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Report Of The

**AIRCRAFT SYSTEMS/FLIGHT TEST WORKSHOP**

Held at East Point, Georgia on 8-17  
November 1977.

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**ENGINEERING AND MANUFACTURING DIVISION  
SYSTEMS AND FLIGHT TEST BRANCHES**

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**U.S. DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION**

Flight Standards Service  
Washington, D.C. 20591

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## SUMMARY

The 1977 Systems Workshop was held at the Holiday Inn, 1380 Virginia Avenue, East Point, Georgia, during the period November 8-17, 1977.

On November 8 and until noon on November 9, FAA Systems Engineers discussed items 1-14; from 1 p.m. on November 9 and on November 10 and 11, FAA Systems and Flight Test personnel combined to discuss items 15-26; on November 14-16, Systems Designated Engineering Representatives (DERs) joined with FAA Systems Engineers to discuss items 27-47; and on November 17, FAA personnel enjoyed a conducted tour of the Delta Airline facility.

The Systems/Flight Test workshop was based on recognition of the vital interdependence of the two technical disciplines, and 12 topics of mutual interest (items 15-26) were discussed. The resulting clarification and increased understanding will contribute toward improved working relationships in future projects, as well as provide useful technical guidance on the specific issues.

In a similar fashion, the Systems/DER workshop had an identical basic purpose, and both technical and administrative topics of mutual interest were discussed. A total of 21 topics (items 27-47) occupied the second week of the 1977 Systems Workshop. The attendance of 57 Systems DERs was most gratifying, and is a firm indication of the high level of interest of our DERs.

Technical presentations by Bendix, by the FAA Systems Research and Development Service, and NAFEC added appreciably to the Workshop, and the efforts of those responsible are very much appreciated.

The hospitality of the FAA Southern Region is also very much appreciated. The Systems Section, ASO-213, led by Mr. Kit Kaiser, handled the many administrative details inherent in a complex technical meeting in a cooperative and highly professional manner.

An additional benefit of the Workshop is expected to be realized from the attendance of two representatives of the airworthiness authority of Brazil, as a bilateral airworthiness agreement has recently been reached with that country.

## INDUSTRY PERSONNEL

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G. C. Carver	ASO-213
J. F. Clayton	ASO-213
Paul Cormaci	AEU-100
Bob Huhn	AFS-130
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Bob Klapprott	ICT-EMDO-43C
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Tom Plummer	ASW-213
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Bernard Schaffer	ANE-213
Earsa Lee Tanksley	ACE-213
Bill Trammell	ASO-213
Jim Treacy	ANW-213
Ronald Vavruska	ANE-213
David Warner	AGL-213
Hugh Waterman	AFS-130
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## OPENING REMARKS

Mr. James O. Robinson, Chief, Engineering and Manufacturing Division, AFS-100, Washington, D.C., opened the Workshop with a short address. He stated that Headquarters has been in a personnel freeze which has recently become a "deep" freeze, meaning that Headquarters cannot replace any personnel lost for any reason. The effects of this will include a need for more assistance to Washington by the regions such as has been given recently on the Concorde project. He suggested that the regions request travel money in their budget submittals for such assistance to Headquarters to make the essential programs less burdensome to the regions.

Mr. Robinson also expressed an intent to get Headquarters people more involved early in major regional projects to facilitate the development of needed guidance and special conditions.

Subjects beyond the scope of the group should be avoided during the Workshop discussions, and Mr. Robinson mentioned as examples the Freedom of Information Act and the Fair Labor Practices subject. Such subjects are controlled by other offices. FAA technical people can only assure that the files are kept clear of opinions and innuendoes, and that all matters of record are factual. With regard to such subjects, about all that can be accomplished in a technical workshop is an exchange regarding how each region handles similar cases, and an attempt to achieve consistency and good responsiveness.

In another area, Mr. Robinson also cautioned against proposing a lot of rule changes because of the time required to process rules. In view of the priority system used in Washington, it is very difficult to push rules through to completion, especially Technical Standard Orders which seldom enjoy the priority needed to see the light of day. Instead of proposing rules, Mr. Robinson encouraged the group to develop guidance and policy material which will effectively standardize our technical policies and make more uniform the application of existing rules.

Mr. James E. Purcell, Chief, Flight Standards Division, ASO-200, welcomed the combined Systems and Flight Test group to Atlanta for the Southern Region. His remarks oriented the group toward an empathetic viewpoint of the needs of the public and he offered the assistance of his office during the Workshop.

1977 SYSTEMS WORKSHOP  
SUMMARY OF ACTIONS TO BE TAKEN

<u>Agenda Item</u>	<u>Nature of Intended Action</u>	<u>Responsible</u> (AFS-130, if not specified)
1	Update TSOs	
1	*Guidance re Substituting Current Standards	
2 (&39)	General TSO	
4	Comment to AFS-130 re ASO Paper on FAR 37	All Attendees
4	Regulatory or Guidance Material re FAR 37	
5	Guidance re TSO vs. Aircraft Certification Basis	
6	Guidance re PMA for TSO Articles	
7	Guidance re Marking Altered TSO Products	
8	Guidance re Marking Omega Units	
9	Manufacturers' Recommendations re Omega to AFS-130	All Regions
9	Guidance re Omega Installations	
10	Review of AC 90-45 Revision and Comment to AFS-130	All Regions
10	Issue AC 90-45 Revision	
11	Guidance re Overwater Navigation Equipment	
13	SAE Anti-collision Light Proposal to Regions	
14	Guidance re Lightning Protection	
14	Guidance re TSO Procedures (Order 8150.1)	

\*Note: 'Guidance' may be Notices, Orders, or Advisory Circulars, as applicable.

**1977 Systems Workshop  
Summary of Actions to be Taken**

<u>Agenda Item</u>	<u>Nature of Intended Action</u>	<u>Responsible</u>
14	Guidance re Policy Index	
14 (&32)	Guidance re Engr./Maint. Coordination	
14	Guidance re ISMLS	
14	Guidance re Altered/Modified TSO Products	
14	Guidance re Fault Analysis Standards	
14	Rulemaking re Lithium Batteries	
14	Rulemaking re Defunct TSO Manufacturers	
14	Guidance re Survivor Light Intensity	AFS-120
14	Rulemaking re Foreign TSOs	
14 (&34/38)	DER Handbook	
15	Omega Flight Test Procedures - TIAS	AWE-130
15	Omega Flight Test Procedures - Comments	All Regions
15	Omega Flight Test Procedures - Guidance	
16	Helicopter IFR Equipment Criteria	
17 (&45)	Guidance re Complex Systems	
18 (&41)	Guidance re Digital Systems	
19	Guidance re Annunciation Systems	ASW-213
19	Guidance re Annunciation Systems - Comments	AWE-130, ANW-213

1977 Systems Workshop  
Summary of Actions to be Taken

<u>Agenda Item</u>	<u>Nature of Intended Action</u>	<u>Responsible</u>
19	Guidance re Annunciation Systems (Order 8110.8)	AFS-160
20	Rulemaking: FAR 25.1309/25.1301	
20 (&31)	Guidance re FAR 25.1309	
21 (&33)	Guidance re FAR 23.1309	
22	Rulemaking: Magnetic Compass Calibration	
23	Guidance &/or Rulemaking: Pneumatic Altimeter	
24/25 (&37)	Information re Smoke Generation/Testing to AFS-120	All Regions
24/25 (&37)	Draft Smoke Generation/Testing Criteria to Regions	AFS-120
26	Comments re FAR 135 to AFS-900	ACE-213
26	Review of AFS-140 Icing Report (copy to Regions)	
26	Guidance re Icing to Pilots from AFS-800	AFS-160
26	Review of Guidance re Icing from AFS-806	
26	Rulemaking: FAR 91, Icing	
26	Pilot Information Film (AFS-800, AOPA)	
26	Improve Icing Definitions in AIM	
27	Guidance re RNAV Autotuning	
28	Guidance re Optional Equipment	
28	Copy Order 8110.10B to DERs	
29	Reliability Training for DERs	

**1977 Systems Workshop**  
**Summary of Actions to be Taken**

<b><u>Agenda</u></b> <b><u>Item</u></b>	<b><u>Nature of Intended Action</u></b>	<b><u>Responsible</u></b>
35	Guidance re FAR 23 Oxygen Installations	
38	Guidance re STCs	
38	Revision of STC Listing	
40	Angle of Attack TSO	
42	Master Switch Arrangement; FAR 23 Rulemaking	
43	Review SAE Draft re Vertical Gyros and Comment	All Attendees
43	TSOs for Vertical Gyro Instruments (or Rulemaking)	
46	Rulemaking: CVRs	
47	DER Forum Comments to AFS-130	All DERs

AGENDA ITEM 1  
PERIODIC TSO REVIEW

PROBLEM

Most Technical Standard Orders (TSOs) are technically obsolescent and should be updated. Legal and procedural problems of priority in Headquarters have prevented expeditious revision of TSOs in the past, and no relief is in sight.

DISCUSSION

An advisory circular is now in process in Washington. It will permit substitution of updated industry documents for out-of-date industry documents which are presently referenced in TSOs. The precedent of the advisory circular which allows substitution of the environmental testing document, DO-160 for DO-138, was mentioned. The use of deviations for allowing the substitution of new documents was discussed, but it was pointed out that there are some legal concerns within some TSO manufacturers and they prefer not using deviations unless it is necessary. It was also mentioned that RTCA is presently in the process of revising the environmental testing document, DO-160, and we will undoubtedly issue an advisory circular authorizing the use of the updated environmental testing document when it is finally published. It was noted that a deviation to use DO-160 necessitates use of DO-160 only, not a combination of DO-160 and DO-138.

Regarding the use of the newer referenced documents, it was also mentioned that the advisory circular now in process makes it clear that such substitution should be based on a finding of equivalent safety not requiring a deviation, or on a deviation that could be done by the region without Washington participation.

CONCLUSION

AFS-130 will continue to search for a way to expedite TSO updating.

## AGENDA ITEM 2

### GENERAL TSO

#### PROBLEM

Since there are a significant number of items of equipment for which no TSO exists, other means of approval need to be used in connection with installation approval. For example, Parts Manufacturing Approval (PMA) has been used to identify parts which were approved as part of an aircraft under STC procedures. Although the PMA is intended by FAR 21.303 to be limited to specific make and model aircraft, in actual practice a PMA label is used to expedite a field approval (Form 337) of such parts on other aircraft. When engineering approval is sought, equipment evaluation, without benefit of TSO authorization, is essentially repeated on each new make and model aircraft.

FAR 37, Subpart B, provides specific standards for certain articles listed. Many types of equipment are not included in the TSO system. FAA approval of such non-TSO equipment is relatively difficult and time-consuming

#### DISCUSSION

A copy of the draft "General TSO" was distributed to all attendees and there was discussion regarding the methods of application. It involved a description of the way equipment is approved by CAA in England and by the Italian Airworthiness Authority.

There were suggestions made relative to review of General TSO approvals for the purposes of standardization, and the possible use of General TSO approvals for the purpose of formulating specific TSOs after several General TSOs of a similar nature have been issued. After a number of items of equipment of a similar nature had been approved under the General TSO, it might be time to originate and publish a specific TSO for that type of equipment.

#### CONCLUSION

There was some doubt expressed as to the viability of the proposal, but we will continue to try to process it and get it published as proposed, with one exception: the last sentence of the tenth paragraph of the Preamble, which states that the FAA has not reviewed or approved adequacy of the performance standards, should be revised to be consistent with the review that is required by the airworthiness rules. With this change, then Washington will proceed with processing the General TSO.

Agenda Item 2  
General TSO

ATTACHMENT

DRAFT  
GENERAL TSO

Department of Transportation  
Federal Aviation Administration  
(14 CFR Part 37)

(Docket No. \_\_\_\_\_; Notice \_\_\_\_\_)

Expanding the Scope of FAR Part 37,  
Technical Standard Order Authorizations  
Notice of Proposed Rulemaking

The Federal Aviation Administration is considering amending Part 37 of the Federal Aviation Regulations for the purpose of permitting the issuance of Technical Standard Order Authorizations for many more articles than are presently allowed, and to provide a streamlined method for issuing these authorizations to which conformance of the articles must be certified by the manufacturers.

Interested persons are invited to participate in the making of the proposed rule by submitting such written data, views, or arguments as they may desire. Communications should identify the regulatory docket or notice number and be submitted in duplicate to: Federal Aviation Administration, Office of the General Counsel, Attention: Rules Docket, GC-24, 800 Independence Avenue, S.W., Washington, D.C. 20591. All communications received on or before \_\_\_\_\_ will be considered by the Administrator before taking action on the proposed rule. The proposal contained in this notice may be changed in the light of comments received. All comments submitted will be available, both before and after the closing date for comments, in the Rules Docket for examination by interested persons.

Subpart B of FAR 37 presently contains Technical Standard Orders only for specific articles, and all the large variety and quantity of articles not addressed are not eligible for FAA approval under Part 37.

This large exclusion has made the FAA approval of many articles more difficult and time-consuming than necessary, and has delayed or hindered the introduction of new equipment in aircraft service, while providing no increase or enhancement of aviation safety.

**Agenda Item 2**  
**General TSO**

Some examples of equipment which are not covered under the TSO system include INS navigation, VLF navigation, area navigation, air data computers, clocks, alternators, batteries, transformer rectifier units, anti-skid systems, fuel system computers and controls, data link, and satellite communication.

All equipment installed on aircraft must be FAA approved, and many items of equipment are suitable for use in many types of aircraft. The TSO system is unique among the administrative methods used by FAA in that TSO authorizations have broad applicability to various aircraft types and are limited, essentially, only by the range of environmental conditions which the TSO authorization covers, based on tests of equipment performance. The installation approval then involves only environmental compatibility and installation details, and is often accomplished in the field.

The other administrative methods by which FAA may approve aircraft equipment are (1) as part of the aircraft manufacturer's type certification approval process, or (2) under Parts Manufacturer Approval procedures, both of which are limited to specific types of aircraft, or (3) any other manner approved by the Administrator.

The process of extending these approvals to other aircraft types is administratively tedious, and costly to the industry as well as the FAA, because the installation approval involves the equipment per se, as well as environmental compatibility and installation details. The FAA recognizes that these methods are not well suited for the approval of equipment of wide aircraft type applicability.

The FAA is of the opinion that achievement of total TSO system coverage of all airborne equipment by issuance of additional specific TSO standards is not practical.

Accordingly, the FAA proposes to amend FAR Part 37 to provide a means for TSO approval based on specifications established by the applicant. Company, industry, or government standards and specifications could be submitted to FAA regional offices by the manufacturers (in the absence of such standards by FAA). The FAA would review and concur with the test procedures proposed to show compliance to the performance standards. The manufacturer would then certify conformance to their standards and specifications for each component and/or system. The tests may be witnessed by FAA. Upon receipt of such certification, FAA regional offices would issue the TSO authorizations with qualification that "FAA has not reviewed or approved adequacy of the performance standards."

This proposal has the advantages of (1) permitting timely approval of new equipment types, (2) assuring that new components would be at the forefront of advancing technology, (3) decreasing manufacturing costs and therefore prices, and (4) reducing FAA administrative handling and costs by enabling manufacturers to provide specification control and shifting some workload from alternate efforts which require reevaluation and amendment for each added aircraft type.

In consideration of the foregoing, the FAA proposes to amend Part 37 of the Federal Aviation Regulations by adding the following Sections:

37.25 General Technical Standard Orders

(a) Performance standards and specifications may be utilized as a basis for TSO authorization, under Section 37.xxx of this Part, for any product manufactured for use in civil aircraft which is not otherwise covered in this Part. Environmental specifications are to be the current RTCA standards, or equivalent.

(b) The Administrator may, upon notice, withdraw approval of performance standards and specifications which he determines have become obsolete, obsolescent, or no longer appropriate. The TSO authorization of any manufacturer of equipment which is manufactured in conformance to withdrawn performance standards and specifications will be withdrawn. Such withdrawal will not affect the authorization of equipment manufactured and delivered before the date of withdrawal.

37.xxx Equipment, General - TSO-Cxx (a number would be assigned, such as C100, to be used for authorizations issued under this TSO)

(a) Applicability.

This TSO provides a means for utilizing performance standards and specifications, and authorizing production and marking of products which are in conformance therewith. Products for which no other specific Section in this Part exists may be authorized under this Section.

(b) Marking.

In addition to the markings required by Section 37.7, the equipment must also be marked to indicate any interface or other requirements necessary to protect the equipment and/or aircraft from damage or hazard.

(c) Data Requirements.

In accordance with Section 37.5, the manufacturer must furnish the Chief, Engineering and Manufacturing Branch, Flight Standards Division (or in the case of the Western Region, the Chief, Aircraft Engineering Division), Federal Aviation Administration (FAA) in the region in which the manufacturer is located, one copy of the following technical data:

- 1 Installation data and information.
- 2 Weight and C.G. data, and power requirements.
- 3 Limitations, including interface and environmental. The manufacturer must clearly state, in addition to any code or symbolic indication, the environmental ranges (altitude, vibration, etc.) for which the equipment is approved.
- 4 Operating instructions.
- 5 Maintenance instructions (including frequency) of such maintenance, calibration, adjustments, and functional tests as may be accomplished by persons other than the manufacturer.
- 6 Equipment standards and specifications governing design and test.
- 7 Performance and Environmental Test Report, including operation under environmental conditions for which approval is sought.
- 8 A description of the methods used to assure reliability.
- 9 Statement of conformance to the standards and specifications. Duplicates of 1 through 6 and TSO authorization letter from FAA must also be supplied with each unit sold, at or before the time of delivery.

FEDERAL AVIATION ADMINISTRATION STANDARD  
Aircraft Equipment, General

(1) Purpose

This document provides a method for utilizing minimum performance standards and specifications and environmental standards for equipment (general) which are to be

approved under this TSO.

(2) Scope

This document may be applied to any type of equipment shown to have applicability to more than one model or series of aircraft.

(3) Procedural Requirements

(a) For each product for which TSO authorization is applied, appropriate performance standards may be submitted to FAA as a basis for TSO authorization. Such performance standards must be adequate to assure that the equipment will perform its intended function for environments for which authorization is requested. The necessary limitations, installation instructions, operation instructions, and any information needed to minimize effects of any anticipated mutual interference should be included. Such performance standards and specifications may be originated by the manufacturer, government, industry associations, manufacturer organizations, or any other person.

(b) Each request for TSO authorization must be accompanied with the proposed test procedures the applicant desires to utilize to show compliance to the performance and environmental standards.

(c) Each FAA regional office will review the proposed standards and test procedures submitted by applicants within its jurisdiction, and, when adequate and satisfactory, issue a letter of concurrence. FAA concurrence or denial, and the manufacturer's or industry's response thereto, shall be subject to the time limitations as set forth in Sections 37.5(c) and (d) of Subpart A of this Part.

(d) All performance standards and test procedures utilized as basis for TSO authorization will be considered as public information, publishable, and releasable to any person without restriction.

(e) Any manufacturer may request TSO authorization under this Section for any equipment manufactured and tested for conformance to performance standards, providing his test procedures have FAA concurrence per (3) (c) of this Order.

(f) The Administrator will issue a TSO authorization when the manufacturer has certified he meets his proposed performance standards and the other requirements of this Section and FAR 37, Subpart A.

This amendment is proposed under the authority of sections 313(a) and 601 of the Federal Aviation Act of 1958 (49 USC 1354 and 1421) and section 6(c) of the Department of Transportation Act (49 USC 1655(c)).

Issued in Washington, D.C., on

Director, Flight Standards Service

## AGENDA ITEM 3

### TSO AUTHORIZATION OF SUBCOMPONENTS

#### PROBLEM

There has been a trend toward granting TSO authorizations for decreasingly significant components of equipment, despite the fact that the TSO standards, in general, do not provide specific criteria for the components, but rather for the total equipment. This dilutes the effectiveness of the TSO system and introduces a question of ultimate responsibility for proper operation of a total system containing TSOed portions made by more than one manufacturer, since each can justifiably disclaim responsibility for the total on the grounds that he has no control over those portions he does not make. Accordingly, it was recommended that the practice of granting TSO authorization for components of TSO designated equipment be discontinued. Any component for which TSO authorization is to be allowed should be independent and should therefore be covered by its own TSO standard.

#### DISCUSSION

The problem was stated by the Eastern Region. Ensuing discussion brought out the point that the TSO Handbook does provide for approval of subcomponents, providing the function of the subcomponent is essential to the function of the related system and that appropriate limitations are required to make that TSO approval. The question then evolved as to whether replaceable component interface specifications should be required. An example given by the Eastern Region was that of a unit which had a battery included as an integral part of the originally TSOed unit; however, the battery was replaceable by other types of batteries in the field. The group recognizes the problems involved in replacement of such component parts and feels that this is a problem to be handled by the operators and the airworthiness authorities on the scene when the substitution takes place. It was also emphasized that equipment approval via a TSO is just that, it is not an airworthiness approval of the unit installed in an aircraft. The airworthiness approval must be a separate approval by STC or a Form 337.

#### CONCLUSION

No action is required.

AGENDA ITEM 4  
FAR 37, SUBPART A

PROBLEM

The Southern Region handed out a paper on this subject which includes an examination of the administration of the TSO system and points out a number of deficiencies in FAR 37.

DISCUSSION

The conference attendees were requested to examine the paper carefully and bring to the attention of AFS-130 any omissions or changes they feel should be made in the paper.

CONCLUSION

The paper and comments will be carefully reviewed by Washington personnel and appropriate action will be initiated to provide either guidance material or regulatory changes as necessary.

ATTACHMENT

Background

Subpart A of FAR 37 is confusing to the public and to FAA personnel.

Manufacturers do not know what their obligations are for TSOed products; they do not understand that the FAA does not make a finding of compliance. FAA people are not sure, either, because TSO authorizations are handled quite differently in the various regions.

Several other problems exist with Subpart A of FAR 37, also. Specific problems need to be discussed, clarifying changes agreed upon, and FAR 37 amended accordingly.

Discussion

Administration of the TSO System:

Our present method of administering the TSO system is confusing to the public and FAA alike and it is creating a bad image for FAA.

The problem is that some regions view FAR 37 as a delegated system in which the manufacturer determines compliance with TSO requirements. Hence, no effort is made by FAA personnel to evaluate an applicant's data to verify that all TSO requirements have been met. Other regions evaluate applicant's data and write letters to applicants requesting

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FAR 37, Subpart A

additional data and/or clarification of existing data and sometimes rejecting data that has been submitted.

The first situation is one in which FAA personnel have the opinion that they do not make findings of compliance and that they merely "authorize" production of an article based on the manufacturer's statement of compliance. The latter situation is one which causes the manufacturer to believe that the FAA is evaluating all data submitted and is, in effect, giving him an "FAA approval" based on an FAA determination of compliance. Therefore, if data is questioned at some future date, problems naturally occur.

Sometimes, even within a region which normally does not evaluate an applicant's data, situations do occur which complicate matters. If an individual has a small workload at any given time, he may actually review data, either for an initial authorization or for a minor change, depending also on his personality and concept of FAR 37, and may write letters or make telephone calls to the applicant. This, then, makes the applicant believe that we are "approving" the product rather than "authorizing" production based on the manufacturer's determination of compliance in a delegated system. This lack of consistency confuses people. They don't know what the FAA is doing and it seems that the FAA does not know what the FAA is supposed to be doing in its role of administering the TSO system.

Another thing which aggravates the system is the ambiguous language used in FAR 37. For example, FAR 37.5(b) states that a TSO authorization is issued merely upon receipt of the required data. Yet paragraph 37.5(c) states additional data may be required if a TSO application is deficient. What does that really mean? Does it mean that an application is deficient if all items of required data were submitted, but failed to substantiate compliance with TSO requirements, or does it mean merely that an item of data that should have been submitted was not included with the application for TSO? It can be interpreted either way.

Also, FAR 37.11 uses the phrase "approval by the FAA." Are we "authorizing" or "approving"? The regulations should be consistent regarding terminology.

Other Deficiencies in FAR 37:

1. Most TSOs require a test report to be submitted, but none of them, nor does FAR 37, contain any information

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FAR 37, Subpart A

as to what should be in the test report. Should they contain actual raw test data or should they, as most of them do, merely contain summary statements of the testing that was done?

For example, many reports contain statements like: the article was tested in accordance with paragraph xx of RTCA DO-xxx. The requirements of paragraphs xxx in RTCA DO-xxx were met. There is no way the FAA can evaluate a report like that and determine that tests were, in fact, conducted in accordance with the specified standard, or that requirements were really met.

2. The second paragraph in 37.5(3) is causing much confusion. Many manufacturers are using open brackets with part numbers rather than with model numbers. Some people believe the brackets should be stamped on the nameplate as part of the model or part number. Others say that it is merely a way of telling a manufacturer that he may change a certain portion of his model or part number when minor changes are made, but that the brackets themselves need not appear on the nameplate. This needs to be clarified.

3. The phrase "a current file of complete technical data," appearing in FAR 37.7(c) and 37.13(a)(1), needs to be amplified to state what the FAA expects to be in that file. One manufacturer has stated that his file of technical data is current (all drawing changes incorporated) and is complete (all drawings and specifications necessary to produce the article are there). There are not any original article test reports, nor any raw test data in his files because he said that a test report had been submitted to the FAA, that the testing was history, and therefore need not be kept since he was required to have only a complete current file.

