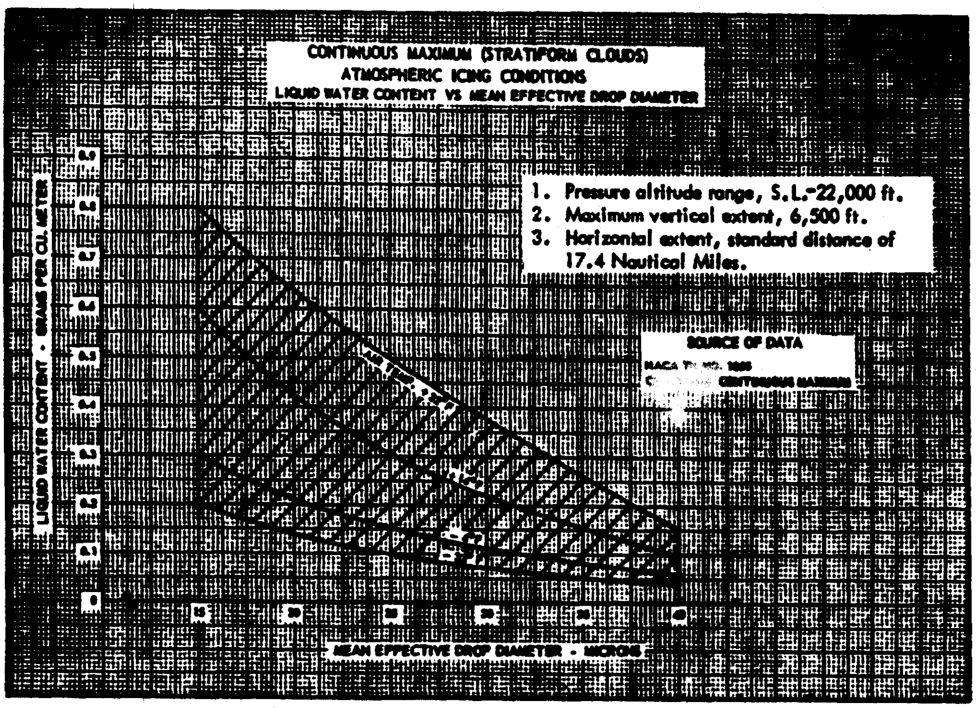
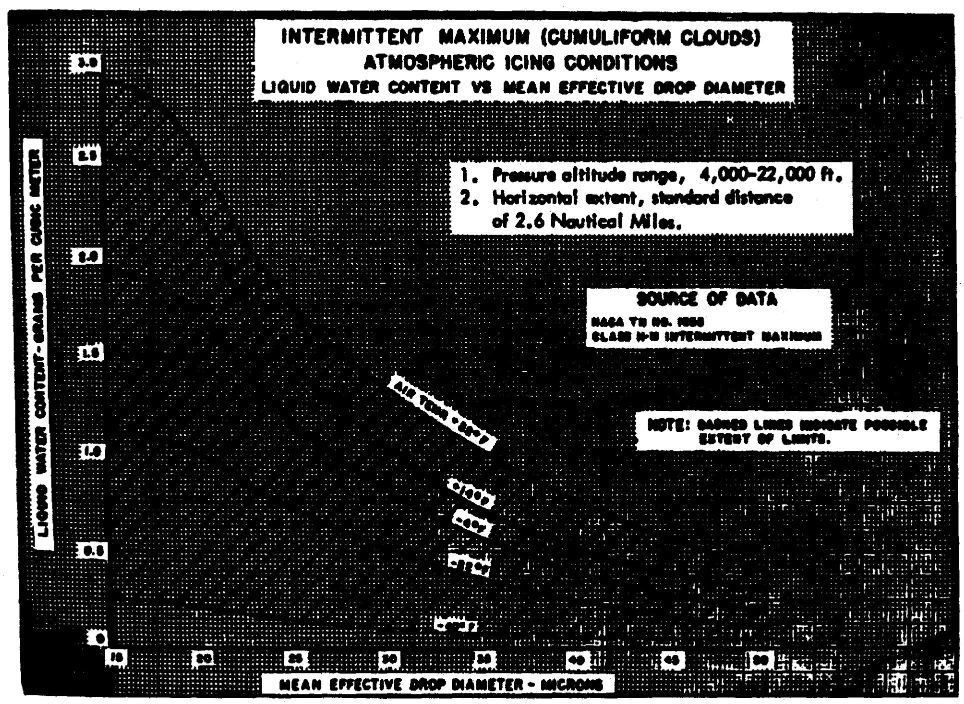
APPENDIX I—PART 25 APPENDIX C ENVELOPE AND FAA STATEMENTS/INFORMATION





14 CFR Part 25 Appendix C Icing Envelope

U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject: INFORMATION: NTSB Accident/Incident Investigation Support Request 97-105; AAI-200 route slip dated 7/31/97

Date: OCT 1 1997

From: Acting Director, Flight Standards Service, AFS-1
Director, Aircraft Certification Service, AIR-1

Reply to Attn. of:

To: Director of Accident Investigation, AAI-1
ATTN: Manager, Recommendation and Analysis Division, AAI-200

The following information is in response to the Board's request for information in support of the investigation into Comair Flight 3272 which crashed in Monroe, Michigan, on August 20, 1997.

Questions 1 and 2: When was the Operation Bulletin 120-002/96 from Embraer received by the FAA? Which offices of the FAA received the bulletin and on what dates?

FAA Response: Embraer maintains a list of FAA offices that it distributes all operations bulletins to. Embraer Operations Bulletin 120/002/96 was sent to the following FAA offices on May 17, 1996: Seattle Aircraft Certification Office (ACO), Atlanta ACO (received. 5/31/96), Southern Region Flight Standards Office (received. 5/28/96), Salt Lake City Flight Standards District Office (FSDO), Program Management Branch of the Flight Standards Service, and the Seattle Aircraft Evaluation Group (AEG) (received. 5/29/96).

Question 3: Which offices that received the bulletin were required to act, approve, forward, or comment on the bulletin?

FAA Response: No FAA offices are required to act, approve, forward, or comment on a manufacturer's bulletin when received.

Question 4: When did the POI receive the bulletin, and from whom?

FAA Response: The POI received the bulletin sometime after March 14, 1997, from Comair.

Question 5: What role does the POI, AEG, or the ACO play in reviewing or acting upon operational bulletins from the manufacturer?

FAA Response: Neither the POI, AEG, nor ACO are required to act upon operational bulletins from the manufacturer.

Question 6: If COMAIR (or any other EMB-120 operators) chose not to implement the recommendations of the bulletin (autopilot HDG and 1/2 bank modes in icing), what communication was necessary by the companies to inform the FAA?

FAA Response: Comair is not required to implement the recommendations of the bulletin. Therefore, no communication is necessary by the companies to inform the FAA.

Question 7: Which carriers have incorporated the recommendations of the ops bulletin in their company flight manuals (CFM)?

FAA Response: There are a total of 7 operators that operate Embraer 120 aircraft. All 7 have incorporated the recommendations of the operations bulletin in their CFM's. The carriers are:

Atlantic Southeast Airlines, Inc.
Comair, Inc.
Continental Express, Inc.
Great Lakes Aviation, Ltd.
Mesa Airlines, Inc.
Skywest Airlines, Inc.
Westair Commuter Airlines, Inc.

Question 8: Please inform me as to the review and approval process following a modification to the manufacturer's airplane flight manual.

FAA Response: The FAA Aircraft Certification Office responsible for approving revisions to an FAA approved Airplane Flight Manual (AFM) will coordinate the subject revisions with the cognizant ACO technical branches or specialists, the AEG, and the appropriate FAA Flight Standards office. Once approved, the manufacturers distribute the AFM revisions to operators and other interested parties. General guidance for the development, review, and approval of an operator's CFM, from information provided in the manufacturer's AFM, is provided in FAA Order 8400.10, "Air Transportation Operations Inspector's Handbook."

<u>Question 9</u>: Once Embraer's Revision 43 was approved, what are the lines of communication from the approving agency to the POI?

<u>FAA Response</u>: There are no established procedures mandated to communicate to an operator's POI that a revision to an AFM has been approved. A manufacturer will distribute AFM revisions to the affected airplane model's owners who in turn typically supply that revision to the POI.

<u>Question 10</u>: What is the purpose of the Flight Manual Review Board (FMRB) and its relationship to the ACO? How would it have played a role in Embraer's AFM Revision 43 or various airlines that operate the EMB-120 with their own CFMs?

<u>FAA Response</u>: The term "Flight Manual Review Board (FMRB)" is no longer used in aircraft certification terminology. A FMRB was a team composed of an ACO engineer representing each discipline (i.e., flight test, propulsion, mechanical systems, etc.) and chaired by the FAA project test pilot. A FMRB would be formed at the beginning of a type certification project to provide guidance for the development of the AFM and to later review that AFM. The same principle is applied today by coordinating AFM's, and revisions thereto, among the ACO engineering specialties branches prior to approval signature. Revision 43 to the EMB-120 AFM would have been subjected to this current practice, which mimics the role of the FMRB. Any changes made to an operator's CFM would not be subjected to a FMRB process or the system that has replaced the FMRB in the ACO's.

<u>Question 11</u>: Once Embraer's Revision 43 was approved for a change in the way deicing boots were used in the manufacturer's AFM, what communication, directive and guidance is provided to the respective POIs or companies to incorporate such changes CFMs?

<u>FAA Response</u>: There was no direct FAA transmission of Revision 43 to the EMB-120's AFM to the POI's of the operators following approval of that AFM revision by the responsible ACO. An ACO will coordinate the initial release of an AFM for a transport category airplane with an AEG. Any coordination of approved "AFM revisions" by the

responsible ACO with FAA operations personnel will be done on a discretionary basis. In the specific case of Revision 43 to the EMB-120 AFM, the POI received the AFM revision and associated operations bulletin from the operators.

Question 12: Three sections of a manufacturers AFM are approved; limitations, performance, and procedures. Similarly for a company flight manuals as spelled out in FAA's 8400.10. Revision 43 modified the procedure for boot operation in the AFM. Is this not also required to be modified in CFMs? Why or why not?

FAA Response: In accordance with paragraph 2165B(1) of FAA Order 8400.10, which prescribes the information to be contained in the CFM, "*The procedures section of a CFM must contain all procedures required by the AFM or RFM and for each operation the operator conducts.*" Since in some cases a POI may not be aware of an AFM revision (see response to Question 9), unless it is supplied by the operator, that POI will obviously not have control over maintaining the equality of the AFM and CFM procedures.

In order to assure that AFM or CFM procedures are changed, an Airworthiness Directive (AD) mandating that specific text be a part of the AFM/CFM or that a specific, dated revision be incorporated, must be issued. AD's are only issued in instances where the AFM changes are considered to be significant enough to warrant retroactive application to all aircraft.

