the operational date of 1 January <sup>367</sup> 1957.

The first airborne firing of the MB-1 took place at Holloman on 8 March 1956, with a modified F-89D as the delivery vehicle. Fortunately, since the development schedule was so "tight" that ARDC was not able to accomplish the volume of developmental testing it normally devoted to a new weapon, the test rocket performed almost exactly as

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theoretical studies had shown it would. The directed MB-1 operational capability was attained on 1 January 1957. On that date, nine F-89J aircraft were on hand at Hamilton and six at Wurtsmith. The MB-1 rockets needed to give these interceptors atomic capability were also available. This was the very minimum of capability, however, since F-89J development was not complete and there was evidence that calculated MB-1 ballistics were at odds with the test data, probably forcing a change in the manner in which the rocket was mounted on the interceptor. Besides, the complete MB-1 (including the atomic warhead) had never been fired. There was no test data in the background of estimates as to how the MB-1 would perform in a combat situation.

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The informed speculation about the performance of the MB-1 received some slight basis in fact in July 1957 when an F-89J successfully fired an MB-1 as a part of Operation PLUMBOB at the Nevada atomic test area. There was no target and the accuracy of the MB-1 was not checked. Nevertheless, it was proved that the MB-1 could be carried to altitude, could be fired from an aircraft and would detonate pretty much in accord with previous theoretical calculations.

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The MB-1 launched in July 1957 was the only nuclear air defense weapon ever fired (to late 1962). The prohibition against the testing of nuclear weapons, effective 1 November 1958, was in force until Soviet violation of the test moratorium caused President Kennedy to revoke the prohibition against testing. Nuclear testing was resumed in the summer of 1962.

With the basic MB-1 in the hands of tactical units by the National Security Council deadline of 1 January 1957, attention could be given to the improvement of the rocket. The ADC recommendations of late 1955 -- greater ECCM capability for the fire control system and use of a proximity fuze -- were revived in mid-1957 and ARDC agreed to study various avenues of approach. Both ADC recommendations were eventually adopted. A series of extensive modifications calculated to improve the ECCM capability of the F-101B, F-102A and F-106A began in late 1959. The F-101B and F-106A carried the MB-1, but also needed the ECCM modifications to permit realization of the full potential of the GAR-11, a Falcon missile with nuclear warhead, being developed for the F-102A. As to the proximity fuze for the MB-1, ARDC decided that the most logical approach was to add a proximity fuze to the time fuze. In late 1960, Bendix began

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working on a prototype nose cone which would include both fuzes. The double-fuzed MB-1 became known as the MMB-1<sup>370</sup> and was to be ready for operational use in January 1963.

At the middle of 1962, however, it was extremely doubtful that the MMB-1 would be ready by the previously established date. Although Douglas was given a contract for the improved Genie in October 1961, shortages of funds and discussions as to whether or not the MMB-1 would be effective at low altitudes and against chaff tended to delay the development period. The questions concerning performance had not been satisfactorily answered as late as July 1962, only six months from the date the MMB-1 was expected to take its place in ADC's<sup>370a</sup> inventory of operational armament.

When the use of atomic warheads in interceptor armament was first considered in the early fifties, it was acknowledged that guided missiles would probably be more efficient than unguided rockets. Development of a guided atomic missile was likely to be much more difficult than creation of a relatively simple rocket like the MB-1, however. So, since the National Security Council stressed speed in the provision of atomic capability for the interceptor force, early emphasis was placed on the MB-1.

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Despite initial interest in an atomic warhead for guided missiles, the MB-1 probably would have sufficed for a number of years had it been possible to arm all century series interceptors with this rocket. The F-102A could not be so armed, however. And it became doubly important for the F-102A to carry atomic armament when economic factors forced a reduction in the number of F-102A's which would remain in the ADC tactical inventory. In late December 1957, General Curtis E. LeMay, Vice Chief of Staff, USAF, received the plans of an earlier day in suggesting development of a small nuclear warhead for use in Falcon missiles. To fit the case of the Falcon, the warhead had to be about one-third smaller than the warhead used in the MB-1. <sup>371</sup>

From this beginning, events moved swiftly in early 1958. ARDC confirmed the feasibility of a nuclear Falcon in February. Hughes was given a development contract in March. The first unguided firing of an unarmed version of what had become known as the GAR-11 occurred 13 May 1958. The first guided GAR-11 was fired nine days later, 22 May 1958. Late in May the Joint Chiefs of Staff approved the development of a nuclear warhead for the Falcon and on 23 June the Assistant Secretary of Defense for Research and Development authorized the Atomic Energy Commission to

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proceed with development of the necessary warhead. Although the necessary approval actions with regard to the GAR-11 were taken with relative swiftness, ARDC was doubtful, at mid-1958, that the USAF goal of operational readiness by February 1960 was possible. At that time, ARDC estimated that the unarmed missile would be available in April 1960, but that warheads would not be ready until sometime later. It was anticipated that the GAR-11, complete with warhead, would become available in February 1961.

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But ARDC was unduly pessimistic in this instance. Since two Army warheads -- QUAIL and WEE GNAT -- proved satisfactory during AEC tests in Nevada in August-October 1958 and both were believed adaptable to the GAR-11, USAF acted in November 1958 to improve the availability date of the atomic Falcon from February 1961 to June 1960.

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Formal testing began in August 1959, and although the GAR-11 scored a respectable number of near misses during Category I and II testing over the ensuing 16-month period, the proximity fuze was decidedly unreliable. Fuze malfunctions occurred in 21 of 36 test firings between August 1959 and September 1960. By the latter date it had been decided that the GAR-11 could not be released for

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operational use until Hughes came up with an acceptable fuze. Category III testing (a primary responsibility of ADC, in which the GAR-11 would be tested in a normal squadron environment) was delayed from September-October 1960 to the late spring of 1961. The availability date of the operationally ready atomic Falcon was then moved back at least a year. Hughes had developed what it thought was an acceptable substitute fuze by October 1960 and testing began in December 1960.<sup>374</sup>

Another cause for delay of the GAR-11 lay in the warhead. The proposed June 1960 availability date for the complete GAR-11 was rendered unrealistic in 1959 when AEC announced that the warheads would not become available until October 1960. Accidents, involving high explosives, at the Los Alamos Scientific Laboratory necessitated changes in production techniques and safety procedures. Production of components needed in the development testing of the nuclear warhead was temporarily halted. This setback caused the AEC to move the date for delivery of warheads to February 1961. Then in late 1960 it was discovered that the neutron flux within the warhead was lower in density than was required for the desired explosive yield. It was necessary to redesign the high explosive envelope of the


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warhead and thereby create additional delay in delivery  
of warheads, possibly until May 1961.<sup>375</sup>

By the spring of 1961, further delays in the provision of an acceptable GAR-11 missile to ADC F-102A squadrons was in prospect. In April 1961 it appeared that redesigned warheads would not be available for operational suitability testing (OST) until July and August of 1961. ADC insisted that Category III testing of the GAR-11 could not begin until successful completion of the OST of the warhead. This meant that existing plans for conducting the Category III test in July-August 1961 would have to be revised. The Aircraft Systems Division of ARDC insisted that the OST of the warhead and Category III testing of the complete missile could be conducted concurrently, but ADC was not convinced.<sup>376</sup>

The operational suitability test of the warhead, which ADC insisted was a prerequisite for the Category III test of the complete missile, was finally accomplished in December 1961. This would have appeared to open the way to prompt commencement of Category III testing, but a number of new delays cropped up. There was a shortage of suitable drone aircraft, a lack of test missiles and a shortage of available time on the Eglin Gulf Test Range.

  
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At the time the warhead testing was completed in December 1961, it was planned that the Category III test would begin in March 1962 and end in June of that year. At the end of April, however, not a single successful test mission had been flown and ADC was seriously concerned, since the GAR-11 program was already two years behind schedule. Category III testing finally began in May 1962 and was completed in July. Since the test statistics indicated that GAR-11 fuzes reacted properly less than half the time, a further special test of the fuzes was proposed by ADC. Although testing provided evidence that the GAR-11 was not a proven missile, ADC's need was so great that the first atomic Falcon was nevertheless distributed to F-102A units. As early as December 1961, ADC squadrons had 200 GAR-11 missiles on hand, <sup>376a</sup> proven or not.

So long as the F-108 was under active development and ADC was scheduled to receive it, ADC had an active interest in the GAR-9 missile the F-108 was to carry as armament. Although Hughes was the contractor for both the Falcons and the GAR-9, the GAR-9 was not regarded as part of the Falcon family. It was, instead, an advanced missile designed for use with an interceptor capable of speed much greater than any current interceptor. ADC took part in the early

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discussions of the design of the missile and participated in the 1958-1959 conferences which attempted to establish specifications for a warhead. When development of the F-108 was cancelled in September 1959, ADC, for a while, lost interest in the GAR-9, although development of the GAR-9 continued.<sup>377</sup>

But when there appeared a possibility that some sort of advanced interceptor (whether called Long Range Piloted Interceptor System -- LRAPIS -- or Improved Manned Interceptor -- IMI -- or whatever) might eventually be provided for air defense purposes, ADC interest in the GAR-9 quickened. The first successful ground launching of a guided GAR-9 occurred 19 January 1962. The first air-to-air launching, also successful, took place 25 May 1962. On 17 August 1962, the GAR-9 was launched at the direction of the ASG-18 control system and scored a direct hit on a QF-80 drone at an altitude of 30,000 feet and a range of 100,000 feet. The GAR-9 was making such excellent development progress by the summer of 1962 that ADC asked USAF to make sure the GAR-9 was provided with a nuclear warhead. It was evident that ADC felt it was going to use the GAR-9 at some future time.<sup>377a</sup>



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CHAPTER ELEVEN  
INTERCEPTOR MISSILES

That the development and testing of the BOMARC missile was going to be a much longer process than anybody had previously anticipated was fully evident by the end of 1954. Early plans (1950-51) had called for an end of testing in 1954 and the attainment of operational readiness in 1956. At the end of 1954, however, only eight test missiles had been launched from Cape Canaveral and only the last two of these (in October and November 1954) were successful. And the two successful launchings of late 1954 did not involve the complete missile, since Marquardt was still experiencing

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trouble in the development of an adequate ramjet. These missiles, therefore, did not include ramjets. As a consequence, it was necessary at the end of 1954 to give the test completion date as 1957 and the operational readiness date as 1959.

#### THE FIRST BOMARC -- IM-99A

Nine additional missiles were sent on test flights in 1955, Phase I of contractor testing being completed in November of that year. Six of these nine launchings were regarded as successful. The third consecutive successful flight, in a successful series which began in October 1954, occurred on 19 January 1955. This missile, though still without ramjets, went higher, further and faster than any previous test missiles. It reached an altitude of 74,000 feet, flew 54 miles and attained a speed of Mach 3.2, somewhat faster than the design speed of Mach 2.7. Ramjets returned to the test program on 24 February 1955, when another test missile was launched. All systems worked well on this occasion and the BOMARC flew 106 miles. Following another successful launching in March, Boeing experienced three consecutive partial failures between May and August. These abortive missions followed no particular

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pattern. One was caused by a malfunction in the control system, a second by rudder oscillation, the third by trouble in the beacon guidance system which made necessary premature destruction of the missile. The test program recovered in the autumn, however, with one successful launching in September and two in November. At the completion of this phase of testing in November 1955, Boeing claimed, and ARDC agreed, that the airframe, propulsion system and guidance system had proved suitable when tested individually.

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The next step in the test procedure was to determine whether or not the complete missile could intercept a target. Six missiles were therefore sent against relatively slow (185 knots) QB-17 drones between March and July 1956. Half were regarded as successful missions in which interceptions at 28,000 feet and ranges between 55 and 63 miles were achieved. One interception involved a tail-chase approach to the target. The other two were head-on approaches. Again the three failures were of random nature. An April launching fell short of expectations because of a power failure within the missile after 50 seconds of flight. The following month a BOMARC test missile exploded shortly after launching. A June launching was unsuccessful because of a malfunction within the target

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seeker. Despite the fact that only three of the six missiles operated according to plan, Boeing was satisfied that it had successfully demonstrated the ability of the BOMARC to intercept a target. Boeing was also confident, as of August 1956, of its ability to provide operationally ready missiles of 125-mile range (IM-99A) in 1959.<sup>379</sup>

At about this time a new cloud -- cost -- appeared on the horizon. In just one year, between September 1955 and September 1956, the estimated cost of the BOMARC system (40 squadrons of missiles plus associated equipment, but not including shelter construction) jumped from about two billion dollars to nearly three and one-half billion. This startling increase brought from USAF in September 1956 a flat statement that "the present...BOMARC program cannot be funded."<sup>380</sup> This was the first word in the fiscal handwriting on the wall that eventually reduced the final BOMARC program to a mere fraction of the extensive network planned in 1956. ADC, however, was concerned with air defense rather than cost and continued to insist that the full squadrons (120 missiles per squadron for a total of 4800 missiles) were necessary if an adequate defense was to be provided for the country.<sup>381</sup>

  
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Meanwhile the test program continued. In October 1956 the test organization began a series of six launchings intended to demonstrate the capability of the AN/GPA-35 equipment to control the airborne missile. The AN/GPA-35 was a pre-SAGE control system that would be used until SAGE was ready. The target in all cases was the slow QB-17 drone flying between 20,000 and 30,000 feet. Interception was attempted at ranges in the neighborhood of 75 miles and in five of the six test launches the missile was required to make a sharp turn (70-90 degrees) into the target.

The ability of the AN/GPA-35 to control the missile was satisfactorily demonstrated, but the reliability of the missile itself left much to be desired. Only one of the six launchings -- which stretched across the period from October 1956 to April 1957 -- resulted in a successful interception of the lumbering QB-17 drone. In three other instances a foretaste of things to come was provided when the target seeker failed to operate properly. In another instance the missile exploded shortly after launch when it lost the ceramic liner from the throat of a rocket motor. The fifth of the five failures in this test series occurred when thrust control valves failed and it was necessary to destroy the missile only 28 miles from the launch

  
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site. The net result of this series of tests was an indication that the AN/GPA-35 was ready, but that the missile was not.  
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The remainder of 1957 was devoted to a series of tests designed to prove the effectiveness of the fuze and warhead of the IM-99A. Nine missiles were launched during this period. All but one had the QB-17 as a target. The ninth missile was launched at a QF-80 drone flying at 350 knots, nearly twice the speed of the 185-knot QB-17. Interception was attempted at altitudes from 11,500 to 30,000 feet and at ranges from 45 to 110 miles.