4. The meaning of "substantially complete investigation" in FAR 37.11(b) is not clear. Therefore, people have trouble determining whether changes are major or minor. Does this mean, for example, if a change is made and any retesting is necessary, a major change is involved? What if only one test out of many required tests must be repeated? Is that considered a substantially complete investigation, or must 50% or more of the tests be repeated before it is considered to be a substantially complete investigation?

5. Concerning design changes, a new category should be added and called insignificant changes. These could be changes which do not affect form, fit, or function such as

Agenda Item 4  
FAR 37, Subpart A

changing the length of a screw, changing vendors for standard parts and materials, changing the color of the case, etc. There is no need for the FAA to be informed of these kinds of changes and the public should be told that because they don't know. FAR 37.11 is confusing to the FAA and the public.

6. FAR 37 should contain a statement that clearly explains what should be put on the equipment data sheets that are required in some TSOs.

Should these sheets tabulate all parameters at standard and environmental conditions, or only the major ones? Should this tabulation be merely a repeat of specifications listed in the TSO (tolerances) or is something else intended? The TSOs do not make it clear.

Most manufacturers have been merely tabulating TSO requirements for major parameters at standard conditions.

Available Options

1. Do nothing.
2. Revise FAR 37.

Analysis of Options

1. Option 1 would accomplish nothing and the problem would remain.
2. Option 2 would let the public know what their responsibility is and what FAA's responsibility is under FAR 37. Regions would be more likely to have similar procedures with clear regulations.

Recommendations - Revise FAR 37 as follows:

1. FAR 37 should be revised to make crystal clear who determines compliance with TSO requirements. The public and apparently FAA personnel also are confused over this issue. Contributing causes to this confusion are:

- a. FAR 37's vagueness and ambiguity.
- b. Lack of uniformity among FAA regions in administering FAR 37.

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FAR 37, Subpart A

c. Lack of uniformity within a single region in processing individual TSO applications and minor changes.

2. FAR 37 should define what is meant by "complete and current data" as used in FAR 37.13.

3. FAR 37 should specify what should be in a test report.

4. FAR 37.11 should be revised to clarify minor and major changes. A new category called insignificant changes should also be added.

5. FAR 37 should specify in clear terms exactly what should appear on equipment data sheets that are required by some TSOs.

6. FAR 37.11(b) needs to clarify what is meant by the phrase "substantially complete investigation."

If the FAA is to be involved in determinations of compliance, it should be done prior to TSO authorization.

## AGENDA ITEM 5

### TSO vs. AIRCRAFT CERTIFICATION BASIS

#### PROBLEM

Questions have been raised concerning the acceptability, for use in aircraft being type certificated, of equipment TSOed under earlier than the current revision of the TSO. Rules correlating the aircraft and TSO equipment appear to be lacking. It was recommended that a requirement be established that equipment meeting a TSO revision equal to the airplane certification basis be used to assure a total final product representing the current state of the art.

#### DISCUSSION

The Eastern Region stated the problem regarding the applicable TSO vs. the aircraft certification basis. After some discussion, it was pointed out that the only time(s) we specify installation of TSOed equipment of a recent revision is when there is an airworthiness or safety issue at stake, such as was done in the case of the transponder.

#### CONCLUSION

It remains the responsibility of the approval authority for an installation in an aircraft to assure that the equipment being installed is appropriate for that aircraft, and that the aircraft as modified still complies with the certification basis for that aircraft.

AGENDA ITEM 6

PMA on TSO

PROBLEM

Can, and should Parts Manufacturer Approval (PMA) be issued for TSO equipment production?

DISCUSSION

Copies of the following correspondence were given to the group for their information. First, a letter from AGC-21 to AFS-46 dated December 22, 1972; second, a letter from AEA-213 to AFS-100 dated March 28, 1977; and third, a letter from AFS-100 to AEA-200 dated May 13, 1977.

CONCLUSION

The conclusion of the latest item of correspondence is that FAA PMA may not be issued for replacement and modification parts for TSO articles.

ATTACHMENTS

1. AGC-21 to AFS-46, December 22, 1972

Subj: FAA-PMA approval not applicable to replacement parts on TSO articles: AFS-180 draft letter to ASO-218; AFS-46 letter of 29 June 1972

We have reviewed the referenced AFS-180 draft letter and agree with the conclusion reached therein that PMA approval is not applicable to replacement parts for TSO articles. However, we have not concurred in the draft since the legal basis for the conclusion is not clearly set forth therein. The letter should be redrafted to reflect the interpretations set forth below and disseminated as necessary to the field.

With respect to Question 1, "Can PMA be issued based on FAR 37.11(c) and "eligible on" be identified as the TSO article?"

FAR 21.305 reads as follows:

"§ 21.305 Approval of materials, parts, processes, and appliances.

Whenever a material, part, process, or appliance is required to be approved under this chapter, it may be approved -

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PMA on TSO

- (a) Under a Parts Manufacturer Approval issued under § 21.303;
- (b) Under a Technical Standard Order issued under Part 37 of this chapter;
- (c) In conjunction with type certification procedures for a product; or
- (d) In any other manner approved by the Administrator."

Under § 21.303, PMAs are issued only for replacement and modification parts for sale for installation on a type certified product (§ 21.303(a)). The word "product" means an aircraft, aircraft engine, or propeller (§ 21.1(b)). Type certificates are not issued for TSO "articles" (§ 37.1).

Section 37.11 is concerned with design changes to an article for which a TSO authorization has been issued. It does not deal with the manufacture of the article or replacement parts therefor. Under § 37.11, for a design change to be approved under the TSO system, the change must be made by the holder of the TSO authorization (§ 37.11(a) and (b)), or by a manufacturer who applies for a TSO authorization under § 37.5(a).

The last sentence of § 37.11(c) provides that persons other than a manufacturer may obtain approval under Part 43 or under the applicable airworthiness regulations. Part 43 sets forth aircraft maintenance rules and does not authorize manufacturing. Under the maintenance rules of Part 43, a design change to a specific TSO article could be approved in connection with its installation on a specific aircraft.

It should be noted that § 21.303(b)(3) specifically excludes parts produced under a TSO from the PMA system. Although parts produced under a PMA may be replacement parts for TSO articles that are installed on a TC'd product and may involve a change in the design of the TSO article, the PMA part is a replacement part for the specified TC'd product and not for the TSO article. Furthermore, the PMA under which the replacement parts are produced can only be issued after "the Administrator finds, upon examination of the design and after ... tests and inspections, that the design meets the airworthiness requirements ... applicable to the 'product'" (§ 21.303(d)(1)).

In view of the foregoing, answers to questions 2, 3, and 4 are unnecessary.

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PMA on TSO

Finally, it should be noted that procedures for approval of replacement parts for TSO articles produced by manufacturers not holding the necessary TSO authorization could be developed under § 21.305(d). We will be happy to discuss any possible rule making actions AFS may consider appropriate to this situation.

/s/ DEWEY R. ROARK, JR.  
Associate General Counsel

2. AEA-213 to AFS-100, March 28, 1977

Subj: FAA-PMA approval of replacement parts on TSO articles

Aircraft Parts Corporation of Farmingdale, New York, has applied for PMA approval for a starter-generator shaft to replace shafts used in TSO approved Lear Siegler generators.

We intend to rule against issuing a PMA. This decision is based on our interpretation of the current regulations and a past interpretation as delineated in AGC-21 letter of December 22, 1972, to AFS-46, a copy of which is enclosed.

Please confirm whether or not this interpretation is still valid.

/s/ BRIAN J. VINCENT

3. AFS-100 to AEA-200, May 13, 1977

Subj: FAA-PMA approval of replacement parts on TSO articles;  
AEA-200 (AEA-213) ltr dtd 3/28/77

In response to the subject letter we offer the following.

Field personnel were advised during an AFS-100 national telecon on January 29, 1976, that an FAA-PMA may be issued for TSO component (replacement) parts when the applicant is other than the TSO holder.

We have reassessed this position and have determined that FAR 21.303 does not permit the issuance of an FAA-PMA for replacement and modification parts for TSO articles. Consequently, the AGC-21 interpretation of December 22, 1972, (copy enclosed), is still valid.

The foregoing supersedes any previous guidance material issued to the contrary.

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PMA on TSO

FAA-PMAs which may have been issued for TSO replacement/  
modification parts may remain in effect.

We trust we have responded to your inquiry.

/s/ C. E. CHAPMAN

/t/ JAMES O. ROBINSON

AGENDA ITEM 7  
MARKING OF ALTERED TSO PRODUCTS

PROBLEM

Procedures and guidance on this subject are lacking.

DISCUSSION

A copy of a draft letter from AFS-100 to AEA-200 in reference to their letter dated August 18, 1977, was given to each attendee at the conference for their information only. It was made clear that the proposed policy contained in this draft is not effective until they receive a signed letter or a copy of the signed letter. After reading the contents of the draft, the Southern Region expressed dissent; they do not agree with the policy as it has been proposed, that it is not responsive to the Region's needs.

CONCLUSION

The letter will be processed and all regions will receive a copy.

ATTACHMENT

AFS-100 to AEA-200 (Draft)

Subj: Identification of TSO articles which are modified by persons other than the TSO manufacturer; AEA-200 (AEA-213) ltr dtd 8/18/77

A Technical Standard Order authorization is issued on the basis of a statement of conformance certifying that (1) the original manufacturer has met the requirements of Subpart A of FAR 37, and (2) the article meets the applicable performance standards of Subpart B of the applicable TSO.

The original manufacturer is the person most familiar with the test methods used, the performance characteristics of the article, quality control, etc., all of which can have an effect on conformance of the article.

FAR 37.11(c) permits design changes to TSO articles by persons other than the manufacturer who submitted the statement of conformance. If the design changes are approved under Part 43 or under the provisions of the applicable airworthiness regulations, the following identification requirements should be applied to the altered TSO article:

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Marking of Altered TSO Products

If the original manufacturer has not determined that the modified article continues to meet the requirements of the TSO, the TSO identification on the original manufacturer's nameplate should be permanently obliterated in such a manner that it cannot be restored. The design change data should require the modifier to permanently identify the article with his name, address, means of approval of the design change (for example, STC \_\_\_\_\_), date of the design change approval, identification of the modifications which have been performed, and any information pertinent to operating parameters, for example, environmental categories, class, maximum range, etc. Articles so modified would have to be approved as part of an aircraft type design when installed in an aircraft.

If the original manufacturer has notified FAA that the modified article continues to meet the requirements of the TSO, the modifier's nameplate should be added without defacing the original nameplate.

In addition to the identification required by the design change data, the article must also be marked in accordance with the requirements of FAR 45.15, when the modified article is produced under the provisions of FAA-PMA.

We are in the process of developing an AC on this subject, and we expect to discuss these issues at the forthcoming Systems Workshop.

/t/ JAMES O. ROBINSON

AGENDA ITEM 8  
OMEGA TSO MARKING

PROBLEM

See Discussion.

DISCUSSION

Subsequent to this being established as an agenda item, clarification was received relative to proper marking of the equipment. It is therefore no longer considered an item for discussion in the workshop. The following recommendation, however, is passed on in hope that it will prevent potential problems in Omega Nav Systems as a result of intermixing of TSO equipment. It is recommended that the letter to the applicant, approving his Omega Navigation System (per Section 1, 2, or 3 of DO-164), include identification by part number of the basic components of the system. This, then, would be viewed as an "equipment list" and should prevent or minimize interchange of other components that have received TSO-C94 approval for Section 1 (Receiver), Section 2 (Sensor), or Section 3 (Omega Nav System).

AGENDA ITEM 9  
OMEGA AND OMEGA/VLF

PROBLEM

Criteria and guidance on Omega and Omega/VLF is not clear to all FAA personnel. More information is needed.

DISCUSSION

The Southwestern Region presented their proposal regarding system accuracy and it was decided that the present accuracy requirements expressed in Advisory Circular (AC) 90-45A will remain effective for all types of area navigation systems, including Omega and VLF, if and when they are to be approved for use over the continental United States. An information paper which lists the various issuances and guidance material concerning Omega and Omega/VLF was handed out for the information of the various regions. The status of information that has not yet been published was summarized. The Western Region presented some information material and a copy of a letter from the Western Region to the Director, Flight Standards Service dated October 27, 1977, which commented on the issuance of ACs, particularly AC 91-49. The Western Region position was in consonance with that which was previously expressed by AFS-130 in Washington. Continuing discussion of Omega systems and installations emphasized the need for careful evaluation of individual aircraft installations because of the peculiarities being found in Omega installations - in particular, the antenna location and installation must be very carefully determined. The group was reminded that Omega/VLF installations must be approved on the basis of the Omega performance only, without VLF, and VLF is and will continue to be regarded only as a backup navigation system. Mr. Robinson mentioned that Flight Standards Service is considering sending information to all field offices which would, in effect, require engineering evaluation of Omega installations. There was general agreement that advisory material is needed regarding the installation of Omega, and particularly the installation of Omega antennas.

CONCLUSION

Each region in which an Omega manufacturer is located is to obtain the recommendations and procedures recommended by that manufacturer and forward all this information to AFS-130 for consolidation into an advisory document in the future.

Agenda Item 9  
Omega and Omega/VLF

ATTACHMENTS

1. Southwestern Region Paper

Problem: The required accuracy for operation of VLF/Omega systems enroute in the domestic airspace is incompatible with the Rho/Theta RNAV accuracy requirements of AC 90-45A, and pure victor airway navigation.

Background

1. Item 1 of Notice 8110.26 states, in part, "Certain portions of AC 90-45A, such as Section A3, are not directly applicable to VLF. Further guidance information on this subject will be forthcoming." (NOTE: It is assumed that A3 refers to Appendix A Section 2 paragraph a.(3), which is quoted):

"2-D RNAV System not using VOR/DME for continuous navigation information. The total of the error contributions of the airborne equipment (including update, aircraft position and computational errors), when combined with appropriate flight technical errors listed in 2.a.(4), below, should not exceed the following with 95% confidence (2-sigma) over a period of time equal to the update cycle:

	<u>Cross Track</u>	<u>Along Track</u>
Enroute	2.5 NM	1.5 NM
Terminal	1.5 NM	1.1 NM
Approach	0.6 NM	0.3 NM

2. A proposed advisory circular entitled "Omega and Omega/VLF Navigation System Installation Approval in the Conterminous United States and Alaska" was submitted to the regions for comment in July of 1977.

Section 4.c.(3) of that AC is quoted:

"4. CRITERIA FOR INSTALLATION APPROVAL. The installation of airborne Omega or Omega/VLF systems may be approved as a means for VFR/IFR RNAV enroute navigation within the conterminous United States and Alaska through Type Certification (TC) or Supplemental Type Certification (STC) when:

\* \* \* \* \*

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Omega and Omega/VLF

c. A flight test of the system has been performed to evaluate:

\*\*\*                      \*\*\*                      \*\*\*

(3) The enroute accuracy for the initial TC or STC installation which should be  $1\frac{1}{2}$  nm crosstrack  $1\frac{1}{2}$  nm longtrack with two sigma basis. Manual or automatic updating may be considered to meet this accuracy."

This proposed AC did not differentiate between enroute, terminal, and approach accuracy requirements.

3. Conventional airborne DME equipment used on the victor airways is permitted to have up to 3 nm error, according to TSO C66a. Conventional airborne VOR equipment is allowed  $\pm 4^\circ$  error on the preflight check for IFR operation in accordance with FAR 91.25. The formula  $S = r \theta$  can be used to derive cross track VOR error, where the  $\theta$  = the angle in radians which in this case is  $4^\circ/57.3^\circ = .06981$  radians,  $r$  = distance in nm from the VOR and  $S$  = the error. For  $r = 57.3$  nm the error  $S = 4$  miles cross track error.

Discussion

1. Table 2 of AC 90-45 allows enroute RNAV error greater than 1.5 nm cross track and 1.5 nm along track for all VOR/DME referenced stations greater than 20 nm perpendicular distance to the tangent point and 20 nm distance along track from the tangent point. In fact, AC 90-45A allows errors as high as 13.5 nm. In consideration of the fact that the VOR/DME system is the primary navigation means and the proposed AC permits reference to VOR/DME following periods of Omega/VLF dead reckoning, it seems unreasonable to require so much greater accuracy of the VLF/Omega system.

2. Section 4.c.(3) of the proposed AC appears to be unnecessarily stringent on accuracy for an enroute system. The "Speckled Trout" report, #75-08, indicates the Global 500 system can meet the 1.5 nm cross track and 1.5 nm along track error on a 95% probability basis; however, none of the other Omega systems reported in the "Speckled Trout" document met this degree of accuracy.

3. It seems very likely that Global is able to meet the greater accuracy since they use VLF stations in addition to Omega stations. If this is the case, the 1.5 nm accuracy

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standard is further anomalous since VLF alone is not acceptable for navigation because these are communication stations subject to unannounced shut down.

Options

1. Adopt the 1.5 nm accuracy standard on a two sigma basis for enroute Omega navigation.

2. Widen the enroute standard to something less than the North Atlantic mnps of 12.6 nm on a two sigma basis as described in AC 91-49.

Option Analysis

Following Option 1 would provide the most accurate system and high accuracy is a desirable characteristic. Nevertheless, if this degree of accuracy is dependent upon VLF stations which aren't acceptable for a primary means of navigation, the FAA is being inconsistent in acceptance of VLF signals.

Recommendation

Permit VLF/Omega system errors of 3 nm along track and 4 nm cross track on a two sigma basis. This is within the accuracy limits of the present victor airway system for enroute operation.

2. Western Region Paper

Problem: Need to establish Omega Sole Means of Navigation Requirements Overwater.

Background: Current guidance material concerning Omega and Omega/VLF has been issued as follows:

- Genote 8110.26, 9/24/76, "Omega/VLF Navigation Equipment" (enroute IFR domestic Airspace, D.C. and Alaska) now cancelled see AC 20-101.

- AC 120-31A, 4/21/77, Operational and Airworthiness Approval of Airborne Omega Radio Navigation Systems.

- AC 120-33, 6/24/77, "Operational Approval of Airborne long range Navigation Systems for Flight within the North Atlantic minimum Navigation Performance Specifications Airspace."

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- AC 91-49, 8/23/77, "General Aviation Procedures for Flight in North Atlantic minimum Navigation Performance Specifications Airspace."

- N 8700.2, 9/14/77, "Procedures for authorizing General Aviation Flight Operations in North Atlantic minimum Navigation Performance Specification Airspace."

- AC 20-101, 10/14/77, Omega and Omega/VLF Navigation System Installation in the conterminous U.S. and Alaska."

- 8110. , 10/ /77, Guidance Information concerning Omega Navigation System Decision Paper, 8/22/77, Use of VLF in Long Range Navigation Aviation Industry has requested establishment of the requirements for Omega as a sole means of navigation overwater. A draft Advisory Circular has been prepared for review covering outside the United States.

- FAR 37.205 (TSO C94) Omega has been issued.

Options

1. Publish the document for outside the United States after coordination with regions and headquarters.
2. Stop processing documents until more data available on Omega performance.
3. Process documents, but hold from publication until more data available.

Option Analysis

Option one: would provide timely implementation of requirements.

Option two: would not permit completion of technical staff work or a timely implementation.

Option three: would permit completion of technical staff work, but not permit timely implementation.

Recommendation

Option three for North Atlantic - After processing document, but prior to publications review current Omega performance data and Modeling information.

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3. Western Region Paper (Draft prepared by AWE-132)

Background

Long range aircraft navigation using very low frequency (VLF) radio transmissions has become of age. VLF includes the Omega network as well as the Navy telecommunications stations (VLF-COM), because both networks transmit in the very low frequency spectrum.

Many unique problems are associated with this type of navigation aid, and the Western Region has prepared a report "Omega/VLF -- Issues and Answers." This report gives a rather detailed analysis of the technical aspects, but no attempt has been made to cover the political problem areas, which appear equally as important as the technical issues.

Discussion

Because the Loran A network, which serves as a navigation aid in the North Atlantic, will be decommissioned December 29, 1977, pressure was put on the FAA to select a replacement. The following argument was advanced: "Since the Omega network is dedicated to navigation, it is more reliable than the VLF-COM network whose primary purpose is communication." No one challenged this statement or examined the navigation reliability of a combination; Omega plus VLF-COM. The FAA chose Omega.

The facts are:

1. The FAA has no control over either network's transmitting stations.
2. The Omega network is operated by the U.S. (Coast Guard) and six partner nations. The headquarter is the Omega Navigation System Operations Detail (ONSOD) located in Washington, D.C. The agreements between the U.S. and the six partner nations are not particularly effective. For instance: Japan Omega has refused to transmit its assigned, unique frequency. Liberia Omega has threatened to shut down unless the U.S. supplies a yearly oil allotment. Since 1971 Australia and the U.S. have not been able to agree on a location for Omega Australia. No one knows when this station will be operational.
3. The VLF-COM network is operated by the U.S. Navy in the U.S. and by U.S. Navy personnel in several host countries. The treaties related to VLF-COM stations abroad are very strong. Only one incident has marred this relationship. Not long ago the VLF-COM station in Panama was put out of

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commission by terrorist action. The signing of the new Panama Canal Treaty should prevent such action in the future and allow the U.S. Navy to affect the necessary repairs.

4. A new VLF-COM station of 600 kw has just gone on the air in Sardinia (Mediterranean Sea).

5. Omega station reliability is considerably inferior to VLF-COM.

6. Scheduled maintenance down time is much larger for Omega than VLF-COM.

7. The above-mentioned report describes many factors which may reduce the available number of suitable signals. If you add possible shutdowns of transmitters because of international politics, it becomes evident that reliable navigation in the North Atlantic using only the Omega network is questionable.

8. The Western Region has at present two projects in the North Atlantic. Our findings to date indicate that at times and in certain areas six Omega stations are available; however, only four stations can be received reliably over the entire area: Norway, North Dakota, Liberia, and Trinidad. Trinidad is only a temporary station. Our conclusions are: With Trinidad decommissioned and no transmission problems of the other three stations, the North Atlantic can be navigated by Omega systems requiring three suitable signals. This does not provide any margin of safety.

9. The Global GNS-500A which is a Rho/Rho system using both Omega and VLF-COM transmissions was evaluated in the North Atlantic, but with Omega station Trinidad removed from the position fixing capability. Consistently eight suitable signals were received. Thirty fixes were taken in 46.8 flight hours. The total error was 38.09 NM. This works out to 1.27 NM per fix or 0.81 NM per flight hour. Obviously, if both Panama and Trinidad had been available, the error would have been considerably less, because the system is mechanized to use the nearest stations to avoid errors due to long distance signal travel. However, at least two Omega stations are always used.

Recommendation: Shift the emphasis from pure Omega to Omega plus VLF-COM because:

1. The combination of both networks will give increased reliability and accuracy.

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2. Omega systems may have problems meeting the NAT MNPS criteria.

3. Most manufacturers of pure Omega systems are aware of the problems and either offer VLF-COM as an option or have programs underway to do so in the future.

4. Western Region Paper

June 28, 1977

OMEGA/VLF -- ISSUES AND ANSWERS

by

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Aerospace Engineer  
FAA - Western Region

Radio signals in the internationally recognized very low frequency (VLF) spectrum (3 kHz) are well suited for long-range aircraft navigation. These signals travel around the globe using the earth and ionosphere as a waveguide. They are not limited by line of sight distance as are VHF and UHF transmissions.

At present there exist two usable networks which transmit in the VLF spectrum; the Omega network operated by the U.S. Coast Guard and six partner nations and the Naval Communications Network (VLF-COM) operated under the auspices of the U.S. Navy and NATO. Several other countries operate VLF transmission stations, especially the USSR, but no effort has been made to use these stations for international aircraft navigation.

Both Omega and the VLF-Communications Network possess some significant shortcomings with respect to reliable, world-wide aircraft navigation. Before proceeding with individual analysis of navigation equipment using either of these two networks, an examination of the main characteristics, common to both or to any navigation system using very low frequency (VLF which includes both VLF-COM and Omega) radio transmissions, is in order:

A. VLF GENERAL

1. An aircraft navigation system, using radio transmissions, must take into account the exact location of the transmitting stations. An error in the location of the transmitter will lead to an error in the position fix.

2. Signals from all stations must be phase stable and highly precise. A deviation of 2 microseconds will result in a navigation error of approximately 1/3 NM.

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3. To obtain a position fix, the propagation velocity of the signals used for the fix must be known. The propagation velocity is not constant; it varies considerably due to a variety of factors. Some factors, such as diurnal shift, direction of signal travel and passage of signal over certain geographic areas, are predictable; others are not. The result is that at times some signals cannot be used successfully for a reliable position fix.

4. Because of certain properties of the earth, signals traveling in certain directions or over certain geographic areas are attenuated, possibly rendering these signals not usable for a position fix. Signals passing over ice/permafrost, such as the North Pole or Greenland, are often too severely attenuated to be usable successfully for navigation. Eastward vs. westward propagation shows considerable attenuation in the westward directed signals, limiting the usable distance from the transmitter. Long overland travel of signals will also cause attenuation and will limit signal use for navigation.

5. Noise is an extremely important factor which can seriously degrade the navigation use of VLF signals. There are three types of noise:

a. P-static noise can inhibit the use of all signals. Its effects are more prevalent with systems using E-vector (blade) antennas.

b. Aircraft electrical noise can derogate the reception of signals. This is more common to systems employing H-vector (loop) antennas.

c. Atmospheric noise will at certain times of the day and during certain seasons of the year prevent the use of signals which pass over certain geographic regions.