Question 13: Explain how the three approved sections of both the AFM and CFM must agree. It is my understanding that limitations and performance must be the same. Am I correct? Why or why not? What about the procedures sections? Must the information contained in the AFM be incorporated in the CFM? Can accepted procedures in the CFM modify the approved procedures in the CFM? Can accepted or approved procedures in the CFM modify the approved procedures in the AFM?

FAA Response: The basic requirement for the AFM/CFM relationship is contained in 14 CFR section 121.141 which permits CFM operating procedures and presentation of performance data to be revised relative to the AFM if such presentations are approved by the Administrator and clearly identified as AFM requirements. Additional guidance is provided in Section 4 of FAA Order 8400.10, Air Transportation Operations Inspector's Handbook.

The FAA Aircraft Certification Service and Flight Standards Service are in the midst of a special project to review AFM and Flight Crew Operating Manual revision processes, including the level of review and approval of those revisions and the lines of communication between certification and operations specialists. The final report and recommendations resulting from this project are being developed.

If we can be of further assistance, please let us know.

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OCT 1 1997

Mr. Richard Rodriguez
Major Investigations Division, AS-10
National Transportation Safety Board
490 L'Enfant Plaza East, SW.
Washington, DC 20594-2000

Dear Mr. Rodriguez:

The National Transportation Safety Board (NTSB) forwarded three letters dated June 16, 1997, from the Comair Party Coordinator which raised questions and suggested issues which Comair believed should be addressed in the NTSB investigation of the Comair Flight 3272 accident. In your letter addressed to the Party Coordinators dated June 23, 1997, you asked for formal responses to the appropriate portions from each Coordinator and indicated that following input from the Federal Aviation Administration (FAA) and Embraer, you would evaluate the need for additional investigative activity.

The first of the three letters included a detailed list of questions regarding the initial certification process and the certification and operation of the EMB-120 in icing conditions. The FAA response to each of those questions is enclosed.

The second letter involved questions regarding the validity of the digital flight data recorder (DFDR) information from the accident aircraft. The FAA believes that this aspect of the Comair questions was adequately addressed by Mr. Dennis Grossi, NTSB Chairman of the DFDR Team, during the August 20 meeting in Washington, D.C. In addition to Mr. Grossi's statements regarding the accident aircraft, the FAA requested that Embraer conduct an investigation of the EMB-120 DFDR in response to NTSB Safety Recommendations A-96-033 and -034. As a result of this investigation, Embraer issued Service Bulletin Number 120-31-0038, dated February 22, 1997, to correct the potentiometer calibration error. Embraer will also implement a revised potentiometer test procedure through a change to their maintenance manual to address DFDR calibration and signal noise issues.

The third letter included a number of issues regarding the American Eagle Flight 4184 accident at Roselawn and stated that "because of the similarities between this accident and that of Comair Flight 3272, there is a concern that there may be a continuing trend relating to the certification of foreign manufactured aircraft." The letter went on to state that "it is not unreasonable to expect that every effort should be made in determining if there was use of an inadequate protocol by a foreign manufacturer and the CTA in the certification (of) the EMB-120 for flight in icing conditions." The letter also suggested that an independent analysis by the NTSB Performance Group of the tanker testing done at Edward's Air Force Base (presumable on the EMB-120) "should be done to ensure the adequacy of the conclusions and recommendations made for flight in SLD conditions by turboprop aircraft."

The FAA believes that the majority of this third letter is directed more to the NTSB, rather than to the FAA or Embraer for response, particularly in regard to comparison between the Comair accident and the American Eagle accident. The FAA has addressed Comair's more specific concerns regarding the initial certification and oversight of the EMB-120, including the results of the tanker testing, in the enclosed responses to the first letter. In addition, Ms. Mary Cheston, FAA Manager of International Airworthiness Program Staff for Aircraft Certification, offered during the August 20 meeting to make a formal presentation to the NTSB at a later date regarding the FAA certification of foreign manufactured aircraft under a bilateral airworthiness agreement. The FAA believes that the responses to the specific questions listed in the first letter, in addition to Ms. Cheston's proposed presentation, adequately addresses the third letter of June 16.

The subjects of each of these letters were discussed during the August 20 meeting held at NTSB headquarters with Comair, Embraer, the Air Line Pilots Association, and the FAA. At the conclusion of that meeting, the NTSB announced its intention to have the Aircraft Performance Group conduct a detailed analysis of all EMB-120 icing certification data, including the results of the icing tanker tests conducted in late 1995 at the Embraer facilities in Brazil. The FAA plans to participate in this review, and Ms. Carla Worthey, FAA Embraer Program Manager and member of the NTSB Performance Team, will support this effort. The FAA also requests that Mr. Gene Hill, FAA National Resource Specialist for Icing, be allowed to participate in this review even though he is not a formal member of the NTSB team.

The last issue discussed briefly during the August 20 meeting was the FAA oversight of changes to operator's manuals versus FAA oversight and approval of airplane flight manuals. This topic was the subject of a memo (NTSB Log Number 97-101) from Mr. David J. Ivey, NTSB, addressed to the FAA's Recommendation and Analysis Division, AAI-200, which included a number of specific questions. The FAA Aircraft Certification members present at the meeting noted that a written response to each of the questions in the memo was being prepared jointly with the Flight Standards Service of the FAA. The FAA agreed that if, after reviewing the written responses, NTSB had additional questions on this subject, the FAA would support another meeting with the NTSB when all appropriate FAA specialists could be available.

Sincerely,

David F. Thomas

David F. Thomas
Director of Accident Investigation

Enclosure

FAA RESPONSES TO COMAIR QUESTIONS ADDRESSED TO THE NTSB via JUNE 16, 1997 LETTER

Section 1 - Initial Certification Process

1. During the testing phase of initial certification, did the EMB-120 exhibit any adverse handling characteristics?

FAA RESPONSE: The Centro Tecnico Aeroespacial (CTA), the Brazilian Airworthiness Authority, provided constant oversight of the EMB-120 certification program, and participated in all certification flight tests. The FAA has had no indication of any adverse handling characteristics exhibited by the EMB-120 during this certification testing. If Embraer discovered any characteristics which did not meet FAR 25 or RBHA 25 requirements during company development testing, they would have had to take whatever steps were necessary to bring the aircraft into compliance prior to certification testing. This procedure would be the same for any aircraft manufacturer.

2. During testing of actual aerodynamic stall, did the aircraft exhibit a roll-off problem with roll rates in excess of FAA certification criteria?

FAA RESPONSE: FAR 25.203 presents the stall characteristics requirements for the EMB-120. FAR 25.203(b) states that "For wings level stalls, the roll occurring between the stall and the completion of the recovery may not exceed approximately 20 degrees." Thus, there is an acceptable roll *angle* limit of 20 degrees in wings level stalls, but not a roll *rate* criteria.

FAR 25.203(c) requires "For turning flight stalls, the action of the airplane after the stall *may not be so violent or extreme* as to make it difficult, with normal piloting skill, to effect a prompt recovery and to regain control of the airplane." This is the only "roll rate" stall characteristics criteria. The certified type design of the EMB-120 includes a stall barrier system, which provides stall warning via a stick shaker and stall prevention via a stick pusher. All stall demonstrations for certification were conducted with the aircraft in the "production" configuration, with the stall barrier system installed. Stall recovery was prompted by the stick pusher and acceptable stall characteristics were shown with the stick pusher installed.

The FAA has reviewed the results of some aerodynamic stall testing conducted by EMBRAER during company development testing. Review of this company data provided no indication that the action of the airplane after an aerodynamic stall is so violent or extreme as to make it difficult to effect a prompt recovery and to regain control of the airplane using normal piloting skill.

3. If the roll rates at the stall were excessive, by what margin did they exceed permissible limits?

FAA RESPONSE: See response to Question 2.

4. Was the installation and certification of the stick pusher necessitated by a roll-off problem

during actual stall?

FAA RESPONSE: The decision to install a stick pusher was made by EMBRAER. The details of this decision involves information proprietary to EMBRAER. However, the EMB-120 with the pusher installed met all FAR 25 stall warning and stall characteristics requirements. The testing of aerodynamic stall characteristics beyond stick pusher is not required by the FAA during certification of aircraft with stall barrier systems installed, provided the stall barrier system meets acceptable reliability criteria. During CTA certification evaluation and testing, the stall barrier installation on the EMB-120 was found to reliably provide adequate and consistent stall warning and stall prevention.

5. Is it essential that the stick pusher prevent the aircraft from reaching an actual stall condition, otherwise the possibility of recovery is limited, or non-existent?

FAA RESPONSE: The FAA has reviewed the results of some aerodynamic stall testing conducted by EMBRAER during company development testing. Review of this company data provided no indication that the action of the airplane after an aerodynamic stall is so violent or extreme as to make it difficult to effect a prompt recovery and to regain control of the airplane using normal piloting skill.

Certification testing conducted by the CTA, and validated by the FAA, included stall demonstrations to show compliance with FAR 25.203 with the stall barrier system installed. This certification evaluation included wings level and turning flight stalls, both 1 kt/sec and 3 kt/sec entry rate tests, in all appropriate configurations, both in a "clean" condition and with ice shapes installed. These demonstrations showed that the airplane is fully recoverable from a stall within the certification criteria with stall recovery prompted by the stick pusher.

6. How is the "firing angle-of-attack" for the stick pusher determined during certification?

FAA RESPONSE: Development of the EMB-120 into a certifiable configuration was accomplished by EMBRAER. The aircraft handling characteristics at the firing angle of attack selected by EMBRAER for stick shaker and stick pusher activation was found to meet all certification criteria.

7. At what margin above the stall does the stick pusher activate?

FAA RESPONSE: The actual margin between aerodynamic stall and stick pusher angle of attack varies with aircraft configuration and mach number, and involves information that is proprietary to Embraer. As with all certification programs, certification testing is conducted only for the final type design, which in the case of the EMB-120, includes a stall barrier (stick pusher) system. Therefore, the only flight test data available for definition of aerodynamic stall is Embraer company development data. The certification testing conducted with the stall barrier system operative and with the stick shaker and stick pusher schedules defined by Embraer were used to show compliance with FAR and RBHA 25 requirements. This testing showed that in all configurations, both with a "clean" airplane and with the airplane contaminated with simulated ice shapes, the stall barrier schedules were adequately set to provide consistent stall warning and to prevent the aircraft from encountering aerodynamic stall, provided the ice protection systems were operated properly.