Three of the nine launches in this series of tests were regarded as successful. Oddly enough, the first launching against a QF-80 target, 16 September 1957, was successful. The missile passed within six feet of the target at an altitude of 30,000 feet and a range of 90 miles. In this test the drone flew at right angles to the flight path of the missile, then executed a 90-degree turn which brought it into a "head-on" aspect. Other successes were experienced on 11 October and 23 October 1957. The failures, again, were of a random nature. The initial launching in this series, 22 July 1957, failed when random radar pulses forced the missile to destroy

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itself after only 64 seconds of flight. The missile was just 12 miles from the launch pad at Cape Canaveral. The mission of 15 August failed when the target seeker achieved lock-on 10 seconds late. The missile was unable to execute the sharp turn required to maintain lock-on and the interception was not completed. The first missile containing a live high-explosive warhead was launched 27 September 1957, but a ramjet failure prevented the mission from being a success. The following month, however, the second missile with a live warhead made a direct hit on a QB-17 at the longest range -- 108 miles -- achieved to that time. Other failures were the result of faulty mid-course guidance from the GPA-35 and malfunctioning command systems within the missile.

It had been anticipated that IM-99A testing would be shifted to Eglin (Santa Rosa Island) in November 1958, but at the end of 1957 it began to be doubtful that Eglin would be ready in time. Contracts for only four of the six launchers planned for Santa Rosa had been let and there was a nagging difference of opinion over the construction specifications for the Santa Rosa launchers. There was a distinct possibility that the shift of the test program from Cape Canaveral to Eglin might be delayed several months.

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The next series of IM-99A tests, which occupied the period from March to August 1958, also experienced only indifferent success. Eight of the nine missiles fired during this time were intended to demonstrate the ability of BOMARC "A" to make interceptions at ranges in excess of 100 miles. At this time the IM-99A was designed for a maximum range of 125 miles. The ninth shot was to check the theoretical minimum range of 43 miles. Four of these missions were regarded as successful. The others experienced various degrees of failure. All but one involved the QB-17 drone. The minimum-range mission, and it was one of the successful ones, made use of the QF-80.

The first three missions in this series were unsuccessful and it was not until 20 May 1958 that success was experienced, although the second and third missiles in the series, launched 2 April and 1 May, flew 187 and 197 miles, respectively and were partially responsible for the subsequent decision to revise the range criteria for the BOMARC. Prior to the autumn of 1958, the goal of the IM-99A development program was a range of 125 miles, for the IM-99B a range of 250 miles. Because test results indicated that the BOMARC was capable of a much greater range, the design goals for the two types of interceptor missiles were raised to 230 miles for the IM-99A and 440



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miles for the IM-99B. The long-range flight of 2 April had to be regarded as a partial failure, however, because the target seeker failed to function and the planned interception was not completed. That of 1 May was also considered unsuccessful because the GPA-35 could not control the missile beyond 130 miles. Other failures resulted from ramjet malfunctions, flaws in the flight control system and fuze difficulties.

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The 1957 doubts that BOMARC testing could begin at Santa Rosa Island in November 1958 were well founded. The pessimistic forecast that there would be "several months" of delay was not borne out, however. The first BOMARC launching from Santa Rosa occurred 15 January 1959. But even though the initial launching of an IM-99A missile was delayed only two months, it was still necessary to revise the plans which called for the firing of all IM-99B test missiles from Santa Rosa. Because of delays in the construction of missile shelters and associated facilities, it appeared, at the end of 1958, that the first eight IM-99B missiles would have to be launched from Cape Canaveral. IM-99B testing at Santa Rosa was not expected to begin until 1960.

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The matter of targets also began to cause concern in 1958. If the BOMARC was to be tested realistically, it had to be sent against something at least resembling a possible enemy. Early testing made use of the QB-17, but this freight-train-slow World War II bomber was useful only in indicating that the BOMARC could intercept a target -- any kind of target. This done, it was necessary to send the missile against a target offering much improved performance. USAF first suggested use of the QF-80, but ADC argued that the obsolete fighter was entirely inadequate. ARDC provided a ray of hope when it got tentative USAF approval of the use of three X-10 (Navaho guided missile) drones as BOMARC targets, but this hope was dashed in February 1958 when USAF explained that the three X-10 drones were for use at Cape Canaveral and that none could be provided for ADC use. The Q-4 was a specially designed supersonic Ryan drone that appeared to offer promise as a target for BOMARC, but engine troubles made it unlikely that the Q-4 would be available before July 1960, if at all. The SNARK strategic missile (SM-73) was also considered as a BOMARC target, but was rejected because of excessive cost. This left the obsolete QB-17 and QF-80 for immediate target use.

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Later, there would be some improvement when the QB-47 became available. Also, ARDC was debating the possibility of converting the F-104 to drone use.

Testing of the production prototype of the IM-99A missile began at Cape Canaveral in August 1958. This series of tests brought SAGE into the test program for the first time. Determination of the compatibility of SAGE and the missiles, once the missiles were emplaced in tactical sites, was imperative. Also, the missile itself was to be put through more and more intricate maneuvers. Multiple launchings were scheduled, as were missions involving maneuvering targets and supersonic targets. Ten missiles of this test series were launched by the end of 1958.

The first attempt at SAGE control of BOMARC occurred 7 August 1958, but was not successful. Because of split radar returns, SAGE was not able to give the missile the proper commands and 153 seconds after the launching the GPA-35 took control. The command system within the missile malfunctioned, however, and the missile refused to accept commands. As a result, the missile remained at cruise altitude (65,500 feet) until its fuel was exhausted and it dropped into the Atlantic Ocean about 180 miles from the

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launch site. The second attempt at SAGE control, 15 August 1958, was successful. The missile made a direct hit on a QB-17 at a range of 78 miles and an altitude of 30,000 feet. SAGE was in complete control until the terminal phase, at which time guidance equipment within the missile took over.


Another milestone in BOMARC development was reached 21 October 1958 when two missiles under SAGE control were almost simultaneously launched against two QB-17 targets spaced far enough apart to present two distinct radar tracks. Surprisingly enough, in view of earlier experience, the dual mission was an almost complete success. The experimental SAGE computer at Kingston, New York, retained effective control of both missiles and placed them in proper position for successful interception. Only the fact that the fuze in the first missile did not operate properly was a double interception prevented. The first missile passed within four feet of the drone at a range of 100 miles. The second missile, launched 12 seconds after the first, made a direct hit on the drone at a range of 159 miles. Both drones were flying at an altitude of approximately 30,000 feet, the practical ceiling of the B-17.

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The first attempt at interception of a supersonic target was also made during late 1958, but was much less successful than the two-missiles-against-two-targets mission. On 24 September, an IM-99A was launched against an X-10 drone flying directly toward the launch site at an altitude of 53,000 feet and a speed of Mach 1.57. The early phases of the mission went exactly according to plan, but during the last 72 seconds of the mid-course phase the SAGE computer received no information about the target. As a result the missile was positioned so far to the right of the target that, because of the rapid closing rate between missile and target, there was not enough time to steer the missile back on the correct course. The missile, as a consequence, missed the target by 12,000 feet. <sup>390</sup>

Although the double launching of 21 October was generally successful and an indication of major progress in the test program, production prototype testing between August and December 1958 was marked by more failures than otherwise. Of the 10 missiles fired during this period, only two were regarded as unqualified successes. Various things went wrong with the other eight. On four occasions the fuze failed to operate as planned. The other four failures were credited to command system and target seeker

  
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malfunctions. Fifty-seven IM-99A test missiles had been  
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launched from Cape Canaveral by the end of 1958.

A new era in BOMARC testing began 15 January 1959 when the first missile was launched by the Air Force Missile Employment Facility at Hurlburt Field, Florida. Hurlburt (officially designated Eglin Auxiliary Field No. 9) was located in Northwest Florida, across the peninsula from Cape Canaveral. Launchers were emplaced on a narrow strip of sand known as Santa Rosa Island and missiles were launched into the Gulf of Mexico. The beginning at Santa Rosa was auspicious, since the missile made a direct hit on a maneuvering QF-80 drone at an altitude of 25,000 feet and a range of 79 miles. The initial launching at Santa Rosa was not made without difficulty, however. Earlier plans called for the first launching from the AFMEF in November 1958, but a number of malfunctions in missile testing equipment, notably the Mobile Inspection Equipment (MIE) caused delays. Finally, a group of Boeing engineers was sent from Cape Canaveral to Hurlburt on 30 December 1958 and by using makeshift testing methods was able to provide the successful launching of 15 January  
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1959.



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In all, 20 test missiles were fired during the first half of 1959, six from Cape Canaveral and 14 from Santa Rosa. Although this was a greater number than had ever been launched in any previous six-month period, it was considerably below the number of launchings planned. The six missiles launched from Cape Canaveral represented the end of Category I testing, wherein the contractor demonstrated the reliability of the weapon. The first 11 launchings at Santa Rosa represented the beginning of Category II testing of the IM-99A, wherein ARDC attempted to demonstrate to the using command that it was receiving a combat-ready weapon. The last three launchings at Santa Rosa were part of the SAGE/BOMARC Demonstration, designed to prove the compatibility of SAGE and the IM-99A. Approximately two weeks after the initial launching at Santa Rosa, a "double shoot" took place. These missiles intercepted the single QF-80 drone at an altitude of 30,000 feet and ranges of 103 and 46 miles, but the fuze of the second missile failed to fire in the vicinity of the target.

Because of burned wiring in the missile launchers and difficulties with the weighing mechanisms on the fuel and acid trailers it was impossible to fire another missile from Santa Rosa for nearly a month. And when firing was

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resumed, the results were not encouraging. The missile launched on 27 February was destroyed prematurely because the target seeker locked on several things besides the target. The missile launched on 6 March 1959 took a heading which caused it to cross the western boundary line of the missile range. Destruction, of course, was mandatory. Subsequent investigation revealed that the GPA-35 control system had given the missile the wrong pre-launch commands. The missile was destroyed before it was possible to correct the error.

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Following the discouraging launchings of late February and early March, the testing program on the Eglin Gulf Test Range was brought to a temporary halt while an attempt was made to remedy an eminently unsatisfactory situation. The principal problem was the Mobile Inspection Equipment (MIE) van. Although the van was supposed to check a missile in four hours, 10 to 14 days were being required to process a missile. Even so, it had been impossible to put a missile through the entire processing cycle without forcing acceptance at some steps in the procedure and by-passing others. Only once had the processing procedure gone as far as Step 104, and then only because several troublesome steps had been skipped. It

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had been possible to launch missiles on 15 and 28 January only through the special efforts of experienced Boeing engineers who readied the missiles without reference to the MIE van. The other two missiles fired had been forced through the MIE by continually juggling drive signals, voltages and references.

In an effort to improve van operations, a calibration attempt was begun on 27 February. Calibration, according to available manuals, could be accomplished in four days. Sixteen 12-hour days were required, however, to do the job at Hurlburt. And even when the MIE van was put back in operation on 17 March, no particular improvement was noted. The ADC missile personnel at Hurlburt were forced to the conclusion that it was impossible to use the MIE van as it stood and that redesign was imperative. It was believed that some of the trouble resulted from the possibility that all shelter/missile combinations did not look alike to the van and that proximity to the Gulf of Mexico was causing an environmental problem. In any event, ADC was unable to process missiles through the equipment supposedly designed for that purpose.

Because of this situation, the BOMARC Weapons System Project Officer (WSPO), an ARDC official, gave permission

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for the launching of 12 YIM-99A (the "Y" designated experimental missiles) without MIE processing in order to complete the expenditure of "Y" model missiles by the deadline of 24 April. It was planned to devote three weeks to the maintenance of the GPA-35 control system and its associated FPS-20 radar beginning 24 April. By the middle of May, when the guidance equipment would presumably be ready for operation again, it was hoped that the MIE van could be improved to the point where the BOMARC test program could be resumed with a minimum of improvisation. <sup>395</sup>

This special dispensation from the WSPO touched off a flurry of test activity that saw the test organization attempt to launch eight missiles within two weeks in April 1959. On 13 April a double launch was planned in an effort to determine the multiple launch and control capabilities of the GPA-35/YIM-99A combination and discover whether or not the blast of a launching had any effect on nearby shelters. Unfortunately, the first missile could not be launched because of an error in the command message structure. The second missile left the shelter 12 seconds later, but the target seeker acted irrationally and the missile missed the target by two miles. A second attempt to launch two missiles almost

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simultaneously was made four hours later, but again the first missile failed to fire. The second missile, as before, was successfully launched, but the mission was not completed, because the GPA-35 lost control of the missile 100 seconds after it was launched.<sup>396</sup>

While the launching of only two missiles was intended on 13 April (the second pair having been held in backup status), a serious attempt was made on 24 April to launch four missiles -- two double launchings. One pair was controlled by GPA-35, the other by the SAGE Direction Center at Montgomery. The first SAGE-controlled missile got off the ground, but just barely. It rose only eight feet, then settled back into the launcher, causing serious damage to both launcher and shelter. Three hours later the second SAGE-controlled missile was launched, but its performance was not much better than the first. It began its terminal dive far too early and was destroyed at a point 50 miles from the launcher, probably because it was given erroneous commands by SAGE. Just 10 minutes later the first of the missiles controlled by GPA-35 was launched and acted according to specifications until the terminal phase of the mission was reached. The target seeker never achieved lock-on, however, and the missile was destroyed

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73 miles down-range. The fourth missile succeeded in intercepting the QF-80 target at a range of 73 miles. At the end of this hectic day, when testing activity was shut down for six weeks to allow preparation for the formal SAGE/BOMARC test in June, 11 IM-99A missiles had been launched from the Santa Rosa Island test site since 15 January. In only four instances would it have been safe to assume that a successful interception had taken place. This was the measure of the state of readiness and reliability of the IM-99A as of April 1959.

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Although nearly seven years of BOMARC testing had failed to produce a missile that inspired confidence, the test organization pushed ahead doggedly to the next item on the evaluation agenda -- the SAGE/BOMARC evaluation. And this phase of the test program began well. While there were suspicions that a SAGE error had caused the failure of 24 April, SAGE performed perfectly on the occasion of the first launching of the SAGE/BOMARC demonstration on 4 June 1959. The missile was guided to a direct hit on a QF-80 drone at a range of 100 miles. The second SAGE/BOMARC mission on 24 June was similarly successful. Two IM-99A missiles were launched, 30 seconds apart, at QF-80 drones flying 18 miles apart. The first missile

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passed very near the target at an altitude of 26,000 feet and a range of 100 miles. The second was just as accurate at an altitude of 25,000 feet and a range of 103 miles. Although the launchings were successful and the targets were reached, it was doubtful that fuzes and arming devices had operated properly.

Jubilation over the successes of June was tempered by the fact that all interceptions had been scored against subsonic targets of the B-17 and F-80 variety. If the BOMARC was ever called upon to fight a war it would obviously be expected to destroy supersonic bombers. This same weakness in BOMARC testing had also occurred to the Chief of Staff, USAF. On 3 June 1959, ADC learned that the Chief of Staff had "expressed strong personal interest in the earliest possible launching of a BOMARC at a supersonic target."