6. Sudden ionospheric disturbances, caused by solar activity, will produce phase anomalies of VLF signals passing beneath the sunlit portion of the earth. Their effect on VLF radio navigation may last from 30 minutes to several hours and may cause an unreliable position fix.

7. Polar cap absorption events, caused by slow solar protons trapped in the earth's magnetic field at the Poles, have adverse effects upon VLF signals. A reliable position fix, using signals which pass through this region, is problematic.

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8. Meteor showers, geomagnetic storms, and auroras can result in significant phase anomalies. Affected signals may not produce a reliable position fix.

9. As was stated earlier, VLF signals have the ability to travel clear around the globe. To avoid reception from both directions and prevent a phase ambiguity, navigation systems are usually designed to reject signals from stations more than 8500 to 9000 miles distant from the aircraft.

10. Stations which are too near to the aircraft will usually cause a phase ambiguity between the ground and the sky wave. Provisions are usually made for the navigation system to disregard such signals.

11. Phase ambiguities may also occur due to modal interference and multipath activity. Most systems are able to reject signals which are so affected.

12. To obtain a reliable position fix, the geometric relationship between the aircraft position and the location of the ground stations whose signals are used, is of great importance. Signals which do not meet the required geometric criteria will usually be rejected by the navigation system.

13. There are two methods by which a VLF navigation system may function; the Rho-Rho mode and the hyperbolic mode. The Rho-Rho mode requires a time reference. With an onboard Rubidium time standard, by the Rho-Rho mode, the navigation system can obtain a position fix using only two suitable signals. Some systems use a third suitable signal as time reference.

14. The hyperbolic mode does not require a time reference, but three suitable signals are required for a position fix. Navigation by the hyperbolic mode is much more geometry-sensitive than by the Rho-Rho mode.

B. FACTS PERTAINING TO OMEGA ONLY

1. Considerable theoretical research into very low frequency radio transmission was conducted in the late forties and early fifties. The concept of the Omega network as a navigation aid for ship use on a world-wide basis was developed in the mid-fifties. Not until the late sixties was serious thought given to the use of the Omega network for aircraft navigation. There exists a world of

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difference between aircraft and naval navigation. A ship moving at 10 to 15 knots does not face the problems of an airliner traveling at 400 to 500 knots. A navigation error of 20 to 30 NM may prove to be catastrophic to an aircraft, while it may merely delay the ETA of a ship by a few hours.

2. When the Omega network was conceived, it was believed that the station sites had been selected in optimum locations to achieve suitable worldwide signal coverage. Actual experience has proven otherwise.

3. It was initially assumed that 8 Omega stations, dispersed around the globe about one earth radius apart, would provide adequate signal coverage for a reliable position fix anywhere on earth. Data collected to date has proven this assumption to be too optimistic. At this time, a site has not been selected as yet for the South Pacific station to be located somewhere in Australia. It will take about three years from the day construction begins until the station becomes operational. Omega station TRINIDAD is only a temporary station which transmits very erratically at only one tenth the normal Omega transmission power of ten kilowatts. TRINIDAD is scheduled to be decommissioned on September 30, 1977. The remaining Omega stations are: ARGENTINA, HAWAII, JAPAN, LA REUNION, LIBERIA, NORTH DAKOTA, and NORWAY.

4. The station reliability (on-air time vs. scheduled on-air time) for the Omega network is about 97%. Scheduled maintenance down time equals about one month per year per station.

5. Omega is designed to transmit a three frequency signal format. Each station broadcasts 10.2 kHz, 11-1/3 kHz, and 13.6 kHz in such a fashion that no station will transmit the same frequency at the same time. By a process called "commutation", the navigation system is able to identify the stations. Omega stations HAWAII and NORTH DAKOTA transmit also a discrete frequency; 11.8 kHz and 13.1 kHz respectively. Omega stations must be precisely time-synchronized.

6. The Omega signal format reflects the state-of-the-art electronics of the fifties and early sixties. Recent developments in microelectronics, computer capability, electronic circuitry, and Rubidium time standards make the signal format obsolete. Changes in signal format and the addition of new frequencies are under consideration by the Naval Electronics Laboratory Center. As it stands now, the

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frequencies in use are susceptible to noise interference from 400 Hz aircraft voltages, especially in view of the fact that the "pure" Omega systems, with which we are familiar, use H-vector antennas.

7. Because of its unique transmission format, the Omega network has only a 10% duty cycle. For instance, a plane tracking the 13.6 kHz frequency will have a signal available for only one second out of every ten. This would be of little consequence to slow moving naval vessels, but high speed maneuvering aircraft require rate aiding.

8. A lane (space between lines of position when the phase angle equals zero, or the distance which is equal to  $1/2$  wavelength) is approximately 8 NM wide for the 10.2 kHz frequency along the baseline (line between two transmitting stations). It is conceivable that an aircraft may skip into the wrong lane due to a navigation error. The use of Omega difference frequencies allows the aircraft to reorient itself in the correct lane and to resolve the lane ambiguity.  $13.6 \text{ kHz} - 10.2 \text{ kHz} = 3.4 \text{ kHz}$ . At 3.4 kHz a lane is approximately 24 NM wide along the baseline.  $11\text{-}1/3 \text{ kHz} - 10.2 \text{ kHz} = 1133\text{-}1/3 \text{ Hz}$ . At 1133-1/3 Hz a lane is approximately 72 NM wide along the baseline. Resolution of lane ambiguity is a good feature of Omega.

9. Most "pure" Omega navigation systems do not employ an onboard time standard because it adds about 5 to 10 thousand dollars in cost. As pointed out above, VLF navigation systems without an onboard time reference require suitable signals from 3 stations. A number of factors were discussed above which render certain signals unsuitable for a position fix. Thus, it appears conceivable that a variety of conditions can occur in various global areas when 3 suitable signals are not available.

10. The LORAN A network, which has been used for aircraft navigation in the North Atlantic, is scheduled to be decommissioned December 29, 1977. The intention is to use the Omega network as a replacement. Analysis of this proposal for the North Atlantic reveals:

The signal from Japan is severely attenuated because it travels across the ice/permafrost area. Signals from Argentina and La Reunion are attenuated because of long overland passage, are affected by atmospheric noise, and are not usable during certain times of the day and during certain seasons of the year. The Hawaii signal passes over excessive land area in one direction, and in the other direction crosses ice/permafrost which causes attenuation.

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Trinidad will be decommissioned. North Dakota and Norway, used as a pair of stations to generate a position fix, present unacceptable geometry for much of the North Atlantic area. Stations North or South of the North Atlantic route structure are needed for reliable navigation. Only Liberia remains in the North/South direction. Liberia has exhibited modal interference problems and maintenance outages. Reliable navigation by "pure" Omega in the North Atlantic will pose some very interesting problems.

C. FACTS PERTAINING TO THE VLF-COM NETWORK ONLY

1. The VLF-COM network was not designed for navigation. Its primary purpose is to communicate with U.S. naval vessels at sea.

2. Because the aim is not navigation, the stations are not dispersed about the globe in optimum locations for navigation use.

3. Each VLF-COM station transmits its own unique frequency. Commutation is not necessary, which is an advantage; however, resolution of lane ambiguity is not possible, which is a drawback.

4. There are ten VLF-COM stations. The weakest of these transmits at 6 times the power of Omega while the stronger ones transmit at 100 times the power of Omega. Because of the relatively high transmission power, navigation systems using VLF-COM signals are not as susceptible to noise and are less affected by attenuation.

5. Although there are two more VLF-COM stations than Omega stations, the VLF-COM network does not provide adequate signal coverage on a global basis.

6. Like the Omega stations, the VLF-COM stations use Cesium beam time standards. VLF-COM signals are as phase stable as Omega signals and are equally as accurate, but do not require time-synchronization.

7. The VLF-COM signal format provides for a 50% duty cycle. Rate aiding is not required, but can be used.

8. Recently the U.S. Navy has changed the standard FSK (frequency shift keying) format to narrow band MSK (minimal shift keying) and wide band MSK for some VLF-COM stations.

VLF-COM navigation system computer capability

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was redesigned to track signals regardless of type of transmission format. Critics of VLF-COM navigation systems point out that such changes in format may degrade the navigation capability. Use of the redesigned systems has proven otherwise.

9. The VLF-COM station reliability is over 99% with a planned goal of 99.9%. Scheduled maintenance down time averages about 5 hours per week per station.

10. The VLF-COM network transmits at somewhat higher frequencies than Omega. The lowest VLF-COM frequency is 16.0 kHz (Rugby, Great Britain); the greatest is 24.0 kHz (Balboa, Panama). The lower the frequency, the longer the wavelength; as a result, a given phase angle error will cause a more pronounced position error at Omega signal frequencies than at VLF-COM signal frequencies.

11. The main objection to the use of VLF-COM stations for aircraft navigation is the fact that the VLF-COM network is "not dedicated to navigation," however, U.S. submarines use it for that purpose. The above reasoning is not valid in view of the following:

a. VLF-COM transmissions are ideally suited for aircraft navigation. They possess some qualities which make them superior to Omega signals.

b. In a letter, dated September 8, 1976, addressed to the Director, Flight Standards Service of the FAA, Admiral G. B. Schick, Jr., Commander, Naval Telecommunications Command, states that the U.S. Navy has no objection to the use of VLF-COM broadcasts for aircraft navigation.

c. Admiral Schick's letter also contains information detailing phase stability of VLF-COM signals, transmitter reliability, and availability of NOTAMS describing maintenance schedules and planned signal format changes.

d. From this letter, it is apparent that while the VLF-COM stations may not have navigation as their prime objective, the U.S. Navy recognizes their suitability for aircraft navigation and does not restrict their use to that end. After all, it is a national resource; why not make fullest use of it?

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e. Report No. FAA-RD-74-198, issued by NAFEC in January 1975, which is based on actual flight test data collected by FAA personnel in a Convair 880, concludes (Item 10, page 54): "VLF-COM navigation should be considered as a replacement for Loran A."

CONCLUSION: Both the Omega network and the VLF-COM network possess limitations. Neither network will provide adequate signal coverage for reliable, global navigation capability.

RECOMMENDATION

A marriage of the two networks alters the situation dramatically. Combining the two networks results in a considerable number of stations of sufficient power dispersed about the globe to assure adequate coverage by suitable signals anywhere on earth.

Important advantages will be achieved: Many suitable signals are now available for a given global position. Several fixes are possible for a given global position using all suitable signals. Averaging these fixes refines the final data and produces increased navigation accuracy as well as a vastly greater level of confidence in the displayed position.

POSTSCRIPT

The writer is the project engineer who, with the assistance of other FAA personnel, conducted the tests and evaluations which resulted in FAA engineering STC approval of the only two Omega/VLF-COM airborne navigation systems manufactured in the U.S. These systems use an onboard Rubidium time standard and obtain a position fix by the Rho-Rho mode. The two approvals sanction VFR-IFR RNav operation within the domestic airspace in accordance with the enroute criteria of FAA Advisory Circular AC 90-45A. No "pure" Omega system has obtained such an approval to date.

During the qualifications tests of these two navigation systems remarkable navigation accuracy was achieved. To make the flight test data more meaningful, a geographic area was selected for the tests where computer analysis and previous experience indicated the most inadequate and unsuitable Omega/VLF-COM signal coverage. The collected data indicate that well above 95% of the time the navigation error was below 2NM C.P.E. (Circular Position Error), no matter how long the flight. In fact, most of the time the navigation error was below 1 NM C.P.E.

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To further increase the severity of the test program, the navigation systems were degraded by removing some of the best suited signals from the position fixing capability. Still, excellent navigation accuracy was recorded.

Only once during the lengthy test programs was an error of significance observed; 7 NM.

Different from Inertial Navigation Systems which exhibit an unbounded, time dependent navigation error due to gyro-drift, Omega/VLF-COM navigation systems will, if an abnormal error should occur, maintain this bounded error or usually correct this error back to the normal accuracy in a short time span.

A large number of operators use Omega/VLF-COM equipment for flights all over the globe. At the time of this writing, one manufacturer of Omega/VLF-COM navigation systems has sold more units than have all manufacturers of "pure" Omega navigation systems combined.

We have seen accuracy data, collected by various operators without FAA sanction for long, transoceanic flights to almost any part of the globe. Terminal error data below 1 NM C.P.E. is very common using Omega/VLF-COM equipment for lengthy, overwater flights.

The writer, who is familiar with most types of long-range aircraft navigation equipment, does not believe that Omega/VLF-COM navigation systems are a "cure-all" for all long-range navigation problems; however, the systems, which we have evaluated, have exhibited superior navigation accuracy and reliability. We foresee no problems for these systems to meet the accuracy requirements of FAR 121, Appendix G or the criteria for the North Atlantic MNPS airspace. Considering some of the problem areas discussed above, we are not convinced that "pure" Omega systems can meet these requirements with an adequate degree of reliability.

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5. Western Region Letter: AWE-1 to AFS-1, October 27, 1977  
Subj: Advisory Circular 91-49, 120-31A, and 120-33

The subject advisory circulars have stimulated discussions within the regional office and inquiries from industry.

To perform our function in a manner consistent with national FAA policy and our mission to assure safety in both airworthiness and operational approvals in our jurisdiction, some clarification is needed of the following:

1. AC 120-31A covers approval of Omega as a means of updating self-contained navigation and includes both airworthiness and operational approval criteria.

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2. Neither AC 120-33 nor AC 91-49 provide for airworthiness approvals of equipment installations. No criteria are included for (a) engineering evaluation of the system performing its intended function, and (b) flight manual limitations or normal operating procedures.

3. AC 120-33, paragraph 4a.4), prohibits authorization in FAR 121 or 123 operation of Omega or Omega/VLF COM as sole means of navigation until more operational experience is obtained.

4. AC 91-49 provides for operational approval for FAR 91 operation in the same airspace of various system combinations including: dual INS, dual Omega, single INS with Omega update, single Doppler with Omega update, and "Newly developed navigation equipment and systems other than those listed." The latter description could refer to satellite navigation such as Global Positioning System (GPS), laser gyro inertial platforms, and other systems of advanced design. Such approvals are to be based on a 1000-nautical-mile (nmi) flight, with no accountability requirements for geographic variations in signal reception and atmospheric disturbances (precipitation static), and with an accuracy level of 4 nm at three points, plus subjective evaluation by personnel of a GADO or FSDO.

5. The above interpretation of AC 91-49 appears to have been confirmed at the International Operations Committee meeting Wednesday afternoon, September 28, 1977, during the NBAA convention at Houston, Texas. An FAA representative was quoted as stating that the FAA was taking a "unique approach" to the North Atlantic problem by allowing each operator to demonstrate his ability (or lack of it) to meet the ICAO accuracy criteria during a trial period prior to the reduction of lane separation.

SUMMARY

It has been our experience after evaluating results of Omega (or Omega/VLF COM) system test flights on both transport and general aviation aircraft, that a functional flight test is not adequate to assure repeatable performance in other airplanes, even of the same type. These systems have known sensitivity to geographic location, antenna relationship to other installed equipment on each airplane, precipitation static, solar flares and other conditions of the atmosphere, including the location of the day/night terminator. It is also necessary to evaluate station combinations with

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various station signals de-selected to simulate station maintenance down-time and other probable interruptions of transmitted signals. A single flight of total distance of 1000 nautical miles, which may be the sum of several legs, is not sufficient and may be misleading.

In addition, we know of no satisfactory procedure for determining the degree of compliance with ICAO criteria actually achieved by airplanes operating under FAR 91 in the North Atlantic environment.

Manufacturers of equipment affected in the Western Region would prefer to obtain engineering evaluation leading to airworthiness approvals, including airplane flight manual limitations, prior to operational evaluations; however, they recognize the competitive realities and will be responsive to their customers' needs in this and other regions. We believe that the authorization of equipment operational approvals, with neither evaluation of airworthiness considerations nor accuracy and reliability data, involves an unacceptable risk of uncontrolled electrical/electronic systems approvals which may need to be rescinded.

RECOMMENDATION

Internal instructions to FAA employees will not be sufficient to clarify the situation until the guidance material (AC 91-49) is amended to include certification in accordance with the appropriate airworthiness standards in order to account for the susceptibility of Omega and Omega/VLF COM to geographical variations in signal quality, precipitation static, solar flares, etc. Therefore, we recommend that the portions of AC 91-49 dealing with Omega only operations be revised to require certification in accordance with airworthiness standards.

/s/ M. C. Beard

/t/ R. H. STANTON

AGENDA ITEM 10

AC 90-45, "AREA NAVIGATION," REVISION

PROBLEM

Information item.

DISCUSSION

The Northwest Region presented their redraft of the advisory material on this subject. It is a very comprehensive job and has been given to all regions for information purposes only. It will have to be coordinated among the various Washington offices before it is sent to the regions for coordination. The Northwest Region representative explained the background of this revision and the various factors that have been considered.

CONCLUSION

Each of the regions is to review the draft and advise AFS-130 if anything is found that is obviously in error or would be troublesome in application.

ATTACHMENTS

The draft revision is too bulky to reproduce in this record; however, the FAA Systems Workshop Briefing Paper follows.

Area Navigation  
Revision of Advisory Circular (AC) 90-45A

1. Problem. The problems with AC 90-45A, which contains the criteria for approval of area navigation systems, fall into three main categories.

a. The advisory circular is too complicated to administer and contains material not applicable to the certification of aircraft installations.

b. The advisory circular does not identify specific tests which can be used by the applicant and the FAA in certifying an aircraft installation.

c. The criteria for VNAV system accuracy is higher than the accuracy for altimetry systems which is currently required by regulations.

2. Background. Advisory Circular 90-45A is complicated because it contains the criteria for the construction of RNAV

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routes as well as for the approval of airborne installations. Some applicants have taken the position that if they show that they can remain within the route width specified by the advisory circular, their system could then be approved without meeting the specific accuracy criteria for the approval for an airplane installation defined by Appendix A. This is not actually the case because of the needs of ATC to have route widths which are more narrow than specified by the advisory circular in some special cases such as passage through or near restricted airspace.

Some systems have been developed which do not use the reference facility defined for the route being flown. The advisory circular does not contain specific guidance for the approval of these systems. The problems associated with the stringent VNAV accuracy requirements were discussed at last years (1976) systems workshop with a recommendation that VNAV accuracy requirements be deleted from AC 90-45A.

3. Description of Current Activity. As a solution to the problem, a new advisory circular is being developed which contains only the criteria to be applied for the approval of airborne RNAV equipment. Advisory Circular 90-45A will be revised to delete Appendix A which currently contains most of this information. The revised AC 90-45B will only contain information necessary for the construction of RNAV routes and procedures.

The new advisory circular will contain specific tests to be conducted for each of the three major categories of RNAV systems which currently exist, those which use the reference facility, those which use VOR/DME information, but not necessarily from the reference facility, and those which navigate using methods independent of VOR/DME information.

VNAV equipment will be used only as a pilot aid for climb and descent. VNAV equipment will not be required to fly any RNAV procedures. In the terminal area a procedure similar to a profile descent will be used on RNAV routes with crossing altitudes specified at the waypoints. If VNAV equipment is installed, it should be capable of defining a path to or from a waypoint with an accuracy of 150 feet in the terminal area and 100 feet for final approach (2 sigma values). These values are the differences from the altitude indicated by the barometric altimeter installed in the airplane. In all cases the altimeter will be the primary reference for maintaining the correct altitude.

AGENDA ITEM 11  
OVERWATER NAVIGATION REQUIREMENTS

PROBLEM

Information item.

DISCUSSION

Letters as indicated were handed out for information purposes: AFS-400 to the Regional Directors, November 13, 1972; AWE-278 to AFS-804, June 6, 1977; and AFS-800 to AWE-200, August 17, 1977.

CONCLUSION

None reached.

ATTACHMENTS

1. AFS-400 to the Regional Directors, November 13, 1972

Subj: Required navigational equipment for overwater operation under Subpart D

It has come to our attention that a misunderstanding of Section 91.191 may exist within Flight Standards in regard to navigational receivers required for overwater operation.

Consequently, the following should be provided to all GADOs for guidance:

Section 91.191 states in part, that Subpart D aircraft engaged in overwater operations must have two independent receivers for navigation appropriate to the facilities to be used.

If a self-contained navigational system is used (e.g., inertial or doppler), duplication is not necessary provided one other navigational receiver appropriate to the ground based system to be used is installed, e.g., VOR or ADF.

If a self-contained navigational system is not installed, then two navigational receivers appropriate to the kind of surface system used would be required.

For example, if both VOR and ADF were necessary for a route to be flown, then two VOR receivers and two ADF receivers would be required. However, if the route traversed requires only VOR or only ADF, then two VOR receivers or two ADF receivers, whichever is appropriate, would be required.

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Overwater Navigation Requirements

There is no intention in this section to require redundancy of self-contained navigational systems, provided they are supplemented with at least one other appropriate navigational receiver or receivers.

/s/ Melvin F. Derry (for)

/t/ J. A. FERRARESE, Chief  
Flight Operations Division, AFS-400

2. AWE-278 to AFS-804, June 6, 1977

Subj: Navigation Equipment Requirement for overwater operations

There appears to be some question as to the number and type of navigation equipment required by FAR 91.191. This FAR states in part that flight in excess of 100 nautical miles or 30 minutes flying time requires navigation equipment appropriate to the facilities used. FAR 91.191(a)(4) indicates the need for two independent receivers for navigation to meet the requirements. Therefore, we are requesting confirmation that self-contained navigation systems such as INS meet the navigation receiver intent, and the number and capability of navigation devices required for long range overwater operation.

We further request that you coordinate your reply with AFS-100 as engineering approval of some transport aircraft with a single INS have been proposed and the proposed AFM indicated that this single system met the sole source navigation requirements. We are of the belief that such a statement is misleading and goes beyond the need for AFM content. Also, since we cannot portend what future regulatory action may take place, we believe that the AFM should only indicate the accuracy capability of the system and not specify the operational acceptability for use. We desire this issue to be resolved as soon as possible to prevent misinterpretation of the certification and operational requirement for long range overwater navigation system.

/s/ JAMES C. MUIR

3. AFS-800 to AWE-200, August 17, 1977

Subj: Navigation Equipment Requirement for Overwater Operations; AWE-278 (AWE-270:8000) ltr to AFS-804 dtd 6/6/77

Agenda Item 11  
Overwater Navigation Requirements

The AFS-400 November 13, 1972, letter intended to recognize that self-contained navigation systems such as inertial navigation systems (INS) meet the definition of "navigation receivers."

Where two independent navigation receivers are required by Section 91.191, an approved and properly functioning INS unit would be an acceptable substitute for one of the two navigation receivers necessary to operate over the route involved. For example, a long-range overwater route requiring both VOR and ADF navigation receivers could be flown with one VOR receiver, one ADF receiver, and one INS unit. In such a case, no matter where the aircraft might be along the route, the pilot would have two independent navigation systems to determine the position of the aircraft.

/s/ BERNARD A. GEIER

AGENDA ITEM 12  
AIRWORTHINESS REVIEW STATUS

PROBLEM

Status of the various Systems proposals in the Airworthiness Reviews was given.

DISCUSSION

Bob Owens, Review Coordinator, summarized. Salient points follow:

- a. In 23.1327 on magnetic direction indicators, the revision recognizes that some Whiskey compasses do deviate more than  $10^{\circ}$ . This is a permissive type change stating that if you have another indicator which is not affected by the ambient magnetic effects, then that indicator which is affected may deviate in excess of  $10^{\circ}$ , but it must be placarded.
- b. A part was added to the flight director paragraph (1335) which says that there must be some way to know what the current mode of operation is, and a knob position is not an approved way. If you select the knob to the VOR, that does not necessarily tell you that you're actually getting VOR information on the flight director. There must be another type of annunciation confirming that.
- c. There was an addition to paragraph .1351, Electrical, General, which talks to external power. I'd say take a look at it.
- d. An added requirement to FAR 25.1353 on storage battery design is new as far as regulations are concerned, but it has been a special condition. A nickel cadmium battery installation, the battery box, etc., must be installed so as to be self-containing, prevent a hazard to the structure or to the systems, and to provide a warning of overheat or to provide current limiting.
- e. There are some changes in the ventilation area, FAR 25.831, you might want to look at.
- f. We have standardized the warning, caution, and advisory light requirements. We've added FAR 25.1322 to speak to the colors that are to be used for a warning light and a caution light. It's red for warning, amber for caution, and green for safe operation. It then speaks to how you'd use other colors. Interestingly, we had more international feedback on this than national. There was strong European support to standardizing this type of lighting.