8. What was the actual involvement of the FAA during the initial certification of the EMB-120?

FAA RESPONSE: The FAA was involved in the US certification of the EMB-120 throughout both the Brazilian and the US certification programs. This process formally started at the preliminary type board meeting, continued through two interim board meetings and validation flight testing, and concluded with the final type certification board meeting. In addition to these formal meetings in which all specialty areas are typically addressed, a total of twelve additional specialist meetings were held with the FAA during the three year certification program. As Embraer applied for a US Type Certificate for the EMB-120 soon after applying for the Brazilian TC, many of these meetings were held concurrently with the CTA. Under the Bilateral Airworthiness Agreement with Brazil, the FAA recognizes CTA as competent to apply FAR 25 certification requirements. However, the FAA maintained involvement throughout the certification and provided guidance on acceptable means of compliance and FAA positions on any new issues and new means of compliance. The FAA retains the final authority on equivalencies and other critical issues, and ultimately makes the finding of compliance to FAR 25.

9. The terms of the Bilateral Airworthiness Agreement and Annex 8 of the International Civil Aviation Organization, notwithstanding, was there comprehensive flight testing conducted by the FAA?

FAA RESPONSE: The terms of the Bilateral Airworthiness Agreement (BAA) between the US and Brazil are never "notwithstanding". The BAA is a formal agreement between the two countries which indicates that the US recognizes the CTA as a competent airworthiness authority with the expertise and organization to apply US standards. Under the terms of the BAA with Brazil, as with other countries, the FAA conducted validation flight tests of the EMB-120 after the CTA indicated they had found compliance with FAR 25 requirements applicable to the EMB-120. These FAA validation tests covered a number of areas, including stalls, but were no more, or less, comprehensive than other bilateral validation test programs.

In addition to the validation flight testing conducted for the initial certification, the FAA has also conducted flight tests associated with oversight of continuing airworthiness. The FAA participated directly in both the icing tanker tests conducted as part of the supercooled large droplet icing investigation, and in the subsequent handling qualities testing with the SLD shapes installed on the EMB-120.

10. If comprehensive flight testing was not conducted by the FAA, were there significant issues involving noncompliance or other concerns resolved through "issue papers," whereby the FAA describes its position on a certification issue and the methods necessary to achieve regulatory compliance?

FAA RESPONSE: COMAIR is correct that Issue Papers are used by the FAA to describe the FAA position on various certification issues and the methods necessary to achieve regulatory compliance. These issues include definition of the type certification basis, application of new criteria and procedures, findings of equivalent level of safety to existing criteria, and often simply clarification of acceptable methods of compliance. Issue Papers only sometimes relate to "noncompliance". As with all type certification programs, both foreign and domestic, a number of Issue Papers were prepared for the EMB-120 certification. Prior to the issuance of the US type certificate, all applicable Issue Papers on the EMB-120 were satisfactorily closed.

11. If "issue papers" were published, did the FAA delegate oversight to the CTA to ensure compliance?

FAA RESPONSE: FAA Issue Papers, which describe acceptable means of compliance, assist the foreign airworthiness authority in applying the FAR 25 certification requirements. In most cases, FAA delegated oversight to CTA, as is normal for bilateral certification programs. However, in some cases, such as for Special Conditions, the FAA has maintained closer oversight of the means of compliance, since a Special Condition is a new requirement which may encounter issues not anticipated during its promulgation. All findings of compliance were ultimately made by the FAA.

12. In the review of actual flight test data by the FAA, was it determined if there was a need to duplicate any tests or portions of tests by the FAA?

FAA RESPONSE: As previously stated in response to Questions 8 and 9, the FAA conducted validation flight tests on the EMB-120 after the CTA indicated that they had found compliance with FAR 25 requirements. This validation testing is conducted primarily to provide the FAA pilots with familiarity with the airplane, and generally includes a variety of tests. Because this is a "validation" of testing that has already been conducted, it will always duplicate the original certification testing. In addition to the "standard" set of validation tests, the FAA will typically review portions of the flight test data results to determine if any areas of particular interest should be included. In review of the CTA certification test data for the EMB-120, the FAA found no need to go beyond the normal validation exercise.

Section 2 - Icing

1. During the initial certification of the EMB-120, did the FAA conduct any flight tests in icing conditions?

FAA RESPONSE: No.

2. If the FAA did not conduct flight testing in icing conditions, to what extent did the FAA delegate compliance oversight to the CTA in Brazil?

FAA RESPONSE: The CTA participated in all natural icing flight tests on the EMB-120. The CTA also participated in all tests with simulated ice shapes. In accordance with bilateral procedures, the FAA relied on the CTA to apply the FAR 25 requirements during their evaluations. The FAA reviewed the results of both the natural icing and simulated icing tests prior to US approval of the EMB-120 for flight into known icing and ultimately made the findings of compliance to FAR 25 requirements.

3. During the review by the FAA of flight test data, was there any evidence that the aircraft may not actually have been tested in icing conditions described in the certification documentation, e.g. the use of "test data points," not near the boundaries of Appendix C certification criteria?

FAA RESPONSE: No. During natural icing tests numerous icing encounters were recorded, several of which exceeded FAR 25, Appendix C boundaries for continuous maximum and intermittent maximum atmospheric icing conditions in terms of liquid water content.

4. Subsequent to the ATR-72 accident at Roselawn in response to a recommendation in the SCR of the ATR-72, the FAA did a series of roll evaluations of transport category turboprop aircraft. The EMB-120 failed the high speed taxi test with a simulated ice shape in the form of a quarter round installed on the upper wing, in front of the ailerons. Allegedly, the roll control forces were in excess of the FAR limits. Was the failure of this test the basis for the decision to do airborne testing behind the tanker?

FAA RESPONSE: The purpose of the FAA's Phase II Icing Program was to determine that there were no unsafe conditions related to roll upset susceptibility when operating in certain freezing drizzle conditions outside the FAR 25 Appendix C icing envelope. The Phase II program was used to screen aircraft with unpowered roll controls and pneumatic de-ice boots used in regularly scheduled passenger service. The high speed taxi test was one of the FAA approved methods for screening the airplane. The FAA believed the continuous 1" high quarter round shape attached to the upper wing surface, ahead of the ailerons, was a conservative shape that would likely produce a more severe aerodynamic effect on the aileron than ice accreted during a freezing drizzle encounter.

The EMBRAER test technique was to apply the quarter round shape to both wings and jettison one wing shape in flight. High speed taxi tests were performed only to verify the operation of releasing devices necessary to jettison the shape in flight. Following the high speed taxi test, EMBRAER elected to perform a more representative flight test. During these flight tests, the measured roll control forces exceeded the FAA's evaluation criteria.

Since the airplane exceeded the roll control force criteria, EMBRAER conducted the tanker testing to determine the shape, location, dimension and texture of the ice accreted on the airplane during a freezing drizzle encounter. These tests were to specifically define the actual characteristics of the ice shape rather than the arbitrary and conservative shape selected by the FAA. The tanker test was also used to determine whether visual cues were adequate for the pilot to identify a freezing drizzle encounter. Artificial ice shapes determined by the FAA icing team to be a conservative representation of the ice accreted during the tanker tests were then manufactured and flight tests were performed with those shapes attached to the upper surface of the wing behind the de-ice boots to evaluate the roll characteristics of the airplane.

5. What was the protocol used in the tanker tests conducted during the time frame September, 1995 to January, 1996?

FAA RESPONSE: The EMB-120 tanker test was conducted during the period December

3 & 4, 1995, in accordance with an FAA approved test plan. EMBRAER summarized the testing conducted in Operations Bulletin 120-002/97.

6. Was the environment behind the tanker intended to replicate the conditions found within the envelope of Appendix C for a period of 45 minutes in holding?

FAA RESPONSE: No. The primary purpose of the tanker test was to characterize the accreted ice shapes on the EMB-120 during an exposure to conditions outside Appendix C. The test was also designed to determine whether visual cues existed to alert the flightcrew that they were outside of Appendix C. The tanker test was not intended to replicate the previous certification testing of the EMB-120.

However, one research test point was done to investigate whether runback ice would accrete within Appendix C icing conditions at near freezing temperatures. This test point targeted a 45 minute hold condition, but was terminated after 36 minutes because there was no indication of runback ice and the tanker ran out of water. Since no runback ice accreted during the first 36 minutes of the test, it was determined that no additional research testing of this condition was needed.

7. What methods were used to determine the MVD (mean volumetric diameter) and LWC (liquid water content) of the water droplets behind the tanker? In the past, alternate methods have produced different results.

FAA RESPONSE: During the tanker testing, three different instruments were used to measure the full range of tanker cloud droplet sizes from 8 microns to 800 microns in overlapping size ranges: the Forward Scattering Spectrometer Probe (FSSP) from 8 to 74μm, 1D-C probe from 83.5 to 300μm, and 2D-C probe from 104 to 800μm. This instrumentation was installed on a Learjet which was used as a chase plane during the tests.

There were no anomalies reported during the flight tests. Data processing techniques are described in "Processing Data from Particle Measuring Probes for Icing Certification" by Ray Hobbs, Brian Morrison, and Darrel Baumgardner, presented at the International Icing Symposium, September, 1995, Montreal. Additional modifications to the processing techniques for the 1D-C, and 2D-C probes are described in "Modifying the NCAR Processing Technique" by Ray Hobbs, October, 1995.

8. During the tanker testing, was there an attempt to replicate the conditions used during the taxi test?

FAA RESPONSE: No. The purpose of the tanker test was only to characterize the accreted ice shapes on the EMB-120 during a freezing drizzle encounter, and to determine whether satisfactory visual cues existed to allow the crew to identify severe icing conditions. The taxi test was only designed to screen the aircraft for susceptibility to roll anomalies with an artificial, continuous 1" high quarter round shape attached on the upper wing ahead of the aileron.

9. What airspeeds were used during testing?

FAA RESPONSE: Speeds representative of the EMB-120 in holding conditions of 175 KIAS and 165 KIAS were used during the tanker testing. The minimum acceptable test speed of the tanker was 165 KIAS.

10. What maneuvers were used to assess the handling qualities of the aircraft (level flight, approach to stall, turns)?

FAA RESPONSE: Handling qualities were evaluated during the tanker testing only as a build up to determine whether it was safe to proceed to the next test point. Since the area sprayed by the tanker is limited to approximately 9 feet, the ice was accreted across a relatively small area of one wing. The ice accreted, therefore, would not be representative of that occurring during a natural ice encounter.

The purpose of the tanker test was to characterize the ice shapes accreted on the wing. Handling qualities were then evaluated during dry-air testing, with simulated ice shapes installed on the upper surface of the wing. These tests did include level flight approach to stall and turns.

11. During flight testing behind the tanker, was there any evidence of the deterioration of roll control as demonstrated during the taxi test?

