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Improving U.S. Air Force Readiness and Sustainability

Michael Rich, William Stanley,
Susan Anderson

April 1984

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PROJECT AIR FORCE

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A Project AIR FORCE Report
prepared for the
United States Air Force



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PREFACE

This report seeks to promote discussion of the way the Air Force develops its weapon systems, manages its support resources, and conducts its wartime logistics operations. It describes the enemy threat facing the Tactical Air Forces in the next several decades, how that threat affects the combat environments within which those forces will have to operate, how those environments should shape force characteristics, and the implications for various resource management functions.

By linking trends in enemy military capabilities to desirable elements of future resource management policies, the report should interest a broad cross-section of the defense community. It should be useful to persons in operations, intelligence, and logistics positions because it illustrates how projections about future warfighting environments ought to shape future combat support policies and organizations and important parts of the force modernization process.

The report was produced under the Project AIR FORCE Resource Management Program. It is based on a presentation given at Future Look, the U.S. Air Force logistics long-range planning conference held at Homestead AFB, Florida, in August 1983.

SUMMARY

Because of the expanding military capabilities of potential U.S. adversaries, primarily the Soviet Union, Air Force planning and decisionmaking must now accommodate the likelihood that future combat environments will be more complicated and less predictable than in the past. Emerging characteristics of the enemy threat suggest that improvements will be needed in several aspects of force capability if the Air Force is to maintain adequate readiness and sustainability of its combat forces. This report is concerned with the implications of the emerging threat for the acquisition and management of critical combat resources. Its central conclusion is that **effecting the necessary improvements in readiness and sustainability will require fundamental changes in the way the Air Force perceives weapon system requirements, develops and procures those systems, manages logistics resources, and organizes and operates combat support systems.**

Other important conclusions include the following:

- In the future, the Air Force will have to contend with greater air base vulnerability, reduced response time, greater deployment distance, unfavorable force ratios, and austere operating locations in addition to heretofore unrecognized uncertainties in support demand rates (component removal rates).
- The force characteristics required for the expected operating environment include more sophisticated weapon systems, greater resilience under attack, the ability to sustain high effective sortie rates, and the ability to deploy rapidly.
- An aircraft's basing posture and support system now figure crucially in its combat effectiveness because of changes in the potential operating environment.
- Logistics planning must now more directly consider the wartime threat, and wartime supportability must receive more emphasis in the development and modification of weapon systems.

Logistics operations will have to be sufficiently lean, robust, and flexible to permit rapid deployment over long distances and sustain sortie generation in austere locations and hostile environments. This will necessitate changing the composition of both forward combat forces and the rearward support infrastructure:

- Forward combat forces should be streamlined to operate with fewer support resources (e.g., the amount of required aerospace ground equipment and the number of flightline specialists should be reduced). This should be complemented by efforts to provide more fluid base-to-base interaction to permit enhanced lateral support (even among different Allied air forces) and, if necessary, wide dispersal of critical combat force elements.
- The infrastructure supporting forward operating bases will have to be responsive and flexible. The configuration, number, and locations of intermediate repair facilities should be considered jointly with the potential role of U.S.-based depots, which offer a promising way to defend against inevitable theater shortages caused by unanticipated support demands or simultaneous conflicts in different regions.

The critical importance of basing and support to combat effectiveness is not being adequately reflected in new weapon system designs. The weapon system development community should develop analytical approaches and tools to evaluate tradeoffs in operating concepts founded on alternative basing and support arrangements. Moreover, a weapon system's support characteristics should receive increased emphasis and clearer articulation in the formal expression of system requirements in the design and development stage. That emphasis must be matched by a more concerted use of logistics capability assessment models during concept formulation and advanced development and by earlier testing and evaluation aimed at uncovering and correcting weapon system support characteristics that could limit the system's combat effectiveness.

ACKNOWLEDGMENTS

As the numerous citations in the body of the report indicate, the authors have relied on much published and unpublished research by colleagues at The Rand Corporation. Other colleagues provided useful comments on early drafts, most notably Christopher Bowie, I. K. Cohen, Edmund Dews, Jack Ellis, and Giles Smith. Responsibility for any remaining errors in fact or interpretation rests with the authors.

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I. INTRODUCTION

Within the defense community, increased concern over the readiness and sustainability of U.S. forces has taken many forms, including critical appraisals of how the U.S. Air Force develops, allocates, and uses combat resources. In this report we outline several ideas for improving the acquisition and management of critical resources to respond to emerging characteristics of the enemy threat. These improvements should contribute to the formulation of a strategy for strengthening U.S. force capabilities.

The growing military capabilities of adversary countries introduce new complications and uncertainties into future combat environments. When coupled with resource constraints, these new environments will require significant improvements in force capability. Attaining those improvements will require fundamental changes in the way the U.S. Air Force perceives weapon system requirements, develops and procures those systems, manages logistics resources, and organizes and operates combat support systems.

This report argues that the growth in enemy capabilities has enlarged the combat arena facing the Tactical Air Forces to encompass critical elements of the U.S. logistics infrastructure. As a consequence, we must test our basing posture and support systems against the demands of probable combat scenarios and increase our emphasis on supportability in the field during weapon system development and modification.

The second section of this report illustrates the growing qualitative, quantitative, and geographic nature of the threat to American interests. The growth stems from the Soviets' access to ports and facilities in all regions of the world, their increased ability to insert combat forces and military equipment into distant areas, and the performance improvements in Soviet and hostile third world tactical aircraft inventories.

Section III shows how these trends will probably make future operating environments more demanding and less predictable. U.S. forces must be capable of deploying on short notice to distant locations lacking established base and support facilities. During combat, adversaries will probably outnumber U.S. forces and be able to attack the U.S. combat support infrastructure. The difficulty of forecasting weapon system component removal rates complicates the planning and provisioning of support even further. This phenomenon is only now being extensively quantified and studied.

The report concludes with a discussion of how the Air Force should change the way it develops and manages weapon systems and support systems so that current and future forces can effectively meet the enemy threat. The changes involve increasing the robustness and flexibility of logistics operations by making forward bases leaner and more resilient, increasing the capability for mutual repair and supply among bases within a theater, and strengthening the responsiveness of the U.S. depot system so that it plays a timely and effective role in supporting the combat forces. Projected changes in the threat and operating environments should also influence weapon system performance requirements, test and evaluation practices, and development strategies for critical subsystems.

II. CHARACTERISTICS OF THE ENEMY THREAT

In the competition between the two superpowers, the Soviet Union enjoys some strategic advantages over the United States, stemming mainly from its location contiguous to vital American security interests—Western Europe, Southwest Asia, and East Asia. The Soviet Union has the advantage of being able to strike against U.S. interests by pushing relatively short distances across its borders; the United States must be able to deter these thrusts by projecting effective combat forces across vast oceanic distances.

To protect our vital interests in these theaters, the United States has followed a policy of containment. This policy is supported through the placement of forward-based deterrent forces in Europe and the Far East and, more recently, the commitment to develop a capability for rapidly inserting combat forces in Southwest Asia to protect the flow of oil from the Persian Gulf. We enjoy several strategic advantages over the Soviet Union stemming from our superior industrial and technological base, our alliances with wealthy countries in Europe and the Far East, and the higher quality of our weapon systems.

In recent decades, however, the Soviet Union has attempted to improve its strategic position by expanding its influence in the Third World and aggressively modernizing and enlarging its arsenal. The Soviet Union, more so than any other potential adversary, drives the need for large improvements in U.S. force capabilities; hence, this section emphasizes key dimensions of the Soviet threat, particularly its air forces.