ADC was also interested in seeing the BOMARC launched at a supersonic target, but finding such a drone was proving, in 1959, to be a major problem. With the destruction of the last supersonic X-10 drone at Cape Canaveral in early 1959, there were no supersonic drones in the Air Force inventory. In April 1959, ARDC evaluated the Radioplane Q-4, the Lockheed Q-5 and a drone version of the Navy's Regulus missile (manufactured by Chance-Vought). The Q-4 was

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dropped from consideration because it was limited to a speed of 1.2 Mach. The Q-5 was also found to be impractical because it was too fast. For use with the BOMARC, the IM-99A would have to be launched before the drone in order to make interception possible. This left the Regulus as the only practical target of the three analyzed. ADC was hopeful that the B-47 would be converted to drone use, but that hope was temporarily destroyed in June 1959 when USAF cancelled the QB-47 program for economy reasons. At the time the USAF Chief of Staff expressed his wish, therefore, the only available supersonic targets were eight Regulus missiles which the Navy had agreed to provide.  
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The wish of the USAF Chief of Staff to have BOMARC launched at a supersonic target was fulfilled 3 September 1959 when a test missile destroyed a Regulus II target at a range of 125 miles. To prove that this mission was not an isolated fluke, another Regulus II was knocked down 17 September 1959, this time at a range of 140 miles. It was apparent that the BOMARC, when operating properly, was capable of dealing with a supersonic target.  
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Aside from the two demonstrations of BOMARC capability against a supersonic threat, the test record during

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the summer of 1959 was an almost unrelieved catalogue of failure. Twice during the last two weeks of July the test staff planned a "triple shoot," but none of the six missiles got off the ground. Various things went wrong. There were power failures, failures to receive launch commands, loose fire control plugs, ruptured solenoid valves in the launch mechanism and various other malfunctions. Probably the most unnerving occurred 29 July when two of the three missiles erected when the count-down was still six seconds short of launch time. The mission was immediately cancelled and an investigation organized because of the unpleasant implications as regards missile safety. It was later discovered the premature "fire-up" command had resulted from test channel noise produced by a faulty rectifier at the Chipley (Florida) microwave relay station. This problem had a simple solution. It was necessary merely to replace the faulty rectifier.

Other "triple shoots" were scheduled for 20 August, 17 September and 9 October, but in no instance did more than one missile leave the launcher. To indicate the magnitude of the test debacle during the period 1 July-9 October 1959, only six of the 25 missiles it was planned to launch were actually launched and of this number only two (oddly enough, the two directed against the supersonic Regulus II)

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completed interceptions. Following the failure of 9 October, the 1959 testing season at Santa Rosa Island ended, because it was necessary to prepare the test site and the range for IM-99B testing.<sup>403</sup>

As of late 1959, the reliability rate of the IM-99A was unacceptably low. Boeing had predicted that 40 per cent of the missiles in ready storage would fire and that 40 per cent of the missiles fired would accomplish interception. The Boeing forecast offered, therefore, a system effectiveness of a very modest 16 per cent when missiles in the ready storage condition were considered. Experience gained during the launching of 20 IM-99A missiles from Santa Rosa Island between 14 January and 9 October 1959, however, indicated that Boeing was optimistic. While 43.5 per cent of the ready missiles were launched, only 23.5 per cent found the target, for a composite effectiveness rate of 10.7 per cent. It had also been expected that reliability would improve as test equipment more nearly approached a uniform tactical configuration. But this had not proven true. The situation had rapidly become worse instead of better. ADC hoped to achieve an in-commission rate of 83 per cent at the tactical sites, but

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on the basis of test operations at Santa Rosa it appeared likely that the in-commission rate was likely to be closer to 10 per cent.<sup>404</sup>

USAF sensed that all was far from well with the BOMARC program and on 29 October 1959 requested an ARDC briefing on the matter, since "the recent unsuccessful IM-99A firings and attempted firings [had] caused considerable concern to the Air Staff."<sup>405</sup> ADC responded, although not charged with providing the briefing, with another long list of BOMARC deficiencies. USAF thereupon appointed a General Officers' BOMARC Review Board to study BOMARC problems and decide what was to be done to improve matters. The first meeting of the Board was held at Wright-Patterson<sup>406</sup> on 18 December 1959.

Meanwhile, by severely straining the concept of operational readiness, it was possible to declare the BOMARC squadron at McGuire operationally ready on 1 September 1959, according to plan. On that date, Brig. Gen. Arthur C. Agan, Jr., commander of New York Air Defense Sector, announced that he had "reasonable confidence one BOMARC at McGuire [could] be fired and guided by New York Air Defense Sector to destroy targets."<sup>407</sup>

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This was the shakiest sort of operational readiness, however, because there was much to be done before McGuire could be considered really ready. As late as mid-December 1959 only one missile was in ready storage at McGuire. Following the initial declaration of operational readiness ADC worked feverishly to improve the degree of readiness at McGuire. Engineers of the 46th Air Defense Missile Squadron (ADMS) and Boeing were formed into an integrated team, under Boeing direction, to process missiles to operationally ready status. Between 1 September and 22 October 1959, the team was engaged in getting the MIE, functional check-out gear (FCO) and the propulsion and hydraulic testing equipment in sufficiently operable condition to permit processing of a second missile. Testing of a second missile began 22 October. Four days were spent on FCO operations and two days on fueling. Ten days were devoted to repeated MIE tests. With completion of these procedures, operational readiness testing of this second missile began 13 November. But the missile was not ready. After 21 successive failures, the missile was returned to the MIE sequence on 16 November. By this time there were indications that missile components had been worn out by excessive testing. These failures were adequate proof



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that the FCO and MIE test equipment was inadequate and Boeing was put to re-engineering both sets. Despite the difficulties at McGuire, the second IM-99A site was declared operational at Suffolk on 1 December 1959, primarily because ADC was adamant in insisting that programmed dates for operational readiness be met.

There was a heartening upsurge of successful IM-99A testing in May 1960. Energetic action by the USAF General Officers' BOMARC Review Board, ARDC and ADC and thousands of engineering manhours on the part of Boeing finally produced results at that time. Suddenly, albeit temporarily, the IM-99A became a fairly reliable missile that could often do, at least in test launchings, what it was intended to do. On 12 May 1960 the first reasonably successful "triple shoot" was accomplished. One missile intercepted a supersonic Regulus drone at an altitude of 43,000 feet and a range of 150 miles. The second theoretically destroyed a QF-80 at an altitude of 30,000 feet and a range of 125 miles. Only in connection with the third missile was there any trouble. In this instance a ramjet failure made it necessary to destroy the missile 22 miles from the launch site. Six days later, 18 May, three more IM-99A missiles were launched, with even more success than was experienced

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on 12 May in that all three missiles completed interceptions. Two targets were Regulus drones and the third was a QF-80. Interceptions were accomplished at ranges of 78, 102 and 150 miles and at altitudes of 30,000 (QF-80) and 43,000 feet (Regulus). All six of the missiles launched during the week beginning 12 May were controlled by the Montgomery SAGE Center, 150 miles to the north of the launch site. Prior to the successes of April and May, the BOMARC test record for 1960 was one of total failure. Four times between 11 February and 7 April the test organization attempted "double shoots" of IM-99A missiles. Of the eight missiles scheduled for test firing, six experienced troubles that prevented their leaving the launcher. On the two occasions the missiles became airborne, malfunctions in the target seeker and yaw rate gyro prevented interception of the target.

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But shortly after this spate of successful test launchings, the sort of incident ADC safety personnel had been working to prevent occurred at McGuire. On the afternoon of 7 June 1960, the rupture of the helium tank on a "ready storage" IM-99A missile caused a fire which involved the TNT detonator and destroyed the missile and its nuclear warhead. There was no atomic explosion and


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radiation from the warhead was confined to the immediate vicinity of the missile shelter. Although uninformed rumor created considerable anxiety among the civilian population in the McGuire area, the accident was in reality a minor  
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one.

That the accident at McGuire should be caused by materiel failure was especially frustrating after the considerable pains which had just been taken to avoid human failure. While an April 1960 inspection of the McGuire BOMARC site had revealed that the unit was not ready to either store or maintain warheads, primarily because of weaknesses in arrangements for physical security and because of a lack of experience among warhead maintenance personnel, sufficient corrective action was taken by the 46th Air Defense Missile Squadron, New York Air Defense Sector and 26th Air Division that by 10 May 1960 the missile  
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unit had received permission to mate warheads with missiles.

Following the mating of missiles and warheads, a USAF inspection team conducted an 'operational readiness' inspection of the 46th ADMS between 22 May and 3 June 1960. The inspection team's report, made 3 June, actually foretold what happened at McGuire four days later, although there was no means of knowing, 3 June, what the inspection report

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portended. The inspection team was well pleased with the way the loading and mating crews had done their jobs. At the same time, the team pointed out that 60 per cent of the missiles considered in a combat ready storage status were overdue minor periodic inspections. These missiles had been released to operational status by granting exceptions to the inspection regulations. The team discovered, however, that when these periodic inspections were actually performed, 52 per cent of the missiles inspected required that components be replaced before they could be returned to ready status. Exceptions to periodic inspections had been granted the 46th ADMS, because the squadron possessed only 15 of the 40 items of test equipment authorized and strict adherence to maintenance standards would have severely curtailed the number of missiles in combat ready storage. The missing items of test equipment either had not been accepted from the contractors or were undergoing extensive modification at the hands of the contractors. There were, therefore, apparently a considerable number of sub-standard components among the missiles classed as combat ready on 7 June 1960. The failure which led to the fire occurred "in the forward center section of the tank, at or near the machined base

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containing the threaded inlet/outlet fitting. This failure was due to one or a combination of these conditions: (1) low cycle fatigue at points where the gage of the metal did not meet specifications, (2) unequal stress distribution in the fitting as a result of design deficiency and/or poor manufacturing and quality control practices in cutting and finishing the fitting threads which permitted localized stresses high enough to crack the material." <sup>412</sup>

The 7 June incident revealed how poorly equipped the McGuire unit was to cope with an accident that released radiation from a nuclear warhead. Within the entire New York sector only one alpha ray detector was available and it was inaccurate and unreliable. To determine the amount of alpha radiation in the vicinity of the burned warhead it was necessary to borrow an alpha detector from the New Jersey National Guard. Some of the radiation detection equipment intended for McGuire had been on order for more than a year. <sup>413</sup>

As soon as the cause of the McGuire accident had been determined, the helium pressure of all BOMARC missiles was reduced from the tactical pressure of 4,300 pounds per square inch (psi) to atmospheric pressure until all helium tanks could be inspected to determine the prevalence of

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the weaknesses discovered at McGuire. This meant that ADC had no combat capability with BOMARC until the scope of the helium tank problem was outlined and the necessary improvements were made.

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The six IM-99A launchings, of early May 1960 convinced the test organization that the launch system was reliable and that the missile could be directed by SAGE to intercept an uncomplicated target. Testing against more sophisticated targets was begun. On 27 May, an IM-99A was launched first against a QF-80 flying at 30,000 feet. When the missile was 75 miles from the launch site an attempt was made to recommit it against a Regulus flying a parallel course, but at 19,000 feet. The SAGE computer, however, rejected the recommitment as impossible in view of the existing missile-target geometry, so the IM-99A proceeded to complete the interception of the QF-80 at a range of 125 miles. A second missile was then launched against the Regulus and the interception was completed at a range of 75 miles. A similar test took place on 2 June and both the missile and SAGE performed flawlessly. In this instance, the QF-80 was again placed at 30,000 feet, but the Regulus was flown at 43,000 feet. Recommitment action was taken at a range of 65 miles and the missile



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reacted exactly according to plan. The Regulus was intercepted at 121 miles. A second missile sent against the original QF-80 target did not complete the mission because of a failure in the airborne command equipment. It was destroyed at a range of 117 miles.<sup>415</sup>

The missile's ability to discriminate between targets was tested on 9 June 1960. In this test, two QF-80 targets were stacked at 23,000 and 35,000 feet, with the lower target 12,000 feet ahead of the higher one. The missile experienced no difficulty in intercepting the lead target at a range of 115 miles. Later the same day the IM-99A was checked on its ability to maneuver and still intercept a close-in target. Here the missile made the required 45-degree turn and made a direct hit on the QF-80 target at an altitude of 20,000 feet and a range of 42 miles. Another test of the missile's short-range capability occurred 16 June when an IM-99A caught an outbound QF-80 drone (flying at 35,000 feet) at a range of 31 miles. This test of the minimum range of the missile bore out exactly theoretical computations that placed the minimum range at 31 miles.<sup>416</sup>

This fairly lengthy string of test successes was broken 24 June when two special tests resulted in failure.

  
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The first again involved the selection of the proper target from among two targets in the same area. This time the lower of the two targets was 12,000 feet to the left, 12,000 feet ahead and 1,000 feet below the higher target. Unfortunately, however, the missile climbed almost vertically to an altitude of 70,000 feet because of a malfunction in the flight control system. The ramjets lighted, but remained lit only four seconds as a result of the abnormal climb path of the missile. The missile hit the Gulf only 24 miles from the launch site. The second missile was to determine what the IM-99A could do against a descending low-altitude target. The QF-80 target was stationed at 30,000 feet, but began to descend at 1,600 feet a minute when the missile countdown reached T-6 seconds. The IM-99A was successfully launched and had approached within 2,000 feet of the target when the missile exploded through operation of the low-altitude self-destruction system designed to prevent an armed IM-99A from harming ground installations. This occurred somewhere between 10,000 and 12,000 feet.

Despite the misadventures of late June, the IM-99A gave evidence of being a reasonably reliable weapons system during the first half of 1960. Seventeen missiles were

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launched during the first half of 1960 as opposed to six during the last half of 1959. More impressive, however, was the fact that 15 of the 16 launch attempts made after 11 May resulted in an airborne missile, although the hoped-for results were not always achieved. It had been established, to everybody's satisfaction, that the IM-99A could be launched almost every time. What remained to be proven was whether or not the airborne missile could cope with a difficult target. Establishing the reliability of the launch system had been much more of a chore than had been realized in the planning days of 1949-50. To reach this point, the test organization, as of 24 June 1960, had launched 100 IM-99A missiles in a test series that stretched back to September 1952.