Agenda Item 12  
Airworthiness Review Status

g. There was a change regarding FAR 23 position lights that had been recommended by many manufacturers before - that you be able to put a tail light on the wing tip as we have permitted in some large, swept-wing aircraft. Tail lights in this case. There is now a part of the rule which permits that. There was a question concerning the criteria we've been using that if you can see those two lights within 1200 feet on the centerline of the airplane, it is considered a single source. That was put out as policy when we permitted strobe lights on the wing tips, and we're using that same criteria now for wing tip tail lighting.

h. In 25.1303 we finally got into the rules recognition of digital clocks, instead of saying "sweepsecond."

i. We now have a new requirement for wing icing detection lights, FAR 25.1403. It says that you must provide some way of determining icing on the wings if the aircraft is being approved for flying into icing conditions, and the light must not give any reflections back into the cockpit area.

j. Protective breathing is another agenda item, but we'll hit part of it here. FAR 25.1439 was amended to state that protective breathing equipment must be installed in each isolated, separate compartment, adequate for the maximum number of crew members to be expected in that area. The intent is that protective breathing must be provided primarily in the lower galley.

k. FAR 23 and 25.1401 were changed in the Airworthiness Review to include a coverage up to 75°. It previously stopped at 30. That was the only change. Helicopter anti-collision lights continue to be limited to red color. The Army did extensive studies at Fort Rucker in which they varied intensity and color, and they learned that they have much better control of backscatter with red than they have with white, and the helicopter people who did much work in this were very strongly in agreement with that finding. Now, we also require less light intensity on helicopters.

CONCLUSION

None reached.

ATTACHMENTS

None.

AGENDA ITEM 13  
ANTI-COLLISION LIGHT TSO

PROBLEM

Status of the proposed TSO.

DISCUSSION

Bob Owens, AFS-130 representative to SAE A-2, summarized as follows:

Another thing coming up is a TSO for anti-collision lights. We've just completed this with SAE, and there's only one area that might be a surprise to some; that we are recognizing a double flash, with a limit of 225 milliseconds. Two flashes, as long as they come within 225 milliseconds of each other, will be recognized as a single flash. That's spelled out in the SAE document. We will mail to you the final draft of that document so you'll have it ahead of time, as we have done with several others. If you see anything in there that's really glaring, that we have to change, then get the comments back to us. We propose to go forward with a multiple proposed rule change for the anti-collision lights. We plan to remove the specifications that are in .1401 and reference the TSO as we have done in several other areas such as the ATC transponder. The standards will be in the TSO. The TSO will contain a reference to the SAE document. This will be across the board in Parts 23, 25, 27, and 29. The TSO categorizes a helicopter operation and speaks to color and intensity there. It categorizes the older aircraft which can be approved with 100 candlepower lights, and the current requirements for the newer aircraft. One more point to be covered in the proposed regulations is counting the number of flashes when multiple strobes are installed on an aircraft, particularly of different colors. If you have one that's red and one that's white, these are obviously two distinguishable lights and the flashes will be counted independently. There is an upper limit of flashes per minute proposed. We expect to see proposals of a single fixture with an anti-collision light, a position light, and perhaps a tail light in it. Position light - anti-collision light - and tail light - in one fixture. There's nothing wrong with that, as long as it meets the requirements when installed on the airplane. Assuming we get a TSO for anti-collision lights, then it will meet two TSOs.

CONCLUSION

None reached.

AGENDA ITEM 14  
PAST WORKSHOP ITEMS

PROBLEM

The status of past workshop action items was reviewed.

DISCUSSION

1972

Item 3                      Lightning Strike Protection

AFS-130 will attempt to develop guidance material based on Scotty Salmond's proposed AC and Oklahoma City information document.

Item 13                      Pressurization Warning Systems

AFS-132 has modified FAR 23 cabin warning requirements. See FAR 23.841 as amended by Amendments 23-14 and 23-17.

Item 19                      Stall Prevention

No action was proposed.

Item 35                      Evaluation of TSO Data

AFS-130 will review 8150.1, TSO Handbook, for including standard TSO evaluation procedures, i.e., incorporating AFS-130's past letters.

1975

Item 3                      Integration of Policy with FARs

AFS-130 is unable to cross index at present. We have neither the manpower, nor the resources. AFS-180 initiated project, progress has been made, but manpower is too limited for completion.

Item 8                      Engineering/Maintenance Coordination

Frank Rock and AFS-206 are working on this. A draft AC is out for comment. It is a controversial subject.

Agenda Item 14  
Past Workshop Items

1975 (con't)

Item 9                      Aircraft Instrument Environments

Do we need an AC to explain that a TSO does not mean installation approval? Reference FAR 23.1301(a), 25.1301, and 25.1309(a). RTCA has adopted a new, more comprehensive format for their documents which may help alleviate this situation.

Item 12                      Unpaired ILS Indicators

AFS-512 has this now. A new project authorized in August 1977, due in 1978. AC prepared - pilots affected. No problem - will cancel.

Item 31                      Ground Proximity Warning Systems

No action was proposed.

Item 33                      Interim Microwave Landing Systems

Bob Owens is working on this. A draft AC will be available (at the upcoming systems workshop). TSO has been issued.

Item 41                      TSO Labeling and Marking

This is in process as part of an AC on Altered/Modified TSO Products. There is also the possibility of an NPRM. AFS-130 received the package in August from AFS-510.

Item 50                      Fault Analysis Standards

Ev Morris' drafts were dropped from FAR 25.1309 AC with the intent of separate publication in the future. We plan to revise AC 20 and will consider expansion into this area.

1976

Item 1                      Aircraft Systems  
Responsibility and Alignment

AFS-130 distributed a list of Washington and available regional systems alignments.

Item 8                      Batteries as a Back-up  
Power Source for FAR 27

No progress to date. AFS-130 could initiate low priority project.

Agenda Item 14  
Past Workshop Items

1976 (con't)

Item 12

General TSO

AFS-130 has drafted a proposed General TSO which is being coordinated within AFS-100.

Item 17

Lithium Batteries

Paul Neumann has drafted an NPRM on this subject. In addition, there is pending proposed AD action on lithium batteries.

Item 21

Service Difficulties with  
Defunct Manufacturers

This item is now at AFS-512 with project on revision of Subpart A of FAR 37. It is due in AFS-130 in 1978.

Item 25

Survivor Locator Light Intensity

AFS-120 will issue an interpretation on this matter. AFS-120 estimates completion in October 1978.

Item 31

TSO Procedures Under a  
Bi-Lateral Agreement

This item is now in AFS-512 as part of Subpart A of FAR 37 revision. It is due in AFS-130 in 1978.

1976

Combined Systems/Flight Test

Item 2

Application of FAR 23.1309  
and 25.1309

The requested guidance material is still in process.

Item 6

Dissemination of DER  
Guidance Information

AFS-512 is working on this. A draft handbook has been sent to the regions for comment. Estimated completion date is 1978.

Item 7

DME Accuracy

A letter from AFS-130 to AFS-800 was sent September 1, 1977.

Agenda Item 14  
Past Workshop Items

1976 - Combined Systems/Flight Test (con't)

Item 11                      Helicopter IFR Instrumentation

AWE-160 is working on this. Due date is 1978. Further discussion scheduled in this workshop.

Item 16                      Omega and VLF Navigation  
Equipment Approvals

Bob Huhn is working on an AC. It is near completion.

Item 31                      Standards for Aircraft  
Electrical Wire

Bob Owens in monitoring this. He reports that SAE hasn't issued anything, yet; the best guess is 1979.

CONCLUSION

None reached.

ATTACHMENTS

None.

## AGENDA ITEM 15

### OMEGA, GENERAL

#### PROBLEM

The Northeast Region proposed that a procedure for testing Omega is needed and should be promulgated by Washington. The Great Lakes Region representative stated that Advisory Circular 20-101 had incorporated rather cumbersome procedures.

#### DISCUSSION

Western Region stated that they have issued type inspection authorizations for testing Omega. It was pointed out that Advisory Circular 20-101 was developed with the advice of those regions having experience with such approvals and we do not presently contemplate revision of the Advisory Circular to simplify those procedures. It was also pointed out that for approval of Omega/VLF systems for use in the continental United States, Advisory Circular 20-101 applies. It incorporates requirements that are similar to 90-45A, but it was published specifically for the purpose of approval of Omega/VLF systems.

#### CONCLUSION

Western Region will distribute copies of appropriate type inspection authorizations and aircraft flight manual supplements to all other regions by the end of November. The other regions are to return their comments with the benefit of their experience with various systems to the Western Region by the end of December. Western Region will then redraft and forward a draft flight test procedure to Washington by the end of January, as a goal date. In the meantime, any requests for approval of Omega for use in the continental United States must be approved using Advisory Circular 90-45A/20-101.

#### ATTACHMENTS

1. Flight Test Workshop Paper  
ANE-213

Subj: Combination Omega/VLF Receivers

Background: A recent STC project required IFR approval of a combination VLF/Omega receiver on a JetStar. Flight test was conducted during a period when the Navy VLF signals were unreliable for navigation because of a recent FSK modulation format change; VLF and Omega signal strengths were normal. The result was an eight mile error in position after two hours, with the error induced by the bad VLF signals.

Agenda Item 15  
Omega, General

This receiver (GNS-500) incorporated no means in the cockpit to deactivate the VLF portion of the receiver; it automatically selects and combines all available signals based apparently on signal strength. A recent Advisory Circular (AC), 91.49, excludes the use of VLF for update use in the North Atlantic under the recent ICAO MNPS (Minimum Navigation Performance Standards); Omega update is allowable.

The recent Omega TSO does not provide for pilot selected exclusion of signals/stations known or suspected to be unreliable.

Discussion: It would seem that the TSO (and current receiver design) is at odds with the ICAO MNPS (as well as U.S. airspace navigation accuracy standards, since VLF is not accepted for use within U.S. airspace).

Available Options:

1. Do nothing.
2. AFS-130 investigate the potential problem areas, and publish notices that would make the public aware that VLF is not allowable as part of a sole update source for U.S. or North Atlantic navigation.

Analysis of Options:

1. It would seem that if nothing is done, the Navy VLF system will be inadvertently used for navigation update in receivers in which IFR flight is predicated upon.
2. This would seem the most obvious approach. Apparently the receivers are easily modified for Omega only use by pulling the circuit boards that control VLF station selection.

2. Omega  
AFS-130

Problem: Need to establish Omega Sole Means of Navigation Requirements Overwater.

Background: Current guidance material concerning Omega and Omega/VLF has been issued as follows:

Genote 8110.26, 9/24/76, "Omega/VLF Navigation Equipment" (enroute IFR domestic Airspace, D.C. and Alaska) now cancelled see AC 20-101.

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Omega, General

AC 120-31A, 4/21/77, Operational and Airworthiness Approval of Airborne Omega Radio Navigation Systems.

AC 120-33, 6/24/77, "Operational Approval of Airborne long range Navigation Systems for Flight within the North Atlantic minimum Navigation Performance Specifications Airspace."

AC-91-49, 8/23/77, "General Aviation Procedures for Flight in North Atlantic minimum Navigation Performance Specifications Airspace."

N 8700.2, 9/14/77, "Procedures for authorizing General Aviation Flight Operations in North Atlantic minimum Navigation Performance Specification Airspace."

AC 20-101, 10/14/77, Omega and Omega/VLF Navigation System Installation in the conterminous U.S. and Alaska.

8110. , 10/ /77, Guidance Information concerning Omega Navigation System.

Decision Paper, 8/22/77, Use of VLF in Long Range Navigation Aviation.

Industry has requested establishment of the requirements for Omega as a sole means of navigation overwater. A draft Advisory Circular has been prepared for review covering outside the United States.

FAR 37.205 (TSO-C94) Omega has been issued.

Options:

1. Publish the document for outside the United States after coordination with regions and Headquarters.
2. Stop processing documents until more data available on Omega performance.
3. Process documents, but hold from publication until more data available.

Option Analysis:

Option one: would provide timely implementation of requirements.

Option two: would not permit completion of technical staff work or a timely implementation.

Agenda Item 15  
Omega, General

Option three: would permit completion of technical staff work, but not permit timely implementation.

Recommendation: Option three for North Atlantic - After processing document, but prior to publications review current Omega performance data and Modeling information.

AGENDA ITEM 16  
SINGLE-PILOT IFR HELICOPTER

PROBLEM

The New England Region noted that the draft airworthiness criteria of September 1, 1977, does not differentiate between FAR 27 and FAR 29 helicopters, and questioned this lack of differentiation.

DISCUSSION

Don Armstrong, the Western Region flight test representative, stated that the helicopter group will reconvene in mid-December and that systems personnel will participate. It had been the understanding of the Systems Branch that the Helicopter Association of America was going to submit a proposal for systems installations in these helicopters, but the proposal has not been received. Mr. Armstrong emphasized that one of his major concerns is that allowance be made for tailoring the configuration of the cockpit and its equipment complement to particular operations without undue difficulty.

CONCLUSION

AFS-130 will notify the Helicopter Association of America that at this time, paragraph 8 of the draft criteria reflects our position. In preparation for the mid-December meeting, the Systems Branch will solicit comments from the Helicopter Association of America regarding the equipment for these helicopters.

ATTACHMENTS

None.

AGENDA ITEM 17  
COMPLEX SYSTEMS

PROBLEM

Control of safety-critical configurations can be difficult.

DISCUSSION

The Western Region used Air Research RNAV 200 as a typical system, with numerous inputs and complex internal functions. The approval of such systems is predicated largely on maintenance of the approved configuration and Western Region advised all other regions to be alert to this problem.

CONCLUSION

Western Region will send appropriate information to AFS-130 regarding the problems of interface of equipment.

ATTACHMENTS:

1. Complex System Interface  
Prepared By  
Dick Thompson & Ev Morris, AWE-132

Background:

Current state-of-the-art electronic equipment allows a greater amount of computing capability per dollar and per pound than has ever been possible in the past. Because of this situation, some of the current systems being presented to the FAA for certification go far beyond the traditional systems interface functions.

Discussion:

A new RNAV system submitted to the Western Region has the capability of completely programming the way points and updating an INS system, a VLF Omega system, or, conversely, the RNAV system can be updated or programmed from an external navigation system via a data bus between the systems. This concept presents many problems with regard to failure aspects and suitable annunciation to inform the crew with respect to the system status and "which system is doing what" to another system. Additionally, from an airworthiness standpoint, it is imperative to provide a means to define which systems have been found satisfactory for such interface operation.

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Complex Systems

To assure that proper interfacing equipment is maintained for continuing airworthiness, the Western Region required special handling in the STC. Under "limitations and conditions" on the face of the STC, the following statement was provided: "For AirNAV 200 Navigation System installations the interfacing navigation systems must be in accordance with AiResearch Report No. C-3216 dated July 26, 1977, or later approved revision."

This report lists those systems which have been found to be satisfactory. One advantage of this approach is that all AirNAV 200 STCs will refer to the same report and as additional systems are added to the list it is only necessary to approve the report rather than to revise each STC.

Available Options:

(1) Do nothing. This would be based on the assumption that changes to interfacing systems would not degrade the approved system performance beyond acceptable limits.

(2) In connection with the approval of a system depending on critical interfacing inputs or outputs, provide some document to control or limit interfacing systems which, if modified or replaced, could degrade the performance of the system being approved so that its airworthiness may be questionable.

Analysis of Options:

(1) We do not believe that the assumption is valid that modifications to or replacement of interfacing systems will not degrade the performance of a system which depends on input/output interfacing systems for its acceptable level of airworthiness. The risk of doing nothing is not considered justified.

(2) Similar controls were provided in the certification of automatic landing systems to assure that input systems or equipment items would not be changed in an arbitrary and capricious manner. This option is considered preferred.

Recommendations:

(1) We recommend that the type certification handbook, 8110.4, be amended to require documentary control of systems which interface and "play" together so that equipment replacement or modification must be specifically approved when the effect on other systems may not be obvious to an aircraft operator or modifier.



AGENDA ITEM 18  
DIGITAL SYSTEMS

PROBLEM

Evaluation and approval of digital systems may be difficult, and may require new techniques.

DISCUSSION

Mr. Jim Treacy, ANW-213, gave the following presentation relative to experience in the Northwest Region:

"I can give you a little background on what we've been doing - the two most recent ones we've seen are the Tern 100, a Sperry system which I don't know if anyone else has seen, and another one which is a performance data computer system. They seem to be proliferating around the country. I understand that Sunstrand is working on one with the Flying Tigers, and other people are working on them, supposedly to save fuel. I say 'supposedly' because the fuel saving is somewhere on the order of one or two percent and it's hard to tell whether you save that much or not, but the manufacturers claim that you do.

"The Tern 100 system, a digital RNAV system that did all sorts of wild and wonderful things, presented us with a problem of how to test the thing. We found out only through flight testing, not through simulation. There were some problems with it, and while I may sound more like a flight test guy than a systems guy, I believe very strongly that a detailed flight test is hard to beat on a lot of these things. Not just one flight, necessarily, but several flights which involve all the types of operation you're going to see, and maybe some you don't really expect to see, because there was one I'd like to mention. It had an anomaly of a system overflow which occurred if you did a go-around and then went into a holding maneuver. Detailed tests are necessary and they should be done with care to exercise every mode that thing has and to look at the modes in different sequences, because sometimes strange things can happen.

"After the first approval of one of these things, though, the simulator seems to be a pretty good way of approving subsequent changes that do not necessarily affect the accuracy of the system. Some of these more complex gadgets have lots of modes that can be tailored to the customer simply by changing software. If he might want to have true airspeed, or ground speed, or some other kind of display come up on his panel, it can be changed just by changing the software program. Those kinds of changes, the manufacturers like to call them

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Digital Systems

them product improvements, but we still think of them as probably major changes, can be done pretty well on a simulator that looks like an airplane flying along and has all the good inputs, with some noise on the inputs and all that kind of thing. We've authorized some of our DERs who are particularly familiar with that kind of system to actually do those tests for a follow-on system or an update of a system that's already been approved and is working pretty well. The key to the thing is to really give it a good workout; once it's working to begin with, they seem to be pretty good, they don't seem to have faults creeping into them because of programming errors made in the revision.

"The problem we've got with that is we don't know how to evaluate the failures of the processor and of the memory. There are two ways around it for the RNAV type system. You can install two systems, which happens to be the way Sperry went on the Saudi Arabian airplane, although that's really not too feasible, or you might examine the probability of a failure of the CPU unit and of the memory unit. They have reliabilities close to those of a single transistor because they're built practically the same way, and if you can show for the area navigation systems that a failure, any kind of failure, no matter what its characteristics, is improbable or roughly on the order of  $10^{-5}$ , you've got the problem licked because that's all you have to have for the area navigation system. The criteria is to annunciate failures not shown to be improbable, so for these systems, the manufacturers can have in-line tests of most of the components which will catch most of those types of failures, but they cannot show you that for a memory failure. Although some manufacturers claim they can catch memory failures, we haven't been convinced of that, or that the failures of the central processor unit can be detected by the computer itself, so you might consider the option of looking at the reliability of those particular components because, really, you're only talking about maybe two chips, and they might have quite a high reliability in and of themselves, sufficient for the performance or the failure reliability that you have to have for that kind of system.

"That approach isn't going to work with a more complex system like a flight control system or an active control system, but that's one way we've looked at it. The performance data computer is different, and we've said there's no way for us, FAA, to evaluate whether or not this system performs its intended function, because we have no way to prove it. We

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Digital Systems

took the approach that we would look at those functions of the system which do have an impact on safety; for example, a thrust setting computer that the pilot can use to punch up for take-off mode and get back a take-off thrust setting for that particular condition. We tell them that for that one you've got to show, based on either service history or whatever, that it's a reliable system; the system has got to have a self test; and before you use it, on each flight, you punch up the initial condition and you look at the AFM, and if the numbers match within, I think, .005, then you go ahead and use the computer for that flight. For the other functions, we've evaluated them only to say here's a detailed operating handbook and the manufacturer says the system will perform in accordance with this handbook, and we've checked out all the modes to see that it does. And that's all we say about it. Then we have a limitation that says do not predicate calculations of range or fuel consumption on this computer, and let it go at that.

"My main objection to this kind of system is that there doesn't seem to be any limit on how much pilot involvement there can be with the thing. They've got multi-level switches - you turn the knob to one position and punch up another button, then hit a couple more buttons, and it does different things each time, and you could spend your whole flight looking at it. I think there's a real need to develop some kind of a limit to stop this thing from going into the airplanes, but I don't have a real suggestion as to how to do it."

In response, Don Armstrong, AWE-160, stated:

"Generally the pilots are smart enough to prioritize their attention, and I'm not sure we're in a position, particularly in engineering, to say we've got to establish pilot performance margins and rule out capabilities that might exceed his performance margin. Even if the thing can serve the purpose of an encyclopedia, he's probably not going to want to read all the pages. That's a tough one to try to rule out, because that's design control if I ever saw it. You can't say don't predicate operation on its use, because that's the navigator, and if it takes 3-1/2 bananas worth of pilot effort, and work on a plain old VOR/DME takes half of a banana, then you've got a real problem on your hands with pilot workload. In Part 25 it isn't so bad; in Part 23 it's downright frightening. We have no workload measurement rule to deal with the issue at all in Part 23.

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Digital Systems

CONCLUSION

The regions and the public need guidance regarding approval of digital systems as soon as possible. AFS-130 is to plan toward development and issuance of appropriate guidance.

ATTACHMENTS

None.

AGENDA ITEM 19  
ANNUNCIATION SYSTEMS  
(Standards for Multiple Navigation Systems)

PROBLEM

The Southwest Region Flight Test Section presented a write-up of findings which they detected during evaluation of an integrated navigation system, the Tern 100. The listing of 16 items is relatively specific and applicable only to this system, but some of them are also applicable to all automatic navigation systems.

DISCUSSION

There is evidence of a need for guidance material.

CONCLUSION

The Southwest Region will attempt to develop guidance material, generalized to apply to all types of systems. They will forward this draft material to the Western and Northwestern Regions for their comments. The final material will be forwarded to AFS-160 for inclusion in Handbook 8110.8.

ATTACHMENT

Tern 100 System  
ASW-216

1. VOR/DME received accuracy requirements when used for updating.
2. Both tru and mag nav charts available for world-wide nav. What standards are needed to specify the use of each?
3. The LIT 72R can auto tune during approaches. This is not allowable (safety).
4. To prevent inadvertent delay or omission in changing to manual tuning prior to appr.
5. This system provides tru crs display enroute (only), but reverts to mag crs during appr to be compatible with published charts (crew confusion - some systems GNS 500 require manual variation inputs for mag crs info).
6. This system provided lateral offset tracking capability during approaches (not allowable - safety).
7. Auto tune and/or freq alert annunciations may be provided. Freq alert illuminates anytime the auto tuning frequency desired by the ans is not selected when in the manual tune position.

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Annunciation Systems  
(Standards for Multiple Navigation Systems)

8. This mode is used automatically at the present speed (unless selected prior) when the VNAV mode is entered (coupled operations).
9. A lighted (amber) annunciation occurs when a valid VOR/DME signal is lost (a nuisance light on overwater flights).
10. If ofst mode is selected to last fix and holding is desired - system enters auto holding, but returns to wpt rather than ofst wpt (ofst annunciation could not be extinguished).
11. System has ins position info - but installation did not allow for hsi ins window to be used (even when VOR/DME updating not being used!).
12. System only allowed mag crs info to be displayed to pilot's hsi (Jep mag charts).
13. While in level acceleration an auto VNAV coupling occurred (flashing light warning only). Crew did not notice and a prior commanded descent resulted in a climb (power was not reduced and aircraft attempted to hold constant IAS).
14. This is an idealistic operational feature - not practical in current traffic control system where assigned altitudes are common.
15. Auto appr to 50' AGL with auto missed appr not safe and violate appr published minimums.
16. When CDN modules are located on low pedestals, the crew workload and distraction would not allow single pilot IFR operations.

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Annunciation Systems

<u>Integrated Nav Systems</u>	<u>Annunciations</u>	<u>Displays</u>	
		<u>Inst. Panel</u>	<u>Pedestal Module</u>
VLF/Omega) and/or ) (lateral INS ) position)	Yes (when selected or invalid)	Opt	Yes
VOR/DME (Lat. Position & Updating)	Yes (when invalid)	Yes	Opt
RNAV/VNAV (Operations) INS	Yes (when selected or invalid)	Yes	Opt
w/ANS                      w/INS (1) INS Pos                      INS Pos		Opt	Yes
Added Curr x Updated Pos              New x INS Pos			
<u>OVERWATER</u> INS Drift + Update Errors			
Orig INS                      Unknown Pos. Known			
VLF/Omega (Manual Variation Inputs) TRUE CRSE vs. Mag CRSE Requirements (2)			
AUTOTUNING Freq Display	Yes (when not appropriately selected Auto/ Man)	Yes	Opt
ENR                      APPR			
LIT 72R Sys Autotune              Yes              Yes (3)			
Man-tune              Opt              Opt			
Below 10M (4?)	Yes (flashing)		
Tru Crs              Yes              No              Blue			
			(5?)
Mag Crs              Yes              Yes              Green			
Ofst Trk              Yes              Yes/ No              (6?)			

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Annunciation Systems

<u>Integrated Nav Systems</u>	<u>Annunciations</u>	<u>Inst. Panel</u>	<u>Pedestal Module</u>
<u>Autotuning</u>			
	<u>ENR</u> <u>APPR</u>		
Tern 100 ANS Autotune or Freq Alert (7?) Man Tune	Yes    No (Chart Sel.)  Opt    Opt		
	Yes (when not appro- priately sel - ENR)		
	Yes (if req'd - APPR & not selected)		
LAT TKC	Yes (G light)	Yes	Yes
VERT TKC	Yes (G light)	Yes	Yes
IAS (8?)	Yes (G light)	Yes	Yes
DR	Yes (G light)	Yes	Yes
RAD (9?)	Yes (A)		
INS)	(A)		
BAT)	(A)		
OFST (10?)	(W)		
HOLD	(W)		
DSPY	(W)		
RN	HSI (window)		
VN	HSI (window)		
INS (11?)	HSI (window)		
ALERT	(A)		
TRU CRS (12?)	HSI (window)		
MAG CRS			
Auto VNAV (coupled) (13?)	Yes (flashing)	Yes	-
Auto APPR (coupled) (14?)	Yes	Yes	-
APPR to 50' AGL (15?)	Yes	Yes	-
CDU Location (workload) (16?)		Opt	Opt

AGENDA ITEM 20

FAR 25.1309

PROBLEM

The application of FAR 25.1309 is regarded as a potential problem by regions and the industry.