GEOGRAPHIC BREADTH

The Soviet Union has established numerous and dispersed potential staging and operating locations throughout the world since the early 1960s. Table 1 lists some third world nations, by region, currently allied by treaties of friendship with the Soviets or allowing them special military access to air or seaport facilities.¹ Although this list of

¹For a discussion of recent Soviet strategy for gaining leverage in the Third World, see Alexander R. Alexiev, "The New Soviet Strategy in the Third World," The Rand Corporation, N-1995-AF, June 1983; see also Laurie Mylroie, "Politics and the Soviet Presence in the People's Democratic Republic of Yemen: Internal Vulnerabilities and Regional Challenges," The Rand Corporation, N-2052-AF, December 1983.

Table 1

SELECTED THIRD WORLD NATIONS WITH SPECIAL MILITARY TIES
TO THE SOVIET UNION, BY REGION*

Latin America	Africa	Near East and Southwest Asia	East Asia
Cuba	Angola Algeria Congo Ethiopia Libya Mozambique	Afghanistan India Iraq People's Democratic Republic of Yemen Syria	Vietnam

*This excludes Albania, Yugoslavia, Mongolia, North Korea, and China, among Communist states.

nations has experienced many changes, especially since the mid-1970s, no defection from it during that period has yet denied the Soviets a potential military base of operations in that region. These facilities are, however, probably less developed and less capable of supporting a major military escalation in any given region than are the U.S. facilities there, because the Soviets have been reluctant to invest heavily in third world facilities following their losses in Egypt and Somalia.

Apart from such formal ties, a large and growing number of third world governments use or purchase modern Soviet military equipment and employ Soviet or Soviet-bloc advisers. Since many of these same governments also purchase military equipment or accept aid from outside the Soviet bloc (e.g. from France) and in some cases even from the United States, this may not provide a reliable measure of Soviet leverage in the Third World. Nevertheless, these nations, both formally aligned and militarily dependent, would probably be subject to some degree of Soviet influence during a U.S.-Soviet military confrontation. Their sheer geographic extent therefore presents a serious problem: They are located at or near almost every site of strategic importance to the United States. Moreover, the Soviet bloc provides widespread support, in the form of equipment, advisers, or both, to several powerful insurgency groups, which could complicate U.S. military access to important bases of operation or staging areas during a confrontation. (The Soviets' support of Dhofar rebels from the People's Democratic Republic of Yemen could jeopardize U.S. operations based in Oman, for instance.)

Furthermore, in large part driven by the requirements of linking and developing their own vast territory, as well as by their desire to project their influence into foreign territories, the Soviets are rapidly increasing their ability to move combat personnel and equipment to distant sites. Although they have not produced their largest capacity airlifter, the An-22 COCK, since 1974, the newer Il-76 CANDID (introduced in the early 1970s) has demonstrated that it can operate under bare-base conditions while transporting cargo for pioneering efforts in Siberia.² In the 1980s, Soviet Military Transport Aviation (VTA) will probably greatly increase its lift capability, thereby strengthening the Soviets' ability to wage war in more remote regions as well as in the principal theaters. The Soviets have reportedly completed a prototype of the An-400 CONDOR, an airlifter similar to the U.S. Air Force's C-5A in range and payload. After its scheduled introduction into the VTA fleet later this decade, the CONDOR may be capable of transporting missile systems such as the SS-20, as well as troops and such large, heavy equipment as tanks.³ The inventory of the Soviet national airline, Aeroflot, includes substantial numbers of transport aircraft (including both the Il-76 and the An-22) that can supplement the VTA lift capability as needed. Figure 1 shows the improving range and payload capacity of these Soviet transport aircraft.

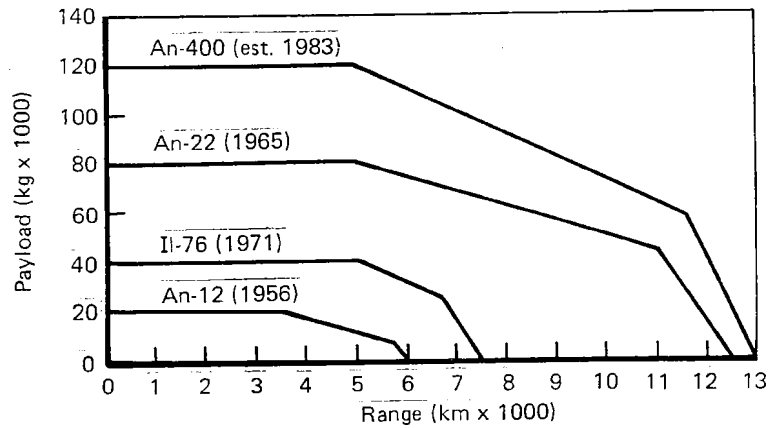
The Soviet air transport fleet has less capacity and shorter range than the U.S. fleet. It does not, however, need the U.S. fleet's capabilities because of its proximity to Europe, as well as to many strategically important areas of the Third World. Moreover, although the Soviets have not yet demonstrated they can deploy tactical air units long distances from their borders,⁴ they have shown they can rapidly transport troops and cargo over very long distances (during several Middle Eastern and African deployments for example).⁵ Furthermore, some

²John W. R. Taylor, "Jane's Aerospace Survey, 1984," *Air Force Magazine*, January 1984, p. 54; U.S. Department of Defense, *Soviet Military Power 1983*, Washington, D.C., 1983, pp. 56, 74; Christopher Chant, "Ilyushin Il-76M 'Candid,'" *Air Forces of the World*, Chartwell Books, Inc., Secaucus, N.J., 1983, p. 159; Clark S. Young, Jr., *Soviet Strategic Airlift and Power Projection*, U.S. Army Command and General Staff College, Fort Leavenworth, Kansas, 1980.

³Taylor, "Jane's Aerospace Survey, 1984," pp. 54-55; Bill Sweetman, "New Soviet Aircraft. Quality with Quantity?" *International Defense Review*, No. 1, 1984, pp. 37-38; "Soviets Build Largest Jet Cargo Plane," *The Washington Post*, December 16, 1983, p. A37; *Soviet Military Power 1983*, p. 46.

⁴The Soviets have so far relied on naval transport to ferry tactical aircraft to remote areas; see Keith A. Dunn, "Power Projection or Influence: Soviet Capabilities for the 1980's," Strategic Issues Research Memorandum, Strategic Studies Institute, U.S. Army War College, Carlisle Barracks, Pennsylvania, November 1, 1980, p. 6.

⁵The Soviets have also shown they can mobilize their merchant marine fleet in support of military objectives in remote locations, as witnessed by their sealift of military



SOURCE: Adapted from Peter Borgart, "The Soviet Transport Air Force. Aircraft and Capabilities," *International Defense Review*, 1979, p. 948.

NOTE: As customary, performance estimates for the An-400 (before the recent Jane's update referred to as the An-40) are approximated as a 5 percent improvement over those for the C-5A. Dates shown represent maiden flights.

Fig. 1—Increasing lift capability of Soviet military transport aviation (VTA) aircraft

reports suggest that they may now be modifying additional Tu-16 BADGERS to serve as aerial refueling tankers for their long-range bombers.⁶ Although this does not imply that they have added in-flight refueling capabilities to their transport or tactical aircraft, it indicates that they could develop this option if they wished.

The wide range of Soviet access and the growing Soviet force projection capabilities have important implications for several aspects of likely future U.S. Air Force operating environments. They imply reductions in available response time, increases in deployment distances, less favorable force ratios, and an insufficiency of available operating locations for our own forces. Stated another way, the

supplies to Angola during the civil war in 1975-1976. Since the early 1960s, they have increased their naval strength and have gained military access to several strategically located deep-water ports, such as Cam Ranh Bay in Vietnam. They can therefore deploy more rapidly than before into areas they consider strategically important.