The successes of spring 1960 were not repeated during the remainder of the year, however. Eleven attempts were made to launch IM-99A missiles in July and August 1960, but only six actually left the pad. Five missiles aborted for various reasons -- loose wiring within the missile, failure of the missile to accept command signals, failure of radar sites to receive the telemetry signals sent out by the missile. In four of the six instances in which the missile was actually launched the target was intercepted,

  
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but the mission was not accomplished, since the purpose of the launchings was to determine the capability of the primary fuze against a target the size of a B-47. There had been continuing difficulty with the proximity fuze in the IM-99A, but the Diamond Ordnance Fuze Laboratory, manufacturer of the fuze, insisted that the difficulty lay in the size of the target. Diamond contended that the fuze had been designed with the B-47 in mind and that it was not surprising that it had trouble dealing with smaller targets such as the QF-80 and Regulus. A QB-47 drone was therefore obtained for the purpose of proving, or disproving, Diamond contentions. Tests, however, were inconclusive. In launchings on 5 and 11 August, three missiles successfully intercepted the target, but only secondary fuze action was observed. A fourth test was undertaken on 18 August, but in this case the missile, if such a situation can be imagined, was too efficient, since the missile made a direct hit on the QB-47 target. Thus the only target suitable for fuze testing was destroyed and fuze testing, of course, ended. The other two test missions attempted in July and August 1960 involved the minimum-range, low-altitude interception of a QF-80 and the relatively high-altitude (46,000 feet) interception of a supersonic Regulus target. The low altitude

  
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mission failed because the missile was launched 14 degrees to the left of the commanded azimuth and the missile's target seeker never acquired the target. During the course of the high-altitude mission, the missile lost all contact with the ground at a point 25 miles from the launch site and crashed into the Gulf of Mexico.<sup>418</sup>

Following the unsuccessful high-altitude mission of 19 August 1960, IM-99A testing entered a long dry spell. No more test missiles were launched until January 1961. The launching of 19 August also proved to be the last of the Category II test series (the phase of testing during which the development organization proved to the using organization that a combat ready weapons system was being provided). Earlier planning had called for the end of Category II testing on 15 August 1960, with Category III to begin immediately thereafter. Because all Category II objectives had not been met within the allotted time, however, the BOMARC General Officers Board, meeting at Wright-Patterson on 22 August, extended the Category II cut-off date to 1 October 1960. This concession was of little help, since it was necessary to decommission the Montgomery SAGE facility between 25 August and 19 September to permit a change of computer programs. Brief consideration was given to scheduling a few Category II shots for late September, but the idea was soon dropped.<sup>419</sup>

  
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The end of Category II testing had left a number of Category II projects incomplete. The capability and reliability of the fuze had not been verified. The ability of the IM-99A to operate as planned in an ECM environment had not been established. The ability of the missile to operate in all types of weather had not been proven. Its reliability after tactical maintenance recycles and extended periods of ready storage had not been fully checked. It was necessary to move these test items over into the Category III phase of testing, although Category III was primarily intended as a demonstration of the tactical capability of the IM-99A in a normal squadron environment.


The last quarter of 1960 was spent in getting test equipment and missiles ready for the Category III firing program. Special effort was applied to bringing the test equipment to the point of effectiveness where it could be maintained and operated without the constant presence of Boeing engineers. The Contractor Review Program, established in early 1960 to insure the improved reliability of the test equipment used in determining the operational capability of missiles, was virtually complete by the end of 1960. Although much was done during this period, ADC,



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in early 1961, could foresee three major problems that might act to prevent prompt and successful completion of Category III testing. One was the continuing vulnerability of the IM-99A to electronic countermeasures. ARDC indicated that steps could probably be taken to make the target seeker put up a stronger fight against ECM if ADC money and manpower was available to do the job. ARDC, however, planned to put forth no effort in this regard. The second problem dealt with Boeing assistance during Category III. Although Category III was intended to show how Air Force personnel could handle the operation and maintenance of the missile, there were sure to be times when Boeing help would be required. In August 1960 the BOMARC Weapons System Project Office (AMC) had assured the BOMARC General Officers Board that \$100,000 would be available to pay for Boeing help during Category III. But in December 1960 ADC was informed that no funds were available to pay Boeing after the end of 1960. Finally, ADC needed help in obtaining "C" band beacons for its QF-80 drones. Only one such beacon was available and should it be lost by accident, the special drone tracking radars on the Gulf Test Range would no longer be able to mark the progress of the QF-80 drones to be used in Category III. Both ARDC and AMC indicated that no funds were available for additional "C" band beacons.

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In spite of ADC misgivings, however, Category III testing of the IM-99A was almost completed during 1961, with only three test missiles remaining to be launched at the end of the year. The necessary "C" band beacons were available when needed and money was found to pay the necessary Boeing technicians. No special effort was made to provide a greater counter-ECM capability for the IM-99A, however. This effort was reserved for the IM-99B.

Twenty-five IM-99A test missiles were launched during 1961. These were mostly missions against high-level or low-level maneuvering targets, both subsonic and supersonic. The purpose was to prove that SAGE could direct to a successful interception missiles which had been maintained and made ready by uninformed technicians similar to those who manned ADC's tactical sites in the northeastern United States.

While there were the usual abortive missions because of defective components and drone problems, fifteen of the 25 launches made during 1961 experienced some degree of success. This was a greater percentage of successes than had been realized during earlier periods of testing. One-hundred-thirty-one IM-99A test missiles had been launched by the end of 1961.

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Despite the greater degree of test success during 1961, there were still serious doubts about the liquid-fuel boost system of the IM-99A as the official test program drew to a close. Throughout the program there had been periodic failures, including the fire at McGuire in June 1960, traceable to the boost system. These failures persisted through 1961. On 16 February 1961 it was necessary to destroy a missile only 200 feet from the launcher when the boost system failed only a few seconds after the launch process began. Similar failures occurred on 3 March and 21 March. On the latter occasion the missile caught fire and hit the water a half-mile from the launcher. Investigation of this accident revealed that a faulty shock absorbing crush cone had brought about helium starvation within the missile and had resulted in the fire and the failure of the mission. Metallurgical test of all crush cones on all missiles -- test or tactical -- was directed and it was believed that this problem was solved. <sup>422</sup>

Meanwhile, the problem of the unreliable boost system was being attacked from another direction. Study of the question of helium pressure following the fire of 7 June 1960 forced the conclusion that it was impractical to attempt to maintain a constant helium pressure of 4,300

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feet per square inch (psi) within combat ready missiles. After months of research it was decided that the best solution was to maintain pressure within the missile at a nominal 3,000 psi, while placing within each missile shelter a "top off" tank containing 10 cubic feet of helium at a pressure of 7,000 psi. In the last 30 seconds before launching the helium from the "top off" tank would raise the pressure of the helium within the missile to the required 4,300 psi. This awkward procedure, known as Engineering Change Proposal (ECP) 391-4, was apparently the best solution available. It was first tested in an IM-99A missile launched 29 June 1961. This initial test was a success. The missile was launched without incident and proceeded to intercept the target. This single test was by no means conclusive, however, since several missiles without ECP 391-4 had completed successful missions during the weeks immediately preceding the initial test of the ECP 391-4 missile.

The completion of several successful test interceptions after the crush cone inspection of late March and the initial affirmative test of the helium system modification in late June created a cautious optimism over the boost system of the IM-99A. This optimism was not severely

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shaken when a missile launched on 8 September fell back into the shelter and the shelter was extensively damaged in the resulting fire, because there was a completely logical explanation for the accident. The cause was determined to be a defective diaphragm in the helium control valve. The grooves in this part had been cut to only a depth of .068 inches instead of the specified .094 inches. This malfunction was not likely to be repeated if the diaphragms were correctly machined. Therefore, since none of the remaining Category III missiles contained helium control valves with diaphragms from the defective lot, another test missile was launched on 26 September 1961. This missile, equipped with special instrumentation to measure helium pressure at various points, performed perfectly, making a direct hit on an inbound supersonic Regulus target at a range of 125 miles and an altitude of 20,000 feet.<sup>424</sup>

Nevertheless, the USAF Deputy Inspector General for Safety recommended, 29 September 1961, that further testing of the IM-99A be halted until there was reasonable assurance that the main helium release valve was safe. The successful launching of 26 September was not regarded as reasonable assurance. The test organization protested that the burst diaphragm was an isolated incident that had occurred only

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once in 66 launchings from Santa Rosa Island and was not likely to happen again. Because of this fact, and since the IM-99A test program was so close to completion, permission to continue was requested. The USAF Inspector General answered that its comment on the situation had constituted a recommendation, not a prohibition, and that ADC was free to continue with testing if it was convinced that further testing was safe.

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Armed with this somewhat reluctant clearance from the USAF Inspector General, the test organization scheduled another test launching for 17 October. On this occasion, unfortunately, the experience of 8 September was repeated. The missile accepted the boost fire signal and the launch sequence appeared normal until ignition of the boost motor. At this point a large cloud of acid fumes was observed and the missile was enveloped in flames. It did not lift off the launching pad. Subsequent investigation revealed that an abnormal degree of helium pressure was present in the missile and that this was the cause of the fire and failure to launch. This incident, coming so soon after the 8 September accident, convinced everybody concerned that there was still something seriously wrong with the boost system of the IM-99A. The test organization

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noted that this forced the IM-99A tactical units (of which five were operational) to live with a serious problem of unknown proportions. In this connection, it was also noted that a large number of the Emergency Unsatisfactory Reports submitted by tactical units involved components of the propulsion system.<sup>426</sup>

While this combination of serious propulsion system failures caused ADC to direct a temporary cessation of test activities, it, at the same time, asked the Aeronautical Systems Division (ASD) of the Air Force Systems Command (AFSC) for authority to proceed with the launching of the five IM-99A missiles remaining in the Category III test series. ADC pointed out that suspension of the test program for several months while the boost system was being studied would seriously disrupt ADC test plans. ASD agreed to the continuation of testing on the grounds that nothing had happened during September and October to prove that there was a design deficiency in the propulsion system. ASD was convinced that the problems could be traced to lack of quality control in the manufacture of components.<sup>427</sup>

Two IM-99A test missiles were therefore launched on 17 and 22 November. The first reacted according to plan and intercepted a QF-104 target at a range of 120 miles

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and an altitude of 35,000 feet. The second, however, experienced a power failure shortly after launching and was destroyed after only 21 seconds of flight.<sup>428</sup>

Meanwhile, a new complication arose to prevent the completion of IM-99A testing in 1961. In early September, the Air Force Special Weapons Center (AFSWC) announced that an environmental sensing device had been designed for the Mark 40 warhead of the IM-99A and that two IM-99A missiles would be required for testing the device (known as Modification 2). ADC replied that all remaining IM-99A test missiles were required for Category III projects and suggested that IM-99B missiles be used for the MOD 2 project. AFSWC insisted, however, that only the IM-99A would do, so ADC agreed to make two missiles available for this purpose. The AFSWC testing required installation of special instrumentation and as a result it was not possible to launch IM-99A missiles between 22 November 1961 and 1 February 1962.<sup>429</sup>

The 27th, and last, Category III missile was launched 10 May 1962, one of two Category III missiles launched after 1 January 1962. In keeping with the approximately 50 per cent success rate experienced during the later stages of BOMARC testing, only one of the last two IM-99A Category

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III missiles made a successful interception. On 1 February, however, the IM-99A made a direct hit on a supersonic QF-430 104 at a range of 120 miles and an altitude of 35,000 feet.

One other IM-99A test missile was reserved for a demonstration against the GAM-77 (Hound Dog) missile carried by the B-52 bomber. This demonstration was discussed as early as the autumn of 1961, but, for one reason and another, was delayed for several months. It finally took place on 27 June 1962, but proved nothing, because the BOMARC experienced a power failure during the mid-course phase of flight and had to be destroyed before the point of interception was reached. This mission was not a valid demonstration of the capability of the IM-99A versus the GAM-77. Whether or not the demonstration would be re-scheduled had not been determined by October 1962.<sup>431</sup>

One-hundred-thirty-four missiles and nearly 10 years were expended in testing the IM-99A (although early test missiles were known simply as BOMARC and bore no numerical designation). Even so, the IM-99A was not a fully proven weapon, although it had demonstrated the ability to destroy a supersonic target when all subsystems worked according to specifications.

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## THE ADVANCED BOMARC -- IM-99B

Coincident with the operational readiness of the first IM-99A squadron at McGuire on 1 September 1959, testing of IM-99B missiles began at Cape Canaveral. Early test experience was not conducive to optimism with regard to the reliability of the IM-99B, since the five missiles launched from Cape Canaveral by the end of 1959 were all counted failures because of malfunctions in the ramjet engines.<sup>432</sup>

When Secretary of Defense Thomas S. Gates, Jr., went before the House Appropriations Committee in January 1960 to defend the defense budget for Fiscal 1961, confidence in BOMARC was at a low ebb. Although Mr. Gates, Dr. Herbert F. York, Director of Defense Research and Engineering, and General Thomas D. White, Air Force Chief of Staff, attempted to put the best possible face on the development testing of the IM-99B, it was obvious that the Committee was not impressed. The Department of Defense at that time was asking for 421 million for BOMARC in the Fiscal 1961 budget. This amount was required to provide a force<sup>433</sup> of 18 BOMARC squadrons (including two in Canada).

Possibly because of the obvious reluctance of Congress to spend large additional sums on an interceptor

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missile whose reliability was being seriously questioned, USAF returned to Congress on 24 March 1960 with a revised budget proposal that proposed a drastic cut in procurement of IM-99B missiles -- from 421 million to 40 million in Fiscal 1961. According to the BOMARC program presented to Congress in March 1960, only the northeast corner of the United States would be protected by BOMARC. The reasons given by USAF for the curtailment of the IM-99B were various. Increasing Soviet emphasis on intercontinental ballistic missiles, against which the BOMARC was impotent, was mentioned. The necessity of diverting BOMARC production funds to projects of higher priority (such as the Atlas and Titan intercontinental missiles) was underscored. When pressed, the USAF representatives admitted that nagging technical difficulties which had continued to delay operational use of BOMARC were also factors. The general impression left by USAF and Department of Defense testimony was that BOMARC had been outdistanced in the technology race, but that it could be put to good use in defending the northeastern United States against the still-potent Soviet bomber fleet.