FAA RESPONSE: No evidence of deterioration of roll control was experienced during the tanker testing, nor in high speed taxi tests. High speed taxi tests were performed by EMBRAER only to verify the operation of releasing devices necessary to jettison the shape in flight.

12. Did the test aircraft experience any undue buffeting from the effects of icing?

FAA RESPONSE: No buffeting was reported during the icing tanker tests.

13. If buffeting occurred, at what airspeed did it occur?

FAA RESPONSE: No buffeting was reported.

14. How was the minimum speed in icing conditions (160 knots) derived?

FAA RESPONSE: The 160 knot minimum speed was defined by EMBRAER as the recommended holding speed for icing conditions during the original icing certification for the EMB-120. The simulated ice shapes on unprotected surfaces used for the handling qualities and stall testing prior to icing approval were defined using the leading edge impingement criteria associated with this speed. These tests demonstrated that the aircraft can be maneuvered at this speed (160 KIAS) up to 30° of bank angle, the maximum bank angle typically used during holding, with an adequate stall margin to the buffeting boundary, stick shaker and stick pusher with these ice shapes on the aircraft. In addition, the natural icing tests were conducted to verify that this minimum operating speed was satisfactory. These tests demonstrated that the EMB-120 meets all FAR 25 requirements during flight in icing conditions, provided the ice protection systems are properly activated.

15. Were the handling qualities of the aircraft assessed with ice on the protected surfaces, but with the de-ice system not active?

FAA RESPONSE: Handling characteristics with up to 3/4 inch ice accreted on protected surfaces were qualitatively evaluated during the natural icing certification. In addition, detailed handling qualities testing was conducted during the Canadian certification. A one inch ice shape was applied to all protected surfaces as well as ice shapes on the unprotected surfaces for those tests.

16. If this aspect of icing tolerance was tested, how much ice was accreted?

FAA RESPONSE: See response to question 15.

17. Was testing conducted, specifically, to determine the tolerance of the EMB-120 to SLD conditions outside the Appendix C envelope?

FAA RESPONSE: Yes. As previously stated, EMBRAER conducted testing of the EMB-120 in cooperation with the FAA Phase II icing program to screen airplanes for susceptibility to roll upset during or after flight in certain freezing drizzle conditions (which are, of course, outside Appendix C).

18. What criteria were used to assess the ability of the aircraft to operate in SLD icing long enough for the crew to recognize the SLD environment and exit it?

FAA RESPONSE: As previously stated, the FAA determined from the results of the icing tanker tests that the visual cues associated with the SLD icing conditions on the EMB-120 are adequate to allow the flightcrew to identify severe icing conditions. Additionally, the roll control characteristics testing of the EMB-120 in SLD conditions conducted in early 1996 by the FAA and CTA showed that once the flightcrews activate the de-ice system, the handling characteristics of the EMB-120 are adequate to allow the crews to safely exit the severe icing conditions. The criteria used to assess the EMB-120 roll control capability following flight in SLD were the same as those used for similar evaluations of other turboprop aircraft with unpowered roll controls.

19. Was tanker testing conducted at night to assess the ability of the crew to identify and evaluate SLD under those conditions?

FAA RESPONSE: No tanker testing was conducted at night. However, original certification testing demonstrated that the wing ice inspection lights provide sufficient illumination to allow the flight crew to visually inspect the wing leading edges, propeller spinners, and engine air inlet lips. As presented in the EMB-120 AFM and in EMB-120 Operational Bulletin No. 120-002/96, one of the best visual cues for severe icing on the EMB-120 is accumulation of ice on the propeller spinner farther aft than normally observed. Since this area is illuminated by the wing inspection lights, and the lights must be operative prior to dispatch at night into icing conditions, the FAA believes this concern has been adequately addressed.

20. What flight test data exists to support an assertion that the EMB-120 is safe to operate, up to recognition and exit, of SLD icing conditions?

FAA RESPONSE: Based on the tanker test data, the FAA has determined that the visual cues associated with the SLD icing conditions on the EMB-120 are adequate to allow the flightcrew to identify severe icing conditions. Additionally, the roll control characteristics testing of the EMB-120 with artificial ice shapes determined by the FAA icing team to be a conservative representation of the ice accreted during the tanker tests conducted in early 1996 by the FAA and CTA has shown that the handling characteristics of the EMB-120 are adequate to allow the crews to safely exit the severe icing conditions. This testing was based on the assumption that the flightcrews would properly activate the de-ice systems. Therefore, simulated ice shapes were installed only aft of the protected areas.

21. What were the worst SLD conditions experienced in flight testing?

FAA RESPONSE: The tanker test condition varied from 104 to 135 μm MVD and .59 to .86 g/m3 LWC. Since SLD conditions are outside the Appendix C envelope, the natural ice testing would not have included results of an SLD encounter.

22 Did the FAA do any icing testing with any foreign airworthiness authorities other than the CTA in Brazil?

FAA RESPONSE: No. The FAA did not participate in icing testing of the EMB-120 with any foreign airworthiness authority other than the CTA.

23. If testing with other airworthiness authorities was accomplished, are there published results of such testing?

FAA RESPONSE: See response to question 22.

24. During the original icing certification, it was expected that pilots would wait for 1/4 to 1/2 of inch of ice to build up prior to activation of the boots. Under these conditions, was the full maneuvering envelope of the aircraft available with that amount of ice on the aircraft?

FAA RESPONSE: Handling characteristics with 1/4, 1/2 and 3/4 inch ice accretions on protected surfaces were qualitatively evaluated during the CTA natural icing certification flight tests. In addition, Transport Canada required testing with 1 inch ice shapes on all protected surfaces and 45 minute ice shapes on unprotected surfaces, prior to Canadian certification in 1989. These stall characteristics tests showed it was possible to slow the aircraft beyond shaker speed to the pusher speed, with demonstrated satisfactory handling and no tendency for loss of control.

25. Specifically, were the handling qualities at stick shaker onset and stall assessed during icing conditions?

FAA RESPONSE: Stall warning, stall speed, stall characteristics and other handling qualities evaluations were satisfactorily conducted with simulated ice shapes installed on unprotected surfaces. The ice shapes used for these tests exceeded the 45 minute hold in the maximum continuous icing conditions of FAR 25 Appendix C. Various simulated failures of the ice protection systems were also tested during the handling qualities evaluation.

26. Was the required maneuver margin to stall still available at the onset of the stick shaker with the ice accumulated?

FAA RESPONSE: It is not clear what is meant by the "maneuver margin to stall" at the onset of stick shaker. FAR 25.207(c) requires that the "stall warning must begin at a speed exceeding the stalling speed...by seven percent or at any lesser margin if the stall warning has enough clarity, duration, and distinctiveness, or similar properties." The EMB-120 certification testing with ice shapes installed demonstrated compliance to this requirement for stall warning margin, both for CTA, FAA and DOT Canada.

27. If it was performed, are there published reports of such testing?

FAA RESPONSE: Yes. Embraer prepared flight test reports to show compliance to certification requirements.

28. What criteria did the FAA use, initially, in determining that the pilots should *not* wait for any ice to build up, but they should turn on the de-ice system at first recognition of icing conditions?

FAA RESPONSE: While at Edwards Air Force Base for the icing tanker tests of the EMB-120, FAA, CTA, and EMBRAER representatives reviewed the reported EMB-120 roll upset events. It became apparent during this review that there was no indication of de-ice boot activation prior to any of the upset events and that airspeed was allowed to deteriorate. It appeared that in all of the events, the flightcrew had either not recognized that they were in icing conditions or had waited too long to activate the boots, and did not recognize the loss in airplane performance resulting from the accumulated ice. Subsequent to the meeting, EMBRAER proposed a change to the AFM to require activation of the de-ice boots at the first indication of ice. The FAA discussed the proposal with the de-ice boot manufacturer and with several operators to determine whether "bridging" of the de-ice boots was a concern.

The de-ice system of the EMB-120 is controlled by a timer that inflates the de-ice boots in a 3 minute cycle in light mode and 1 minute in the heavy modes. Since there are approximately one or three minutes when the boots are deflated, it is likely that inflation cycles had already been occurring in service with less than the earlier recommended 1/4 to 1/2 inch ice accumulation. No bridging was evident during the EMB-120 natural icing testing, even when the ice protection system was activated at the first detection of icing. Photographs indicated only a light residual of ice particles remaining on the boot surface. Additionally, de-icing system technology has improved over the years to include higher pressures, smaller chambers, more rapid inflation and deflation, and greater coverage of the leading edge, which increased the system's ability to shed smaller accretions. The FAA was able to find no documented evidence of "bridging" occurring on the EMB-120 and therefore approved the AFM revision so that the flightcrew would not be required to assess the thickness of the ice accretion prior to activating the boots.

29. What factual data exists to support the most current procedure for selection of one of two auto modes for de-ice operation at the first indication of icing conditions?

FAA RESPONSE: See response to question 28.

30. Recognizing that in the future, circumstances may change, does the FAA anticipate that any further icing tests of the EMB-120 will be carried out?

FAA RESPONSE: The FAA currently plans no further icing tests of the EMB-120. The FAA has requested that Embraer conduct further research into the effect of residual and inter-cycle ice on the protected surfaces.

31. Is it the opinion of the FAA, that the proposed AD adequately addresses the problems that led, either directly or indirectly, to the icing upsets of the EMB-120?

FAA RESPONSE: The AD proposal was prompted by reports indicating that flightcrews experienced difficulties controlling the airplane during (or following) flight in normal icing conditions, when the ice protection system either was not activated when ice began to accumulate on the airplane, or the ice protection system was never activated, and airspeed was allowed to deteriorate. These difficulties may have occurred because the flightcrews did not recognize that a significant enough amount of ice had formed on the airplane to require activation of the deicing equipment, and the loss in airplane performance resulting from the accumulated ice. The actions specified by the proposed AD are intended to ensure that the flightcrew is able to recognize the formation of significant ice accretion, take appropriate action, and maintain a proper speed. It is the FAA opinion that installation of an ice detector and revising AFM procedures to require activation of the ice protection systems at the first sign of ice accumulation and to maintain a satisfactory minimum speed will assist the flightcrews in recognizing icing conditions and taking appropriate action.

32. What factual data supports the assertion that during the potential encounter of icing conditions, operation of the autoflight system should be restricted to the 1/2 bank mode?

FAA RESPONSE: This was a recommendation made by Embraer for flight in severe icing conditions in their Operational Bulletin 120-002/96 as a result of the Phase II SLD testing. However, in the Phase II AD's, the FAA prohibited the use of the autopilot in severe ice conditions for all aircraft for standardization.