⁶"Soviet Bomber Sorties," *Aviation Week & Space Technology*, December 12, 1983, p. 25.

geographic breadth of the enemy threat greatly magnifies the Air Force's uncertainty as to where and whom it may be called upon to fight.

FIGHTER AND FIGHTER-BOMBER AIRCRAFT CAPABILITIES

The Soviets are steadily improving the quality of the weapon systems in their aircraft inventory. The remainder of the century will undoubtedly bring major qualitative advances in their fighters and fighter-bombers.

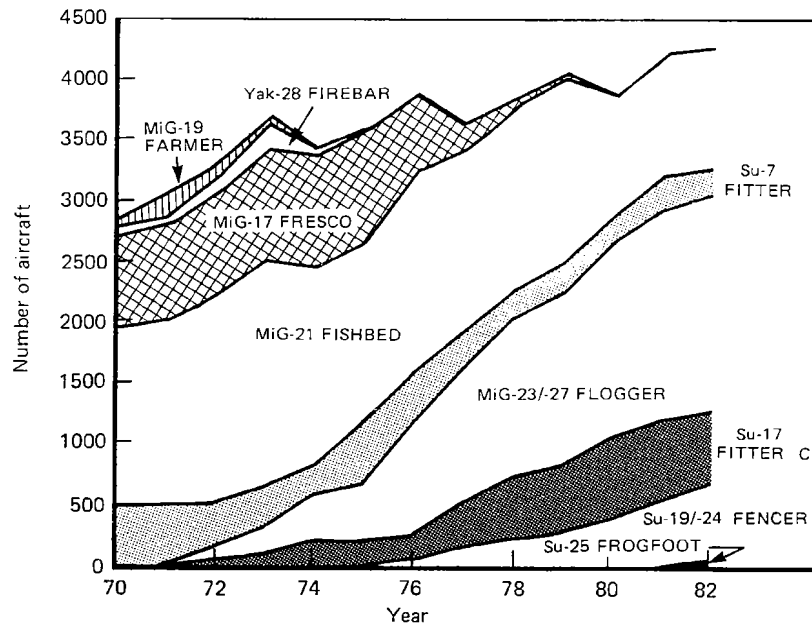
During the 1970s, total Soviet fighter production peaked at an estimated 1200 aircraft per year. Current estimates are that the Soviets are producing almost 1000 additional fighter aircraft of all types each year.⁷ Even allowing for the fact that these figures include aircraft destined for the Warsaw Pact and for sale abroad, the annual addition of such quantities of modern aircraft to the Soviet inventory represents an important, on-going change in the combat environment for which the U.S. Air Force must plan. As illustrated in Fig. 2, estimates of the Soviets' fighter and fighter-bomber inventories show a gradual numerical increase between 1970 and 1982, in combination with a progressive retirement of older aircraft and their replacement with newer models. This pattern of modernization will undoubtedly continue during the 1980s and beyond, as new Su-27 FLANKER and MiG-29 FULCRUM aircraft enter service. Furthermore, the Soviets' recent reorganization of their Frontal Aviation and Air Defense (PVO Strany) forces has shifted a sizable number of aircraft between them, thus adding many highly capable interceptors to the Frontal Aviation inventory.⁸

The new Soviet aircraft expected to enter service in the 1980s and 1990s will undoubtedly embody significant performance improvements. For example, the Su-27 FLANKER and, to a lesser extent, the MiG-29 FULCRUM are expected to narrow the maneuverability advantage the F-15 and F-16 now enjoy over such contemporary Soviet aircraft as the MiG-23 FLOGGER.⁹ Because of the Soviets' high production rates for these more advanced aircraft, they may achieve something close to a fleet-wide technical parity with U.S. and NATO air forces by the late

⁷Sweetman, "New Soviet Aircraft," p. 35; *Soviet Military Power 1984*, U.S. Dept. of Defense, Washington, D.C., 1984, p. 96.

⁸International Institute for Strategic Studies, *The Military Balance 1983-1984*, London, 1984; *Soviet Military Power 1984*, pp. 54-56.

⁹Sweetman, "New Soviet Aircraft," pp. 36-37.



SOURCE: Adapted from John M. Collins and Thomas Peter Glakas, *U.S./Soviet Military Balance. Statistical Trends, 1970-1982 (as of January 1, 1983)*, The Library of Congress, Report No. 83-153 S, October 1981, updated August 1, 1983, Table 15, pp. 64-65.

Fig. 2—Soviet Frontal Aviation fighter aircraft inventories, 1970-1982

1980s; if they retire their older aircraft as they introduce new ones, they will enhance their overall qualitative capabilities even though they slow their rate of numerical increase.

When aircraft types intended for the air-to-ground mission are segregated from those with air-to-air missions, it becomes apparent that the numerical strength of the Soviet Frontal Aviation's air-to-ground element has grown spectacularly since the early 1960s, approximately doubling between 1970 and 1980. The Soviets have also qualitatively improved their fighter-bombers by introducing new aircraft designed specifically for the air-to-ground mission (such as the Su-24 FENCER and Su-25 FROGFOOT), extensively modifying air-to-air aircraft for air-to-ground operations (such as the MiG-27 FLOGGER D and Su-17 FITTER C), and retiring older air-to-air fighter aircraft

(such as the MiG-17 FRESCO and MiG-21 FISHBED) modified for air-to-ground missions. Although the numerical growth rate of this Soviet ground attack force may slow during the rest of the century, continuing qualitative improvements will no doubt enhance its effectiveness against U.S. and NATO forces while it continues to gain in comparative numbers.

Product improvements and new designs are also improving the detection range and tracking functions of Soviet airborne radars. Building on the technology base of the MiG-31 FOXHOUND, new Soviet tactical fighters soon entering service are expected to possess lookdown-shutdown capability and to rival U.S. aircraft target-acquisition and fire control capabilities.¹⁰

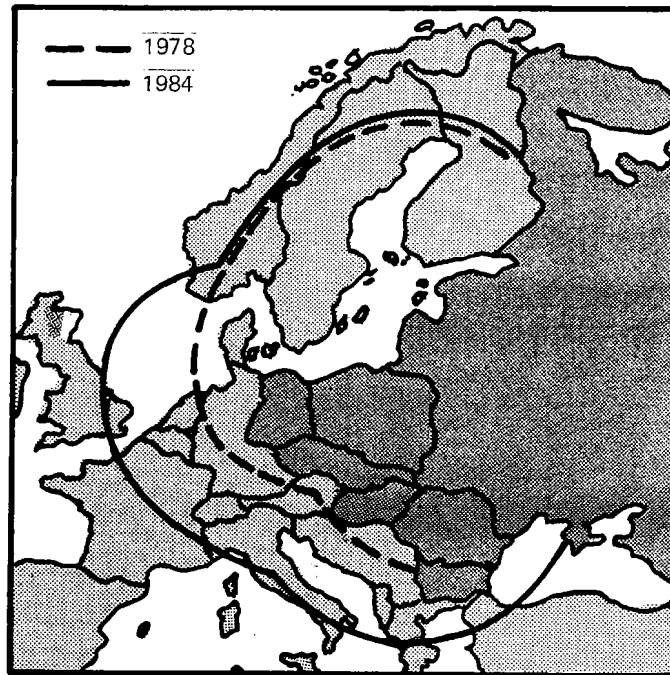
One of the most apparent and alarming areas of Soviet improvement is in range-payload capability. The Su-7 FITTER A, introduced in the early 1960s, can reach only a short distance from Warsaw Pact territory into FRG airspace with an appreciable payload. By the late 1970s, the introduction of the MiG-27 FLOGGER D and Su-24 FENCER extended the range and effectiveness of Soviet ground attack capabilities, thus threatening airbases increasingly deep into NATO territory, as shown in Fig. 2. The FENCER is particularly lethal because of its capability for low-level dash and impressive payload carriage. By the end of the 1980s, Soviet Frontal Aviation ground attack aircraft are expected to be able to strike NATO bases in the United Kingdom with sizable payloads.¹¹ The newest aircraft operated by the Soviet Long-Range Air Force, the Tu-22M BACKFIRE, and the Tu-160 BLACKJACK A (now under development), pose an additional potential threat to NATO facilities throughout Europe and to possible U.S. bases of operation in third world areas.