The House of Representatives, however, could not be convinced that any further expenditures for BOMARC were

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justified and removed all BOMARC funds from the Department of Defense appropriation bill. All was not yet lost, though, because the Senate still had to take action on the appropriation bill. It was against this background that the Undersecretary of the Air Force, Dr. Joseph V. Charyk, "inquired as to the possibility of getting some successful BOMARC B firings before the end of May." <sup>435f</sup>

The first successful IM-99B test had already taken place at Santa Rosa on 13 April 1960. On this occasion the booster lifted the missile to 65,000 feet and the ramjets lighted properly. At a range of 100 miles the missile was successfully directed to descend to 40,000 feet. It was then commanded to proceed to a pre-determined interception point, although no target was involved, and obeyed perfectly. This was the eighth test launching of the IM-99B and the first from Santa Rosa. The first seven test launchings, from Cape Canaveral, had been considered failures because of ramjet malfunctions. It proved possible to fulfill Dr. Charyk's desire on 17 May when a second IM-99B was launched from Santa Rosa. This missile successfully executed virtually the same maneuvers required of the missile launched 13 April, except that the May missile flew 236

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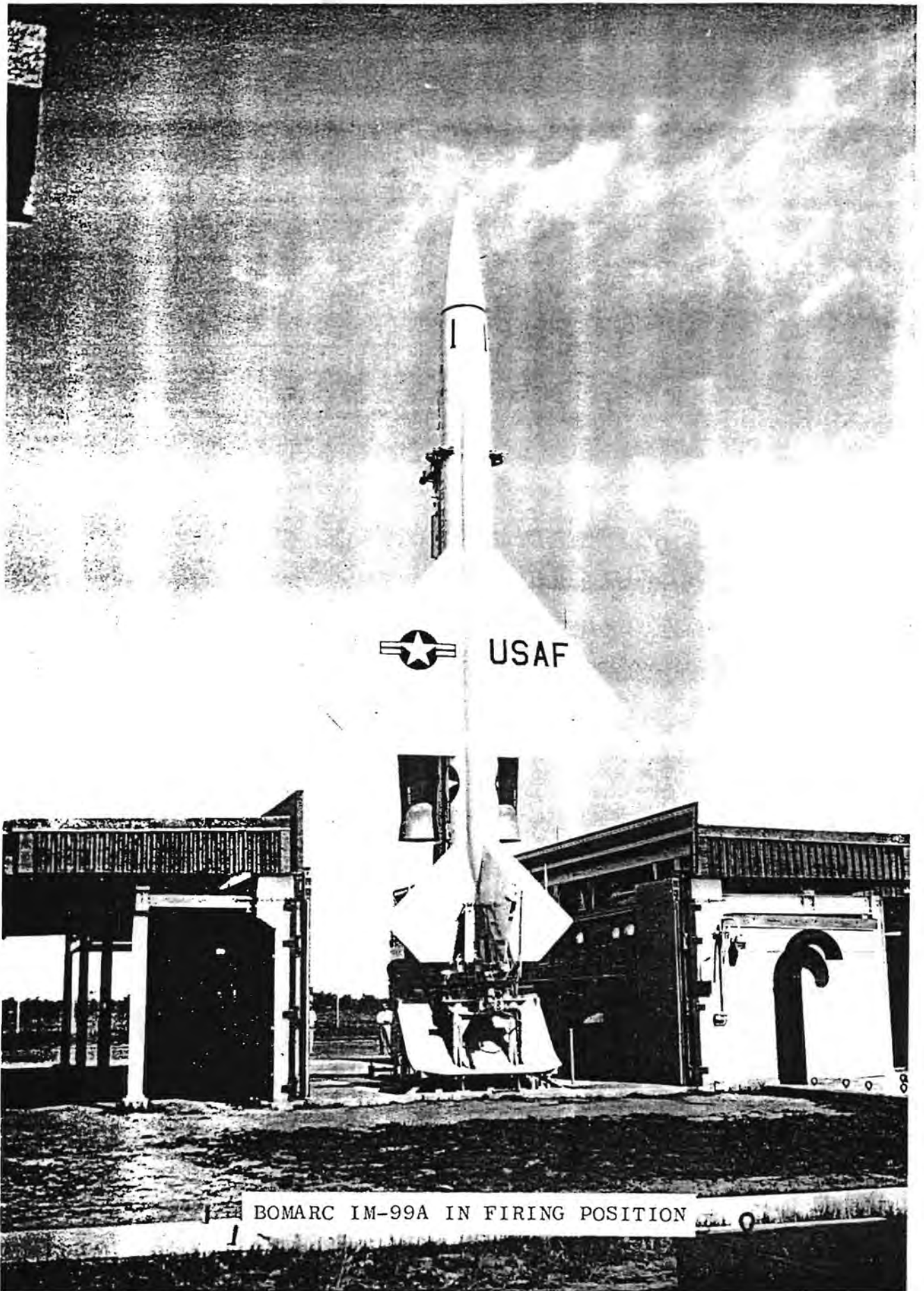
miles before impact with the water while the April missile  
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was destroyed at a range of 125 miles.

Whatever the reason -- the spate of successful test launchings, the bitter results of the Paris Summit talks, or the U-2 incident -- the Senate voted to restore funds for the IM-99B. In the conference called to reconcile the differences between the House and Senate versions of the appropriation bill, the House receded somewhat from its no-money-for-BOMARC stand and the compromise bill which re-  
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sulted was passed 30 June 1960.

Following the successful IM-99B launchings of 13 April and 17 May 1960 and the subsequent Congressional decision to proceed with the procurement of a limited number of IM-99B missiles, 63 more test missiles were launched by the end of September 1962. Thirteen of these missiles were sent aloft during the last half of 1960 and although the percentage of successful missions was higher than it had been at Cape Canaveral during late 1959 and early 1960, when none of the seven missiles launched had operated satisfactorily, the success rate was still low. Only five of the 13 missiles launched from Santa Rosa between July and December 1960 were considered successful. Certain milestones were passed, however. On 8 July 1960, an IM-99B

  
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BOMARC IM-99A IN FIRING POSITION



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intercepted a supersonic Regulus target at an altitude of 35,000 feet and a range of 148 miles. This was the first time the IM-99B had been sent against a target and the first time an active target seeker and fuze was used.  
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Then it was nearly six months before the success against a target was repeated. Two IM-99B test missiles were launched in August 1960, but both were failures, because in both instances the missile failed to receive mid-course commands and therefore did not know where to look for the target. At this point IM-99B testing was halted temporarily while the IM-99B test range (400 miles) was tested. Early IM-99B testing was conducted on the IM-99A range, which was only 150 miles long. The launching of IM-99B test missiles (after a 30-day delay caused by Hurricane Donna) was resumed on 14 October, but during October and early November targets were not used, since the primary purpose of the launchings was to test the instrumentation of the lengthened range. Four missiles were used for this purpose. The tests were not overwhelmingly successful. In two instances the missiles responded to directions from a down-range ground-to-air transmitter at MacDill AFB in the Tampa area, but the two other missiles

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failed to give similar responses. Although this brief test did not establish the complete reliability of down-range instrumentation, the business of testing IM-99B missiles against live targets was resumed in late November 1960.<sup>439</sup>

At this stage of the IM-99B testing program, serious misgivings were beginning to be entertained about the reliability of the target seeker. Only twice during the test program to that point had the target seeker appeared to operate normally and considerable difficulty was being experienced in checking out the target seeker on test equipment. This problem was underlined during the course of launchings on 23 November, 2 December and 16 December 1960 when target seeker failures prevented the completion of successful missions. On the other hand, the target seeker operated normally during two other missions in December and interceptions were completed. The successful interception of a QB-47 drone on 16 December was the second such interception of a live target in IM-99B test history. The initial interception (8 July 1960), however, had involved a supersonic target.<sup>440</sup>

The doubts about the target seeker were not dispelled by IM-99B testing in early 1961. Although three successful

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interception missions were run in late January and early February (equalling the total number of successful interceptions achieved in all IM-99B testing to that time), target seeker problems emerged again in March. The first three test missiles launched in March failed to complete the mission because of erratic operation of the target seeker. The Contractor's Functional Demonstration (a part of Category II testing) in which Boeing was expected to demonstrate the reliability of the weapons system was halted in the middle of March while the design of the target seeker was reviewed.

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A redesigned target seeker, known by the complicated title of Low Velocity Target Capability Modified Target Seeker, or LVT, was first used in a Category I missile launched on 30 March 1961. Everything worked well and a subsonic QB-47 target at 35,000 feet was intercepted at a range of 205 miles. Because of the availability, and apparent reliability, of the LVT target seeker, the Contractor's Functional Demonstration (CFD) was resumed on 18 April. But experience with this missile and the preceding CFD missile launched on 26 April revealed a problem which temporarily overrode the priority of the target seeker problem. Both launchings were failures, because ramjets failed to light. Both missiles

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crashed into the Gulf shortly after launching. Although the cause of these failures was never precisely determined, it was decided that the effect of humidity on the ramjet flares was probably responsible. Action was therefore taken to protect the flares from humidity.

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The difficulty with the IM-99B target seeker appeared to have been surmounted in May 1961, when the test organization recorded five successful missions in as many tries, by far the best performance yet offered by the IM-99B. Four of the five missiles were equipped with the LVT target seeker and all types of missions were flown. QB-47 targets were intercepted at altitudes of 10,000 20,000 and 35,000 feet and at ranges of 50, 70, 163 and 300 miles. The ability of the improved target seeker to cope with close-in targets (50 and 70 miles) was particularly impressive, because the original target seeker had never been able to lock-on such targets. In addition, the IM-99B also proved that it could intercept a supersonic Regulus target at an altitude of 55,000 feet. During this period the test organization also accomplished, on 23 May, the first completely successful triple launching in BOMARC history.

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In all, 20 IM-99B test missiles were launched during the first half of 1961. Exactly half completed missions that were considered successful. Of this number, five were concentrated in the month of May. Target seeker and ramjet failures accounted for seven of the abortive missions. At mid-1961 the Category I test program for the IM-99B was virtually complete, with only two missiles remaining to be launched. Category II testing began in January 1961 and was at about mid-point, with 11 missiles yet to be launched. It was expected that Category II testing would be complete by the end of 1961. Category III testing had not yet started. Twenty-six missiles were allocated for Category III testing.

Although the IM-99B test program had taken an abrupt turn for the better in May 1961, a new worry assailed the test organization in late June. An analysis of low altitude missions indicated the possibility of structural failure in the vertical stabilizer area of the IM-99B missile. A campaign to reduce the weight of the IM-99B had resulted in the removal of eight pounds of metal from the rudder and this was suspected as the cause of the sudden rash of structural failures, though Boeing insisted that company tests proved the effect on missile performance



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was negligible. In view of this conflicting information, ASD directed, 22 June 1961, that missions below 18,000 feet be postponed until the true cause of structural failure could be determined.

Originally three heavily instrumented missiles were allocated to this test within a test, although six missiles and two months of valuable testing time were eventually expended in reaching a solution. The first of the instrumented missiles, launched 13 July, did not provide much information, because it exploded at 14,000 feet, shortly before completion of the interception planned at 5,000 feet. Whether structural failure was at fault was not determined, even though most of the tail section was eventually salvaged from the Gulf. Experience with the second of these missiles, launched 27 July, was nearly as frustrating, since the missile again disintegrated, this time shortly after interception of the target at an altitude slightly less than 20,000 feet. There was time for the instrumentation on the missile to prove that overheating was not the cause of the trouble, but not much information was obtained with regard to tail flutter. Visual observation of this mission, however, indicated that structural failure had probably occurred. A second mission the same day provided support for the visual observations. On this

  
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occasion the missile held together long enough to prove that there was a severe flutter in the tail before the missile came apart.  
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On the basis of the information received from these three instrumented missiles, ASD proposed to solve the flutter problem by adding a mass balance weight to the rudder of the IM-99B. A mass balanced missile was launched 14 August, but the test was inconclusive because a loose wire in the aileron position potentiometer caused the missile aileron to operate erratically and forced destruction of the missile when it was only five miles from the launcher. A similar mission of 17 August was also inconclusive because the test missile made a direct hit on the QB-47 target at an altitude of 5,000 feet and a range of 50 miles. On 7 September, however, conclusive evidence of the suitability of mass balancing as the answer to the tail flutter problem was obtained. The missile successfully intercepted a QB-47 target at an on-the-deck altitude of 1,500 feet and a minimum range of 20 miles. The missile retained its structural integrity until it hit the water. Action was then taken to modify all IM-99B missiles with the necessary mass balance weights.  
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Since the solution of the tail flutter problem required a number of low altitude missions, the finding of a satisfactory answer made it possible to turn to high altitude testing. The Regulus target was not capable of reaching the 80,000-foot altitude desired by the test organization, however, so the high-altitude test missions of 21 and 30 September had to be regarded as failures, although there was no indication of malfunction in the missiles involved. With the failure of the mission of 30 September 1961, there was an end to high-altitude testing, because the Chance-Vought contract for the support of Regulus operations expired 30 September. The QB-47 and QF-104 remained as BOMARC targets. The QF-104 flew its first target mission on 17 October 1961.

With the target seeker and tail flutter problems in the past, the percentage of successful test missions should have increased, but this logical progression did not occur. Instead, a perplexing series of control system malfunctions began. Three of the last four IM-99B test missiles launched in 1961 failed to complete the planned mission. The missile launched 17 October rolled abnormally during the early stages of flight and crashed 12 miles from the launching site. The mission of 21 November failed when the flight

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control system directed the missile to engage in such violent maneuvers that the missile disintegrated at 30,000 feet. On 13 December the test missile rose to 71,000 feet, transitioned to level flight then went into a series of rolls that ended with an uncontrolled dive into the Gulf. Oddly enough, these failures could not be traced to any particular subsystem, so engineering personnel were at somewhat of a loss, at the end of 1961, as to how to proceed in correcting what was obviously a serious situation. A more stringent pre-flight testing of missiles was directed, but localization of the problem required additional test flights. Since only a few test missiles remained, it was imperative that the exact cause of these failures be determined early in 1962.

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Structural failures, target problems and control system malfunctions gave the IM-99B test program a low success rate during the last half of 1961. Of the 16 missiles launched during that period, only seven managed to intercept the target. This high percentage of abort missions was disturbing, because the test program was nearing a end. Category I testing was completed in September 1961 and earlier plans called for completion of Category II testing in December. Five missiles remained to be launched at the end of the year.

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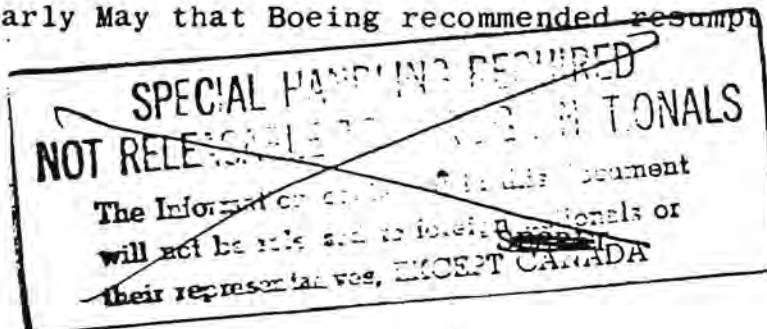
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Test successes came no oftener during the first nine months of 1962. Fourteen IM-99B test missiles were launched between 1 January and 30 September 1962. Only five were considered successful. While the last four launches of 1961 were failures, the first three launches of 1962 (all involving Category II missiles) resulted in interceptions. That of 21 March 1962 was especially noteworthy because the target was an unaugmented QF-104 drone. The F-104, when it was not augmented with a radar beacon to give it the aspect of a much larger aircraft, was an extremely small target, although ADC was of the opinion that the operational BOMARC should be capable of dealing with a target of this size. <sup>449</sup>

Between 21 March and 30 September 1962, however, the IM-99B test program was an almost unrelieved catalogue of failure. Only two successful missions were flown during this six-month period. Missiles launched on 23 March and 8 April failed to complete interceptions because of power problems within the missiles. Since the two malfunctions were very similar in nature, the test organization suspended testing, ostensibly until the contractor could determine the nature of the trouble. The precise difficulty was not immediately located, but enough progress had been made by early May that Boeing recommended resumption of testing



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and the test organization agreed. The 20th, and last, launching of the Category II test series was therefore accomplished on 16 May. Category II testing ended on a disappointing note. The missile rose at such a steep angle that the ramjet flares were blown out and the missile crashed into the Gulf only 34 miles from the launcher.

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At this point in the test program, ADC began to have doubts that it would be possible to complete the series of experimental launchings by the previously announced date of 1 November 1962. For example, only one of eight scheduled launchings was accomplished in May. Part of the trouble was the inability of AFSC to provide the necessary high-performance drones for target purposes. AFSC promised extraordinary action in this regard and therefore did not think it necessary, at that time, to change the closing date of the test program.