In the same Operational Bulletin, Embraer also recommended restricting the use of the autopilot to the 1/2 bank mode during flight in "normal" icing conditions. FAA certification testing demonstrated that the EMB-120 had adequate handling characteristics with simulated ice shapes on the unprotected surfaces throughout the approved operational envelope. Since the control characteristics of the airplane were acceptable, the FAA found no reason to limit the use of the autopilot for certification. It is not clear why Embraer made this recommendation, except

perhaps to provide a consistent flightcrew procedure for all operations in icing conditions.

33. At 28 degrees of bank is there a difference in controllability between an airplane being flown manually and one being flown by the autopilot?

FAA RESPONSE: No. The controllability of the airplane remains the same.

FLIGHT STANDARDS REGULATIONS AND GUIDANCE MATERIAL

Task 1. Improve training and operation regulations and guidance material related to icing.

A. The FAA will require Principal Operations Inspectors to ensure that training programs for persons operating aircraft under parts 121 and 135 of the Federal Aviation Regulations (14 CFR parts 121 and 135) include information about flight into freezing rain/freezing drizzle conditions as well as conventional icing conditions.

PLAN DETAILS, TASK 1.A.:

Responsible Party: Flight Standards Service.

Schedule:

- March 1997: Completed Flight Standards Handbook (Information) Bulletin requiring POI's to ensure that training programs include information about all icing conditions including flight into freezing drizzle and freezing rain.

B. A working group will review, revise, and develop regulations and advisory material as necessary to accomplish the following:

- **Ensure that icing terminology (e.g., known, forecast, observed, trace, light, moderate, severe, and "Appendix C" icing) is used consistently and clearly by the Flight Standards Service, pilots, dispatchers, the National Weather Service (NWS) Aviation Weather Center, the Aircraft Certification Service, and Air Traffic.**
- **Update guidance related to icing reporting and pilot, Air Traffic Control, and dispatcher actions.**
- **Provide advisory information concerning ice bridging.**
- **Consider the need for an icing regulation that is applicable to all general aviation aircraft operated under part 91 of the Federal Aviation Regulations (14 CFR part 91), since section 91.527 does not apply to most general aviation aircraft.**

- **Direct Principal Operations Inspectors to ensure that all air carriers that operate aircraft under part 121 of the Federal Aviation Regulations (14 CFR part 121) require their dispatchers to provide pertinent weather information to flight crews.**
- **Require that Hazardous Inflight Weather Advisory Service broadcasts include pertinent weather information.**

PLAN DETAILS, TASK 1.B.:

The review includes, but is not limited to, the following documents:

a. Aeronautical Information Manual (AIM)
b. Advisory Circular 91-51
c. ATC Handbooks 7110.65 and 7110.10
d. Advisory Circular 135-9
e. Winter Operations Guide
f. Sections 91.527, 135.227, and 121.341 of parts 91, 135, and 121, respectively, of the Federal Aviation Regulations (14 CFR 91.527, 135.227, and 121.341)
g. FAA Order 8400.10
h. Weather Service Operations Manual (WSOM), Chapter D-22.

The working group will also review the following documents and will attempt to coordinate with the international organizations that publish these documents. (The working group has no authority to revise the documents.)

a. International Civil Aviation Organization's Manual of Aeronautical and Meteorological Practice (Document 8896-AN/893/4)
b. World Meteorological Organization's Annex 3.

Responsible Parties: Flight Standards Service; Aircraft Certification Service; FAA Technical Center; Aviation Weather Center; and Air Traffic.

Schedule:

- March 1997: Completed Flight Standards Handbook (Information) Bulletins on Freezing Drizzle and Freezing Rain training and pilots' and dispatchers' responsibilities regarding pilot reports (PIREPS).
- February 1999: Complete revisions to the FAA material listed above.
- April 1999: Determine whether or not a rule change is required.

C. The FAA will explore the feasibility of incorporating icing performance and handling characteristics in airplane training simulators.

PLAN DETAILS, TASK 1.C.:

To enhance pilot awareness of the effects of inflight icing, how inflight icing affects airplane performance, and to provide realism to pilot training in an inflight icing environment, the FAA will explore the feasibility of incorporating icing performance and handling characteristics in airplane training simulators.

Responsible Parties: Flight Standards Service; Simulator Team; Aircraft Certification Service.

Schedule: December 1997: Complete feasibility study.

D. The FAA will participate with appropriate organizations to encourage coordination among manufacturers, operators, associations, and organizations, research communities, and pilots in the international community for development of inflight icing training aids (written, pictorial, video, etc.) and advisory material.

PLAN DETAILS, TASK 1.D.:

Responsible Party: FAA Icing Steering Committee.

Schedule: Ongoing.

ICING FORECASTING

Task 2. Improve the quality and dissemination of icing weather information to dispatchers and flight crews.

A. The FAA will continue sponsoring icing forecasting research that is intended to refine the data and information being provided to forecasters at the Aviation Weather Center (AWC) in Kansas City to improve the ability to forecast inflight icing, including icing due to SLD.

PLAN DETAILS, TASK 2.A.:

The FAA sponsors icing forecasting research though the AWR program under FAA Aviation Weather Research Program, AUA-460. Inflight icing is currently AWR's highest priority. Present work continues a seven-year history of FAA research in icing. Activities described under paragraphs A. and B. of this task are described in greater detail in "FAA In-Flight Icing Product Development Plan: FY97 & FY98," dated October 15, 1996. The program also has provided leveraging of funds through cooperation with the National Science Foundation, National Center for Atmospheric Research (NCAR), National Oceanic and Atmospheric Administration (NOAA), National Air and Space Administration (NASA), Department of Defense (DOD), NWS, various universities, and the private sector. The FAA has provided funding for three major field validation experiments: the Winter Icing and Storms Projects (WISP) in the winters of 1989-90, 1992-93, and 1994-95. Planning is underway for a joint freezing drizzle program with NASA Lewis Research Center (LeRC) during the winter of 1996-97 and for another WISP field effort in the winter of 1997-98.

The present AWR program direction is to refine the data and information being provided to forecasters at the AWC in Kansas City to improve the ability to forecast inflight icing, especially in the cases of freezing rain, freezing drizzle, and SLD aloft. The effort is focused on learning how to incorporate a variety of data sources into the forecast process, including satellite observations, wind profilers, Next Generation Weather Radar (NEXRAD), and Terminal Doppler Weather Radar (TDWR). The goal is to produce hourly three-dimensional icing forecast fields from model-based algorithms for aviation users with at least a one-hour lead time (up to as much as a 12-hour lead time) with high accuracy. The AWR program not only supports model and icing algorithm development, but also funds the Experimental Forecast Facility (EFF) within the AWC by which emerging icing forecasting technologies are tested in an operational setting. Icing forecasts from the EFF are distributed currently in text or 2D graphic format. A three-dimensional gridded system for use by flight service specialists, pilots, and other users is planned. As a result of work completed thus far, in January 1996, the AWC issued the first-ever forecast of freezing precipitation aloft.

As the FAA continues to sponsor research, it will encourage other governmental, academic, private, and international organizations to pursue their own research. All such research should be conducted in mutual collaboration for maximum effectiveness.

(See also Tasks 13.E. and 13.H. of this plan.)

Responsible party: FAA Aviation Weather Research Program, AUA-460.

Schedule:

- November 1996 - March 1997: NASA LeRC/NCAR freezing drizzle program to include forecasting of SLD conditions.
- July - September 1998: Statistical verification of icing algorithms completed. Determine upgrades to single input and combined model-sensor input algorithms. Report on NCAR-produced icing forecast guidance and value added by AWC and Alaska AWC forecasters.
- FY99 and beyond:
    - Complete combined sensor-model icing algorithm and implement at AWC and Alaska AWC.
    - Develop higher resolution icing guidance product (down to 10 km horizontal scale) commensurate with the National Centers for Environmental Prediction (NCEP) capability improvement.

B. The FAA will continue to support the use of operationally available sensor technology (ground-based or airborne sensors that send data to ground-based equipment) for icing detection and diagnosis. The FAA also will consider funding the development of new sensor technologies for icing detection or diagnosis.

PLAN DETAILS, TASK 2.B.:

As a result of FAA efforts, in the summer of 1996, the first commercial aircraft having a humidity sensor was flown. Humidity sensors will be installed on five additional aircraft within the year. These sensors will allow automated reports of a key icing algorithm input parameter -- atmospheric humidity -- to supplement the temperature and wind data already reported. This effort is highly leveraged with NOAA and the National Science Foundation (NSF) in collaboration with United Parcel Service. Furthermore, AWR is working with the governments of France and the United Kingdom to obtain sensor certification on Airbus aircraft and Boeing 747 aircraft, respectively. After several months of flight tests and experience in using the humidity data to improve forecasts, as many as 160 sensors will be deployed on air carrier aircraft. This will greatly enhance the information available to meteorologists and numerical modelers.

While this airborne humidity sensor is an essential first step in icing detection and forecast verification, it does not directly identify the icing phenomenon itself. The FAA will consider funding research into icing detection technologies and facilitating transfer of these technologies to industry.

The AWR program-sponsored radar detection work has resulted in several methodologies to determine icing altitudes, to determine the amount and sizes of SLD, to discriminate between liquid droplets and ice crystals by combinations of ground- and satellite-based radars and radiometers, and to use low-cost balloon-borne packages for supercooled liquid detection and quantification. Preliminary results have been published, yet thorough testing under a variety of atmospheric conditions is needed to ensure the methods are sufficiently robust for technology transfer to operational systems such as NEXRAD and TDWR.

The FAA will encourage other governmental, academic, private, and international organizations to pursue their own research and technology transfer. All such research should be conducted in mutual collaboration for maximum effectiveness.

(See also Task 3 of this plan.)

Responsible Party: FAA Aviation Weather Research Program, AUA-460.

Schedule:

- September - December 1996: Experimental, off-line (in the NCAR environment) implementation of combined model-sensor input icing diagnosis algorithm. NCAR installs satellite-based icing display at AWC and Alaska AWC.
- September 1997: Report on the feasibility of using remote sensor data to determine icing severity. Report on theoretical studies of possible NEXRAD/TDWR upgrades for improving icing detection.
- October - December 1997: Implement upgrade to satellite algorithm at AWC and Alaska AWC.
- November 1997 - March 1998: (Tentative) Field experiment in western Great Lakes to test NEXRAD upgrade concepts.
- September 1998: Report on evaluation of NEXRAD upgrades tests.

INFLIGHT ICE DETECTION

Task 3. Accelerate development of airborne technologies that remotely assess icing conditions by working with groups that already are supporting research in this area.

PLAN DETAILS, TASK 3:

The development of equipment carried on an aircraft that could detect icing conditions in an area that is remote from the aircraft would assist aircraft that are not certified for flight in icing conditions in avoiding those conditions. The ability to remotely detect icing is envisioned as an important capability of aircraft developed in accordance with the "avoid and exit" concept advanced as part of the Advanced General Aviation Transportation Experiment (AGATE). Such aircraft are not planned to be certified for flight in icing conditions.