Current-generation Soviet fighter-bomber aircraft exemplified by the Su-24 FENCER not only can carry greater payloads longer distances than could earlier generations of Soviet aircraft, but can also deliver free-fall weapons much more accurately than their predecessors, thereby increasing the potential damage they can inflict on NATO airbases.¹² The accuracy improvement means that the Soviets can inflict the same level of damage with a fraction of the sorties and far fewer bombs than they previously required. As long as the Soviet fighter-

¹⁰*Soviet Military Power 1983*, pp. 28-29; James W. Canan, "Toward the Totally Integrated Airplane," *Air Force Magazine*, January 1984, p. 36.

¹¹*Soviet Military Power 1983*, p. 43.

¹²For example, the Soviets have improved the free-fall weapons delivery accuracy of newer aircraft, such as the Flogger D, with laser ranger/seekers; see, e.g., Chant, "Mikoyan-Gurevich MiG-27 'Flogger-D'," and "Sukhoi Su-24 'Fencer-C,'" pp. 174-175 and 198.



SOURCE: *Soviet Military Power 1984*, p. 56.

NOTE: Mission radii calculations assume that the Soviet aircraft fly NATO-lo-lo-hi mission profiles.

Fig. 3—Range improvements of Soviet ground attack aircraft

bomber force size increases or even remains stable, this will represent a substantial absolute improvement in their air-to-ground capability. The improved accuracy also allows the Soviets more latitude to trade payload for fuel to strike deeper into NATO territory or further into third world areas.

Such Soviet improvements will require that we make continued efforts to retain qualitative superiority. Continual improvement in our own detection capabilities and reduction in the detectability of our aircraft will involve advances in sensor technology (e.g., passive detection and tracking subsystems), signal processing, air vehicle structures, and other areas. The introduction of new, more sophisticated equipment

potentially even more difficult to repair and costly to stock will complicate effective operational support. The improvements we must make in aircraft structures, aerodynamics, propulsion, electronics, and armaments will also present major logistical challenges. For example, aluminum structure will be replaced with composites, for which rapid and convenient field battle damage repair techniques are still being developed. In the future, mechanically driven, continuously variable camber airfoils may replace the fixed-wing surfaces now requiring minimal maintenance and support. The expected integration of flight and fire controls will complicate the already difficult job of fault isolation. Furthermore, continuing Soviet additions of precision-guided munitions to their inventory require that we pay more attention to the resiliency of our support infrastructure.

FORCE SIZE

The size of the Soviet Frontal Aviation inventory gives a rough picture of the numerical strength of the enemy threat. Most estimates of the actual forces suggest that the Warsaw Pact can probably contribute more than 3000 combat aircraft of all types to the Soviet forces confronting NATO's central region.¹³ Until the mid-1970s, many, if not most, of these Warsaw Pact aircraft would probably have been deployed defensively, against intruding NATO fighters and bombers. Since then, however, increasingly numerous and sophisticated Soviet surface-to-air missiles and anti-aircraft weapons have freed a growing proportion of the Warsaw Pact inventory for offensive missions.¹⁴ About two-thirds of these aircraft might be used in a ground attack role.

Not only do the Soviets have large numbers of aircraft available to use in third world conflicts, if they choose to commit them there, several of their third world allies also possess sizable air forces with sophisticated aircraft and capable surface-to-air weapons. The Soviets could therefore seriously threaten U.S. operations in regional conflicts, either directly or by proxy. Table 2 illustrates this growing threat from potential Soviet allies by showing the large recent qualitative and quantitative increases in the aircraft inventories of Libya, North Korea, and Cuba.

¹³Harold Brown, *Department of Defense Annual Report, Fiscal Year 1982*, Washington, D.C., 1981, p. 69. Brown indicated that these forces were then undergoing both numerical expansion and modernization, so an estimate of 3000 Warsaw Pact aircraft contributable to the Soviet forces is undoubtedly a low one for any future conflict.

¹⁴Brown, *Department of Defense Annual Report, Fiscal Year 1982*, p. 70.

Table 2
FIGHTER AND GROUND ATTACK AIRCRAFT IN SELECTED
THIRD WORLD INVENTORIES

Libya		North Korea		Cuba	
1972	1982	1972	1982	1972	1982
22	513	578	692	185	219
F-5A	Blinder	IL-28	IL-28	MiG-15	MiG-17
Mirage III	Mirage F1	MiG-15	MiG-15	MiG-17	MiG-21
	Mirage 5	MiG-17	MiG-17	MiG-19	MiG-23
	MiG-21	MiG-19	MiG-19	MiG-21	} 86%
	MiG-23	MiG-21	MiG-21	} 27%	
	MiG-25	Su-7	Su-7		
	Su-20/22				
	on order				
	230				
	MiG-23				
	MiG-25				
	Mirage F1				

SOURCE: International Institute of Strategic Studies, *The Military Balance 1972-1973*, London, 1973; *The Military Balance 1982-1983*, London, 1983.

SUMMARY

This section obviously cannot cover all the relevant aspects of the evolving enemy threat, nor can it treat the dimensions cited in exhaustive detail. For example, in addition to the capabilities and trends summarized, there is evidence that Soviet air forces have made command and control improvements in East Asia. This would substantially strengthen their ability to wage war in that area without drawing down forces committed to other parts of the world or, alternatively, to wage war elsewhere without diminishing forces in East Asia.¹⁵

This abbreviated characterization of the changing threat is intended mainly as a "reminder" of a general pattern: We face many potential

¹⁵For more information on the recent Soviet military build-up in Siberia, Central Asia, and the Soviet Far East, see Harry Gelman, *The Soviet Far-East Buildup and Soviet Risk-Taking Against China*, The Rand Corporation, R-2943-AF, August 1982. More recently, newspaper reports also point toward similar conclusions; see, for example, Drew Middleton, "Soviet Buildup in Far East Causing U.S. Concern," *New York Times*, January 30, 1984, p. 2.

enemies in all parts of the world who are steadily improving in terms of aircraft weapon system capabilities. Most important, the implications of that threat shape the environment within which our own forces must prepare to fight.

III. FUTURE OPERATING ENVIRONMENTS

In the past, the expectation that combat support services could be delivered in a fairly predictable and benign environment has shaped both the support infrastructure and the support characteristics of Air Force tactical weapon systems. However, the distribution, quality, and size of the threat are making the environment within which U.S. forces must operate more stringent and less predictable with respect to

- the time they will have to respond to enemy action
- the location of potential conflicts
- the size and composition of adversary forces
- the availability and extent of support facilities, and
- the exposure of those facilities to enemy action.