As a result of this extraordinary AFSC action, it proved possible to launch four test missiles in June, although the success rate was not encouraging. Of the two successes experienced between March and September, the first occurred 5 June 1962 when an IM-99B passed within 18 feet of a maneuvering QB-47 at an altitude of 35,000 feet and a range of 250 miles in an ECM environment. The program

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fuze fired normally. The other three missiles operated erratically, however, and in all three cases the power supplies associated with the target seeker were suspect. Since the problem concerning electrical power within the missile obviously had not been solved, no test launches were undertaken during July while engineers continued  
452  
their study of the matter.

Category III testing of the IM-99B was resumed on 10 August 1962, but the results were not encouraging. On this occasion, the target was an unaugmented QF-104 at 48,000 feet. The mission failed for several reasons other than the target seeker, although there was doubt that the target seeker was capable of handling a target as small as the unaugmented QF-104. This feeling was prevalent in the test organization despite the 21 March success against  
453  
an unaugmented QF-104.

Because time for the completion of the test program was growing short, Headquarters ADC took over direct control of the Category III test program in August 1962. ADC announced that no further BOMARC missions would be devoted solely to SAGE testing and that missions having less than a 95 per cent probability of success would not be undertaken. Later, ADC spelled out the types of test missions

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that would be flown: (1) head-on attacks against a QB-47 at 35,000 feet, (2) attacks against a QB-47 in a 27-degree turn at 35,000 feet and (3) head-on attacks at 35,000 feet against a QF-104 augmented with a 9-inch Luneberg lens. Progressive successful achievement of such missions, ADC said, would result in permission to attempt interception of an unaugmented QF-104 at 48,000 feet. Meanwhile, AFSC bowed to the inevitable and extended the date for completion of BOMARC testing from 1 November 1962 to 1 January 1963.

The first mission under the new ADC dispensation occurred 31 August when an IM-99B made a direct hit on a non-maneuvering QB-47 at a range of 250 miles and an altitude of 35,000 feet. A deviation from the schedule established in August was then allowed to permit a test against a non-maneuvering augmented QF-104 rather than a maneuvering QB-47. Similar success was not experienced with the launching of 13 September, however, because the missile overshoot the target as the result of a malfunction in the microwave oscillator of the target seeker. On the first time such a failure had ever occurred. A test mission against a QF-104 was flown 27 September. In this case the interception was made, but the target was not destroyed by fire.

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If the school of thought that believed the existing BOMARC fuze could not be effective against the unaugmented F-104, was correct, ADC was not sure it was getting the air defense missile advertised. "Gravely concerned" over this situation, ADC, in early October 1962, asked the Aeronautical Systems Division of AFSC to take action to improve the fuze and make every effort to complete the necessary improvement in time for testing before the Category III test program was completed at the end of 1962. Eight Category III test missiles remained to be launched as of 1 October 1962.<sup>456</sup>

After 10 years of testing, during which 206 missiles (as of 1 October 1962) were launched, the limits of the BOMARC's effectiveness as a weapons system were becoming clear. Long testing had resulted in a launch system that was reasonably reliable. By late 1962 a BOMARC commander could have confidence that when the SAGE sector ordered the launching of a missile the missile would usually be launched. But he could not be nearly so confident that the launched missile would intercept the target. On the basis of testing through September 1962 there was only about a 50-50 chance that the interception would be completed. Development work on missile components was continuing and the combat capability of the BOMARC would undoubtedly improve, but as of October 1962 it was not a completely reliable weapon.

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386. Msg, AFIRSAR-100, AFIR, Atlanta to Det 1, ARDC, 23 Jan 1958 [Doc 627 to Hist of ADC, 1958]; Msg, ADORQ-C 130, ADC to USAF, 3 Feb 1958 [Doc 628 to Hist of ADC, 1958]; Msg, ADORQ-C 173, ADC to APGC, 13 Feb 1958 [Doc 629 to Hist of ADC, 1958]; Msg, ADORQ-C 322, ADC to 73 AD, 6 Apr 1958 [Doc 630 to Hist of ADC, 1958]; Msg, MCXN 1408, AMC to ADC, 28 Apr 1958 [Doc 631 to Hist of ADC, 1958]; Msg, ADORQ-C 345, ADC to 73 AD, 21 May 1958 [Doc 632 to Hist of ADC, 1958]; Msg, ADCST-O 8525, ADC to USAF, 19 Nov 1958 [Doc 633 to Hist of ADC, 1958]; Msg, 73DO 1323L, 73 AD to ADC, 20 Nov 1958 [Doc 634 to Hist of ADC, 1958]; Msg, ADLPR-C 58-103, ADC to USAF, 10 Dec 1958 [Doc 635 to Hist of ADC, 1958]; Msg, 73DO-OT-1415M, 73 AD to ADC, 18 Dec 1958 [Doc 636 to Hist of ADC, 1958]; Msg, LMDN 3854, ASC (AMC) to ADC, 19 Dec 1958 [Doc 637 to Hist of ADC, 1958]; Msg, PGYU 558C, APGC to AMC, 23 Dec 1958 [Doc 638 to Hist of ADC, 1958]; Msg, ADCST-O 8587, ADC to USAF, 31 Dec 1958 [Doc 639 to Hist of ADC, 1958]; Colorado Springs Gazette-Telegraph, 17 Jan 1959; Msg, ADORQ-C 272, ADC to USAF, 7 Apr 1958 [Doc 660 to Hist of ADC, 1958]; Msg, ADORQ-C 328, ADC to USAF, 8 May 1958 [Doc 661 to Hist of ADC, 1958]; Msg, AFD RD-AD 52715, USAF to ADC, 30 Jun 1958 [Doc 662 to Hist of ADC, 1958]; Msg, ADLSI-D 409, ADC to Det 1, ARDC, 14 Jul 1958 [Doc 663 to Hist of ADC, 1958]; Msg, RDZSDB-7-31004-E, Det 1, ARDC to ADC, 31 Jul 1958 [Doc 664 to Hist of ADC, 1958].

387. Msg, RDXSMB 30002-E, Det 1, ARDC to USAF, 2 Jan 1958 [Doc 674 to Hist of ADC, 1958]; Msg, ADORQ-C 37, ADC to USAF, 9 Jan 1958 [Doc 675 to Hist of ADC 1958]; Msg, AFD RD-AD 56579, USAF to ADC, 13 Feb 1958 [Doc 676 to Hist of ADC, 1958]; Msg, ADORQ-C 269, ADC to USAF, 3 Apr 1958

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[Cont'd] [Doc 677 to Hist of ADC, 1958]; Msg, AFDRQ-SC 59039, USAF to ARDC, 3 Oct 1958 [Doc 679 to Hist of ADC, 1958]; Msg, RDZSD 31382-E, Det 1, ARDC to USAF, 31 Oct 1958 [Doc 680 to Hist of ADC, 1958]; Msg, ADLSI-B 560, ADC to Det 1, ARDC, 1 Dec 1958 [Doc 681 to Hist of ADC, 1958]; Msg, AFMPP-EQ-3 52224, USAF to ARDC, 19 Dec 1958 [Doc 682 to Hist of ADC, 1958].

388. BOMARC Flight Test Summary, ADC, n. d., pp. 48-50 [HRF].

389. Ibid., pp. 54-55; Msg, RDZSDB-31347-E, Det 1, ARDC to USAF Rqmts Interchange Off (Ottawa), 24 Oct 1958 [Doc 626 to Hist of ADC, 1958].

390. BOMARC Flight Test Summary, ADC, n. d., p. 53 [HRF].

391. Ibid., pp. 48-59.

392. Ibid., p. 60; Msg, 73CP-SS X2A, 73 AD to ADC, 7 Jan 1959 [Doc 503 to Hist of ADC, Jan-Jun 1959]; Msg, 73CP X5A, 73 AD to ADC, 13 Jan 1959 [Doc 504 to Hist of ADC, Jan-Jun 1959]; Msg, ADCST-O 8000, ADC to USAF, 21 Jan 1959 [Doc 505 to Hist of ADC, Jan-Jun 1959].

393. Msg, 73DO-OT-X85A, 73 AD to ADC, 28 Jan 1959 [Doc 506 to Hist of ADC, Jan-Jun 1959]; Msg, RDZSDB-30125-E, ARDC, Det 1 to ADC, 30 Jan 1959 [Doc 507 to Hist of ADC, Jan-Jun 1959]; Msg, 73DO-OT X113B, 73 AD to ADC, 4 Feb 1959 [Doc 509 to Hist of ADC, Jan-Jun 1959]; Msg, PGYU 6CR, APGC to ARDC, Det 1, 5 Feb 1959 [Doc 510 to Hist of ADC, Jan-Jun 1959]; Msg, 73DO-OTM X151B, 73 AD to ADC, 10 Feb 1959 [Doc 511 to Hist of ADC, Jan-Jun 1959]; Msg, 73DO-OT X174B, 73 AD to ADC, 18 Feb 1959 [Doc 512 to Hist of ADC, Jan-Jun 1959]; Msg, 73DO-OTM X200B, 73 AD to ADC, 25 Feb 1959 [Doc 513 to Hist of ADC, Jan-Jun 1959].

394. Msg, 73DO-OTM X218C, 73 AD to ADC, 3 Mar 1959 [Doc 514 to Hist of ADC, Jan-Jun 1959]; Msg, PGG 107C, APGC to ARDC, Det 1, 4 Mar 1959 [Doc 515 to Hist of ADC, Jan-Jun 1959]; Msg, SIAC-3-116-E, ADSID to ADC, 5 Mar 1959 [Doc 516 to Hist of ADC, Jan-Jun 1959]; Msg, 73DO-OTM X259C, 73 AD to ADC, 10 Mar 1959 [Doc 517 to Hist of ADC, Jan-Jun 1959]; Msg, RDZSDB-30320-E, ARDC, Det 1 to USAF Rqmts Interchange Off, RCAF, 16 Mar 1959 [Doc 518 to Hist of ADC, Jan-Jun 1959].

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395. Msg, 73DO-OTM X283C, 73 AD to ADC, 17 Mar 1959 [Doc 519 to Hist of ADC, Jan-Jun 1959]; Msg, 73DO-OTM X316C, 73 AD to ADC, 24 Mar 1959 [Doc 520 to Hist of ADC, Jan-Jun 1959]; Msg, 73DO-OTM X352C, 73 AD to ADC, 31 Mar 1959 [Doc 521 to Hist of ADC, Jan-Jun 1959]; Msg, 73DO-OTM X404D, 73 AD to ADC, 7 Apr 1959 [Doc 523 to Hist of ADC, Jan-Jun 1959]; Msg, 73DO-OTM X403D, 73 AD to ADC, 7 Apr 1959 [Doc 524 to Hist of ADC, Jan-Jun 1959]; Msg, ADMLP-CD 491, ADC to APGC, 7 Apr 1959 [Doc 525 to Hist of ADC, Jan-Jun 1959].

396. Msg, 13 CR, APGC to USAF, 13 Apr 1959 [Doc 526 to Hist of ADC, Jan-Jun 1959]; Msg, RDZSDB 30558E, ARDC to USAF Rqmts Interchange Off, RCAF, 7 May 1959 [Doc 527 to Hist of ADC, Jan-Jun 1959].

397. Msg, PGYU 15 CR, APGC to USAF, 25 Apr 1959 [Doc 529 to Hist of ADC, Jan-Jun 1959].

398. Msg, MOODC 632, MOADS to 32 AD, 5 Jun 1959 [Doc 536 to Hist of ADC, Jan-Jun 1959]; Msg, MOODC 709, MOADS to 32 AD, 24 Jun 1959 [Doc 537 to Hist of ADC, Jan-Jun 1959]; Msg, PGYU 22 CR, APGC to USAF, 24 Jun 1959 [Doc 538 to Hist of ADC, Jan-Jun 1959].

399. Msg, AFDRD-AD 51637, USAF to Dir of Sys Mgt, ARDC, 3 Jun 1959 [Doc 539 to Hist of ADC, Jan-Jun 1959].

400. Msg, RDXSDB-30524-E, Dir of Sys Mgt, ARDC to USAF, 29 Apr 1959 [Doc 540 to Hist of ADC, Jan-Jun 1959]; Msg, ADCMA 2261, ADC to USAF, 19 May 1959 [Doc 541 to Hist of ADC, Jan-Jun 1959]; Msg, ADOOP-S 18-F-38, ADC to USAF, 11 Jun 1959 [Doc 542 to Hist of ADC, Jan-Jun 1959]; Msg, PGYU 257C, APGC to ADC, 24 Jun 1959 [Doc 543 to Hist of ADC, Jan-Jun 1959].

401. 4751 ADW to Joint BOMARC/SAGE Test Staff, "Status Report, as of 10 September 1959," 14 Sep 1959 [Doc 220 to Hist of ADC, Jul-Dec 1959]; Msg, PGYU 31CR, APGC to USAF, 11 Sep 1959 [Doc 221 to Hist of ADC, Jul-Dec 1959]; 4751 ADW to Joint BOMARC/SAGE Test Staff, "Status Report, as of 24 September 1959," 25 Sep 1959 [Doc 222 to Hist of ADC, Jul-Dec 1959]; Msg, PGYU 32CR, APGC to USAF, 17 Sep 1959 [Doc 223 to Hist of ADC, Jul-Dec 1959].

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402. 4751 ADW to Joint BOMARC/SAGE Test Staff, "Status Report, as of 24 July 1959," 3 Aug 1959 [Doc 214 to Hist of ADC, Jul-Dec 1959]; 4751 ADW to Joint BOMARC/SAGE Test Staff, "Status Report (1 through 13 August 1959)," 17 Aug 1959 [Doc 215 to Hist of ADC, Jul-Dec 1959].

403. 4751 ADW to Joint BOMARC/SAGE Test Staff "Status Report, as of 31 August 1959," 31 Aug 1959 [Doc 219 to Hist of ADC, Jul-Dec 1959]; Msg, MOODC 2009, MOADS to 32 AD, 25 Sep 1959 [Doc 224 to Hist of ADC, Jul-Dec 1959]; Msg, PGYU 415C, APGC to USAF, 9 Oct 1959 [Doc 225 to Hist of ADC, Jul-Dec 1959].

404. Msg, ADAMA 2316, ADC to USAF, 28 Oct 1959 [Doc 120 to Hist of ADC, Jul-Dec 1959].

405. Msg, AFMDC 86956, USAF to ARDC, 29 Oct 1959 [Doc 226 to Hist of ADC, Jul-Dec 1959].

406. Weekly Activities Reports, ADC, ADLSI-C, 18 Nov, 23 Nov, 24 Nov and 3 Dec 1959 and ADLPG-I, 18 Dec 1959 [HRF].

407. Msg, CMD 59S-1656, NYADS to ADC, 1 Sep 1959 [Doc 247 to Hist of ADC, Jul-Dec 1959].

408. Msg, ADAMA-P 80, ADC to USAF, 24 Nov 1959 [Doc 248 to Hist of ADC, Jul-Dec 1959]; Msg, LMDN 2755, ASC, AMC to ADC, 30 Nov 1959 [Doc 249 to Hist of ADC, Jul-Dec 1959]; Msg, ADLSI-C 0001, ADC to 26 AD, 2 Nov 1959 [Doc 252 to Hist of ADC, Jul-Dec 1959]; Msg, ADOOP-ES 313, ADC to ADES Proj Off (N.Y.), 18 Dec 1959 [Doc 253 to Hist of ADC, Jul-Dec 1959]; Weekly Activities Reports, ADC, ADLSI-C, 11-14 Nov and 8 Dec 1959 [HRF].