Remote sensing could be useful to aid in avoidance of severe icing conditions by all aircraft including transport airplanes. The Department of Defense (DOD) and FAA are funding investigative research in this area; Cold Regions Research Engineering Laboratory (CRREL) will provide the primary technical management. NASA LeRC is organizing a workshop on the airborne remote sensing concept.

Responsible Party: FAA Technical Center, DOD, CRREL, NASA LeRC.

Schedule:

July 1998: Reports on airborne remote sensing technology proof of concept investigations.

CERTIFICATION REGULATIONS AND GUIDANCE MATERIAL

Task 4. Ensure that aircraft having unpowered ailerons and pneumatic deicing boots do not have roll control anomalies if exposed to certain SLD conditions.

A. The FAA will develop and publish interim procedures for aircraft receiving new, amended, or supplemental type certificates.

PLAN DETAILS, TASK 4A:

In 1994, an accident occurred in which severe icing conditions outside of the icing certification envelope contributed to uncommanded roll. The accident profile was nearly replicated during flight tests when the aircraft was flown with ice shapes developed from testing in an artificial icing cloud having droplets in the size range of freezing drizzle at a temperature near freezing. This condition created a ridge of ice aft of the deicing boots and forward of the ailerons. Dry air testing with this ice shape resulted in uncommanded motion of the ailerons and rapid roll. Subsequent mandatory modifications to enlarge the deicing boot to remove the ice formation corrected these unsafe characteristics. In addition, flight manual procedures were adopted that allowed flight crews to identify inadvertent flight into severe icing conditions, and provided restrictions and procedures to allow a safe exit from those severe conditions. The deicing system modification provides an increased margin of safety in the event of an encounter with freezing conditions exceeding the icing certification envelope.

The FAA initiated a review of aircraft similar to the accident airplane to determine if other type designs might experience control difficulties should a ridge of ice form aft of the deicing boots and forward of the ailerons. The investigation addressed part 23 and part 25 airplanes that are equipped with pneumatic deicing boots and non-powered flight control systems, and that are used in regularly scheduled revenue passenger service in the United States.

The FAA has determined that similarly equipped aircraft receiving new, amended, or supplemental type certificates should be evaluated for roll control problems if exposed to large supercooled droplets. The procedures that will be based upon those used during the previous FAA evaluation program and will continue until specific regulations are adopted to address conditions outside of the current regulatory icing envelopes in Appendix C of part 25 of the Federal Aviation Regulations (14 CFR part 25).

Responsible parties: Small and Transport Airplane Directorates.

Schedule:

- July 1997: Develop and publish guidance applicable to airplanes receiving new, amended, or supplemental type certificates.

B. The FAA will issue Notices of Proposed Rulemaking (NPRM) to require that certain aircraft exit icing conditions when specific visual icing cues are observed. The NPRMs will be applicable to those aircraft (1) that have pneumatic deicing boots and unpowered ailerons and (2) that were not addressed by the icing AD's issued on April 24, 1996.

PLAN DETAILS, TASK 4B:

In April 1996, the FAA issued 18 Airworthiness Directives (AD) to require revising the FAA-approved Airplane Flight Manual to provide the flight crew with recognition cues for, and procedures for exiting from, severe icing conditions. The AD's were written because flight crews were not provided with the information necessary to determine:

- when the airplane is operating in icing conditions that have been shown to be unsafe; or
- what action to take when such conditions are encountered.

The AD's applied primarily to parts 23 and 25 airplanes that have unpowered primary roll controls, pneumatic deicing boots, and are used in regularly scheduled revenue passenger service in the United States.

The FAA will propose similar mandatory action through the NPRM process for all part 25 and certain part 23 airplanes that have unpowered roll controls and pneumatic deicing boots that were not addressed by the earlier AD's. The part 23 NPRM's will address airplanes certificated in normal and utility categories (not used in agricultural operations) having unpowered roll controls and pneumatic deicing boots that are used in part 135 on-demand and air taxi operation, and other airplanes regularly exposed to icing conditions.

These part 23 NPRM's will include:

a. All single and multi-engine turbopropeller powered airplanes.
b. All multi-engine piston powered airplanes.
c. Single-engine piston powered airplanes generally having retractable landing gear, constant speed propellers, and powered by engines rated at 200 horsepower or greater.

Responsible parties: Small and Transport Airplane Directorates.

Schedule:

Task 5. Task ARAC with a short term project to consider a regulation that requires installation of ice detectors, aerodynamic performance monitors, or another acceptable means to warn flight crews of ice accumulation on critical surfaces requiring crew action (regardless of whether the icing conditions are inside or outside of Appendix C). ARAC will also be tasked with a long term harmonization project to develop certification criteria and advisory material – possibly including envelopes supplementing those currently in Appendix C – for the safe operation of airplanes in SLD aloft, in SLD (freezing rain or freezing drizzle) at or near the surface, and in mixed phase conditions.

PLAN DETAILS, TASK 5:

The current icing certification regulations ensure that airplanes are safe for operation in icing conditions defined by the envelopes in Appendix C of part 25 of the Federal Aviation Regulations (14 CFR part 25). However, service experience has shown that airplanes may encounter icing conditions exceeding Appendix C, which may have catastrophic consequences. This initiative will provide certification requirements to increase the level of safety when icing conditions exceeding Appendix C are encountered.

Another key issue that requires analysis is the recognition of aircraft icing. ARAC will be given the task to consider the need for a regulation that requires installation of ice detectors or other acceptable means to warn flight crews of ice accumulation on critical surfaces requiring crew action.

Responsible party: FAA.

Schedule:

- September 1999: Reach technical agreement.
- October 2001: Publish Final Rule.

Task 6. Improve the regulations and guidance related to certification of airplanes for operation in icing conditions defined by Appendix C.

A. The FAA will review, revise, and develop the following guidance material:

1) **Review and revise Advisory Circular (AC) 20-73, Aircraft Ice Protection.**
2) **Review and revise AC 23.1419A, Certification of Part 23 Airplanes for Flight in Icing Conditions.**
3) **Develop AC 25.1419, Certification of Part 25 Airplanes for Flight in Icing Conditions.**

PLAN DETAILS, TASK 6.A.1, 6.A.2, and 6.A.3:

A review of existing advisory material indicates that improvements can be made and additional new information incorporated to benefit all users. The AC's will address icing conditions that are defined by the current Appendix C. Consideration will be given to combining the information into one AC. It is anticipated that additional advisory material will be required for icing conditions outside of Appendix C (see Task 5 of this plan).

Responsible Party: Aircraft Certification Service.

Schedule:

September 1998: Issue proposed AC's.

4) **Review and update FAA Icing Handbook.**

PLAN DETAILS, TASK 6.A.4:

The FAA Icing Handbook is a compendium of technical information pertaining to design, analysis, test, and certification of aircraft with ice protection. The Handbook is intended primarily for use by airframe, powerplant, and flight test engineers. The update will include, but will not be limited to, new information on the following:

a. Airfoil and aircraft aerodynamics, performance, and stability and control with ice accretions.
b. Characterization of supercooled large droplet icing conditions.
c. Analytical icing accretion and performance codes.
d. Ice protection systems.

Responsible Party: FAA Technical Center.

Schedule:

December 1997: Complete update of the FAA Icing Handbook.

5) **Develop an engine and propulsion icing AC.**

PLAN DETAILS, TASK 6.A.5:

The engine and propulsion icing AC will provide certification guidance that is more definitive than AC 20-73, Aircraft Ice Protection. It will also present information that will cover engine certification and part 25 engine induction system certification as a coordinated process.

Major areas to be covered include:

a. Ice shed damage conditions
b. Power loss instability conditions (e.g., rollback, flameout, surge/stall, etc.)
c. Acceptance criteria (acceptable damage, acceptable power loss, etc.)
d. Natural icing flight tests [part 25 of the Federal Aviation Regulations (14 CFR part 25)]

Responsible Parties: Engine and Propeller Directorate, Transport Airplane Directorate.

Schedule:

September 1998: Issue final AC.

6) **Develop an advisory circular to provide guidance on how to evaluate the susceptibility of a horizontal tail to stall.**

PLAN DETAILS, TASK 6.A.6:

Aerodynamic stalling of the horizontal tailplane, when the leading edge was contaminated with ice, has been responsible for a number of catastrophic accidents. It has been found that even the small amounts of ice that may accumulate before activation of an ice protection system can cause reductions in the tailplane stall margin.

Airplanes with powered pitch control systems may be susceptible to this phenomen in terms of alteration of the aerodynamic characteristics of the tailplane. However, there has only been adverse service history with leading edge contamination on airplanes with unpowered pitch control systems. Airplanes with a history of accidents and incidents attributed to tailplane stall are required by the FAA to limit the use of flaps, modify the ice protection system, or modify the horizontal stabilizer airfoil design. The changes improve the performance of the ice protection system or increase tailplane stall margins. The FAA also evaluated the tailplane stall margins of other part 121 and 135 airplanes with unpowered pitch control systems and found the margins to be adequate.

In 1992, the FAA published a memorandum that prescribed a zero-g pushover maneuver to investigate an airplane's susceptibility to tailplane stall. The FAA now plans to develop guidance material that will present design criteria and assessment methods that will aid manufacturers in the design of tailplanes that are not susceptible to stalling when the leading edge is contaminated.

Responsible Parties: Small Airplane Directorate, Transport Airplane Directorate.

Schedule:

September 1999: Issue final AC.

B. The FAA will coordinate an evaluation of a reformatted Appendix C, which could provide a presentation more easily used in certification and for other purposes and which could be incorporated in an AC.

PLAN DETAILS, TASK 6.B.:

Dr. Richard Jeck's AIAA-94-0482 paper, "Other Ways to Characterize the Icing Atmosphere," suggests formats of the Appendix C data that could be used more easily by certification and research personnel. The FAA will consider writing an AC that contains the suggested formats, the use of those formats, and an explanation of the process of translation between the present Appendix C envelopes and the proposed formats. Dr. Jeck's proposals do not necessarily require any change in the Appendix C envelopes.

Responsible Parties: FAA Technical Center, Small and Transport Airplane Directorates, FAA Icing Steering Committee.

Schedule:

- August 1997: Solicit comments from the FAA, industry, and the research community. If the proposals are found to be desirable, then:
- June 1998: Issue proposed AC.

C. Task an Aviation Rulemaking Advisory Committee (ARAC) working group to harmonize the requirements of Section 23.1419 ("Ice protection") of part 23 of the Federal Aviation Regulations (14 CFR 23.1419), and Sections 25.1419 ("Ice protection"), 25.929 ("Propeller deicing"), and 25.1093 ("Induction system ice protection") of part 25 of the Federal Aviation Regulations (14 CFR part 25.1419, 25.929, and 25.1093) and of part 25 of the Joint Airworthiness Regulations, and to produce appropriate advisory material.