Understanding the shortcomings of current forces and the kinds of capabilities and operating characteristics needed for the future requires an appreciation of how these environmental uncertainties complicate the weapon system support process.

RESPONSE TIME

One of the ways the combat environment of the future will differ from past conflicts is the increased probability that our forces will have to deploy and fight on very short notice. For European conflicts, this largely results from the Warsaw Pact forces' position, strength, and readiness. They can strike more quickly, deeply, and lethally than they could even just a few years ago. The ambiguity of certain Pact peacetime operations complicates the problem of assuring adequate warning of an attack. In other areas of the world, such as Southwest Asia, we have the further disadvantage of Soviet proximity to the region, the growing Soviet airlift capability, and our limited presence near areas of potential conflict. Limited response time increases the importance of maintaining high levels of peacetime readiness, of making our forces more mobile, and of assuring that the limited number of immediately deployable aircraft can generate sufficient sorties in the early days of a conflict. We must then be able to maintain the combat efficiency of those aircraft while sustaining a high sortie rate for an extended period of time.

DEPLOYMENT DISTANCES

The global character of the threat has three consequences: greater uncertainty about where our forces will have to fight, possible very long deployments, and worrisome problems en route. For example, some plausible conflict locations, such as the Persian Gulf, involve deployment distances 50 percent longer than a typical U.S.-to-Europe leg. Myrtle Beach AFB, an A-10 installation in South Carolina, is 3800 n mi from Ramstein AB, but 6200 n mi from Dhahran, Saudi Arabia. These distances are daunting, especially when one recalls the support difficulties experienced by the British in 1982 because of the 8000 n mi distance between the British Isles and the Falkland Islands. Consider also that such distances far exceed the unrefueled ferry range of fighter aircraft in the U.S. inventory. But once we have decided to deploy to a given location, distance is not the only problem: We must obtain over-flight rights (to avoid circuitous routings) and arrange access to intermediate bases or tanker support. Moreover, deploying forces must be prepared for hostilities en route.

The possibility of remote conflicts indicates a need to make the support elements of our tactical forces as lean as possible.

FACILITIES

The need to assess and plan for available facilities is especially important in light of the paucity of well-equipped operating locations near probable conflict locations in some vital regions. Figure 4 illustrates this problem in Southwest Asia. We have only one assured operating site, Diego Garcia, in the area; and it is over 2800 n mi from northwestern Iran, where a U.S. force might first have to meet a Soviet invasion. Although we have completed contingency access agreements with several nations in this region, internal political considerations might lead any or all of them to deny us access even to these sites in the event of actual conflict. Moreover, all the sites are at the edge of or outside the combat radii of most of our current frontline combat aircraft, and only one of these nations will soon operate the current generation of U.S. fighter aircraft (Egypt is acquiring F-16s) and thus possesses suitable aerospace ground equipment, support resources, and so on.¹ We must therefore prepare to deploy quickly with everything necessary to set up and conduct combat operations from austere sites.

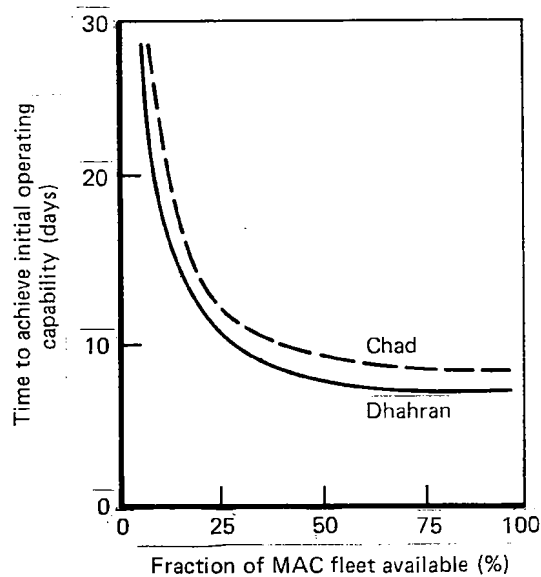
¹Several countries in the uncertain base rights category operate current generation U.S. equipment, including Israel (F-15s, F-16s), Saudi Arabia (F-15s), Pakistan (F-16s), and Turkey (F-16s on order).



SOURCE: Adapted from U.S. Department of Defense Annual Report, FY82.

Fig. 4—Potential U.S. Air Force operating bases for a Southwest Asian conflict

The support characteristics of current U.S. weapon systems make such deployments very difficult. For example, if the Air Force could gain access to an established Saudi airbase in Dhahran, moving two F-15 squadrons there would require approximately a week, even using almost all of the Military Airlift Command's (MAC) fleet² and exclusive of the requirements for fuel and replenishment supplies. Deployment to a bare-base location (such as Chad) would require 50 percent more transport aircraft loads to accommodate the bare-base set, including airfield lighting equipment, housing, and other structures, as well as additional time to set them up. Under the more realistic assumption that about a quarter of the MAC fleet would be available, the overall deployment would require slightly less than two weeks, although limited combat operations might begin somewhat sooner, as F-15s and support personnel arrived. Figure 5 illustrates this situation.



SOURCE: Developed from U.S. Air Force and U.S. Army source data.

Fig. 5—Time for initial deployment of two F-15 squadrons to the Third World

²This assumes a CONUS marshalling time of three days and two days to offload and set up upon arrival in Saudi Arabia.

Peacetime readiness and strategies for minimizing the resources deployed to support high effective-sortie rates are critical.

FORCE RATIOS

Once operations begin, the very large forces the Soviets and their allies can assemble will almost certainly outnumber our forces. In Europe, the ratio of NATO air defense forces to enemy escorts for air-to-ground attackers will be a function of the day in the war (because we must deploy so many of our forces from the United States), the extent of French Air Force involvement, and the way commanders use allied multirole aircraft (such as the F-16). Even under the most favorable conditions, NATO forces will be substantially outnumbered during the early, critical phase of the war. That numerical inferiority could be more extreme in some third world conflicts, particularly in areas adjacent to the Soviet Union, such as northwestern Iran, where the Soviets could achieve their objectives within the range limitations of their fighter aircraft.³ In northwestern Iran, for example, the Soviets could assemble invasion forces several times larger than the U.S. forces available for rapid deployment against them.

INFRASTRUCTURE VULNERABILITY

The numerical strength and growing air-to-ground attack capabilities of potential enemy air forces present a formidable threat to the infrastructure supporting our combat operations. The threat of substantial and repeated airbase attacks—including attacks at the beginning of and during deployment—is probably the single most important difference in future combat environments. U.S. air forces have almost always enjoyed air superiority over their bases and facilities. That superiority is no longer assured and should not be assumed unquestioningly in planning for future combat.

Designed long before the enemy's development of a potent ground attack capability, our current support infrastructure—bases, workforces, and logistics systems—is extremely vulnerable to the damage a modern attacking force can inflict. This vulnerability stems in part from our bases' physical layout, which clusters critical assets, generally in above-ground, fairly soft structures. Although there have been many initiatives in recent years to reduce this vulnerability (by relocating

³Dennis Ross, "Considering Soviet Threats to the Persian Gulf," *International Security*, Vol. 6, No. 2, Fall 1981, pp. 159-180, esp. 175-178.

some support equipment to aircraft shelters, for instance), the general problem posed by the expected continued growth in enemy capability persists, especially at our collocated operating bases in Europe.

The extensive specialization and resulting size of our maintenance force also contributes to our infrastructure's vulnerability. An F-16 wing, for example, includes 1089 support personnel organized into 23 different specialties.