DISCUSSION

There was considerable discussion regarding the application of .1309 as amended by 25-23. The intent of the regulation regarding the evaluation of the system through use of a failure mode and effects analysis, and identification of those critical failure conditions for which a probability analysis would be required, was discussed. It was emphasized that there would be very few probability analyses required in almost all foreseeable aircraft designs. Experience in applying 25.1309 was touched on, especially in regard to the application to the Concorde and the forthcoming Lockheed L-1011 active control project. A paper on Essential Electrical Loads was distributed by ASO-213. It pointed out what was contended to be a discrepancy between Part 25.1309E and 25.1301D. The conclusion was that 25.1301 does not require the installation of any item of equipment. It simply requires that installed equipment perform its intended function, while 25.1309 states that any installation, the function of which is required by the regulations, is an essential load on the power supply. There is a differentiation between these two regulations and we do not feel there is a conflict, or discrepancy between the two. They are intended for different purposes. Two position papers by the Southern Region and the latest draft Advisory Circular on 25.1309 were distributed.

CONCLUSION

AFS-130 will consider the ASO recommendations.

ATTACHMENTS

1. Southern Region Position Paper

Subj: Essential Electric Loads

Background: FAR 25.1309(e) is unnecessarily restrictive when considered in conjunction with FAR 25.1301(d) and it has been that way for years. Of course, FAR 25.1301(d) can be interpreted two different ways also.

Agenda Item 20  
FAR 25.1309

Discussion: The first sentence in FAR 25.1309(e) states "Each installation whose functioning is required by this subchapter, and that requires a power supply, is an "essential load" on the power supply." FAR 25.1301(d) then states in effect that each item of installed electrically powered equipment is an essential load on the power supply because it must function. We do not really need or want each item of installed electrical equipment to be an essential load. Also, FAR 25.1301(d) can be interpreted as saying that each item of equipment must function properly at the time of installation but does not have to function properly after that.

Available Options:

1. Do nothing.
2. Revise FAR 25.1301(d) to state that each item of equipment essential to flight safety is an essential load on the power supply.

Analysis of Options:

1. Option 1 - we would continue to use good judgement although literal compliance with FAR 25.1309(e) may not be obtained.
2. Option 2 - the regulation would be written in practical terms that would allow literal compliance to be found to both regulations.

Recommendation: Revise FAR 25.1309(e) in accordance with Option 2.

2. Southern Region Position Paper

Subj: Reliability Requirements

Background: There have been some attempts made to apply xx.1309 to the whole airplane.

Discussion: Some people believe that xx.1309 is applicable only to systems. Others believe it can be applied to everything on the airplane. However, it is under Subpart F, "Equipment, Systems, and Installation," and as such, infers that it does not apply to other areas such as power plant installations, fuel systems, flight controls, etc.

Agenda Item 20  
FAR 25.1309

Available Options:

1. Leave xx.1309 in Subpart F and issue policy statements that xx.1309 applies only to systems and equipment covered by Subpart F.

2. Move xx.1309 to Subpart A, "General" and apply it to the whole airplane.

Analysis of Options: Option number 1 is certainly easier and less controversial. However, it seems strange to apply these rules to only part of the airplane. Moving xx.1309 to Subpart A would cause controversy but the whole airplane would be covered.

Recommendation: Move xx.1309 to Subpart A and apply it equally to everything on the whole airplane.

3. Draft Advisory Circular on FAR 25.1309

Subj: System Design Analysis

1. PURPOSE. The purpose of this advisory circular is to present acceptable means, but not the only means, of showing compliance with the probabilistic terms as introduced by Amendment 25-23.

2. REFERENCE REGULATION. Federal Aviation Regulation (FAR) 25, Subpart F.

3. DISCUSSION.

a. Neither the probabilistic terms introduced by Amendment 25-23 nor the applicability of the term "analysis" is uniformly understood throughout the aviation community and the Federal Aviation Administration (FAA). It should be recognized that an analysis may range from a report that interprets test results or sets forth a comparison between two similar systems, to a probability analysis using numerical data.

b. Early agreement between the applicant and the FAA should be reached on identification of critical systems and the acceptance of proposed analyses as provided for in subparagraph 3.d. below.

c. Subpart F of Part 25 refers to showing by analysis (in association with tests, when appropriate) that the

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FAR 25.1309

probability of failure related to the consequences of failure should be expected to remain within acceptable limits. The rules are intended to assure an orderly and thorough evaluation of single and multiple failures involving one or more systems, including failures in unrelated systems. Systems, considered separately and in relation to other systems, should be designed with the objective that there is an inverse relationship between the probability of an occurrence and the severity of its effect, such that a catastrophe from any system causes is extremely improbable (see Figure 1). The terms probable, improbable, and extremely improbable are used to denote overlapping subdivisions within the spectrum of probability of occurrences. Consequences as a result of degradation of the system must continue to be addressed by proven principles employed in the design process.

d. The assessment of failure conditions can be addressed by various techniques. Numerical probability analysis can be a useful tool to supplement other practices in showing compliance. The probability analysis may be useful where a system or its application differs from those with substantial satisfactory experience in:

- (1) Technology,
- (2) Functions,
- (3) Interrelationships with other systems of the aircraft,
- (4) Relationship between the system and critical characteristics of the aircraft, and
- (5) Complexity.

e. In addition to the design review and examination of descriptive and substantiating data, including test results, the evaluation of aircraft systems to find compliance may include one or more of the following steps:

- (1) Review of inservice experience with similar systems and equipment.
- (2) Failure mode and effect analysis (FMEA), Fault Tree Diagram, or equivalent technique.
- (3) Numerical analysis dealing with predicted probability of critical failure conditions.

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FAR 25.1309

(4) Other acceptable techniques.

f. The determination of the applicability of probability analysis should consider:

(1) Effectiveness of previously used analytical techniques and/or related service experience, and

(2) Degree to which probability analysis would enhance engineering assessment and judgement.

4. PROBABILITY TERMS. For the purpose of evaluating numerical analysis submitted to show compliance, the following terms apply:

a. Extremely improbable refers to occurrences so unlikely to occur that they need not be considered, or occurrences expected with a mean frequency in the order of  $1 \times 10^{-9}$  or less per flight or flight hour.

b. Improbable refers to occurrences not expected during the operation of an individual airplane, but expected to occur during the total operational life of all airplanes of a type, or occurrences which may be expected with a mean frequency in the approximate range of  $1 \times 10^{-5}$  to  $1 \times 10^{-9}$  per flight or flight hour.

c. Probable refers to occurrences which may be expected during the operational life of each airplane, or occurrences which may be expected with a mean frequency in the order of  $1 \times 10^{-5}$  or greater per flight or flight hour.

d. The probabilities should be on an hourly or per flight basis, depending on which is more appropriate to the assessment. For the purpose of this AC, a flight constitutes one takeoff and landing. Systems which operate continuously during flight should be taken on an hourly basis; those which are confined to takeoff and/or landing should be taken on a per flight basis if appropriate.

e. These terms are not intended to define the reliability of specific components of systems, but rather relate to the effects on the aircraft.

f. The terms defined above are intended to relate to a single consequence resulting from the loss of a function or functions.

Agenda Item 20  
FAR 25.1309

NOTE: The above values should be interpreted as a goal. The numerical limits are not precise and judgement should be used in their application. This is reflected in the overlap of the limits shown in Figure 1 below.

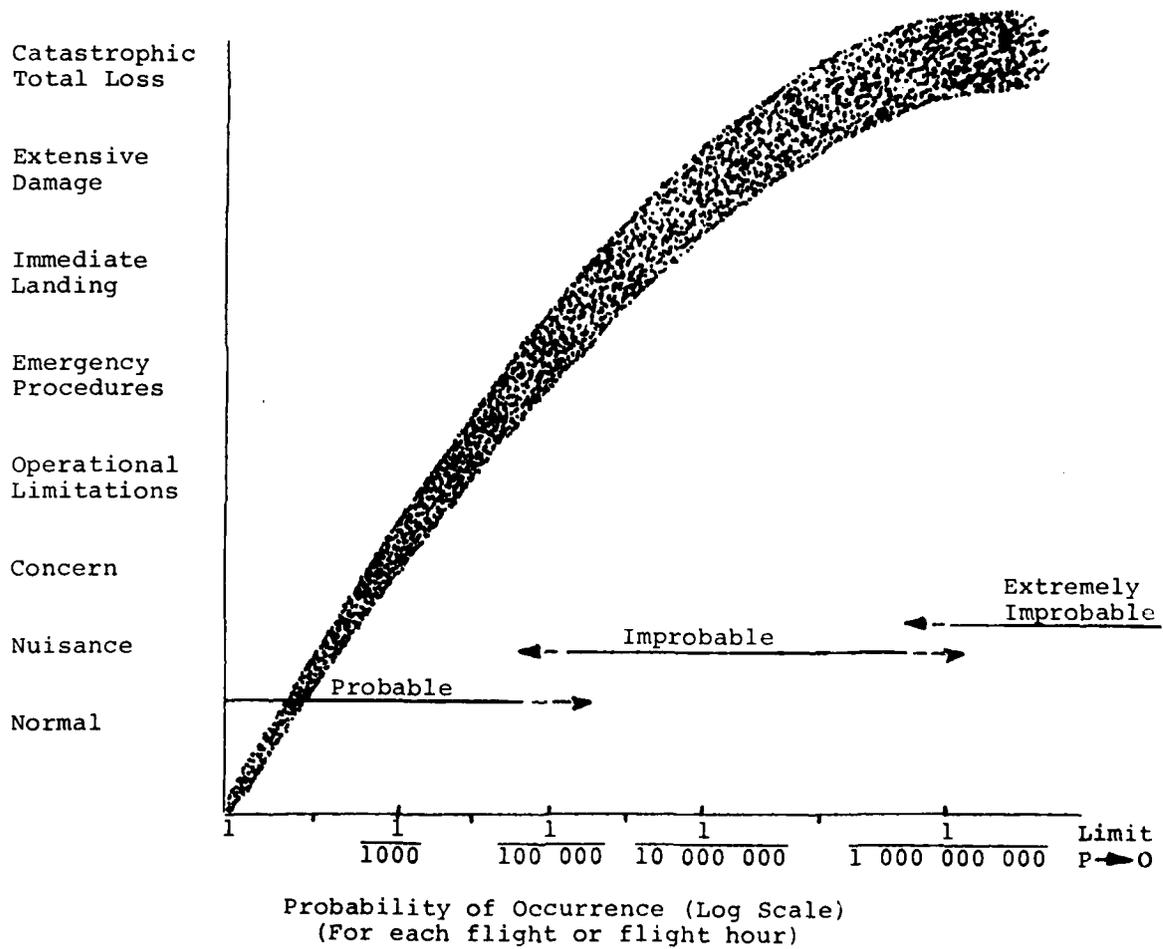


Figure 1.

## AGENDA ITEM 21

FAR 23.1309

### PROBLEM

Application of FAR 23.1309 is not clearly understood.

### DISCUSSION

AFS-130 stated that the intent of 23.1309 is to apply the requirements previously expressed in CAR 4B.606, including the guidance material of CAM 4B.606, and that the design goal intended is protection against probable failures which would create a hazard. The need for more than one electrical and electrical distribution system, especially, was discussed. It was concluded that it is conceivable that a single distribution bus could be found to be adequate to meet the regulation, but our experience in the past, and application to 4B transport category airplanes, has almost invariably resulted in split electrical buses which may be tied together by a bus-tie breaker, for example; in which case that single point of contact between the two systems would be subject to detailed scrutiny. A position paper by the Southern Region was distributed.

Relative to the application of FAR 23.1309, a letter from AFS-100 to ACE-200 dated October 22, 1976, was quoted as containing the essential policy; however, it was to be noted that this letter pertains specifically to a single inquiry, a single circumstance on a specific model aircraft, and that it is not necessarily applicable 100% to all other cases. The letter does, however contain basic policy and guidance material for the application of FAR 23.1309. Copies of this letter were sent to all regions, but apparently some regions did not receive it. It did not receive wide distribution.

### CONCLUSION

AFS-130 will make copies of the relevant correspondence and send them to all regions, both systems and flight test. Guidance material is to be considered. See, also, Agenda Item 33.

### ATTACHMENTS

1. Working Draft on FAR 23.1309 by ASO-213

The intent and requirements of FAR 23.1309 in a twin engine airplane are to show by analysis and/or testing that critical conditions, particularly after the occurrence of a single

Agenda Item 21  
FAR 23.1309

probable fault, do not exist, or can be accounted for, alleviated, or otherwise compensated for by the flight crew before they develop into a hazardous condition. This would apply, for example, in the electrical system by showing continued availability of electrical power for essential systems after any single probable fault, including loss of bus or feeder lines or bundles which could reasonably be expected to suffer fault conditions. In the mechanical area, loss or breakage of single structural items or load paths and breakage of lines are normally classified as probable, and as such should be analyzed to see if the occurrence would result in a hazardous condition to further safe flight or a safe landing. Gear-up landings in a multi-engine aircraft are generally considered a hazard. A probable fault that would preclude normal lowering of the gear, would therefore be considered critical and could not comply with the FAR 23.1309 requirements unless a suitable alternate means for extension is available to preclude a locked-up gear. Examples of other areas which should be considered, at least by means of an analysis, are: (1) a tire blowing while in the wheel well, (2) loss of all pneumatics, unless completely independent systems are utilized, (3) loss of all electrical power for any one distribution system supplying avionics, navigation, and/or communication, (e.g., under IFR conditions a pilot might lose navigation and communications because both were tied to one power source or distribution point, or being common in their operation, and (4) loss of all attitude and direction information because all these instruments were tied to the same vacuum/pressure source.

These are only a few examples of specific areas in which analysis and/or testing might be accomplished to provide the information for determining adequate compliance with the intent of FAR 23.1309. The manufacturer is expected to analyze each system in the airplane to determine its single fault survivability and resultant compliance with FAR 23.1309 requirements.

It should be pointed out that where analysis may not be conclusive, testing on the airplane or a suitable mock-up may be necessary to satisfactorily demonstrate compliance. For example, where timing may be critical, the only method of assuring that a hazardous condition does not exist after the occurrence of a single fault is by actual testing under fault conditions to determine the actual results. The proper operation of the electrical system while undergoing low voltage or loss of excitation from the generator can generally only be assured from adequate testing of a prototype configuration. Where a common element, such as a circuit

Agenda Item 21  
FAR 23.1309

breaker, fuse, valve, transfer component, etc., is used to provide isolation between two system sources, the common element must be analyzed for compliance.

FAR 23.1309 requires a finding of probability, the means of distinguishing between a probable versus improbable faults is defined in the attached table for probability versus hazards.

2. Communication from AFS-100 to AWE-100, November 1975

Subj: Loss of Navigation/Communication Equipment in Multi-engine, Part 23 Airplanes

Reference to application of Part 23.1309(b) to Ted Smith's twin engine airplane, Part 23,1309(b) does apply to Navigation and Communication equipment.

The single failure concept of Part 23.1309(b), as previously discussed at the Systems Workshops in San Francisco, does apply to electrical/electronic equipment including Navigation and Communication equipment.

However, when applying these criteria to particular systems, it should be clear that the degree of hazard resulting from a type of malfunction may vary considerably with the kinds of operation to which the airplane is limited, as established by the category in which it is eligible for certification. For example, the single failure of either a navigation receiver or a communication transceiver (but not both) during IFR operation is not considered a hazard; however, a single failure of a common power supply to those systems would be considered a hazard.

/s/ JAMES E. PURCELL

3. Communication from ACE-210 to AFS-100, September 24, 1976

Subj: Guidance in applying FAR 23.1309(b)

Beech Aircraft Corporation is in the process of certifying their Model 76 airplane to FAR 23 through Amendment 23-14, which includes Section 23.1309. Beech has objected to applying single fault criteria, as defined in CAM 4b.606, to the single bus electrical system to show compliance to FAR 23.1309(b).

Agenda Item 21  
FAR 23.1309

Based on Beech's objections to our interpretation of 23.1309(b), we request your guidance/support in applying this requirement in regards to the Model 76 electrical system.

A complete loss of the Model 76 electrical system can occur as a result of a single malfunction on either the single bus or extensions of the bus. Beech has stated that they will request a rule change/exemption to 23.1309(b), in regards to the Model 76 electrical system, if they are required to apply single fault criteria in showing compliance to 23.1309(b). The Beech system is not acceptable as we interpret the rule, since a single fault can result in complete loss of the electrical system.

Beech contends that the single failure criteria should not be applicable to airplanes configured, or in the same class as the Model 76, since past history shows that a fault to the single bus is not a probable malfunction. We disagree with Beech, since a single fault applied to extension of the bus, which Beech has not considered, is capable of causing a complete electrical system failure. The bus extension runs from the bus located under the sloping instrument panel to the battery terminals.

The Model 76 is a twin-engine, four-place airplane of conventional design, powered by two 180 h.p. engines and will have an approximate take off weight of 3900 lbs. with a dry weight of 2400 lbs.

The enclosed copy of the Model 76 load analysis, which includes a wiring diagram, shows that the right and left main busses are hard wired together and with the feeder cables form a loop back to the battery terminal. A fault at the battery terminal, or at any point in the loop, could result in a complete loss of the electrical system.

Experience with electrical systems has shown that an electrical failure of the extensions of the bus is probable. A failure of the bus extensions will result in the loss of both navigation and communication equipment. In accordance with AFS-130 letter of November 3, 1975, to AWE-100 this type of failure would be considered to be a hazard, and therefore does not meet the requirements of FAR 23.1309(b).

The battery is a 35 ampere hour lead acid battery, which may not clear all faults, depending upon the fault load and condition of the battery.

Agenda Item 21  
FAR 23.1309

We would appreciate your response by October 15, 1976.

/s/ Donald Page

/t/ EDWARD J. GRIFFIN

4. Communication from AFS-100 to ACE-200, October 22, 1976

Subj: Guidance in applying FAR 23.1309(b); ACE-200  
ltr dtd 9/24/76

This is in reply to your subject letter concerning the requirements of FAR 23.1309(b), as applicable to the Beech Model 76 electrical power distribution system.

We have reviewed the background of the rule and have the following comments:

1. As you have noted, a single failure in any of the several parts of the distribution system would cause a failure of all parts of the system. Accordingly, we concur that a single failure in the system would be hazardous.

2. FAR 23.1309(b) requires that the system must be designed to prevent hazards to the airplane in the event of a "probable" malfunction or failure. We asked AAC-230 to review the number of malfunctions and failures in similar twin-engine airplanes during the last five years. Enclosed is their report. In our judgement, this service history concerning similar systems shows that a failure in the Beech Model 76 system should be considered probable.

3. As noted in Agenda Item 50 of the Systems Workshop of August 1975, the guidance material in CAM 4b.606 (particularly Note 36) accurately reflects the intent of FAR 23.1309. We recommend that, while using the guidance material of CAM 4b.606, specific reference to CAM 4b is neither necessary nor appropriate when negotiating with FAR 23 applicants.

We trust the above comments will provide the guidance you requested.

/s/ James Dougherty

/t/ JAMES O ROBINSON

AD-A082 938

FEDERAL AVIATION ADMINISTRATION WASHINGTON DC FLIGHT --ETC F/8 1/2  
REPORT OF THE AIRCRAFT SYSTEMS/FLIGHT TEST WORKSHOP HELD AT EAS--ETC(U)  
NOV 77

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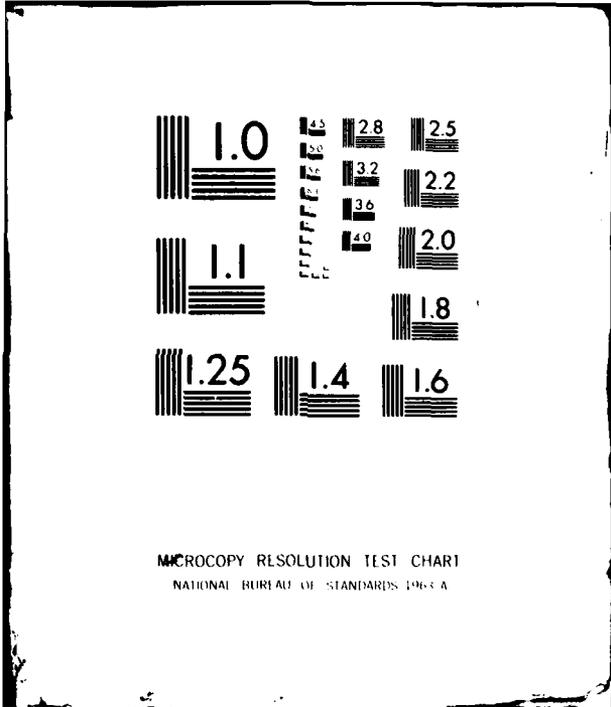
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AGENDA ITEM 22  
MAGNETIC COMPASS CALIBRATION

PROBLEM

There is a difference between FAR 23 and FAR 25 regarding compass calibration.

DISCUSSION

It was brought out that Amendment 23-20 changed FAR 23 to permit a deviation of the magnetic compass greater than 10° under certain conditions, i.e., that the pilot would be informed of the conditions of the electrical system which would cause the magnetic compass to deviate more than 10° and that there be an alternate direction indicator which is not affected by that electrical condition. Southern Region suggested that Part 25 should be amended to require calibration under the condition where the magnetic compass is most likely to be really needed, that is with either all electrical power off or with only the emergency electrical power on. The Southern Region position paper also pointed out that there is a discrepancy in the calibration increments required by Part 23 as compared with Part 25, and suggested that both should be made identical, requiring calibration at 30° increments.

CONCLUSION

The Southern Region recommendation will be considered when the related rules are next reviewed.

ATTACHMENT

1. Southern Region Position Paper

Subj: Magnetic Compass

Background:

For many years FAR 23.1547(d) has required the magnetic compass to be calibrated in 30° increments. FAR 25.1547(d) requires calibration in 45° increments.

Discussion:

Normally FAR 25 requirements are more severe than FAR 23. In this case though FAR 23 requires more calibration points than FAR 25. It could be argued that most FAR 23 airplanes are not as well equipped as FAR 25 airplanes and would be more likely to have to depend on the magnetic compass. Also many

Agenda Item 22  
Magnetic Compass Calibration

FAR 23 airplanes have nonstabilized directional gyros which must be reset periodically. Therefore, it is important for the magnetic compass to be calibrated in smaller increments.

It could also be argued that the high performance FAR 25 airplanes need the magnetic compass calibrated in increments no larger than the FAR 23 requirements because higher standards normally apply to them and although it is more unlikely to occur, if the high performance FAR 25 airplane ever had to depend solely on the magnetic compass for heading information, the calibration increments should be small.

Available Options:

1. Do nothing.
2. Change FAR 23 magnetic compass calibration increments to 45° - same as FAR 25.
3. Change FAR 25 magnetic compass calibration increments to 30° - same as FAR 23.

Analysis of Options:

1. Option 1 - This causes no problems. The regulations have been this way for years and there have been no problems.
2. Option 2 - This would ease FAR 23 airplanes calibration requirements and save companies a small amount of time and, therefore, money. Impact on safety would probably be minimal. May use more fuel by not being able to set DG accurately and, thus, cause some wandering off course.
3. Option 3 - Magnetic compass calibration would take slightly longer and, thus, cost a little more money. No savings in fuel since FAR 25 airplanes are not really flown using the magnetic compass as a reference. Safety would be increased somewhat in the event that other directional equipment had failed - such as during a total loss of electrical power. If this option is selected, we should require that magnetic compasses be calibrated with all electric power off.

Recommendation: Adopt option number 3 because cost is small and safety is enhanced.

AGENDA ITEM 23  
ALTIMETRY

PROBLEM

A pneumatic altimeter has been required by policy, rather than by regulation.

DISCUSSION

The Southern Region presented their position with an information paper.

CONCLUSION

It was concluded that it has been a long standing policy to require that a barometric altimeter be available to the crew, and that all-electric altimetry is not permissible. It was also concluded that it is conceivable that an all-electric altimeter system could be shown to be adequately reliable to permit removal of the barometric altimeter, but that this has not been done to date and it is not expected in the near future. As a matter of information, the policy applies to airspeed as well, although the subject under discussion was limited to altimetry.

ATTACHMENT

Altimetry  
ASO-213

Background: As a matter of policy, we have always required an airplane to have at least one barometric altimeter although the regulations do not necessarily say that.

Discussion: If we really need or want one barometric altimeter to be installed on each airplane, we should say that in simple terms. It is much easier to regulate by regulations than policy. The problem becomes even more pronounced with the present FAR 25.1309. Are we really ready at this point in time or will we be ready in the foreseeable future to allow certification without a barometric altimeter even if reliability figures show an acceptable failure rate with electric altimeters?