409. Msg, ADLPG-IM 1259, ADC to WADD, 27 Apr 1960 [Doc 295 to Hist of ADC, Jan-Jun 1960]; Msg, WWSDBE-FA 12-5-30, IM-99 Field Test Sec to USAF, 12 May 1960 [Doc 296 to Hist of ADC, Jan-Jun 1960]; Msg, WWXDBE-A 12-5-29, IM-99 Field Test Sec to ADC, 13 May 1960 [Doc 297 to Hist of ADC, Jan-Jun 1960]; Msg, WWXDBE-U 12-5-33, IM-99 Field Test Sec to USAF, 14 May 1960 [Doc 298 to Hist of ADC, Jan-Jun 1960]; Joint AF-Boeing IM-99A Weekly Status Report No. 18, 20-26 Apr 1960 [Doc 299 to Hist of ADC, Jan-Jun 1960]; Joint AF-Boeing IM-99A Weekly Status Report No. 20, 4-10 May 1960 [Doc 300 to Hist of ADC, Jan-Jun 1960]; Joint AF-Boeing

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410. SECRET-RD, Msg, NYCRR 2473 60S, NYADS to USAF, 8 Jun 1960 [Doc 191 to Hist of ADC, Jan-Jun 1960]; Msg, NYCVC 2799, NYADS to Dep IG for Nuclear Safety Research, USAF, Norton AFB, 24 Jun 1960 [Doc 192 to Hist of ADC, Jan-Jun 1960]; N. Y. Times, 8 Jun 1960.

411. Msg, 26CCR-26MLP 5-812, 26 AD to ADC, 10 May 1960 (SECRET-RD) [Doc 193 to Hist of ADC, Jan-Jun 1960]; SECRET-RD, Msg, 26CIG 14, 26 AD to ADC, 12 May 1960 [Doc 194 to Hist of ADC, Jan-Jun 1960].

412. Msg, NYCVC 2799, NYADS to Dep IG for Nuclear Safety Research, USAF, Norton AFB, 24 Jun 1960 [Doc 192 to Hist of ADC, Jan-Jun 1960]; Msg, AFCRM-A USAF IG Inspection Team (at McGuire) to USAF, 3 Jun 1960 [Docs 196 and 197 to Hist of ADC, Jan-Jun 1960].

413. Msg, 26MSS 6-635, 26 AD to ADC, 16 Jun 1960 [Doc 198 to Hist of ADC, Jan-Jun 1960].

414. Weekly Activities Report, ADLPG-I, ADC, 11 Jul 1960 [HRF]; Msg, 26CIG 18, 26 AD to ADC, 22 Jun 1960 [Doc 199 to Hist of ADC, Jan-Jun 1960]; Msg, 26CIG-19, 26 AD to ADC, 22 Jun 1960 [Docs 200, 201 and 202 to Hist of ADC, Jan-Jun 1960]; Msg, ADOOP-PR 2112, ADC to 46 ADMS, 25 Jul 1960 [Doc 203 to Hist of ADC, Jan-Jun 1960].

415. Msg, WWSDBE-A 27-5-82, IM-99 Field Test Sec (WADD) to ADC, 27 May 1960 [Doc 306 to Hist of ADC, Jan-Jun 1960]; Msg, WWSDBE-FA 27-5-81, IM-99 Field Test Sec (WADD) to USAF, 27 May 1960 [Doc 307 to Hist of ADC, Jan-Jun 1960]; Msg, WWZDBE-FA 2-6-7, IM-99 Field Test Sec (WADD) to ADC, 3 Jun 1960 [Doc 308 to Hist of ADC, Jan-Jun 1960]; Msg, WWZDBE-A 5-6, IM-99 Field Test Sec (WADD) to ADC, 3 Jun 1960 [Doc 309 to Hist of ADC, Jan-Jun 1960].

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416. Msg, WWXDBE-FA 9-6-26, IM-99 Field Test Sec (WADD) to USAF, 9 Jun 1960 [Doc 310 to Hist of ADC, Jan-Jun 1960]; Msg, WWXDBE-A 9-6-29, IM-99 Field Test Sec (WADD) to ADC, 10 Jun 1960 [Doc 311 to Hist of ADC, Jan-Jun 1960]; Msg, WWXDBE-FA 9-6-28, IM-99 Field Test Sec (WADD) to USAF, 10 Jun 1960 [Doc 312 to Hist of ADC, Jan-Jun 1960]; Msg, WXDBE-A 16-6-50, IM-99 Field Test Sec (WADD) to ADC, 17 Jun 1960 [Doc 313 to Hist of ADC, Jan-Jun 1960]; Msg, WWXDBE-FA 16-6-48, IM-99 Field Test Sec (WADD) to USAF, 17 Jun 1960 [Doc 314 to Hist of ADC, Jan-Jun 1960]; Joint Air Force-Boeing IM-99A Weekly Status Report No. 26, 15-21 Jun 1960 [Doc 315 to Hist of ADC, Jan-Jun 1960].

417. Msg, WWXDBE-A 23-6-61, IM-99 Field Test Sec (WADD) to ARDC, 23 Jun 1960 [Doc 316 to Hist of ADC, Jan-Jun 1960]; Msg, WWXDBE-A 24-6-64, IM-99 Field Test Sec (WADD) to ADC, 25 Jun 1960 [Doc 317 to Hist of ADC, Jan-Jun 1960]; Msg, WWZDBE-FA 24-6-71, IM-99 Field Test Sec (WADD) to USAF, 25 Jun 1960 [Doc 318 to Hist of ADC, Jan-Jun 1960]; Msg, WWZDBE-FA 24-6-66, IM-99 Field Test Sec (WADD) to USAF, 25 Jun 1960 [Doc 319 to Hist of ADC, Jan-Jun 1960]; Msg, WWXDBE-A 27-6-71, IM-99 Field Test Sec (WADD) to ARDC, 27 Jun 1960 [Doc 320 to Hist of ADC, Jan-Jun 1960]; Joint Air Force-Boeing IM-99A Weekly Status Report No. 27, 21-28 Jun 1960 [Doc 321 to Hist of ADC, Jan-Jun 1960]; Joint Air Force-Boeing Weekly Status Report No. 28, 28 Jun-5 Jul 1960 [Doc 322 to Hist of ADC, Jan-Jun 1960].

418. Msg, WWXDBE-A 28-7-71, IM-99 Field Test Sec (WADD) to USAF, 29 Jul 1960 [Doc 466 to Hist of ADC, Jul-Dec 1960]; Joint Air Force-Boeing IM-99A Weekly Status Report No. 32, 26 Jul-2 Aug 1960 [Doc 467 to Hist of ADC, Jul-Dec 1960]; Msg, WWXDBE-A 5-8-11, IM-99 Field Test Sec (WADD) to USAF, 5 Aug 1960 [Doc 469 to Hist of ADC, Jul-Dec 1960]; Joint Air Force-Boeing IM-99A Weekly Status Report No. 33, 3-9 Aug 1960 [Doc 470 to Hist of ADC, Jul-Dec 1960]; Msg, WWXDBE-A 11-8-21, IM-99 Field Test Sec (WADD) to ADC, 12 Aug 1960 [Doc 472 to Hist of ADC, Jul-Dec 1960]; Joint Air Force-Boeing IM-99A Weekly Status Report No. 34, 10-16 Aug 1960 [Doc 473 to Hist of ADC, Jul-Dec 1960]; Msg, WWXDBE-A 18-8-39, IM-99 Field Test Sec (WADD) to USAF, 19 Aug 1960 [Doc 475 to Hist of ADC, Jul-Dec 1960]; Joint Air Force-Boeing IM-99A Weekly Status Report No. 35, 17-23 Aug 1960 [Doc 476 to Hist of ADC, Jul-Dec 1960]; Msg, WWXDBE-A 19-8-44, IM-99 Field Test Sec (WADD) to USAF, 20 Aug 1960 [Doc 477 to Hist of ADC, Jul-Dec 1960].

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419. Weekly Activities Report, ADC, ADLPG-I, 24 Aug 1960 [HRF]; Joint Air Force-Boeing IM-99A Weekly Status Report No. 35, 24-30 Aug 1960 [Doc 479 to Hist of ADC, Jul-Dec 1960]; Msg, WWZDB 29-8-435E, WADD to ARDC, 29 Aug 1960 [Doc 480 to Hist of ADC, Jul-Dec 1960].

420. Msg, MOY 29-9-43, APGC to ADC, 30 Sep 1960 [Doc 481 to Hist of ADC, Jul-Dec 1960].

421. IM-99A Category III Bi-Weekly Status Reports No. 1, 1-18 Oct 1960; No. 2, 19 Oct-1 Nov 1960; No. 3, 2-15 Nov 1960; No. 4, 16-29 Nov 1960 [Docs 486, 487 and 489 to Hist of ADC, Jul-Dec 1960]; IM-99A Category III Progress Review Reports No. 5, 30 Nov-14 Dec 1960 and No. 6, 15 Dec 1960-11 Jan 1961 [Docs 490 and 491 to Hist of ADC, Jul-Dec 1960]; Msg, ADCCS 183, ADC to USAF, 24 Jan 1961 [Doc 493 to Hist of ADC, Jul-Dec 1960].

422. Msg, MOY 20-1-3, APGC to USAF, 21 Jan 1961 [Doc 579 to Hist of ADC, Jan-Jun 1961]; Msg, MOY 14-2-14, APGC to USAF, 15 Feb 1961 [Doc 580 to Hist of ADC, Jan-Jun 1961]; Msg, MOY 21-2-18, APGC to USAF, 22 Feb 1961 [Doc 582 to Hist of ADC, Jan-Jun 1961]; Msg, MOY 6-3-22, APGC to USAF, 7 Mar 1961 [Doc 583 to Hist of ADC, Jan-Jun 1961]; Msg, MOY 9-3-26, APGC to USAF, 10 Mar 1961 [Doc 584 to Hist of ADC, Jan-Jun 1961]; Msg, MOY 17-3-21, APGC to USAF, 18 Mar 1961 [Doc 586 to Hist of ADC, Jan-Jun 1961]; Msg, MOY 24-3-38, APGC to USAF, 26 Mar 1961 [Doc 587 to Hist of ADC, Jan-Jun 1961]; Msg, MOYU-AM 17-4-20, Eglin Test Br (WADD) to ADC, 19 Apr 1961 [Doc 588 to Hist of ADC, Jan-Jun 1961].

423. Current Status Report, USAF, Air Defense Mission Area, Jan 1961, pp. 3-11; Feb 1961, pp. 3-13; Mar 1961, pp. 3-15 and Jun 1961, pp. 3-13 [HRF]; Msg, AFOOP-DE 79546, USAF to ADC, 24 Jan 1961 [Doc 375 to Hist of ADC, Jan-Jun 1961]; Msg, 26OOP-WM 217-S, 26 AD to BAADS, 24 Apr 1961 [Doc 376 to Hist of ADC, Jan-Jun 1961]; IM-99A Category III Progress Review Reports No. 8, 9 Feb-8 Mar 1961; No. 9, 9 Mar-5 Apr 1961; No. 10, 5 Apr-3 May 1961 and No. 11, 4-31 May 1961 [Docs 380 through 383 to Hist of ADC, Jan-Jun 1961]; Msg, MOY 6-7-120, APGC to USAF, 7 Jul 1961 [Doc 384 to Hist of ADC, Jan-Jun 1961].

424. Msg, MOY 31-3-44, APGC to USAF, 1 Apr 1961 [Doc 589 to Hist of ADC, Jan-Jun 1961]; Msg, MOY 7-4-49,

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425. Msg, AFIMS 1-9-19E, Dep IG for Safety (USAF) to ADC, 29 Sep 1961 [Doc 528 to Hist of ADC, Jul-Dec 1961]; Msg, 4751 CCR 90-387E, 4751 AD Wg to Dep IG for Safety (USAF), 29 Sep 1961 [Doc 529 to Hist of ADC, Jul-Dec 1961]; Msg, AFIMS 1-10-3E, Dep IG for Safety (USAF) to 4751 AD Wg, 3 Oct 1961 [Doc 530 to Hist of ADC, Jul-Dec 1961]; Msg, ADOOP-WM 2213, ADC to OOAMA, 10 Oct 1961 [Doc 531 to Hist of ADC, Jul-Dec 1961].

426. 4751 AD Wg to ADC, "Status of the BOMARC Test Program as of 31 October 1961," 8 Nov 1961 [Doc 532 to Hist of ADC, Jul-Dec 1961].

427. Msg, ADOOP-WM 2540, ADC to ASD, 14 Nov 1961 [Doc 533 to Hist of ADC, Jul-Dec 1961]; Msg, ASZDBE-15-11-56, ASD to ADC, 15 Nov 1961 [Doc 534 to Hist of ADC, Jul-Dec 1961].

428. 4751 AD Wg to ADC, "Status of the BOMARC Test Program as of 30 November 1961," 11 Dec 1961 [Doc 537 to Hist of ADC, Jul-Dec 1961]; NOFORN EX CANADA, Msg, 4751 CCR 11348, APGC to USAF, 30 Nov 1961 [Doc 536 to Hist of ADC, Jul-Dec 1961].

429. Msg, ADOOP-WM 2049, ADC to AFSWC, 25 Sep 1961 [Doc 538 to Hist of ADC, Jul-Dec 1961]; SECRET-RD, Msg, SWVCT-6-10-16, AFSWC to ADC, 6 Oct 1961 [Doc 539 to Hist of ADC, Jul-Dec 1961]; Msg, ADOOP-WM 2462, ADC to 4751 AD Wg,

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430. Msg, 4751 CCR 2-044, APGC to AFSC, 8 Feb 1962 [HRF]; Ltr, 4751 AD Wg (Missile) to ADC, "Status of the BOMARC Test Program as of 28 Feb 1962," 13 Mar 1962 [HRF]; Ltr, 4751 AD Wg (Missile) to ADC, "Status of the BOMARC Test Program as of 31 May 1962," 11 Jun 1962 [HRF].

431. Msg, 4751 ODC-TI-013, 4751 AD Wg to ADC, 3 Jan 1962 [HRF]; Msg, ADOOP-WM 101, ADC to 4751 AD Wg, 12 Jan 1962 [HRF]; Msg, SCSAD 23-1-37, AFSC to SAC, 24 Jan 1962 [HRF]; Msg, AFORQ-AD 95075, USAF to AFSC, 23 Jan 1962 [HRF]; Msg, ASZDBT 20-2-51, ASD to IM-99 Field Test Div (Eglin), 20 Feb 1962 [HRF]; Ltr, Det 1, MOADS to ADC, "Status of the BOMARC Test Program as of 30 Jun 1962," 11 Jul 1962 [HRF].