PLAN DETAILS, TASK 6.C.:

Responsible Parties: Small and Transport Airplane Directorates.

Schedule:

October 2001: Publish Final Rule.

Task 7. The ARAC Flight Test Harmonization Working Group will complete the harmonization project to standardize performance and handling requirements and guidance material for certification of FAR/JAR 25 airplanes to safely operate in the icing conditions of Appendix C.

PLAN DETAILS, TASK 7:

Section 25.1419 of part 25 of the Federal Aviation Regulations (14 CFR part 25) and Section 25.1419 of the Joint Airworthiness Regulations require that the airplane must be able to safely operate in certain specified icing conditions. The Flight Test Harmonization Working Group was tasked with a project to standardize airplane performance and handling requirements for demonstrating safe operation in icing conditions. The harmonization project started when the JAA published Notice of Proposed Amendment (NPA) 25F-219, "Flight Characteristics in Icing Conditions." The NPA provides guidance for demonstrating acceptable airplane performance and handling characteristics for flight in icing conditions.

The Flight Test Harmonization Working Group began work on this project in October 1994. A number of technical issues are yet to be addressed, including coordination with other ARAC working groups relative to systems and avionics requirements during flight in icing conditions. However, agreement has been reached on the majority of performance and handling qualities issues.

Responsible Party: ARAC.

Schedule:

March 1999: Publish Final Rule and AC.

Task 9. The FAA, in concert with airworthiness authorities throughout the world, will consider a comprehensive redefinition of certification envelopes (such as those that appear currently in Appendix C) for the global atmospheric icing environment when sufficient information is available worldwide on SLD, mixed phase conditions, and other icing conditions, and when adequate simulation tools are available to simulate and/or model these conditions.

PLAN DETAILS, TASK 9:

The lack of information to support a comprehensive redefinition of certification envelopes for the global atmospheric icing environment was emphasized by numerous participants at the May 1996 FAA-sponsored International Conference on Aircraft Inflight Icing. Additionally, as the number of aircraft increase, the probability of encountering intense icing conditions that were previously considered rare increases. As available icing cloud information and technologies improve, the FAA will consider a comprehensive change to the icing certification envelopes. This task is extremely complex--it requires information from around the globe and cooperation of aviation authorities around the world. In the interim, the FAA will work with ARAC to improve the safety of airplanes exposed to icing conditions that exceed the current Appendix C icing envelopes (see task 5 of this plan).

Responsible Party: FAA Icing Steering Committee.

Schedule:

June 2003: If appropriate, the FAA will propose a change to the envelope.

Task 10. The FAA Human Factors Team will review the design philosophy of automatic autopilot disconnection due to an external disturbance.

PLAN DETAILS, TASK 10:

Operational experience has shown that in some autopilot modes, the autopilot has disconnected after trimming the aircraft to stall entry during flight in icing. Loss of control from the ensuing roll and pitch excursions has resulted during some instances. The human factors aspect of autopilot use and disconnect during flight in icing will be addressed.

Responsible Party: FAA Human Factors Team.

Schedule:

September 1997: Publish a plan and schedule.

ICING SIMULATION METHODS

Task 11. Develop validation criteria and data for simulation methods used to determine ice shapes on aircraft, including icing tunnel, ice accretion computer codes, and icing tankers.

A. *VALIDATION REQUIREMENTS.* A working group will be formed to identify validation requirements for icing facilities (tunnels and tankers), and droplet impingement and ice accretion computer codes. The validation requirements will be appropriate for use in certification. The working group will develop information describing validation criteria (including specification of limitations) for icing simulation facilities, including instrumentation and data processing methodologies as they relate to facility calibrations, and for impingement and ice accretion codes. This will be a coordinated effort among research organizations, industry, and regulatory authorities. This material will be evaluated by the FAA for adoption as guidance material.

PLAN DETAILS, TASK 11.A.:

The working group will establish a plan for development of validation criteria for experimental icing simulation facilities (tankers and tunnels) and icing simulation codes. The working group will develop level-of-acceptance criteria for validation comparisons. The group will examine correlation of ice shapes (including impingement) from icing facilities with those from flight in natural icing conditions. In addition, the group will examine correlation of ice shapes (including impingement) from ice accretion codes with those from both simulation facilities and natural conditions. The fidelity of artificial ice shapes needed to represent a natural event will be reviewed. Methods will be examined to provide quantifiable information on cloud characteristics, ice accretion shapes, and aero-performance measurements in natural icing to determine the comparison criteria for simulation. Methods for processing time-averaged flight data will be evaluated to support replicating natural icing events in ground-based facilities.

The working group also will address methods for defining tunnel/tanker cloud characteristics and their calibration and accuracy. This will include instrumentation employed in the establishment of those calibrations and methods to determine the facility's envelope. A set of equivalent icing conditions along with a standard model(s) will be identified for use in comparing icing simulation facilities. Means of comparison to cross reference individual facility results will be developed.

Issues related to the simulation of freezing drizzle, freezing rain, and mixed phase conditions either by a facility or a computer code also will be examined.

Responsible Parties: NASA LeRC, FAA Technical Center, and Aircraft Certification Service.

Schedule:

- August1997: Develop interim recommendations on validation criteria.
- June 2001: Develop final recommendations on validation criteria.

B. *VALIDATION DATA*. The FAA shall support research aimed at developing ice accretion data and associated aerodynamic effects that can be used for the validation of ice accretion codes and analysis of aerodynamic performance degradation due to icing. This research also can be used to form the basis of an evaluation of ice shape features resulting in critical performance loss.

PLAN DETAILS, TASK 11.B.:

The NASA LeRC Modern Airfoils Ice Accretions Program receives funding support from the FAA. This program encompasses the development of ice accretions in icing tunnels on modern airfoils (2D) and wings (3D) of interest to industry and the FAA. It includes the acquisition of aerodynamic data using icing tunnel accretion models in high quality aerodynamic tunnels.

Responsible Parties: NASA LeRC, FAA Technical Center.

Schedule:

September 1998: Report on ice accretions for modern airfoils (2D), including C_d, $C_{l,max}$, and stall angles.

C. *SIMULATION IMPROVEMENT*. The FAA will support research on the development and improvement of ice simulation methods such as ice accretions codes, icing tunnels, and icing tankers. This research will be directed at understanding the physical processes underlying the ice accretion process, including phenomena associated with SLD ice accretion.

PLAN DETAILS, TASK 11.C.:

A working group will be formed to publish a research plan that addresses how the FAA can most cost effectively improve the simulation capabilities of industry and research facilities.

Responsible Parties: FAA Technical Center, Aircraft Certification Service.

Schedule:

February 1998: Publish a Simulation Improvement Research Plan.

ICE ACCRETION AND ITS EFFECTS ON PERFORMANCE/STABILITY AND CONTROL

Task 12. Develop guidance material on ice accretion shapes and roughness and resultant effects on performance/stability and control. This material will be relevant to the identification and evaluation of critical ice shape features such as ice thickness, horn size, horn location, shape, and roughness.

A. The FAA, along with industry and research organizations, shall form a working group to explore categories of ice accretions that represent potential safety problems on aircraft.

PLAN DETAILS, TASK 12.A.:

The certification process requires identification and evaluation of critical ice accretions. Criticality of possible ice accretions is not well understood, and guidance information is needed for compliance with established requirements. The working group will evaluate numerous ice shapes to help define areas of concern about the effects of ice accretion on airfoil performance and aircraft stability, control, and handling characteristics.

These ice accretion categories would include (but would not be limited to):

1) "Sandpaper" ice (a thin layer of ice composed of roughness elements);
2) Residual ice (ice remaining after a deicer cycle);
3) Rime ice;
4) Glaze ice;
5) Large-droplet ice (spanwise step accretions beyond the "normal" impingement zone);
6) Beak ice (single horn ice shape on the upper surface); and
7) Intercycle ice (ice accumulated between deicer cycles).

These categories of ice would be considered during various phases of flight such as takeoff, landing, climb, hold, etc., for:

1) Operational ice protection systems;
2) Failed ice protections systems; and
3) Unprotected surfaces.

Responsible Parties: Aircraft Certification Service, FAA Technical Center, NASA LeRC, Industry, Academia.

Schedule:

December 1997: Publish a plan.

B. The FAA will establish a working group to visit various manufacturers to learn how they develop critical ice shapes and their rationale for the ice shapes used for certification. The working group will develop information to be considered for publication.

PLAN DETAILS, TASK 12.B.:

Responsible Party: Aircraft Certification Service.

Schedule:

- October 1997: Complete visits to manufacturers.
- December 1997: Report findings.

C. The FAA will continue to support research on the effects of ice accretion on airfoil performance and aircraft stability, control, and handling characteristics. As the FAA continues to sponsor research, it will encourage other governmental, academic, private, and international organizations to pursue their own research. All such research should be conducted in mutual collaboration for maximum effectiveness. The following research efforts are current FAA-supported programs directed at addressing the issues associated with this task: (1) the NASA LeRC/FAA Tailplane Icing Program and (2) the University of Illinois/FAA Study of Effect of Large Droplet Ice Accretions on Airfoil and Wing Aerodynamics and Control.

The NASA Lewis Research Center (LeRC)/FAA Tailplane Icing Program:

PLAN DETAILS, TASK 12.C.:

This program encompasses a study of tailplane icing using icing tunnel, wind tunnel, computational methods, and flight test. It includes the investigation of flight test and analytical methods to determine aircraft sensitivity to ice contaminated tailplane stall.

Responsible Parties: NASA LeRC, FAA Technical Center.

Schedule:

April 1998: Final Report.

University of Illinois/FAA Study of Effect of Large-Droplet Ice Accretions on Airfoil and Wing Aerodynamics and Control:

PLAN DETAILS, TASK 12.C.:

The objective of this research is to study the effects of spanwise step ice accretions on subsonic aircraft aerodynamics and control. This type of ice accretion can occur in supercooled large droplet icing conditions (freezing rain and drizzle) as well as in smaller droplet clouds at temperatures near freezing. Experimental and computational tasks will be conducted using simulated ice accretions to determine the sensitivity of ice shape and location on airfoil performance and control surface hinge moment as a function of angle-of-attack and flap deflection. Critical conditions will be identified where the hinge moment or aerodynamic performance changes rapidly.

Responsible Parties: University of Illinois, FAA Technical Center.

Schedule:

- 1997: Interim report.
- 1999: Final report.