Available Options:

1. Require a barometric altimeter as a matter of policy.
2. Certificate airplanes without a barometric altimeter if reliability studies show compliance with FAR 25.1309(b)(1).

Agenda Item 23  
Altimetry

3. Revise FAR 25.1303 to require at least one barometric altimeter.

Analysis of Options: Option number 1 is the poorest way to go because of regulating by policy rather than regulations. It is the easy way out. Option number 2 should be acceptable if, in fact, we truly believe in FAR 25.1309. If we are not sure that FAR 25.1309 will provide the results we are looking for, then option number 3 is the way to go.

Recommendation: Adopt option 3. Then we can have the reliable, electric power free, altimeter without getting involved in FAR 25.1309 hassles over altimetry.

AGENDA ITEM 24

SMOKE TESTING

and

AGENDA ITEM 25

SMOKE GENERATION

PROBLEM

Both subjects are approached in a non-uniform fashion.

DISCUSSION

Position papers were presented and it was immediately noted that there is presently an MEO Team (Multiple Expert Opinion Team) studying the whole problem. This Team was organized some time ago as a result of a Pan-American accident at Boston. Bob Allen of AFS-120 is Chairman, and another member of the Committee, Mr. Bill Trammell, was present at this workshop and brought attendees up to date on committee activities.

CONCLUSION

There will be no decision or recommendation made at this workshop, pending issuance of policy and guidance from the MEO Team. It was requested that any region with information on the subjects that might be useful to the Team should send it to Mr. Allen, AFS-120. AFS-130 will also request the MEO Team to send a draft of anything they propose to all regions for comments. It is understood that the MEO Team is studying the establishment of a standard smoke generator and standard smoke evacuation test procedures. It was also mentioned that in the future, Flight Standards should inform all regions of any team established to study a specific topic, and that regional ideas and problems on those topics should be solicited.

ATTACHMENT (to Item 24)

Southwest Region Position Paper

Problem:

There is a lack of uniformity between the regions in smoke evacuation testing. This is especially true in flight testing.

**Agenda Items 24 & 25**  
**Smoke Testing and Smoke Generation**

**Background:**

The Southwest Region received a TIA from the Southern Region to conduct in flight smoke evacuation tests on a Convair 880 at Waco, Texas. The flight test section was apprehensive about conducting in flight tests, nearly to the point of refusal. (Subsequently, the Southern Region advised that these tests are identical to those conducted by the Northwest Region). Since the owner took the aircraft out of the country, and it is reported to have crashed with a load of cattle, smoke evacuation tests were not conducted.

**Discussion:**

A published uniform procedure for accomplishing smoke evacuation testing would minimize conflicts between the regions when inter-region projects are conducted.

Although most aircraft in the Southwest Region have been certified without in flight smoke evacuation tests, we found Bob Gambrill conducted them on the Swearingen turbo prop certified under CAR 3.

Also, the current Rockwell 700 (Fuji) aircraft is being so tested. For the smoke source Rockwell uses a two gallon bucket with two to three inches of sand in the bottom. They put a 50-50 by weight mixture of potassium nitrate and lactose in the bucket and ignite it with matches. A bottle of water is nearby to extinguish the smoke. The procedure below is then followed by Rockwell to demonstrate adequate smoke evacuation.

**Purpose:** Determine adequacy of the ram air system to remove smoke from the cabin.

**Test Procedures:**

1. Takeoff and climb to 12,500 feet with normal pressurization (Sea Level Cabin Setting).
2. With the aircraft operated at normal cruise airspeed, ignite the smoke generator.
3. When the smoke is clearly visible, carry out a smoke removal procedure per aircraft flight manual (emergency procedures).

**Agenda Items 24 & 25**  
**Smoke Testing and Smoke Generation**

**Data Requirements:**

1. Establish the time required to reduce the smoke level to a satisfactory level for aircraft operation.
2. Statement of satisfactory smoke removal by the certification test pilot.

**Options:**

1. Establish an FAA standard for conducting in flight smoke evacuation tests.
2. Prohibit in flight smoke evacuation tests.
3. Continue as is with each region doing their own thing.

**Option Analysis:**

1. To continue as is is undesirable for at least the following reasons:
  - (a) Some regions may not be obtaining full compliance with FAR 25.831(d).
  - (b) Some regions may be obtaining more than minimum compliance with FAR 25.831(d).
  - (c) Lack of uniformity in administering this regulation contributes to friction between the FAA and the aviation industry, as well as within the FAA.

2. In flight smoke flow patterns probably cannot be completely simulated on the ground. Therefore, to avoid an unsafe condition if smoke should fill the cabin during flight, actual in flight evacuation tests should be conducted under rigid uniform controlled and safe conditions.

**Recommendations:**

Develop a procedure for conducting in flight smoke evacuation tests for inclusion in the flight test handbook. This procedure should consist of at least the following:

1. Consideration of the location of out flow valves.
2. Assurance of adequate control of smoke quantity.

Agenda Items 24 & 25  
Smoke Testing and Smoke Generation.

3. Capability to instantly stop smoke generation.
4. A functioning autopilot operating at the start of tests.
5. Sufficient altitude at the start of testing to assure altitude losses during testing will not be catastrophic.
6. Ground tests using the same smoke generation rate and quantity as will be used in flight.
7. Acceptable smoke sources.
8. Company flight tests to be conducted prior to official FAA tests.

ATTACHMENT (to Item 25)

Northwest Region Position Paper

**Problem:** The regulations for smoke detection and penetration (FAR 25.855(e) and 25.857(b)(c)(d)(e)) are not quantitative and therefore it is difficult to assure the uniform application throughout the regions.

**Background:** In July 1973, a Varig 707 passenger aircraft crashed near Paris, France and in November 1973, a Pan American 707 cargo aircraft crashed while attempting to land at Logan Airport, Boston, Massachusetts. As a result of the Logan accident, Boeing proposed a design change in the cockpit. After review of the original certification testing, we determined that it was necessary to retest to cover the changed configuration. Two separate interior configurations were tested and the results from both tests were considered unacceptable. As a result of numerous meetings held to resolve differences, the FAA agreed to request that a Multiple Expert Opinion Team (MEOT) be established to define more quantitative criteria for use in smoke detection and smoke penetration certification testing. The team met in October with an Aerospace Industries Association (AIA) subcommittee to discuss the proposed criteria and to observe a demonstration of smoke generation and smoke density measurements. Within a short time a revised proposal will be submitted to AIA. This revised proposal was based on the AIA comments submitted in writing and made during the meeting.

Agenda Items 24 & 25  
Smoke Testing and Smoke Generation

Available Options:

1. Adopt the more definitive criteria proposed by the MEOT.
2. Test, using the subjective criteria.
3. Define qualitative methods of testing which eliminates all subjective aspects from future tests.

Analysis of Options:

Option 1:

Defines current practices in terms of a quantitative perimeter, such as light transmissibility. It would require that the performance of the smoke generator be documented for comparison to future smoke generator performance. Acceptable documentation would be a plot of time vs. transmissibility for a given volume(s). The smoke shall be uniformly diffused in this given volume. In addition, procedures would be specified for smoke evacuation testing.

The benefit of this option is uniform criteria for testing and test results which can be duplicated.

Option 2:

This option does not provide assurance of an adequate amount of data for investigation and determination that subsequent aircraft meet the same requirements. In addition, retesting as part of incident/accident investigation cannot duplicate the original certification tests. As a result, differences of opinion can arise as to the meaning of the test results.

Option 3:

There are many variables involved in these tests; such as, material, temperatures, combustion by-products, ventilation rates, localized airflows, etc. The FAA would have to define all variables to establish completely quantitative test criteria. We do not at this time have sufficient data available to do this.

AGENDA ITEM 26  
ICING - CAR 3 AIRCRAFT

PROBLEM

An information paper was distributed by ACE-213 which summarized a review of a number of accident reports and records, and makes recommendations for regulatory action to assure safe operation in icing conditions.

DISCUSSION

It was noted that there is an NPRM in existence regarding FAR 135.187 which lists the same equipment as FAR 91 presently lists as required for flight into icing.

CONCLUSION

Central Region is to send comments to AFS-900 regarding the FAR 135 notice. AFS-130 will review a report on icing which was written by Ed Lambert, AFS-140, several years ago to determine if this report contains information that would be useful to field personnel. If so, we will send a copy to each region. It was noted that the Washington General Counsel letter regarding optional equipment (reference Agenda Item 28) may be appropriately used in case of ice equipment installations and that Engineering and Flight Test have authority to require a determination be made that all installations perform their intended functions. One problem is that a lot of the ice protection equipment is installed by field approvals and do not come to the attention of Engineering or Flight Test. AFS-160 will contact AFS-800 regarding the possibility of sending an information letter to pilots on this subject, explaining the hazards of flight into icing without approved systems. It was noted, also, that AFS-806 has drafted an Advisory Circular on this subject and AFS-130 will contact 806 to determine the status of that Advisory Circular and to review it. AFS-130 will also investigate the possibility of adding appropriate requirements to Part 91 via an FAR 91 project that is presently on the AFS-900 regulatory projects list. AFS-130 will also inquire or investigate with AFS-800, and possibly check with AOPA, the possibility of producing a pilot information film on this subject. It was pointed out that the definition of the various icing conditions contained in the Airmans' Information Manual is relatively useless and that better definitions should be developed and put into this Manual.

Agenda Item 26  
Icing - CAR 3 Aircraft

ATTACHMENT

At the 1977 Systems Workshop, the Central Region presented the attached paper on the unsafe operations of CAR 3 airplanes in icing conditions. Discussion at the workshop concluded that the best way to prevent additional occurrences of these unsafe conditions was to pursue changes to the current operating rules (FAR 91 and 135). To support the pursuit of these changes, it was requested that the Central Region prepare a summary of the accidents reviewed for the paper presented at the workshop.

Several summaries of reports of icing accidents were reviewed in an effort to determine if the icing encounters might have been avoided if the airplanes were equipped with a placard to advise the pilot of its operating limits. Accidents reviewed were classified into the following three groups:

A - Those resulting from improper pilot preflight. Takeoff with frost or ice on the airplane are the type placed in this class.

B - Those that contained information that indicated possible other causes and an operating limits placard would not have helped prevent the occurrence. Reports on aircraft where there were other factors in addition to ice are the types placed in this class.

C - Those that contained information that suggested that the icing encounters may have been avoided had the pilot been properly advised of the airplane's operating limits.

The summary and results of the reviewed reports are:

1. Airframe icing as a cause/factor. This is an NTSB report for the period 1970-1973 and contains 132 accident reports which were classified as 43-A, 23-B, and 66-C.

2. Windshield icing as a cause/factor. This is an NTSB report for the period 1970-1973 and contains 28 reports, 16 of which are not duplicated on other reports. These 16 were classified as 2-A, 9-B, and 5-C.

3. Icing accidents involving Cessna 310, 340, and 400 series aircraft. This is an FAA report for the period 1973-1975 and contains 17 reports, 15 of which are not duplicated in other reports. These 17 were classified as 8-A, 1-B, and 6-C.

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4. Briefs of accidents involving Cessna 310, 340, and 400 series aircraft which had airframe icing. This is an NTSB report for the period 1964-1975 and contains 33 reports, 14 of which are not duplicated in other reports. These 14 were classified as 0-A, 3-B, and 11-C.

5. Icing accidents involving Beech Twins. This is an FAA report for the period 1974-1976 and contains 15 reports, none of which are duplicated in other reports. These 15 were classified as 5-A, 0-B, and 10-C.

6. Wire from Germany to AEU which reports two additional accidents classified as C.

A summary of the above six reports showed a total of 194 separate accidents classified as 58-A, 36-B, and 100-C.

These accidents were further reviewed to determine the type of aircraft on which they occurred. It was found that accidents occurred on 107 models manufactured by 15 different companies. The 100 accidents classified as those where a placard may have helped prevent the encounter were then examined to see if there were any occurrences on airplanes whose certification included requirements for the installation of an operation placard. This type of placard was required by CAR 3.772 added to CAR 3 dated 5/15/56 and amended by 3-7 and FAR 23.1559(b). It was found that there were three occurrences on airplanes whose certification included this placard requirement. These three were then subtracted from that group.

When this subject was discussed at the joint Flight-Systems Workshop, the question was raised as to the number of fatalities that resulted from the 97 accidents where the lack of a placard could have been a factor. Following that workshop the summaries were reexamined and it was found that at least 86 fatalities had occurred. This number may be slightly conservative because the report on 6 light twin airplanes only shows there were fatalities, but does not specify the number. One each of these six, only one, the pilot, was counted as fatal.

FAA Systems Workshop Briefing Paper  
ACE-213

Subj: Operation of CAR 3 Aircraft in icing conditions

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A. PROBLEM

The installation of icing equipment not evaluated for its anti or deicing capabilities on airplanes whose certification basis is prior to the requirements of CAR 3.772/23.1559(b) is resulting in pilots mistakenly believing that those airplanes are equipped and safe for flight in icing conditions.

B. BACKGROUND

A safety recommendation received in the Central Region recommended the issuance of an NPRM on Cessna Model 300 and 400 airplanes to require the installation of a placard that would inform the operator whether those airplanes are or are not approved for flight in icing conditions. This recommendation showed that the absence of such a placard creates an unsafe condition on these model airplanes because the installed icing equipment results in pilots mistakenly believing that these airplanes are safely equipped for flight in icing conditions.

Subsequent to the receipt of this recommendation, the Central Region reviewed the following available related aircraft accident reports:

- NTSB Report - Airframe icing as a cause/factor - 1970-1973
- NTSB Report - Windshield icing as a cause/factor - 1970-1973
- FAA Report - Icing accidents involving Cessna 310, 340, and 400 series aircraft - 1973-1975
- NTSB Report - Briefs of accidents involving Cessna 310, 340, and 400 series aircraft which had airframe icing - 1964-1975
- FAA Report - Icing accidents involving Beech Twins - 1974, 1975, and 1976

Several of the above reports include the same time period; therefore, care was taken to see that the same accident listed in more than one report was evaluated only once. Our review showed that in a six-year period 194 accidents had occurred on 107 models of 15 different airplane manufacturers. The information available on each accident was also reviewed in an attempt to determine if a placard of the type required by CAR3.772/FAR 23.1559(b) could have helped to prevent these accidents. Results were as follows:

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Fifty-eight accidents were caused by improper preflight and the airplane crashed because take-off was attempted with snow, ice, or frost on the surfaces. A placard would not have had any effect on these accidents.

Thirty-nine reports contained information that showed circumstances that indicated that a placard probably would not have helped prevent the accident had it been installed or that the accident occurred on an airplane whose certification basis required such a placard under either CAR 3.772 or FAR 23.1559(b).

Ninety-seven reports contained information that showed had a placard been installed to advise the pilot of the airplanes operating limits, he may have avoided the encountered icing conditions and prevented the accident from occurring. These reports included 66 models of seven different manufacturers. Twenty models of the 66 were single-engine aircraft.

The above discussed accident reports verify that there have been occurrences of the circumstances described in the safety recommendation and show that they are likely to occur on other airplanes. These reports also showed that these circumstances were not confined to Cessna airplanes and, therefore, it was not possible to single out this manufacturer's models for required corrective action, therefore, the recommendation was rejected.

Following our review of the accident reports we also reviewed other factors reported to be contributing to unsafe operations in icing condition. The following are factors found to be contributing:

1. Approval of icing equipment with no evaluation of its ability to remove ice under various conditions.

It has been FAA's practice to allowing ice protection equipment to be installed and approved on an airplane without substantiation that the equipment would function to protect that portion of the airplane on which it was installed. Under this type of approval the only substantiation made and verified by FAA is that the equipment will not adversely affect the operation of the airplane when it is used. This type of approval is allowed because it is felt that such equipment provides an additional level of safety for the airplane should inadvertent icing be encountered.

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2. Current practices of airplane manufacturers to have new models approved for icing flight.

This is resulting in airplanes of the same model being delivered, some of which are equipped and approved for icing flight while others are not. Many of these models, whose certification basis are prior to the requirements of CAR 3.772 do not have a placard to advise the pilot of the operating limits. This creates an environment where a pilot may examine one of the approved airplanes and observed the installed icing equipment that was readily obvious. At some time later he may have occasion to fly another airplane of the same model equipped with some icing equipment approved as discussed above. If his observations of those two airplanes showed that the same equipment was installed on both and the discussed placard is not installed he may easily assume that the second airplane is also approved for icing flight and a hazardous icing encounter could result.

3. Icing equipment identified by FAR 91.209(b)(2) and 135.85(b)(2) for VFR flight in light or moderate icing.

Although these requirements are applicable only to large and turbine powered multiengine airplanes operated under FAR 91 and air taxi operators of small airplanes, the list of icing equipment provided in these regulations is being accepted as that needed for flight in icing conditions. This is true regardless of the approval status of that equipment, i.e., whether its ability to remove ice was or was not substantiated.

Additional problems created by these rules that are contributing to the discussed confusion are (1) The interpretation of the word "functioning." To most engineers and technicians functioning means that the equipment operates. To our regional counsel, functioning means the equipment functions to remove ice. (2) They do not list all of the equipment that may be needed to protect an airplane for icing flight. Items such as fuel tank vents, engine indication systems, and approved antennas are not included. (3) There are no readily available definitions of "light to moderate icing conditions" terminology used and this terminology is not consistent with that used in the certification rules.

Despite the above cited problems that could result in an improperly protected airplane being operated in icing conditions, our regional counsel advises that these rules do in fact permit flight into icing conditions when the specified equipment is installed.

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C. AVAILABLE OPTIONS FOR A SOLUTION

Option 1

Do nothing.

Option 2

Require all ice protection equipment to meet the airworthiness requirements of FAR 23.1419.

Option 3

Revise applicable airworthiness requirements to (1) require all aircraft equipped with ice protection equipment to include a placard of the type required by CAR 3.772/FAR 23.1559(b), and (2) revise FAR 91.209 and FAR 135.85 by expanding the list of protection equipment required to identify all the items needed for icing conditions as defined in the other icing regulations and to make it clear that the listed equipment must have been substantiated by showing that it will remove ice from the part of the airplane it protects.

D. ANALYSIS OF OPTIONS

Option C1

The existing regulations and procedures for approving ice protection equipment has created the conditions discussed. Continuing to make approvals with these requirements will result in more confusion and hazardous icing encounters.

Option C2

Tests needed to show compliance with these requirements are costly, therefore, there would be less equipment installed to provide protection for inadvertent icing encounter. Accordingly, this procedure could result in a reduction of the overall safety level of the general aviation fleet.

Option C3

Approvals could continue to be made as they have been. Placard information would be required that would readily advise the pilot of the airplanes operating capabilities with the equipment installed. Changes to the operating rules would make those requirements consistent with certification

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requirements. Wordage change would correct areas currently contributing to confusion regarding the protection needed for flight in icing conditions.

E. RECOMMENDATION

Option 3 is recommended. These changes will correct the areas of confusion that is currently exist. Because of the time needed to accomplish rulemaking action it is further recommended that immediate action be taken to issue an Advisory Circular that will provide information on icing approvals and equipment needed for flight in icing conditions.

AGENDA ITEM 27  
RNAV AUTO-TUNING

PROBLEM

The problem centers about the capability of some systems to auto-tune, especially in the approach mode. Some systems can automatically tune stations, most especially DME stations which are not those on which the approach is predicated.

DISCUSSION

Jim Treacy, ANW-213, spoke about Northwest Region experience.

"The installation I'll refer to is a Carousel 4 or 4A area navigation system. The Carousel is a well-known inertial navigation system and what they've done is update it with DME to create an area navigation system. With respect to enroute and terminals, it's not a big problem. We're dealing primarily with the approach mode. The CDU is on the pedestal and there is an alert light which is inhibited in the terminal area. The DME updating is accomplished by manual crew tuning of the VHF navigation receivers.

"The first of six areas we objected to was an operational procedure that, in order to meet the approach accuracy requirements of AC 90-45A, required that the crew manually tune on the second VHF navigation receiver a DME station at least 15 miles to the side of the final approach course. That was the only geometry consideration given - a DME station at least 15 miles to the side of the approach course. We said that was unacceptable for two reasons: (1) there was no geometry consideration as to the relative angles of this station, and (2) there was no maximum limit. We didn't even understand why the 15 miles was considered a minimum limit, and there also may be many airports at which no DME station is suitably located to provide the cross-track control necessary to meet the approach accuracy standards of 90-45A.

"The second thing we found wrong was that the system as presented does not provide positive indication of loss of inputs; either DME input or VHF receiver. It had a light somewhere, I'm not sure where, that said, 'yes, you've got a signal,' but it obviously was not placed next to the ADI or in prime real estate where it would catch your attention, and we do not feel that the logic is appropriate from a human factor standpoint. A light going out should not tell you of a loss of a navigation signal required to maintain your accuracy.

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"The third item we objected to was that the system does not provide positive indication of way-point passage. As a matter of fact, it provides positive indication that you're 42 seconds short of the way-point, because that's when it shifts gears to the next one. In the case of an approach, the missed approach point, which is classed as a way-point, is not annunciated; it shifts gears to some point beyond the missed approach way-point 42 seconds before you get there. Not only that, but in the case of a missed approach procedure involving a turn to be initiated at the missed approach way-point, you're stuck; 42 seconds before you get to that point, it shifts gears and starts a turn for you.

"The fourth thing we didn't care for was that the system provides only true heading information on the HSI, even in the approach mode, and we believe that true heading information, although appropriate for the enroute mode, is totally inappropriate in an area where all approach plates and all terminal maps, etc. are expressed in magnetic.

"The fifth area of concern I've already mentioned. It has to do with the fact that you couldn't really program a missed approach procedure unless it happened to be a straight-ahead missed approach procedure.

"The sixth area was that the system should permit programming of holding procedures at way-points, but due to programming, once again, you can't get there if the system shifts gears 42 seconds too soon.

"I'm open at this point for questions if you have any areas you'd like to comment on."

An inquiry from the audience:

"Regarding the light location you weren't sure of - I think it's on the instrument panel and merely says "update," and it comes on when there's update information being received. As you said, when update is not being received, it simply goes out."

Response:

"It's a single update light which means you may be receiving either one or two update sources; but when it goes out, that means you're not getting anything."

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Jim Treacy:

"Dual DME for approach is a tricky problem, I must admit, but the Carousel 4A was the first one and we've probably learned a few things from it. Let me review it. The dual updating, or the station location, is something maybe not that critical, if you have an INS system. The only thing you have to do to get good accuracy is to have a station such that it's offset somewhere to give you a correction for cross-track error, and one that's along track to give you update for along track error. But if you have these stations tuned initially, the drift of the INS system, even if you were to subsequently lose the updating information. It really isn't that critical because the INS system accuracy itself is such that it could probably carry you along, although I admit that the words we have in the manuals for the Boeing airplanes are "dual updating is required" and it says nothing about continuing approach if you lose it. At one time they proposed updating with a single source, but we had the problem of how do you know that you've corrected the cross-track errors. There's no way to do it. In the terminal areas, if you have a station 15 miles offset, that should be more than adequate to correct any cross-track errors that have built up due to drift, and it may even be possible to continue with no updating from some point in the approach, but we had no way of specifying that.

"Let me comment for just a second. It might help clarify the picture. If you postulate a DME facility that's located at the field, or a little beyond it, or something more or less in line with the runway, and a straight-in approach typical of the way you go into Los Angeles, for example, where they've got you nose-to-tail from the Colorado River straight in to the runway, you have no cross-track guidance coming from that DME. That kind of approach provides no cross-track improvement, no updating to the INS at all. All it does is improve your along track. This is the kind of problem we had. If, on the other hand, you've got yourself a 180, a box pattern that you have to go through in order to land, you're probably very adequately updated in the process of flying that pattern.

"All we can say is that the procedure is there to tune the station and to receive it for the approach case, and if you can't do it, you shouldn't make the approach. But that's a little late for the guy to say 'hey, I can't make that approach.'"

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**RNAV Auto-Tuning**

**Comments from the audience:**

"The problem is that the RNAV procedure plates only have one station associated with it, so when you say two stations are required, it's putting a burden on the pilot to see if there is another one he can get."

"It was thought to be acceptable to have the green lights to verify that you have updating, because the loss of updating, once you've had the stations tuned and operating correctly, is not significant; however, the Carousel installations do have dual lights and they are on both the pilot's and the first officer's panel. I believe they're somewhere in the neighborhood of the HSI, either low and to the right or to the left, and there is one for each radio tuned for each system. There's a total of four lights. I agree that if you didn't have INS, these would have to be amber lights; a green light would not be appropriate. For the positive indication of way-point passage, I thought you could have a manual way-point position such that it doesn't switch to the next leg until you switch it."

Jim Treacy:

"I thought so, too, but I'm told that is not the case."

Comment from the audience:

"That's strange; most of the INS systems work that way. This must be a recent revision because I haven't seen one that works that way; but I would agree that you've got to have a positive indication of way-point passage for the approach, otherwise it's unsatisfactory."

Jim Treacy:

"This is a problem that's been seen not only on this system, but on some others, too. In the write-up I've attempted for the INS, I've said turn anticipation must be defeated for the missed approach way-point. You can't start a turn before you get to the missed approach way-point. There's a simple way to defeat this by procedure. You can put a way-point on the departure end of the runway and thereby need only a very short interval just to say it's look through to the next one, it's straight ahead, so go ahead, and I don't think you'll seriously violate any air space restrictions if it's located at the opposite end of

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the runway. That's one solution. I think we've looked at that on the TERN 100. They had the same problem - starting the turn before you got there. But you certainly have to have some way of positively identifying the missed approach point, and if the system doesn't do it, there's a problem.