It is impossible to know how much damage an enemy attack would cause to a typical airbase. The simulated results depicted in Fig. 6 reveal the damage a medium-sized enemy attack (featuring 10 fighter-bombers and 10 medium bombers) might inflict.⁴ The circles represent the area within which Warsaw Pact FAB-250 (552 lb) bombs will knock down the walls of standard NATO cinder-block buildings, killing or injuring critical support personnel, destroying support resources, and disrupting sortie generation activities.

What effect would enemy attacks have on our air operations? Figure 7 shows how sortie generation for 120 F-4Es deployed to three NATO airbases in the FRG, 72 to a main operating base and 24 each to two collocated operating bases, might degrade under attacks by Warsaw Pact aircraft on days 1, 3, 5, and 6.⁵

Substantial efforts are underway to toughen our bases, but we believe strongly that the U.S. sortie generation infrastructure's

⁴The results shown in Figs. 6 and 7 were produced with the TSAR and TSARINA models developed at Rand for the U.S. Air Force. For more information, see Donald E. Emerson, *An Introduction to the TSAR Simulation Program*, The Rand Corporation, R-2584-AF, February 1982.

⁵The simulations depicted in Fig. 7 assumed that the Warsaw Pact attacks emphasized targeting of aircraft shelters and support facilities (thus omitting the effects of attacks directed at runways, to reflect on-going U.S. Air Force efforts to minimize the effect of that threat). The total number of Warsaw Pact aircraft (assuming a 10 percent attrition of attacking aircraft per sortie) attacking each base is shown below:

Day	Main Operating Base		Collocated Operating Bases			
	Medium Bombers	Fighter-Bombers	Base 1		Base 2	
			Medium Bombers	Fighter-Bombers	Medium Bombers	Fighter-Bombers
1	8	32	10	32	28	6
3	8	32	4	16	19	4
5	8	32				
6		6	16	19	4	

The simulations also reflect assumptions that extra aircraft battle damage repair teams will be immediately available at the bases and that 72 aircraft can be made available to replace losses within 2.5 days. See Donald E. Emerson, "USAFE Airbase Operations in a Wartime Environment," The Rand Corporation, P-6810, October 1982.

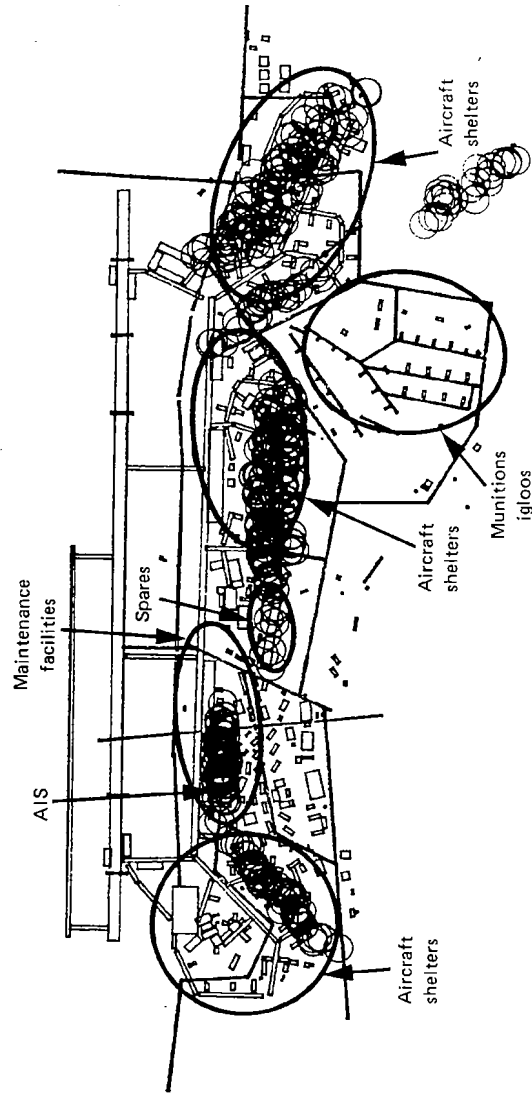
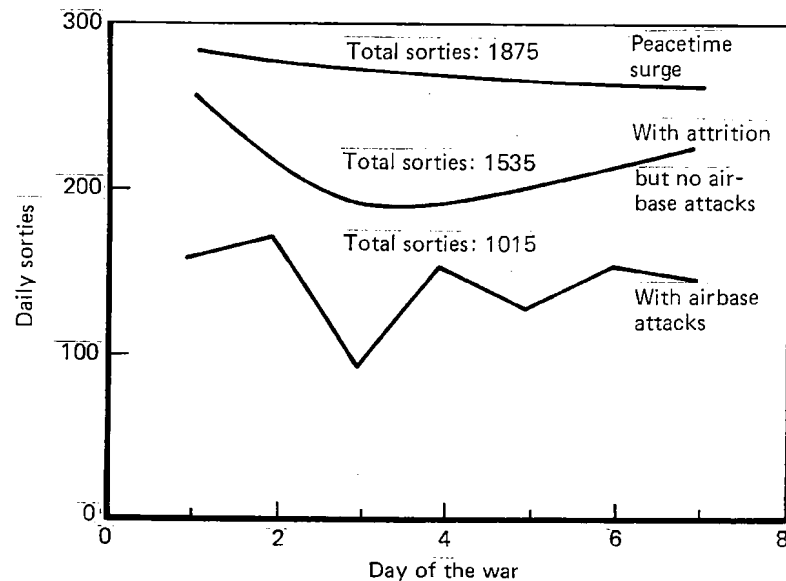


Fig. 6—Airbase facility damage from a Soviet attack

vulnerability to a numerically superior enemy with improving ground attack capabilities also necessitates a thorough reexamination of future wartime logistics. We need to ask what must be done to make the sortie generation process more resilient and more robust.

SUPPORT DEMAND DYNAMICS

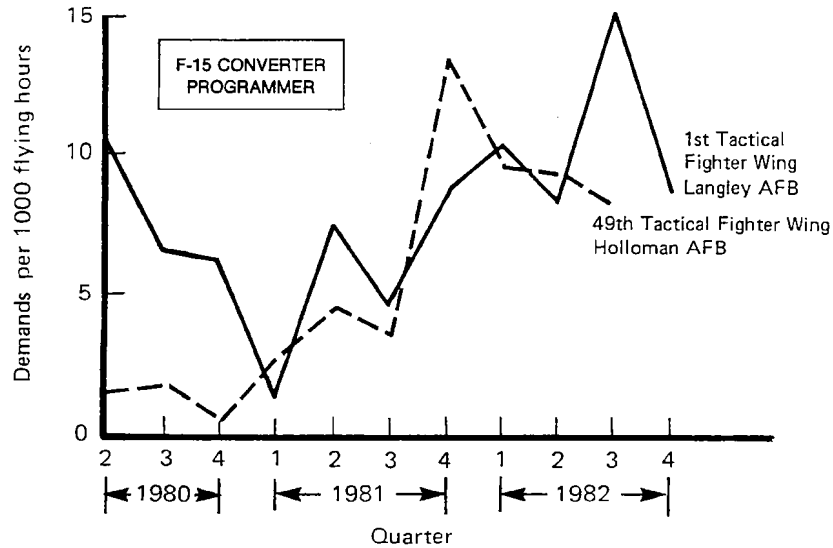
Because they cast doubt on the survival of critical resources, the growing enemy airbase attack capabilities indicate increasing uncertainty about the nature of future combat environments. Hostile enemy actions are only one source of uncertainty, however. Recently collected data indicate that the rates of removal for critical components from their weapon systems and resulting demands on the support system are highly variable and unpredictable, *even in the absence of combat action*. This largely unrecognized unpredictability of demands for support resources will further complicate our ability to sustain wartime air operations.