432. Msg, RDZSDB 31304, Dir of Sys Mgt, (ARDC) to ARDC, 27 Nov 1959 [Doc 272 to Hist of ADC, Jul-Dec 1959].

433. Hearings on Department of Defense Appropriations before the Subcommittee of the Committee on Appropriations of the House of Representatives, 86th Congress, Second Session, January 1960.

434. Ibid., 24 Mar 1960; Msg, AFODC 80054, USAF to ADC, 23 Mar 1960 [Doc 146 to Hist of ADC, Jan-Jun 1960].

435. Msg, ADCVC 1418, ADC to 32 AD, 12 May 1960 [Doc 375 to Hist of ADC, Jan-Jun 1960].

436. Msg, WWXDBE 8-5-22, IM-99 Field Test Sec (Eglin) to ARDC, 8 Apr 1960 [Doc 370 to Hist of ADC, Jan-Jun 1960]; Msg, WWA 4-5-E, WADD to ARDC, 14 Apr 1960 [Doc 371 to Hist of ADC, Jan-Jun 1960]; Msg, WWXDBE-B 14-4-29, IM-99 Field Test Sec to USAF, 14 Apr 1960 [Doc 372 to Hist of ADC, Jan-Jun 1960]; IM-99B Weekly Report No. 13, 9-15 Apr 1960, Joint BOMARC Test Staff [Doc 373 to Hist of ADC, Jan-Jun 1960]; Msg, ADCVC 1418, ADC to 32 AD, 12 May 1960 [Doc 375 to Hist of ADC, Jan-Jun 1960]; Msg, WWSDBE-FB 17-5-40, IM-99 Field Test Sec to USAF, 17 May 1960 [Doc 376 to Hist of ADC, Jan-Jun 1960]; Msg, WWSDBE 18-5-48,

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437. History of NORAD, Jan-Jun 1960, p. 14.

438. Msg, WWZDBE-B 11-7-25, IM-99 Field Test Sec (WADD) to USAF, 11 Jul 1960 [Doc 494 to Hist of ADC, Jul-Dec 1960].

439. Msg, WWXDBE-B 12-8-26, IM-99 Field Test Sec (WADD) to USAF, 12 Aug 1960 [Doc 510 to Hist of ADC, Jul-Dec 1960]; Msg, WWZDBE-B 25-8-58, IM-99 Field Test Sec (WADD) to USAF, 25 Aug 1960 [Doc 515 to Hist of ADC, Jul-Dec 1960]; IM-99B Weekly Reports No. 35, 9-16 Sep 1960; No. 36, 16-23 Sep 1960; No. 37, 23-30 Sep 1960 and No. 38, 30 Sep-7 Oct 1960 [Docs 521 through 524 to Hist of ADC, Jul-Dec 1960]; Msg, WWXDBE-B 18-10-30, IM-99 Field Test Sec (WADD) to USAF, 20 Oct 1960 [Doc 529 to Hist of ADC, Jul-Dec 1960]; Msg, WWXDBE-B 1-11-1, IM-99 Field Test Sec (WADD) to USAF, 2 Nov 1960 [Doc 532 to Hist of ADC, Jul-Dec 1960]; NOFORN EX CANADA, Msg, WWXDBE-B 4-11-14, IM-99 Field Test Sec (WADD) to USAF, 5 Nov 1960 [Doc 536 to Hist of ADC, Jul-Dec 1960]; NOFORN EX CANADA, Msg, WWXDBE-B 18-11-36, IM-99 Test Br (WADD), 19 Nov 1960 [Doc 539 to Hist of ADC, Jul-Dec 1960].

440. NOFORN EX CANADA, Msg, WWZDBE-B 25-11-53, Eglin Test Br (WADD) to USAF, 26 Nov 1960 [Doc 543 to Hist of ADC, Jul-Dec 1960]; NOFORN EX CANADA, Msg, WWXDBE-B 5-12-8, Eglin Test Br (WADD) to USAF, 6 Dec 1960 [Doc 546 to Hist of ADC, Jul-Dec 1960]; NOFORN EX CANADA, Msg WWXDBE-B 19-12-60, Eglin Test Br (WADD) to USAF, 20 Dec 1960 [Doc 548 to Hist of ADC, Jul-Dec 1960]; NOFORN EX CANADA, Msg, WWZDBE-B 19-12-59, Eglin Test Br (WADD) to USAF, 20 Dec 1960 [Doc 549 to Hist of ADC, Jul-Dec 1960]; NOFORN EX CANADA, Msg, WWXDBE-B 22-12-68, Eglin Test Br (WADD) to USAF, 24 Dec 1960]; NOFORN EX CANADA, Msg, WWXDBE-B 29-12-79, Eglin Test Br to USAF, 30 Dec 1960 [Doc 556 to Hist of ADC, Jul-Dec 1960]; IM-99B Weekly Reports No. 45, 18 Nov-2 Dec 1960; No. 46, 2-9 Dec 1960; No. 47, 9-16 Dec 1960 and No. 48, 16-30 Dec 1960 [Docs 544, 550, 551 and 554 to Hist of ADC, Jul-Dec 1960].

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441. Msg, WWZDBE-BE 1-2-52, Eglin Test Br (WADD) to USAF, 8 Feb 1961 [Doc 606 to Hist of ADC, Jan-Jun 1961]; NOFORN EX CANADA, Msg, WWXDBE-BE 1-2-51, Eglin Test Br (WADD) to USAF, 8 Feb 1961 [Doc 607 to Hist of ADC, Jan-Jun 1961]; NOFORN EX CANADA, Msg, WWXDBE-BE 15-2-63, Eglin Test Br (WADD) to USAF, 16-Feb 1961 [Doc 610 to Hist of ADC, Jan-Jun 1961]; NOFORN, Msg, (no number), Eglin Test Br (WADD) to USAF, 4 Mar 1961 [Doc 613 to Hist of ADC, Jan-Jun 1961]; NOFORN EX CANADA, Msg, (no number), Eglin Test Br (WADD) to USAF, 25 Mar 1961 [Doc 620 to Hist of ADC, Jan-Jun 1961]; IM-99B Status Reports No. 51, 13 Jan-3 Feb 1961; No. 52, 3-17 Feb 1961; No. 53, 17 Feb-3 Mar 1961; No. 54, 3-17 Mar 1961 and No. 55, 17-31 Mar 1961 [Docs 604, 611, 616, 617 and 618 to Hist of ADC, Jan-Jun 1961].

442. NOFORN EX CANADA, Msg, WWXDBE-B 31-3-36, Eglin Test Br (WADD) to USAF, 1 Apr 1961 [Doc 622 to Hist of ADC, Jan-Jun 1961]; NOFORN EX CANADA, Msg, WWXDBE-B 19-4-25, Eglin Test Br (WADD) to USAF, 21 Apr 1961 [Doc 628 to Hist of ADC, Jan-Jun 1961]; Msg, WWXDBE-B-WW-S 7-4-36, 28 Apr 1961 [Doc 633 to Hist of ADC, Jan-Jun 1961]; IM-99B Status Reports No. 55, 17-31 Mar 1961; No. 57, 14-28 Apr 1961 and No. 58, 28 Apr-12 May 1961 [Docs 618, 631 and 634 to Hist of ADC, Jan-Jun 1961].

443. NOFORN EX CANADA, Msg, WWXDBE-B 12-5-14, Eglin Test Br (WADD) to USAF, 13 May 1961 [Doc 638 to Hist of ADC, Jan-Jun 1961]; NOFORN EX CANADA, WWZDBE-B 25-5-43, Eglin Test Br (WADD) to USAF, 26 May 1961 [Doc 640 to Hist of ADC, Jan-Jun 1961]; NOFORN EX CANADA, Msg, WWXDBE-B 24-5-41, Eglin Test Br (WADD) to USAF, 26 May 1961 [Doc 641 to Hist of ADC, Jan-Jun 1961]; NOFORN EX CANADA, Msg, WWXDBE-B 25-5-44, Eglin Test Br (WADD) to USAF, 26 May 1961 [Doc 642 to Hist of ADC, Jan-Jun 1961]; NOFORN EX CANADA, Msg, DBE-B 26-5-51, Eglin Test Br (WADD) to USAF, 27 May 1961 [Doc 644 to Hist of ADC, Jan-Jun 1961]; IM-99B Status Reports No. 58, 28 Apr-12 May 1961 and No. 59, 12-26 May 1961 [Docs 634 and 645 to Hist of ADC, Jan-Jun 1961].

444. Msg, ASZDBT 22-6-132, ASD to AFSC, 22 Jun 1961 [Doc 648 to Hist of ADC, Jan-Jun 1961]; Msg, ASZDBT 27-6-146, ASD to AFSC, 27 Jun 1961 [Doc 649 to Hist of ADC, Jan-Jun 1961].

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445. NOFORN EX CANADA, Msg, ASXDBF 3-14-7-96, Eglin Test Br (ASD) to USAF, 16 Jul 1961 [Doc 543 to Hist of ADC, Jul-Dec 1961]; Msg, ASZDB 25-7-113, ASD to AFSC, 25 Jul 1961 [Doc 544 to Hist of ADC, Jul-Dec 1961]; NOFORN EX CANADA, Msg, MOY 28-7-140, APGC to USAF, 29 Jul 1961 [Doc 545 to Hist of ADC, Jul-Dec 1961]; NOFORN EX CANADA, Msg, ASXDBF 3-28-7-119, Eglin Test Br (ASD) to USAF, 31 Jul 1961 [Doc 546 to Hist of ADC, Jul-Dec 1961].

446. Msg ASZDB 4-8-43, ASD to AFSC, 7 Aug 1961 [Doc 547 to Hist of ADC, Jul-Dec 1961]; NOFORN EX CANADA, Msg, MOY 17-8-157, APGC to USAF, 18 Aug 1961 [Doc 548 to Hist of ADC, Jul-Dec 1961]; NOFORN EX CANADA, Msg, ASZDBF 3-18-8133, Eglin Test Br (ASD) to USAF, 19 Aug 1961 [Doc 549 to Hist of ADC, Jul-Dec 1961]; Msg, ASZDB 8-21-126, ASD to AFSC, 21 Aug 1961 [Doc 550 to Hist of ADC, Jul-Dec 1961]; Weekly Activities Report, ADC, ADLSP-A, 7 Sep 1961 [HRF]; NOFORN EX CANADA, Msg, ASXDBF 3-8-9-9, Eglin Test Br (ASD) to USAF, 9 Sep 1961 [Doc 551 to Hist of ADC, Jul-Dec 1961].

447. NOFORN EX CANADA, Msg, ASXDBF 3-22-9-22, Eglin Test Br (ASD) to USAF, 23 Sep 1961 [Doc 552 to Hist of ADC, Jul-Dec 1961]; NOFORN EX CANADA, Msg, 4751 CCR 10074, APGC to AFSC, 6 Oct 1961 [Doc 553 to Hist of ADC, Jul-Dec 1961]; 4751 AD Wg to ADC, "Status of the BOMARC Test Program as of 31 Oct 1961," 8 Nov 1961 [Doc 532 to Hist of ADC, Jul-Dec 1961].

448. NOFORN EX CANADA, Msg, 4751 CCR 10-0291, APGC to USAF, 21 Oct 1961 [Doc 557 to Hist of ADC, Jul-Dec 1961]; NOFORN EX CANADA, Msg, ASZDBF-M 24-11-18, Eglin Test Br (ASD) to USAF, 24 Nov 1961 [Doc 558 to Hist of ADC, Jul-Dec 1961]; 4751 AD Wg to ADC, "Status of the BOMARC Test Program as of 31 December 1961," 11 Jan 1962 [Doc 542 to Hist of ADC, Jul-Dec 1961].

449. NOFORN EX CANADA, Msg, ASZDBF-ME 1-2-1, Eglin Test Br to AFSC, 3 Feb 1962 [HRF]; 4751 AD Wg to ADC, "Status of the BOMARC Test Program as of 28 February 1962," 13 Mar 1962 [HRF]; Msg, ASZDBF-ME 22-3-22, Eglin Test Br to USAF, 23 Mar 1962 [HRF].

450. Msg, ASXDBF-ME 24-3-23, Eglin Test Br to USAF, 26 Mar 1962 [HRF]; Msg, ASXDDBR-ME 30-3-27, Eglin Test Br to ADC, 31 Mar 1962 [HRF]; 4751 AD Wg to ADC, "Status of

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[Cont'd] the BOMARC Test Program as of 30 April 1962," 10 May 1962 [HRF]; NOFORN EX CANADA, Msg, ASXDBF-ME 18-5-23, Eglin Test Br to USAF, 20 May 1962 [HRF].

451. Msg, ADCCS 1422, ADC to 32 AD, 24 May 1962 [HRF]; Msg, 4751 ODC-T6 60, Eglin Test Br to ADC, 6 Jun 1962 [HRF]; 4751 AD Wg to ADC, "Status of the BOMARC Test Program as of 31 May 1962," 11 Jun 1962 [HRF].

452. NOFORN EX CANADA, Msg ASZDBF-ME 766, Eglin Test Br to ADC, 9 Jun 1962 [HRF]; NOFORN EX CANADA, Msg, ASXDBF-ME 15-6-10, Eglin Test Br to USAF, 16 Jun 1962 [HRF]; Msg, SCSAD 19-6-41, AFSC to ASD, 19 Jun 1962 [HRF]; NOFORN EX CANADA, Msg, ASXDBF-ME 29617, Eglin Test Br to SAGE PO, 30 Jun 1962 [HRF]; NOFORN EX CANADA, Msg, ASZDBF-ME 29615, Eglin Test Br to ADC, 1 Jul 1962 [HRF]; Msg, ASZDB 6-7-14, ASD to AFPRO (Boeing), 6 Jul 1962 [HRF]; Det 1, MOADS to ADC, "Status of the BOMARC Test Program as of 30 Jun 1962," 11 Jul 1962 [HRF]; Det 1, MOADS to ADC, "Status of the BOMARC Test Program as of 31 Jul 1962," 10 August 1962 [HRF].

453. NOFORN EX CANADA, Msg, MOBE 14811, Eglin Test Br to ADC, 15 Aug 1962 [HRF].

454. Msg, ADODC 2231, ADC to MOADS, 23 Aug 1962 [HRF]; Msg, SCSE 28-8-119, AFSC to ASD, 28 Aug 1962 [HRF]; Msg, ADODC 2329, ADC to ASD, 31 Aug 1962 [HRF]; Det 1, MOADS to ADC, "Status of the BOMARC Test Program as of 31 August 1962," 14 Sep 1962 [HRF].

455. NOFORN EX CANADA, Msg, MOBE 31830, Eglin Test Br to AFSWC, 1 Sep 1962 [HRF]; Msg, MOBE 6936, Eglin Test Br to ADC, 7 Sep 1962 [HRF]; NOFORN EX CANADA, Msg, MOBE 14-9-47, Eglin Test Br to ASD, 15 Sep 1962 [HRF]; SECRET-NOFORN, Msg, PYYI 27-9-153, APGC to USAF, 27 Sep 1962 [HRF].

456. Msg, ADODC 2673, ADC to ASD, 5 Oct 1962 [HRF].

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