"I don't think there should be any anticipation before you get to the missed approach point. There should be turn anticipation before other way-points, but you should have some way of defeating it for that particular one."

"Regarding true heading information, you've got to have mag, you can't fly true heading on the approach. The airplanes we've seen have a true/mag switch and you can still present RNAV information on either one.

"Regarding holding at the way-point, there again, it's the shift. I think you have to be able to demonstrate a hold; not necessarily that the computer will program your holding pattern, but I think it has to hold that way-point so that you can keep running around on it.

"You can't ever say that an RNAV system is going to give you approach minimums less than the VOR/DME. If you have a straight-in VOR/DME and a straight-in RNAV, straight-in RNAV is going to have equal or higher minimums. The only real benefit from RNAV is that it gives you a straight-in approach where you might have to have a circling approach otherwise.

"RNAV will give you a reduced minimum if it's a difference between a circling VOR and a straight-in RNAV.

"Also, for a beacon approach, air space protection is less than what is necessary for an RNAV approach.

"The main reason for this update function is that the airplane may have just completed an eight or ten hour flight without any update, so you want to give it the best chance. You can update it enroute, but we want to make sure that by the time you're in the terminal area, you are updated.

"I suppose there's one other thing - the way this draft is worded, the approach, as far as an RNAV system is concerned, is only that part of the approach from the final approach fix to the missed approach point, because all of the other maneuvers, even up to the final approach fix, are ruled to be

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in the terminal area which is acceptable using one DME. I don't know exactly what would happen if you looked at what DME stations you can receive when you're at a typical final approach fix altitude. Since you're rather low, you may not be able to find a station that's really far enough away and still get a signal.

"And still another problem with saying 'have an update' is the workload on the pilot to determine 'how long ago was it that I had an appropriate update.'"

CONCLUSION

First, the pilot must be able to manually change the tuning of airborne equipment when he knows it is improperly tuned. Second, the stations assigned by the approach plate must be tuned; secondary stations may be tuned, in addition, if they improve accuracy.

In addition, it was concluded that the pilot should not be allowed to continue an approach using an unapproved station after the assigned station goes off. It was explained that DMEs are not evaluated for coverage on approach when that DME station is not approved for that approach. It was emphasized that DERs and FAA, alike, should be aware of the limitations of stations which are not flight checked for the operation being considered, i.e., stations are not necessarily reliable unless flight checked for an approved approach operation.

AGENDA ITEM 28  
OPTIONAL EQUIPMENT POLICY

PROBLEM

This item was introduced to present and discuss FAA policy.

DISCUSSION & CONCLUSION

Copies of a letter from GC-20 to AFS-100 on this subject, dated June 19, 1972, were distributed. It was pointed out that this legal opinion reminds Engineering that we have the authority to evaluate all installations on aircraft to assure that they perform their intended function(s) and, indeed, FAA has the responsibility to assure that there is no unsafe condition, which inherently implies that the operational characteristics of the installation must be evaluated. There was general agreement with the intent of the letter and it was noted that some FAA field approvals which do not evaluate for performance of intended function could be contrary to the intent of it. It appears that FAA Washington should generate guidance to the various maintenance organizations regarding this need for approval and for evaluation of all installations. In addition, Order 8110.10B, 21 September 1977, was mentioned and AFS-130 will attempt to assure that all DERs obtain copies of this Order.

The need for a definition of the phrase 'intended function' was expressed. The response was: the key to this definition is the information provided to the crew regarding the operation of the installation and any limitations placed on operations as a result of the use of the equipment. There is a wide variation in the generation of a defined intended function because there is a wide variation in the types of aircraft and in the types of equipment installed. There can be no hard and fast definition and we expect there will be variations in application in the field. Over a period of time, it is hoped that the variations will settle down to a certain consistency and AFS-130 will develop and provide guidance in this respect when we are able to determine what should be put out on it.

Although there is some concern about the disclosure of proprietary information, it was pointed out that FAA will be unable to approve any installation for which adequate data is not available. FAA will treat proprietary information as proprietary and the applicant is afforded a degree of protection in this regard by the Freedom of Information Act. It was mentioned that the designation of confidential or proprietary information must be provided to the FAA in writing

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by the applicant to receive the full protection intended by the Freedom of Information Act.

The discussion of optional equipment is understood to be limited to equipment and installations which are safety related. This is made clear in the General Counsel letter on page 4, which also specifically states that the extent of evaluation is a technical determination within the engineering and operational expertise of the Administrator. It was also determined that in those cases where FAA standards of performance for a type of installation do exist, those FAA standards of performance should be used in evaluating the installation; however, those FAA standards may be adjusted to fit the particular installation, since the standards may conceivably have been originated for a considerably different type of installation.

ATTACHMENTS

1. GC-20 ltr to FS-100, 19 June 1972

Subj: Optional Equipment Approvals

Since 1969, various correspondence has circulated among FS-100, FS-40, and GC-20 concerning optional equipment approvals. This is in response to your letter of 16 November 1971 requesting to be advised in regard to questions you had earlier raised. Because of the nature of the subject, the continuing discussions and some difference of opinions between various FS offices, and the relative priorities accorded other projects, it has not been found timely for this office to give a written opinion with regard to the problem heretofore.

Your earlier correspondence of 7 January 1970, 1 August 1969, and 17 June 1969 cited several instances which you believed raised questions involving optional equipment. In that connection, we understood your questions to be essentially these:

1. Whether existing rules provide a legal basis for evaluating optional equipment?
2. What is the FAA responsibility for approving optional equipment?

As a working definition, based on your use of the term, "optional equipment" is taken to mean that equipment, system, or installation not required by regulation for type certification, but installed on an aircraft and included in the type design and listed on the certificate data sheet at the

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time of the aircraft type (or supplemental type or amended type) certification.

The first situation set forth in the letters which raises the question of the legal adequacy of airworthiness rules to cover optional equipment, involved the Boeing 707 accident at Elmendorf in which the takeoff monitor sensor switch was not set to function at the low temperature there encountered. Relying on the takeoff monitor, the pilot was not warned that flaps were improperly positioned. The takeoff monitor warning system was not installed in the airplane to meet any regulatory requirement. The system had been only partially evaluated, and, at the time of accident, pilots were not provided information on the system temperature limitation.

The Aircraft Engineering Division, Western Region (WE-100), in the light of the Elmendorf accident, questioned the applicability of the function and installation requirements to optional equipment and concluded that the regulations did not contain requirements for the normal operation of non-required systems and equipment. This view stemmed from the language in CAR 4b.600 which referred to "required basic equipment as prescribed in this subpart" and from which WE-100 read the following section, 4b.601 (and its recodified version, FAR § 25.1301), as applicable only to basic required equipment. However, § 4b.601 is by its own terms applicable to "each item of equipment" and § 25.1301 to "each item of installed equipment." Therefore, contrary to the WE-100 understanding, the provisions of § 4b.601 and § 25.1301, pertaining to normal operation, apply to each item of installed equipment whether required or optional.

In addition to the regulatory basis for evaluating normal operations, a subsidiary question was raised as to the adequacy of the standards in requiring prevention of hazards to the airplane from malfunctioning or failed optional equipment systems. While you did not doubt the applicability of § 25.1309(b) to optional equipment at the time of your question, the extent of that applicability was evidently not clear since the rule did not differentiate degrees of hazard or distinguish between low and high reliability (redundant) systems. However, subsequent to your inquiry, § 25.1309 was amended (Amdt. 25-23, effective May 8, 1970) to distinguish and provide standards for major failure and catastrophic failure conditions and to list the analytical considerations appropriate to such failure conditions. Since the revised

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¶ 25.1309(b) has not been questioned, we assume Amendment 25-23 resolved any vagueness which may have caused the earlier concern.

The correspondence of both FS-40 and FS-100 indicate their belief that the present rules are adequate for the FAA to evaluate optional equipment systems. In their letter of 7 September 1970 to GC-21, FS-40 has given an analysis of the applicable regulations under which field personnel could conduct a safety evaluation with subsequent acceptance (accompanied by suitable limitations) or disapproval of an optional equipment system. As pointed out by FS-40, these regulations could have been applied to the original 707 takeoff monitor system under any one of a number of regulatory options which either would have disapproved the system outright because it was unsafe or not of a kind and design appropriate to its intended function, or approved it with suitable operating temperature limitations or with adequate information in the AFM as to its temperature peculiarities. Resort to any one of these options would have resulted in an evaluation whose end result should have ensured safe operations. We concur in the FS-40 analysis.

In our opinion the present regulations are legally adequate to provide a basis for evaluating optional equipment systems in connection with type certification programs with respect to both normal operation and to hazard conditions following failure or malfunction. Whether or not a rule change would clarify this applicability, as suggested by FS-40, is a matter on which we believe Flight Standards should make an initial recommendation.

A wholly different problem is presented in the inertial navigation system (INS) situation. Here the inquiry does not concern approval of optional equipment, as such, but rather questions whether a back-up long range navigation system is required in the first place. Presumably if not required, the duplicate navigational equipment would not be installed in the interest of cost and weight reduction and, therefore, no optional equipment is involved.

At the time your inquiry was made (prior to Amendment 25-23), ¶ 25.1309(b) stated a very general requirement that systems be designed to prevent hazards to the airplane if they malfunction or fail. However, since the failure of any system could involve some degree of hazard, a strict application of that rule (to require duplicate systems in every case) could have led to burdensome and absurd results. Under Amendment

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25-23, on the other hand, § 25.1309(b) requires, in effect, that systems be designed so that catastrophic failures are extremely improbable and major failures improbable, and § 25.1309(d) requires that failure conditions be subjected to analyses and tests. As explained in Notice 68-18, the intent of the Amendment was to minimize critical aircraft systems failures by providing sufficient reliability or redundancy. Moreover, a comprehensive systematic failure analysis was stated to be necessary to insure that the safety objectives are met. Section 25.1309 thus sets forth a standard which does not require duplicate equipment for attainment.

The current § 25.1309 standard is flexible and objective and it is entirely possible that, under it, one single installed INS could be technically evaluated as meeting the criteria while another INS in another airplane would not. In the latter case it is conceivable, and allowable under the regulation, for a technical evaluation to conclude that a back-up system could provide redundancy to compensate for any lack of reliability in the single INS so that the combined installation meets the safety standard. The present Part 25 standards require two systems for radio navigation, but do not specify two long-range navigation systems. However, in other situations where duplicate equipment is required, the regulations are specific in that regard (e.g., for airworthiness as in § 25.1307(b) and (d) and for operational requirements as in §§ 121.305(j) and 121.349(a)). Therefore, in view of the foregoing and the burden that duplication of equipment places on regulated persons, in our opinion the current airworthiness standards do not per se require back-up long-range navigation equipment as a condition for approval.

As pointed out by FS-40 in their 4 September 1970 letter, requirements for a navigation system are dependent on a particular route or area of operation. Accordingly, should a rulemaking project be considered to require a back-up long-range navigation system, it would seem appropriate that such requirements as are determined necessary for safe operation be made part of the operating rules.

Your second question, concerning FAA responsibility for approving optional equipment, asks in effect whether the FAA is required to evaluate optional equipment. Type certification involving the equipment approvals with which you are concerned is governed by Section 603 of the Federal Aviation Act of 1958. That section conditions the issuance of type certificates by requiring the Administrator: (1) to make, or require the TC applicant to make, such tests as he "deems reasonably

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necessary in the interest of safety" including tests of "any part or appurtenance of such aircraft," and (2) to make a finding that the aircraft "is of proper design, material, specification, construction, and performance for safe operation and meets the minimum standards, rules, and regulations prescribed." "Optional equipment," however, is not a term that is meaningful under the Act in connection with the type certification of any given aircraft. Where an equipment or system is a "part or appurtenance" of the aircraft, and is designed to aid and will obviously be used by the crew, as for example the Boeing takeoff monitor, the statutorily required tests and findings must necessarily account for that equipment whether or not it is characterized as "optional." Moreover, the statutory requirement is implemented in § 21.21(b)(2) under which the Administrator must find that no feature or characteristic of the aircraft makes it unsafe for the category in which certification is requested. In complying, therefore, the extent to which that equipment must be tested or evaluated, in order that the Administrator may make the necessary finding with respect to the whole aircraft, is a technical determination within the engineering and operational expertise of the Administrator. In the case of the Boeing takeoff monitor, the scope of subsequent remedial actions would suggest that the earlier statutory and regulatory findings required of the Administrator (assuming they were made) rested on an insufficient technical basis.

In further connection with FAA's responsibility, your letter of 17 June 1969 raised questions with regard to the "liability" and the "moral obligation" of the FAA with respect to "optional equipment." If after reviewing this letter you believe that a discussion of these items or of any further aspect of this problem would be helpful, please do not hesitate to contact us.

/s/ WILLIAM P. CRANDELL  
Acting Associate General Counsel  
Regulations & Codification Division

2. Order No. 8110.10B, September 21, 1977

Subj: FAA Approvals of Major Modifications/Alterations

1. PURPOSE. This order emphasizes that the appropriate Flight Standards engineering elements must approve design/technical data for major modifications/alterations which are identified in paragraph 5.a. of this order.

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Optional Equipment Policy

2. DISTRIBUTION. This order is distributed to the branch level and above in the Flight Standards organizations in Washington; to the section level and above in Flight Standards offices in the regions and the Aeronautical Center; to the branch level in all area offices; to all Engineering and Manufacturing District Offices (including AEDOs); to all Flight Standards District Offices; to all General Aviation District Offices; to all Air Carrier District Offices; and International Field Offices.

3. CANCELLATION. This Order cancels Order 8110.10A dated June 20, 1977, and Notice 8110.29 (GENOT 7/126) dated August 2, 1977.

4. BACKGROUND. FAA has been criticized for the lack of uniformity in methods employed to approve major modifications/alterations. EMDOs/AEDOs require the applicant to furnish FAA engineering approved data, while other field offices have been "spot-approving" major modifications/alterations beyond the guidelines contained in Order 8310.4A. FAA engineering approval for design/technical data, which will be used to approve major modifications/alterations, is essential since this function is normally beyond the FAA inspector's scope of expertise. "Spot-approvals" have also resulted in design compatibility problems, since it is extremely difficult for the field inspector to determine compatibility with previously approved major modifications/alterations.

5. ACTION.

a. FAA engineering approval must be obtained for design/technical data used to approve major modifications/alterations which are identified in FAR 43, Appendix A, paragraph (a), and Order 8310.4A, Section 3, paragraph 68. These design approvals must be issued in the form of a Supplemental Type Certificate (single or multiple) or an amendment to the Type Certificate, as provided for in FAR 21, Subpart E.

b. The major modification/alteration must conform to the FAA engineering approved data.

c. The major modification/alteration must be coordinated with FAA Flight Test when flight characteristics could be affected.

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d. This order does not apply to temporary installations/  
overweight operations authorized under the provisions of  
FAR 21.197.

/s/ J. A. FERRARESE  
Acting Director  
Flight Standards Service

## AGENDA ITEM 29

### DER TRAINING

#### PROBLEM

DERs are working on projects which involve safety analyses and reliability and probability computations, and may not be proficient in those subjects.

#### DISCUSSION

Southwest Region presented a position paper on the subject and FAA Washington stated the opinion that DERs are basically responsible for maintaining proficiency and for learning new techniques as necessary. The regions and the DERs agreed, but expressed a need for appropriate training to be made available for DERs at their own expense.

#### CONCLUSION

AFS-130 will investigate the possibility that the Reliability Training Course at McDonnell Douglas, Long Beach, can be attended by DERs, or that similar training can be developed for DERs at the FAA Academy.

#### ATTACHMENT

##### Southwest Region Position Paper

Subj: Probability Training for DERs

Problem: DERs are working on projects requiring use of probability studies. As was true of FAA engineers, most of them lack expertise in this field.

Background: With the advent of 25.1309 several years ago, an enlarged problem of regulatory administration arrived. The FAA recognized the inadequacies of some of its engineers and provided a mandatory training course in probability and its associated arts. At the inception of this training, the subject of providing the opportunity for DERs to obtain such training was discussed, but no decision has been made.

#### Discussion

At least two regions are presently engaged in projects requiring compliance with FAR 25.1309, Amendment 25-23. The companies that employ thousands of engineers are well equipped to provide inhouse probability training. Unfortunately, the projects that are here spoken of are being accomplished by companies engaging, by comparison, only a handful of engineers,

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DER Training

only three or four of which are DERs.

The FAA may now either be concerned with the DER training or we can take the position that it's not our responsibility to train DERs. An added problem is that some of the DERs in question in one of the projects are consultant DERs and thus have even less self training capability.

Our DERs by definition have been out of engineering school for many years. We all recognize that probability/statistical courses in our degree programs of 15, 20, or 30 years ago were very minimal.

Options: The following are some of our options:

1. Take the position that training such as this for DERs is no concern of the FAA, and drop the matter.
2. Require all FAR 25 DERs to have demonstrated probability capability or limit their designation to pre 1970 FAR 25 certification bases.
3. Provide opportunity for probability training (i.e., Douglas course) for DERs and require either completion of that course, demonstration of equivalent completion elsewhere, or withdraw designation.

Discussion of Options

1. We can hide our heads in the sand and ignore the training of DERs in this expertise. This will result in either erroneous approvals of DERs or (hopefully) FAA engineers making the complete approvals resulting in greatly increased workloads and time consumption. Most regions already have more than they can handle and do not need this large increase in work. This will also result in an increased delay in handling of other projects.
2. Requiring of DERs to have had probability training sounds very good. However, we know that self training in this area is very difficult to come by due to cost and time, not to mention the fact that it may not even exist. The FAA found that universities just did not have the capability we needed for proper training. If we limit their designations we are back to the same problems of Option 1 above.
3. It may well be that some DERs would not take advantage of training (at their cost) if the opportunity were provided.

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I believe that many would take advantage of the training. The time to withdraw or severely limit designations is when opportunity is given and disregarded.

Recommendations: The FAA should make the necessary arrangements to permit DERs to attend a course such as the Douglas course. The financial arrangements would have to be made within the constraints of the law and policy. If such arrangements are made, DERs should be required to complete the course (or a satisfactory alternate) or their designation limited to pre 1970 certification bases.

AGENDA ITEM 30  
CESSNA 650/FAR 25.1309

PROBLEM

Information item.

DISCUSSION

Bob Klapprott of the FAA Wichita office and Bill Ackerman of the Cessna Company had prepared a presentation regarding the plans Cessna has made for showing compliance with FAR 25.1309. Neither Cessna nor FAA expects to have great problems in complying with the rule or with the draft advisory circular. The general approach of a failure modes and effects analysis, with subsequent classification of the failure conditions, the design review, systems and flight testing, and consideration of service experience were all described.

CONCLUSION

This presentation was made to workshop personnel because the Cessna 650 is the first U.S. transport category aircraft to be certificated completely under FAR 25, Amendment 23.

ATTACHMENTS

1. Central Region Paper

Subj: The Cessna Model 650 and FAR 25.1309

The Cessna Aircraft Company is presently designing and preparing to fabricate a prototype bizjet that will be certificated to the current FAR 25.1309 reliability/probability requirements. First flight of the prototype is planned for early 1979. Certification is scheduled for sometime in 1980. Because of the early stages of the program system designs have not been frozen; therefore, it is not possible to outline a definite plan whereby compliance with 25.1309 will be shown. However, the following tentative plan has been proposed by Cessna.

Design Review

Failure Mode & Effects Analysis (Single Failure Conditions)

Classification of Failures - Single and Multiple

Probable  
Improbable  
Extremely Improbable

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**Cessna 650/FAR 25.1309**

**Rational Analysis - Used to Determine Failure Analysis  
Methods**

**Analysis Criteria**

**All Probable Failure Analyzed by:**

Design Review  
FMEA

**Improbable Failures Analyzed by:**

Design Review  
FMEA  
Systems Test Data - Where Applicable  
Service Experience - Where Applicable

**Extremely Improbable Failures**

Design Review  
FMEA  
Systems Test Data - Where Applicable  
Service Experience - Where Applicable  
Numerical Analysis May be Used Where:

A New & Unique Design Is Used and Can Be  
Applied to the Design Reasonably

Flight Crew Errors Will Not Be Considered in Cases  
Where A Failure Condition Is Announced.

Cessna plans on performing an absolute minimum amount of  
probability analysis. They will rely heavily on FMEA work to  
show compliance with 25.1309. Also, they plan using proven  
analysis techniques when analysis is required (they will not  
"plow new ground").

A copy of Cessna's tentative probability compliance program  
is attached.

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Cessna 650/FAR 25.1309

2. Cessna Paper

Subj: Systems Reliability, 8 June 1977

FAA Requirements for System Reliability  
Status of Means of Compliance  
Tentative Cessna Compliance Proposal

FAA Requirement for Systems Reliability  
Amendment 23 to FAR 25 Effective 8 May 1970  
Basis for Systems Reliability Requirements  
Systems Affected

Flight Controls	25.671
Stab Aug & Power Controls	25.672
Powerplant	25.901(c)
Equipment Systems & Installation	25.1309
Hydraulic Systems	25.1435

Flight Control Systems 25.671

Ease and Smoothness of Operation  
Minimize Probability of Incorrect Assembly  
Safe Flight and Landing after Control System Jamming, Any  
Single Failure, or Combination of Failures

Stability Augmentation Automatic and Powered Systems 25.672

Requires Same Basic Failure Protection as 25.672

Propulsion Systems Reliability Requirement

The Powerplant Installation Must Comply Per Paragraph 25.901(c)  
Which Requires Compliance to 25.1309

Analysis  
Appropriate Testing Where Necessary

Powerplant Installation Definition Includes:

Components Necessary for Propulsion (The Engine is  
Considered One Component)

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Cessna 650/25.1309

Components That Affect Control of Major Propulsive Units  
Components That Affect Safety of Major Propulsive Units  
Between Normal Inspections or Overhaul

Fuel System Requirements per 1309

The Fuel System is a Powerplant System That Must Meet The  
Requirements of 25.901(c) Which Requires Compliance To 25.1309

Analysis  
Appropriate Testing - Where Necessary

Ice Protection and Rain Removal Systems

Powerplant Induction System Ice Protection Provisions as  
Required by 25.901(c) Which Requires Compliance With 25.1309

Airframe Ice Protection As Required by 25.1309

Windshield Rain Removal as Required by 25.1309

Analysis  
Appropriate Testing - Where Necessary

Equipment, Systems, & Installation 25.1309

Design and Installation To Perform Intended Function

Failures Which Preclude Safe Flight and Landing Be Shown  
Extremely Improbable

Failures That Cause Reduced Airplane Capability or Occupant  
Injury Be Shown Improbable

Adequate Warning Information To The Crew To Unsafe Operating  
Conditions

Show Compliance By Analysis and By Tests Where Necessary

Environmental and Pressurization Systems

These Are Airplane Systems Defined by 25.1309

Analysis  
Appropriate Testing - Where Necessary

Hydraulic System Requirements With Respect To FAR Part 25.1309

Reference FAR Part 25.1435(b) (2)

Functional Testing

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Cessna 650/FAR 25.1309

Performance  
System Integration  
Failure Simulation

Endurance Testing

Simulated Typical Flights  
Evaluation of Environmental Effects

Analysis

Status of Means of Compliance

Amendment 23 to FAR 25 was Effective 8 May 1970

No New Airplane Type Certificate Has Been Awarded That Shows Compliance to Amendment 23

Proposed Advisory Circular 25.1309 Has Not Been Issued

Tentative Cessna Compliance Proposal Criteria

Cessna Tentative Position Is To Comply With the Intent of Amendment 23

The Cessna Proposal Is Based On A Review Of The Requirements of FAR 25, Without Additional Compliance Material.

The Tentative Cessna Position Is Based on the Use of Proven, Accepted Means of Analysis, Being Used on Systems For Which These Analyses Are Applicable

Periodic FAA-Cessna Status Reviews

Tentative Cessna Compliance Proposal

Design Review

Failure Mode & Effects Analysis (Single Failure Conditions)

Classification of Failures - Single & Multiple

Probable  
Improbable  
Extremely Improbable

Rational Analysis - Used to Determine Failure Analysis Methods

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Cessna 650/FAR 25.1309

Analysis Criteria

All Probable Failures Analyzed By:

Design Review  
FMEA

Improbable Failures Analyzed By:

Design Review  
FMEA  
Systems Test Data - Where Applicable  
Service Experience - Where Applicable

Extremely Improbable Failures

Design Review  
FMEA  
Systems Test Data - Where Applicable  
Service Experience - Where Applicable  
Numerical Analysis May Be Used Where:

A New & Unique Design is Used and Can Be  
Applied to the Design Reasonably

Flight Crew Errors Will Not Be Considered in Cases  
Where A Failure Condition Is Announced.

AGENDA ITEM 31  
ADVISORY CIRCULAR (FAR 25.1309)

PROBLEM

Information item.