SOURCE: Donald E. Emerson, "USAFE Airbase Operations in a Wartime Environment," The Rand Corporation, P-6810, October 1982.

Fig. 7—Effects of airbase attack on sortie generation at NATO air bases

The demand forecasting uncertainty can be seen in Fig. 8, which displays the demand rates of the converter programmer expressed as the number of demands per 1000 flying hours, experienced by two similar F-15 wings since April 1980. The converter programmer, a critical part of the F-15's weapon delivery subsystem, processes data from the radar and the fire control computer and generates the analog signals necessary for using the aircraft's missiles and gun. The demand rates of this unit vary widely across periods of time and from base to base. Our preliminary investigation, which has involved other important F-15 parts and is now extending to other weapon systems, has revealed no pattern or identifiable causes, nothing to help predict the next quarter's demand rate at either Holloman or Langley AFB.⁶ In addition, this unpredictable variability also appears to plague older, less



SOURCE: Data supplied by Headquarters, Tactical Air Command.

Fig. 8—Support dynamics: Demand rate variability

⁶We have data covering the Tactical Air Command's other F-15 bases as well.

sophisticated weapon systems and is not solely a consequence of the F-15's sophisticated functional performance and attendant subsystem integration, necessitated by the enemy's own performance advances.

If recognized, such unpredictable demands for support are certainly unappreciated. All features of the current combat support system presuppose that we can accurately estimate and forecast the frequency and location of required component removals. Thus, there is generally high confidence that war readiness spares kits (WRSKs) will satisfy the needs of deployed units flying wartime sortie rates; there is also solid support for continuing to strive for wing—and even squadron—self-sufficiency, a longtime goal of the tactical forces. But the magnitude of the demand rate variability we have seen so far makes such a goal unaffordable without profound structural changes in the support system, especially in light of the other emerging uncertainties in the conditions of future wartime environments.⁷

SUMMARY

The *geographic breadth*, the *capabilities*, and the *size* of the enemy threat will have a profound effect on future operational environments confronting the Tactical Air Forces. The Tactical Air Forces must be able to deploy quickly over long distances, operate in locations lacking well-provisioned facilities, and sustain those operations in the face of adverse force ratios, airbase attacks, and the inherent uncertainties in the demand for support (see Fig. 9).

Together with the continuing constraints on operating budgets and the increasing scarcity of personnel, these new and intensified environmental conditions should have far-reaching effects on the way we prepare to fight and how we actually operate. They should also shape the capabilities and operating characteristics we strive for in our current and future forces.

⁷Experience from successful peacetime surge exercises provides ample evidence that self-sufficiency is difficult to attain. Two recent examples are CORONET EAGLE and CORONET HAMMER, 1980 deployments of 18 F-15s and F-111s, respectively, from U.S. bases to allied bases in Europe. In each three-week exercise, the units took along full WRSKs (sized for 24-aircraft squadrons and 30 days of operations). They achieved the planned high sortie rates but, in order to do so, had to draw on neighboring units and U.S. depots for substantial portions of the total number of spare parts required by component removals (36 percent in CORONET EAGLE, 24 percent in CORONET HAMMER). See U.S. Air Force, Tactical Air Command, *Final Report on the CORONET EAGLE F-15A/B Deployment*, January 5, 1981, p. 17; U.S. Air Force, Tactical Air Command, *Final Report on the CORONET HAMMER F-111D Deployment*, June 30, 1980, p. 12.

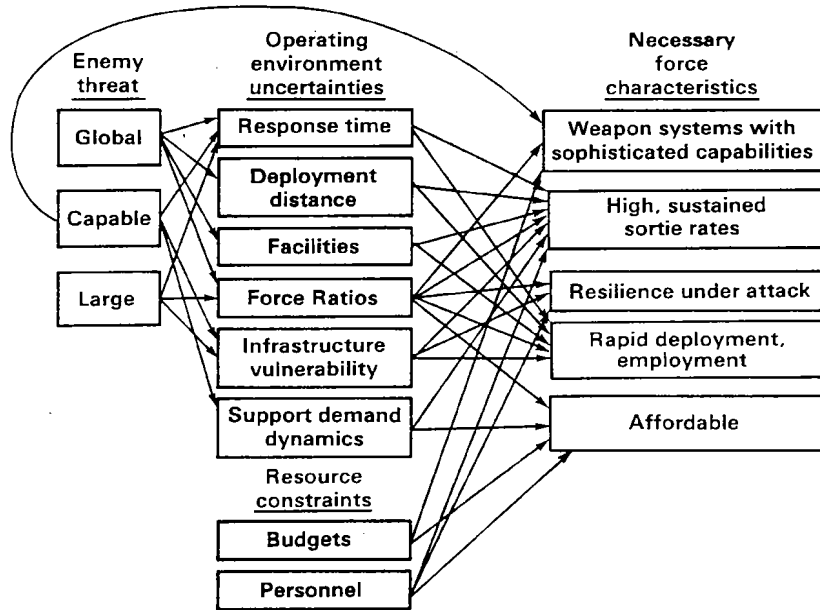


Fig. 9—Factors shaping necessary characteristics of future forces

We need to continue to equip these forces with superior weapon systems to counter the enemy's own advances in quality and numbers. The adverse force ratios, created both by inventory size differentials and by the distances of many plausible conflict locations from the United States, make rapid and sustained high sortie generation capability vital. This capability must be resilient to damage and disruption at our bases and facilities. Further, we must achieve it with a bare minimum of deployed resources, to allow for lack of warning and to permit effective operations in austere environments and necessary or appropriate dispersal and reconstitution options. Finally, we must do all this within the inevitable and foreseeable resource constraints.

As Fig. 9 shows, a complicated combination of probable environmental conditions necessitates these force characteristics; no single conflict characteristic dominates. Even if the enemy threat to our airbases

were to materialize more slowly than today's projections or if our current third world base access restrictions were somehow overcome, the basic goals for our future forces would not change. The levels and combinations of these desired capabilities are without question going to be difficult to achieve and will require new initiatives in almost every aspect of Air Force business.

IV. IMPLICATIONS FOR RESOURCE MANAGEMENT

Developing forces capable of meeting future threats probably requires significant changes in the way the U.S. Air Force develops and manages weapon systems and support resources. These changes must reflect the altered nature of combat settings and conditions. Although the specific steps are neither obvious nor easy, we believe that the U.S. Air Force needs to reexamine the emphasis placed on different weapon system performance characteristics and the organization and management of its weapon acquisition and combat support processes. Here we describe several major hypotheses under investigation at Rand concerning both current shortcomings and potential solutions.¹

An important consequence of the growth in enemy capabilities—especially the ability to strike quickly over long distances—has been an enlargement of the combat arena facing the Tactical Air Forces. Until recently, the combat arena was the area immediately surrounding the enemy target; an aircraft's performance in that area together with its efficiency in traveling to the target were regarded as the primary determinants of combat effectiveness. *Now, however, we must also test an aircraft's basing posture and support systems against the demands of likely combat scenarios.* The wartime threat—including both its dynamics and uncertainties—will have to play a more prominent role in the planning and conduct of logistics operations. Further, wartime supportability must receive more emphasis in the development (and modification) of the weapon systems themselves.

The evolving threat makes *robustness* and *flexibility* the required attributes of future logistics operations. The operational forces must be lean enough to permit rapid deployments and redeployments, but the sortie generation process must also be productive in austere locations and resilient in hostile environments. The entire support system must be more flexible in the face of dynamic and unexpected demands. Satisfying these stringent requirements will require changes in the composition of both the forward combat forces and the rearward support infrastructure. The broad outlines of those changes are emerging, although much work is needed before their details are well understood.