D. The FAA will request that industry form a committee to review data from the Phase II testing to determine if there are significant correlations that can be shared for future use and to identify realistic ice shapes due to SLD. The committee will consider the effect of airfoils, pressure distribution, aileron design, etc., on an aircraft's susceptibility to roll control problems.

PLAN DETAILS, TASK 12.D.:

During the May 1996 International Conference on Aircraft Inflight Icing, manufacturers indicated a willingness to contribute data to accomplish this task.

Responsible Party: Aircraft Certification Service.

Schedule:

July 1997: Prepare letter(s) to industry.

SLD CHARACTERIZATION AND MIXED PHASE CONDITIONS ASSESSMENT

Task 13. **Characterize SLD aloft and assess mixed phase conditions (ice crystals and supercooled liquid water droplets) in the atmospheric flight environment.**

A. The FAA will circulate "trial" SLD dropsize distributions to participating research organizations to assess differences in LWC and dropsize processing methods.

PLAN DETAILS, TASK 13.A.:

This subtask responds to the long recognized problem of trying to correct, or adjust, recorded dropsize distributions for systematic measurement errors that occur with modern, electro-optical, droplet sizing probes. In the absence of a standard procedure, different users employ different correction schemes that can give different results for the same initial SLD size distribution. Unacceptably large disagreements in computed median volume diameters (MVD) and water concentrations can arise this way. In this situation, nobody knows how much artificially introduced error is contained in published SLD results. Therefore, this plan attempts to gauge the seriousness of the problem by allowing all interested researchers to use their preferred correction scheme -- whatever it may be -- on the same initial size distribution and to compare the results.

Responsible Party: FAA Technical Center.

Schedule:

April 1998: Final report summarizing results.

B. The FAA will collect, consolidate, and analyze affordable and accessible existing SLD data. The FAA will recommend that individual Civil Aviation Authorities (CAA's) sponsor an analyses of archived weather data in their own countries to provide statistics on the local occurrences of freezing rain and freezing drizzle.

PLAN DETAILS, TASK 13.B.:

A comprehensive data set was collected by the FAA Technical Center for icing conditions in clouds for which the processed data rarely revealed the presence of significant concentrations of droplets larger than 50 microns in diameter. Therefore, this database cannot be used for analysis of SLD conditions. Several research institutions have collected data in SLD conditions; inquiries must be made regarding additional organizations possessing in-situ measurements that may include these conditions.

A data compilation similar to that for the cloud icing database will be conducted. Processing techniques, whether done on site at the participating institutions or at the FAA Technical Center, will be determined as part of this project.

Records of freezing rain and freezing drizzle from surface observations exist in many countries. These data are valuable for assessing the threat of SLD worldwide and for determining the opportunities for possible flight tests or additional measurements in SLD conditions. Civil aviation authorities worldwide will be encouraged to undertake or sponsor the analyses of their archived weather data.

Responsible party: FAA Technical Center.

Schedule:

- June 1997: Prepare a letter to worldwide CAA's.
- March 1998: Final report on results from FAA effort.

C. The FAA will conduct a study to determine the magnitude of the safety threat that is posed by mixed phase conditions.

PLAN DETAILS, TASK 13.C.:

Responsible party: FAA Technical Center.

Schedule:

February 1998: Report on the findings and recommendations for possible further action.

D. (This subtask is left blank intentionally.)

E. The FAA will support basic research on the formation mechanism of freezing drizzle aloft and at ground level.

PLAN DETAILS, TASK 13.E.:

Through the FAA Aviation Weather Research Program, the FAA has supported ongoing work in this area since fiscal year (FY) 1990. The "FAA Inflight Icing Product Development Plan: FY97 & FY98" includes a section on basic icing science, which focuses on the roles of turbulence and low cloud condensation nucleus concentrations in contributing to the formation of SLD.

Responsible Party: FAA Aviation Weather Research Program, AUA-460.

Schedule:

This is ongoing work. Results from these analyses have already been incorporated into guidance products transferred to AWC as part of the FAA AWR Program. The two-year (FY 1997 and FY 1998) Inflight Icing Product Development Team Plan under review by the AWR Program includes further study and transfer of research results to operations.

F. The FAA will solicit knowledgeable individuals to provide guidance to researchers for developing SLD and mixed phase icing cloud characterizations for possible certification purposes (quantity, geographic location, and characterization format).

PLAN DETAILS, TASK 13.F.:

Guidance will be sought from researchers who collect and analyze the data, modeling and wind tunnel representatives, and industry and FAA representatives who would use any new characterization (SLD, mixed phase conditions) for certification purposes. The need is not solely meteorological (processes, characteristics, extents), but also depends on such factors as location relative to high air traffic use areas, wind tunnel and numerical simulation requirements, and operational requirements.

Responsible parties: FAA Technical Center, Canada [Atmospheric Environmental Service (AES), National Research Council of Canada (NRC), and Transport Canada (TC)], NCAR, NASA LeRC, Aircraft Certification Service.

Schedule:

April 1998: Report on findings.

G. The FAA supported tunnel testing by NASA LeRC and the Canadian AES with the objective of testing LWC meters for droplet sizes greater than 50 microns.

PLAN DETAILS, TASK 13.G.:

Responsible Parties: NASA LeRC, AES, FAA Technical Center.

Schedule:

September 1996: Completed NASA LeRC and Canada (AES/NRC/TC) tunnel testing.
July 1997: Report on the tunnel testing.

H. The FAA will support further icing research to characterize SLD for operations, simulation, and certification purposes. This research will include the collection of data in geographic areas where SLD aloft data has not been collected, such as the Great Lakes Region. Such field programs will be planned to provide information useful for verification of forecasting methodologies, training and guidance material pertaining to operation in SLD aloft (e.g., horizontal and vertical extent), SLD characterization, and simulation of SLD using icing tunnels/tankers and computer codes. The FAA will request that the international community [Canadian AES, NRC, and TC; and European Research on Aircraft Ice Certification (EURICE)] continue their support of similar research efforts (or initiate similar studies) and enter into SLD data exchange agreements promoting compatible operational and data collection procedures, measurement techniques, and data processing procedures.

PLAN DETAILS, TASK 13.H.:

Existing SLD data for North America is almost entirely derived from mountainous regions of the western United States and the maritime provinces of eastern Canada. The mechanisms primarily responsible for icing in those areas (orographic, north Atlantic) are different from those in other geographic areas of North America. Thus, atmospheric sampling in geographic areas representative of other SLD formation mechanisms would be very valuable in the formulation of an SLD characterization envelope. These areas would include the Great Lakes region and other areas determined through consultation with meteorologists and cloud physicists.

Most sampling of SLD aloft must, by definition, be done in flight. However, innovative approaches can be used in some geographic areas, as exemplified by the pilot project on Mount Washington in winter, 1996-97.

A cooperative NASA LeRC/NCAR/FAA project, based at the NASA LeRC flight facility in Cleveland, Ohio, is planned for the 1996-97 icing season. Canada (AES/NRC/TC) has proposed a field project for the Canadian Great Lakes in 1997-98. These projects will provide essential SLD data in the Great Lakes region, which is believed to be a geographic area where severe icing conditions occur with greater frequency than in most other areas of North America. This project is crucial both to possible short-term regulatory action and to effective planning of further SLD flight research.

A scientific field project (WISP98) is planned tentatively for the western Great Lakes area during the following winter (1997-98). That project will include SLD flight research if funding is available. A conservative estimate is that $600,000 would be required from FAA and other sources in order to include SLD flight research in this project. WISP98 involves NCAR, FAA, NASA LeRC and, possibly, several universities, local NWS offices, NOAA's Environmental Technology Laboratory, and industry. Facilities available for this project are directly dependent on funding amounts and sources, both of which are unknown at this time. Canada (AES/NRC/TC) also is planning a field project for the Canadian Great Lakes in 1997-98.

The support of further SLD flight research in 1998-99 will be assessed in light of the outcome of the efforts in 1996-97 and 1997-98. The factors considered will include the success of the research already conducted, the need for further data for regulatory and other purposes, and available funding. If it is determined that three complementary flight programs are needed in different geographic areas of North America, and each costs at least $600,000 (a conservative estimate), then the total cost would be at least $1,800,000.

Data from all efforts will be provided to the FAA Technical Center. The Technical Center will enter the data into the FAA SLD data base, and will provide the data to the ARAC committee described in Task 5 of this report in a form appropriate for their deliberations.

Responsible parties: FAA Technical Center, FAA Aviation Weather Research Program (AUA-460), Canada (AES/NRC/TC), Joint Airworthiness Authorities (JAA), NASA LeRC, NCAR.

Schedule:

- June 1997: Letter from FAA to Canadian AES and EURICE proposing consideration of an agreement on exchange of SLD flight research data.
- June 1998: New SLD data from Great Lakes Project and Mt. Washington Project entered in FAA SLD database and included in package provided to ARAC in appropriate form. FAA SLD database and data package for ARAC also will include data from Task 13b of this report.
- October 1998: New SLD data from WISP98 and other available field projects entered in FAA SLD database and provided to ARAC in appropriate form.
- 1998-99: Additional SLD atmospheric flight research based upon available resources and an evaluation of the research completed to date.

I. A feasibility study will be carried out by a working group to determine if the FAA should solicit cooperation of operational aircraft to carry icing, LWC, and droplet probes.

PLAN DETAILS, TASK 13.I.:

A variety of simple to complex measurement devices exist. These devices are available for installation on aircraft to provide real-time or recorded measurements relevant to the icing problem. The appropriate instruments, aircraft, data collection, format, and applications must be assessed. Some instruments, such as ice detection equipment used for pilot warning/deicing equipment activation, already exist and are installed. Data recorders, including written or voice pilot notes, digital recording, or ground telemetry, are needed to document the information.

Responsible Parties: FAA Technical Center, Flight Standards, Canada (AES/NRC/TC), NCAR, NASA LeRC.

Schedule:

- June 1997: Working group formed.
- December 1997: Report and recommendations.

COORDINATION OF ICING ACTIVITIES

Task 14. The FAA Icing Steering Committee will coordinate inflight icing activities, including recommendations from the FAA International Conference on Aircraft Inflight Icing.

PLAN DETAILS, TASK 14:

The FAA Icing Steering Committee members are drawn from across the FAA, including representatives from the Flight Standards Service, Air Traffic, Aircraft Certification Service, and the FAA Technical Center. The Committee was instrumental in the review of the recommendations from the FAA International Conference on Aircraft Inflight Icing and the subsequent development of this FAA Inflight Aircraft Icing Plan. The Committee will monitor if the Icing Plan tasks are proceeding on schedule and are achieving the desired results.

Responsible Party: FAA Icing Steering Committee

Schedule:

Biannual review of the FAA Inflight Aircraft Icing Plan to determine progress on accomplishing the plan and to identify areas where the plan should be revised.