¹This section draws heavily on unpublished research by Mort Berman, I. K. Cohen, Gordon Crawford, Jean Gebman, Raymond Pyles, Hy Shulman, and the authors, among others.

Future combat forces must be able to operate in forward areas with minimal support resources. This means

- reducing the size of support elements (including large amounts of intermediate level repair) at forward operating locations,
- reducing reliance on large amounts of aerospace ground equipment, and, perhaps,
- streamlining the flightline workforce by training and using more generalists.

These generalists would have to be capable of launching combat sorties for several different types of aircraft, thereby enlarging the combat commander's flexibility in using his available bases. Our airbases' vulnerability to attack suggests further that these sortie production facilities be toughened by various means, including camouflage and deception, and enriched with improved attack recovery.

Perhaps more important, steps should be taken to create a capability for widely dispersing critical combat force elements in a period of tension or during a conflict. First, of course, we must create a rapid and assured lateral support system. This would strengthen a theater commander's ability to use all his resources in responding to unexpected events and extraordinary needs at some bases, brought on by either enemy actions or the unpredictable "demands" described earlier. The European Distribution System is a promising development in this regard, but the expansion of lateral supply and repair capabilities to encompass allied combat forces and support assets in the theater of operations holds substantial additional promise.

The infrastructure supporting forward operating forces must be very responsive and flexible. The amount, locations, and configuration of intermediate-level repair facilities in the major theaters are important issues in the design of future support operations. They should not, however, be addressed apart from the role the U.S.-based depots, with their unequalled breadth and depth of repair capability, can and should play in supporting wartime operations, especially in the critical early days and weeks.² The possibility of simultaneous conflicts in different regions and the probability that theater assets will be unable to satisfy critical demands in an uncertain operational environment underscore the need for a strong and responsive central support system. Such a system would require a sophisticated command and control system to

²Most current plans for a war in Europe provide for only very limited "retrograde" and depot resupply transportation in the early weeks of the conflict. In fact, some important resource allocation decisions assume that the U.S. depot system will be "cut off" from the combat theater for several weeks, while strategic airlift transports ground forces and other cargo. When these assumptions are considered along with projected repair times for broken components, the first depot repaired items are unlikely to return to the combat theater before a conflict is several months old.

pinpoint support needs and assess alternative means for satisfying them. It would also need an agile depot repair system, whose "production" would be closely coupled to the needs of the operational forces, a linkage requiring enhanced (and sustained) intertheater transportation for logistics resources.

These changes—more austere flightline operations, more base-to-base interaction, and more depot responsiveness to combat-generated demands—will involve many difficult tradeoffs. However, moving in this direction would result in a more integrated support system with additional checks against wartime uncertainties and fewer lengthy "pipelines" of parts. It therefore holds the promise not only of providing the necessary resiliency and flexibility in wartime logistics operations, but also of doing so without increased costs.

The enlargement of the combat arena also has important consequences for the way the Air Force conducts weapon system research and development. Although it is widely acknowledged that the combat effectiveness of a weapon system is a function of not only the air vehicle, but also the basing mode and the accompanying support system, new developments (and major modifications) rarely reflect that view. Typically, existing basing and support concepts are accepted as "givens," the development challenge being to conceive the best air vehicle within those constraints. However, the evolving threat requires reappraisal of present-day basing and support system concepts. The weapon system development community should place a high priority on identifying and evaluating tradeoffs in alternative operating concepts embodying different basing and support arrangements.³

A weapon system's support characteristics—those physical and performance attributes dictating the required amount, type, and location of support resources, in particular those that must accompany deploying units—should also receive added emphasis in the formal expression of system requirements issued to guide important design and development activities. The aspects of a weapon system's configuration and performance relating to speed, maneuverability, weight, and payload generally overshadow its support characteristics in requirements statements. In addition, support-related requirements are usually less specific and devoid of the operational context that would make them meaningful. Although the preliminary drafts of important Advanced Tactical Fighter program documents show some improvement along these lines, we must still vastly improve the articulation of support

³For an outline of what such an analytical approach should include, see M. B. Berman with C. L. Batten, "Increasing Future Fighter Weapon System Performance by Integrating Basing, Support, and Air Vehicle Requirements," The Rand Corporation, N-1985-1-AF, April 1983.

requirements to achieve the necessary flexibility and resilience in logistics operations. For example, the changes in the threat and likely combat environments mean that we must replace the classical definition of reliability with one that captures meaningful degradations in an equipment's functional performance—even short of failure—and also captures an equipment's *total* demand for on-site support resources.

Any added emphasis on support-related features in future weapon system requirements statements must be matched by changes in the validation and verification activities of each stage of the development process. This means more concerted use of logistics capability assessment models during concept formulation and advanced development. Even more important, it means a reexamination of how we plan and conduct both component and full-scale system test and evaluation programs. Under current practices, we rarely know support-related performance levels (and therefore shortfalls) until well after *high-rate* production begins (by which time major design changes are essentially foreclosed).⁴

The area in need of most attention is probably combat avionics—the fire control radar, weapons delivery and stores management equipment, the inertial navigation set, the head-up display, and electronic countermeasures. Critical to the combat effectiveness of modern fighter aircraft, these subsystems must perform their individual functions with increasing precision, interdependence, and integration. The problems posed by the design of each subsystem and the integration of the various subsystems into an effective suite are now as great as the challenges the air vehicle designers face.

The avionics development process has not changed with the growing importance of avionics to combat effectiveness, however. Full-scale development of the avionics suite usually begins well after full-scale development of the air vehicle itself (in the case of the F-15 radar, for example, after about a year's interval). By then, there are generally less than two years until *high-rate* production begins—not enough time to mature such a sophisticated and complex suite of equipment. As a result, all recent fighter aircraft have entered operational service with avionics component removal rates that seriously constrain sortie generation capability and force mobility. Those removal rates must improve greatly if we are to achieve the desired leanness in flightline operations and mobility in deployable units.

A promising alternative, based on favorable outcomes of programs involving ballistic missiles, spacecraft, and commercial navigation

⁴We are currently studying ways to improve the requirements and test and evaluation processes. Our findings should be available in the latter half of 1984.

equipment, is to begin the development of critical avionics subsystems *before* the development program for the air vehicle (as in aircraft turbine engines).⁵ An additional development cycle aimed at improving component reliability and fault diagnosis would then become possible in the extra time before production. Such an additional cycle of test and operations and redesign is now being attempted for the F-15 and F-16 radars. As part of an original development program and in conjunction with the other changes described here, this approach would be a very important advance in the treatment of supportability.

By widening the focus of development activities to encompass both the air vehicle and its support infrastructure and by increasing the importance, operational meaning, and achievability of weapon system support requirements, such a revamped weapon system acquisition process would help assure that future Tactical Air Forces possess the necessary operational capability to meet the enemy threat.

An important finding of our research is that an effective strategy for meeting the challenges posed by the enemy threat and its influence on future operating environments must involve a large slice of the Air Force resource management community. Ambitious efforts to strengthen the combat support system by making the sortie generation process leaner and more resilient and the rearward logistics infrastructure more responsive and flexible must accompany similar efforts in the weapon system acquisition process.

⁵For more details, see Michael D. Rich and Stephen M. Drezner, "An Integrated View on Improving Combat Readiness," The Rand Corporation, N-1797-AF, February 1982, pp. 19-27.

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