DISCUSSION

The intent of this advisory circular (reference Item 20) was reiterated, emphasizing that the probability analysis is intended to be an additional tool for the designer, and for FAA to use in making an engineering judgement regarding adequate reliability of any aircraft systems design. The design is to be reviewed relative to failure conditions and the consequences of failure conditions, and the primary means of evaluating these failure conditions will remain engineering judgement, but will be supported by a probability analysis where that is useful. This is expected to be in relatively few cases, and will permit the acceptance by FAA of certain systems designs which might otherwise be rejected.

In response to questions and further discussion of FAR 25.1309, it was pointed out that 25.1309 is intended to eventually apply to the entire aircraft. At the present time, however, it applies only to aircraft systems and installations. It was also pointed out that this encompasses more than subpart F, if we use the broad term of systems and installations, and it is intended to apply to those systems and installations contained in other subparts; however, again at the present time, the advisory circular in all the drafts has been keyed to subpart F. The new draft now in process will consider this particular point and will try to clarify those systems areas to which .1309 applies. It was further noted that where there are specific requirements in other paragraphs of the regulation, those (other) specific requirements apply in addition to FAR 25.1309; i.e., where the specific criteria is more severe, the more severe criteria must be met. The engine itself is not subject to .1309; instead, a recent revision of the regulations exempts the engine itself and includes provisions for protection of the aircraft and its systems from the effects of failure of the engine; i.e., the rotor burst condition is contained in a separate regulation.

CONCLUSION

No action required. Refer, also, to Agenda Item 20.

AGENDA ITEM 32  
ADVISORY CIRCULAR - MAINTENANCE

PROBLEM

Information item.

DISCUSSION

It was explained that we are not going to issue this advisory circular as previously drafted, and that we are not working actively on it at this time. After we have redrafted the advisory circular on design and probability analysis, we may be able to redraft the one on maintenance and put it out for comment.

The application of the concept to maintenance was discussed at some length and it was explained that it was intended to support the design evaluation relative to probability of failure with service experience; that the advisory circular on maintenance was intended to apply only in those cases where specific maintenance tests are required to be in compliance with the certification basis.

CONCLUSION

No action required.

## AGENDA ITEM 33

### FAR 23.1309

#### PROBLEM

There was expressed a very serious need for advisory material for the application of this regulation.

#### DISCUSSION

Letters from AFS-100 to the Central Region dated October 22, 1976 (reference Item 21) were discussed. These letters contain information useful to the DERs as well as to the regions, as they contain guidance pertaining to the application of FAR 23.1309.

The wording of FAR 23.1309 was adapted from CAR 4B, and the CAM 4B does include consideration of undetected failures and of those failures which occur as a consequence of the first failure. This is different from the concept of a single failure, and the Part 23 regulation does not make this clear. The intent in this regard should be made very clear in the advisory circular pertaining to 23.1309

#### CONCLUSION

AFS-130 will undertake the issuance of an advisory circular which will essentially be an embodiment of the CAM material from CAM 4B, with appropriate changes to adapt it to the wording of FAR 23.1309. The Great Lakes Region volunteered to provide some assistance on the development of this advisory circular and the group discussed topics which should be included in it. Among these are a definition of the term 'hazards;' examples of the types of hazards of interest; consideration of the fact that composites are growing in usage and there should be guidance regarding the effect of lightning strikes on the aircraft, especially on composites.

It was suggested that Andy Plumber might be able to provide some advice and assistance. There are also some companies now doing some research in the area of lightning strikes. AFS-130 will attempt to determine what is being done in this field and include in the advisory circular references as appropriate, and perhaps a bibliography of material that might be available. See, also, Agenda Item 21.

## AGENDA ITEM 34

### DER HANDBOOK

#### PROBLEM

The AFS-130 project to publish a DER Handbook was reviewed.

#### DISCUSSION

There was discussion of two recommendations regarding review and coordination. One was that copies be sent to certain DERs for review and comment to Washington; the second was that we issue the Handbook immediately for trial over a certain period of time, and include a discussion of the Handbook and its implementation as an agenda item for the 1978 Systems Workshop.

Further discussion regarding DER activities related to 337 approvals. AFS-130 will check the draft Handbook to assure that it permits DER approval of design for use by the FAA field office in returning an aircraft to service on a 337. A copy of that DER approval and a copy of the design data is then to be sent to the cognizant regional office for their records of DER activity and for whatever post-review they consider necessary.

Several other points were mentioned that should be considered in the Handbook. These included assuring that the serial number of the specific aircraft for which the 337 is being used is included on the design data and the DER approval form to prevent misuse of that approval on other aircraft; that the scope of the 337 approval is defined in the Handbook; and that the recent order regarding approval of major changes is either incorporated or referenced. DERs should also be cautioned to require submittal of all related data and they should indicate the scope of their approval. In addition, we should consider changing Order No. 8310 to delineate the limits of DERs and the use of DER approval by the field offices.

In conjunction with issuance of the DER Handbook, AFS-130 will assure that the revision to Handbook 8110.4, the chapter on DERs, is revised in consonance with the DER Handbook.

#### CONCLUSION

As a result of the discussions, it was decided that we will issue the Handbook as soon as possible and include it on the next Workshop Agenda.

AGENDA ITEM 35  
FAR 23 OXYGEN REQUIREMENTS

PROBLEM

FAR 23 requirements are more severe than FAR 25 requirements.

DISCUSSION

A position paper prepared by the Central Region was distributed in which they recommend that the Part 23 oxygen requirements be revised to agree with the Part 25 requirements because at the present time, Part 23 aircraft are being penalized by being required to carry more oxygen than would be necessary under Part 25 rules. Bill Trammel, who is a member of the SAE Oxygen Committee, explained that the Part 25 rules are expressed in terms of 'tracheal partial pressure,' and that this is a very difficult regulatory requirement in application. He and Ray Borowski explained that the Part 23 requirements were developed with the intent of being simple and practical, and that a related consideration was that the passenger capability to properly use the oxygen system varies between Part 23 aircraft and the typical transport operation in which cabin attendants are available to assist the passengers.

CONCLUSION

A Part 23 manufacturer may have the option of using the Part 25 oxygen requirements, including the flow rate, provided he also shows compliance with all other requirements in Part 25 which are related to the oxygen system as determined by the controlling region.

It was also mentioned that SAE has drafted a new standard on general aviation oxygen masks and FAA intends to reference this SAE standard in a new TSO.

ATTACHMENT

Central Region Position Paper

Subj: FAR 23 Oxygen Requirements

Problem: The minimum mass flow of supplemental oxygen specified in FAR 23.1443 is ambiguous, imposes an unnecessary burden on aircraft manufacturers, and does not allow for direct approval of TSO-C64 masks.

Agenda Item 35  
FAR 23 Oxygen Requirements

Discussion:

(1) FAR 23.1443 specifies a minimum oxygen flow rate, as a function of cabin altitude, for each occupant. No allowance is provided for mask inefficiencies, leakage due to poor fit of face piece, dilution of inspired oxygen, etc. Each of the foregoing can affect the tracheal oxygen partial pressure which is the only positive yardstick for measuring adequacy of supplemental oxygen. The regulation should be revised to specify tracheal oxygen partial pressure requirements at specified flow rates similar to present FAR 25.1443. This action will also allow the manufacturer to select high efficiency masks which will result in weight and cost savings because of a reduced volume system.

(2) FAR 23.1443 requires that oxygen flow rate to each occupant be not less than that defined by a straight line connecting the following points; 0.8 LPM @ 12,500 feet, 3.5 LPM @ 35,000 feet, and 4.2 LPM @ 40,000 feet. TSO-C64, "Passenger Oxygen Mask (Air Carrier Aircraft)," requires the mask to be capable of providing certain tracheal oxygen partial pressure when flowing sufficient oxygen to meet the required percentage oxygen. The TSO masks can provide the required tracheal pressures at flow rates much less than required by current 23.1443. Approving a TSO'd mask on the basis of an equivalent level of safety cannot be done because the lesser flow rates of the TSO mask are not "equivalent" to the regulation. The applicant is forced to show his mask/system provides the greater flow rates.

An example of the foregoing problem: Sierra passenger mask meets TSO-C64 and is marked accordingly with NAS 1179-05152031. The 05 signifies the mask will provide partial pressures at 0.5 LPM flow at 15,000 feet; 15 means 1.5 LPM at 25,000 feet; 20 signifies 2.0 LPM at 30,000 feet; and 31 means it will supply 3.1 LPM at 40,000 feet at the required tracheal pressures. Note that the flow rates do not meet the FAR 23.1443 flow rates; however, the mask is approved for air carrier passengers.

The regulation should be changed to agree with FAR 25.1443.

AGENDA ITEM 36  
FLIGHT ABOVE FL 410

PROBLEM

Information item.

DISCUSSION

The criteria for pressurization and oxygen originally contained in the Supersonic Transport Tentative Standards, known as the White Book, was used as a basis for development of special conditions for the Gates LearJet request for approval for operations at 51,000 feet.

CONCLUSION

AFS-130 will edit as necessary and reproduce the special conditions which would be appropriate for any aircraft flying at virtually any altitude. These edited special conditions are contained in this Workshop report.

ATTACHMENT

Special Conditions

Special Airframe Condition

1. Pressure Vessel Integrity

(a) The maximum extent of failure and pressure vessel opening that can be demonstrated to comply with Special Systems and Equipment Condition No. 3 must be determined. It must be demonstrated by crack propagation and fail safe testing that a larger opening or a more severe failure than demonstrated will not occur in normal operations.

(b) Inspection schedules and procedures must be established to assure that cracks and normal fuselage leak rates will not progress or pressurization system capability will not deteriorate to the extent that an unsafe condition could exist during normal operation.

(c) The pressure vessel structure, including doors and windows, must comply with § 25.365(d) using a factor of 1.67 in lieu of the 1.33 factor prescribed therein.

(d) In addition to the requirements of § 25.571, the loads prescribed in § 25.571(c) and this paragraph must be multiplied by a factor of 1.15 unless the dynamic effects of failure under static load are otherwise considered. In addition, the following apply as ultimate loading conditions:

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Flight Above FL 410

(1) The normal operating pressures combined with the expected external aerodynamic pressures must be applied simultaneously with the flight loading conditions specified in ¶ 25.571(c); and

(2) The combined pressures set forth in paragraph (1) of this paragraph multiplied by a factor of 1.67 must be applied to the pressurized cabin without any other load.

Special Systems and Equipment Conditions

1. Ventilation

In lieu of the requirements of ¶ 25.831(a), the following applies:

The ventilation system must be designed to provide a sufficient amount of uncontaminated air to enable the crewmembers to perform their duties without undue discomfort or fatigue and to provide reasonable passenger comfort during normal operating conditions and in the event of any minor failure of any system on the airplane which would adversely affect the cabin ventilating air. For normal operations, crewmembers and passengers must be provided with at least 10 cubic feet of fresh air per minute per person, or the equivalent in filtered recirculated air, based on the volume and composition at standard sea level conditions.

2. Air Conditioning

In addition to the requirements of §§ 25.831(b) through (e), cabin cooling systems must be designed to meet the following conditions during flight above 15,000 feet MSL:

(1) After any probable failure, the cabin temperature-time history may not exceed the values shown in Figure 1.

(2) After any failure which is not shown to be extremely improbable, the cabin temperature-time history may not exceed the values shown in Figure 2.

3. Pressurization

In addition to the requirements of ¶ 25.841 the following apply:

(a) The pressurization system must be capable of maintaining the following relationships between specific failure and cabin altitude-time histories for operations

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Flight Above FL 410

above 45,000 feet.

(1) The cabin altitude-time history may not exceed that shown in Figure 3 or Figure 4, as applicable, after each of the following:

(i) Any probable double failure in the pressurization system.

(ii) Any single failure in the pressurization system combined with the occurrence of a leak produced by a complete loss of a door seal element, or a fuselage leak through an opening having an effective area 2.0 times the effective area which produces the maximum permissible fuselage leak rate approved for normal operation, whichever produces a more severe leak.

(2) The cabin altitude-time history may not exceed that shown in Figure 5 or Figure 6, as applicable, after each of the following:

(i) The maximum pressure vessel opening resulting from crack propagation for a period encompassing two normal inspection intervals. The initial crack must be at least one-half the local panel width in length. Mid-panel cracks and cracks through skin-stringer and skin-frame combinations must be considered.

(ii) The pressure vessel opening resulting from probable damage, while under maximum operating cabin pressure differential, due to a tire burst, engine rotor burst, loss of antennas or stall warning vanes or any probable equipment failure.

(iii) Complete loss of thrust from all engines.

(b) In showing compliance with paragraph (a) of this Special Condition, it may be assumed that an emergency descent is made in accordance with an approved emergency procedure. In showing compliance with paragraph (a)(2) of this Special Condition, a 17 second crew recognition and reaction time must be applied between cabin altitude warning and the initiation of an emergency descent.

4. Oxygen Equipment and Supply

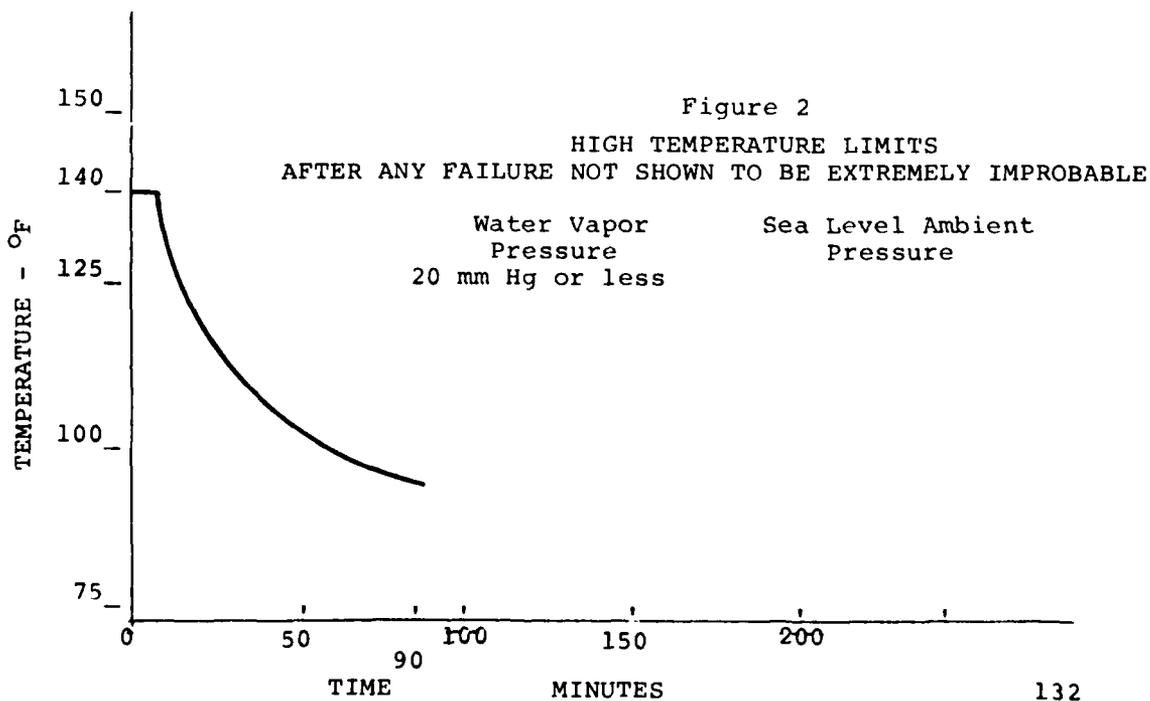
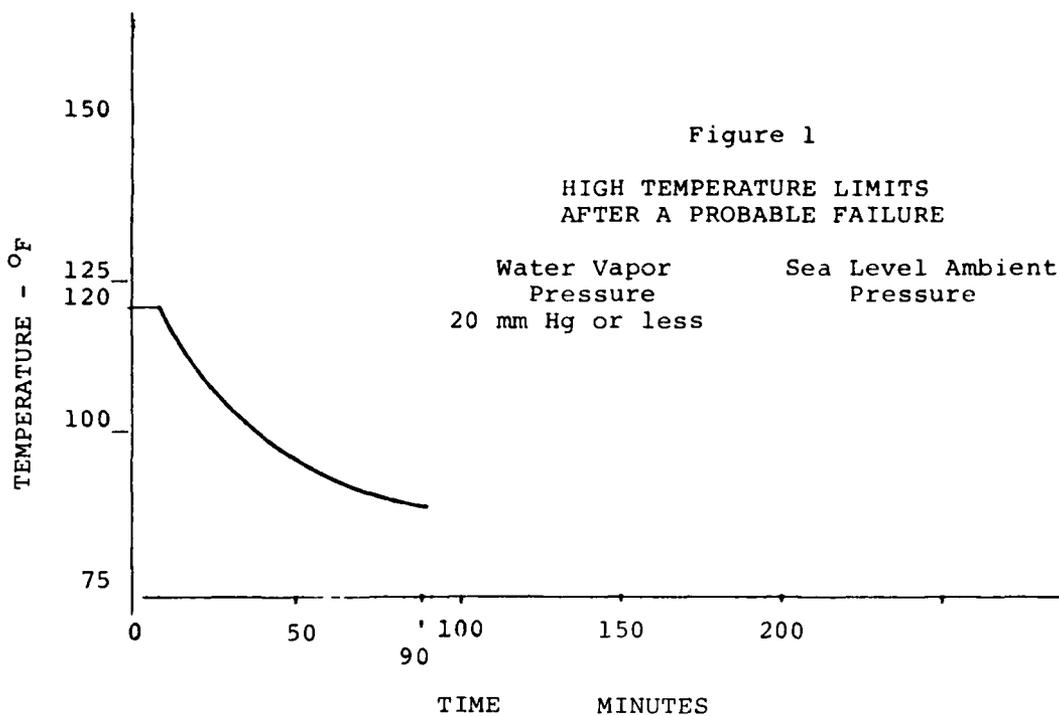
(a) A pressure demand oxygen system with quick donning masks must be provided for the flight crew. It must be

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Flight Above FL 410

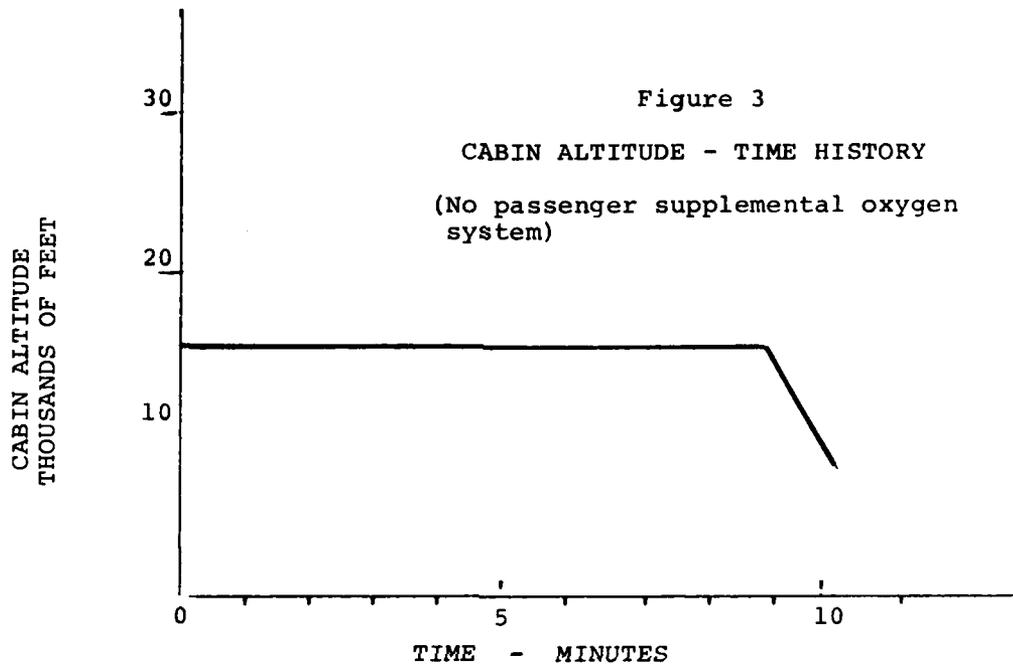
shown that each quick donning mask can, with one hand and within five seconds, be placed on the face from its ready position, properly secured, sealed, and supplying oxygen upon demand.

(b) A continuous flow oxygen system must be provided for the passengers.

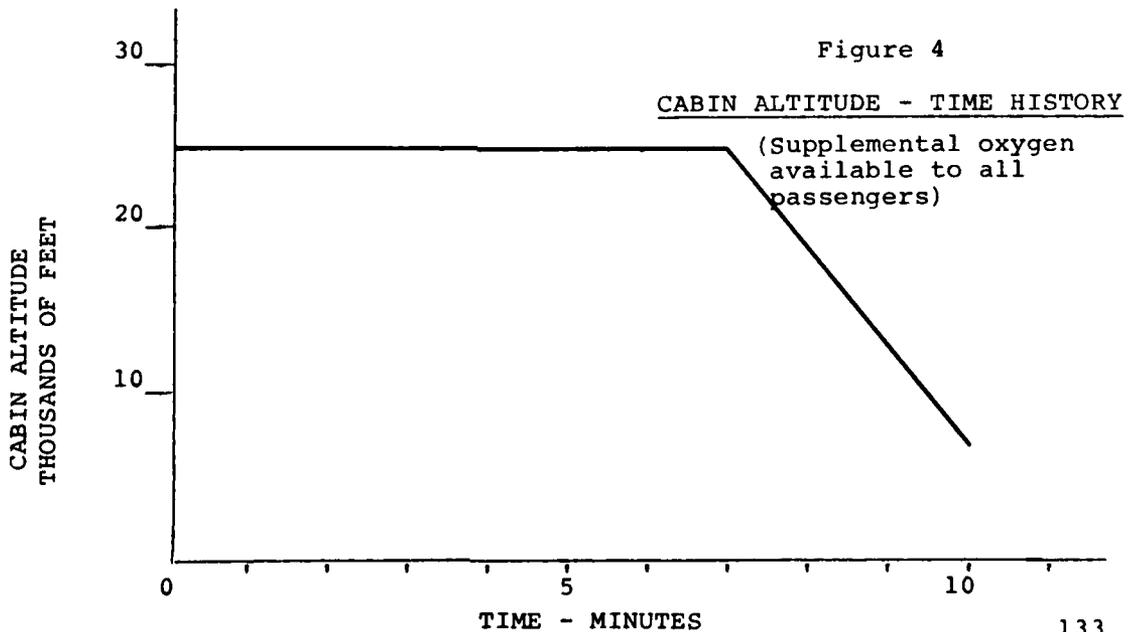
SPECIAL CONDITIONS  
FOR OPERATIONS ABOVE AN ALTITUDE OF 45,000 FEET



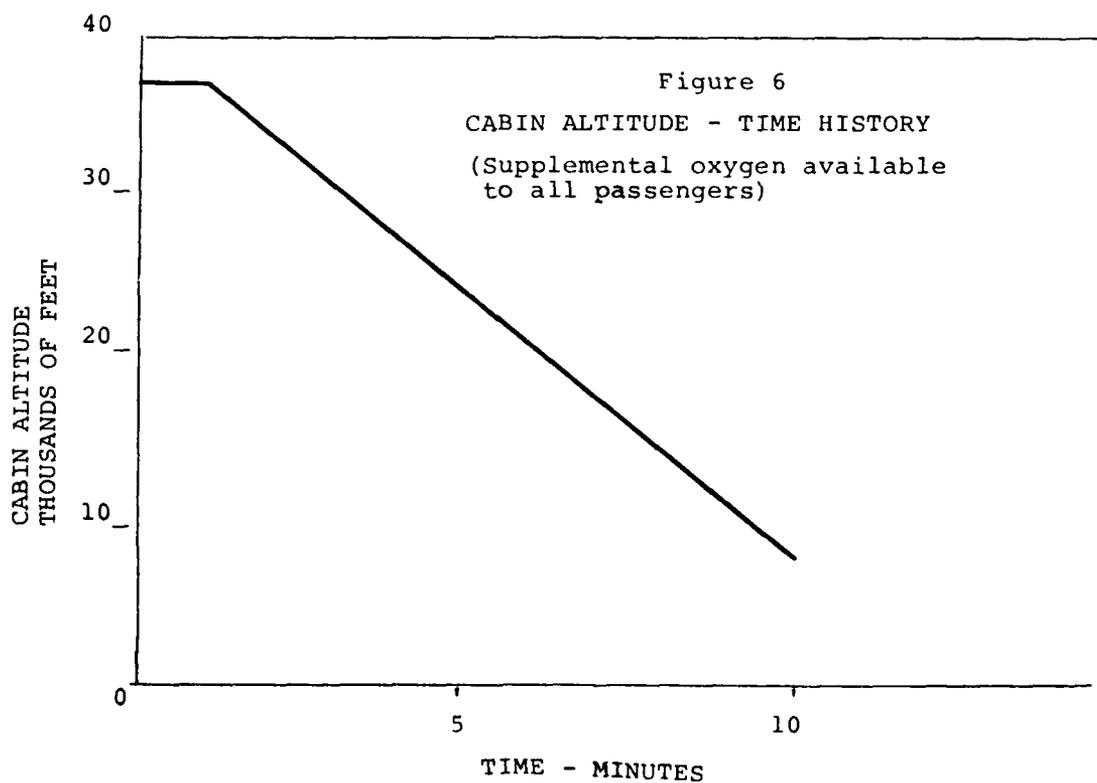
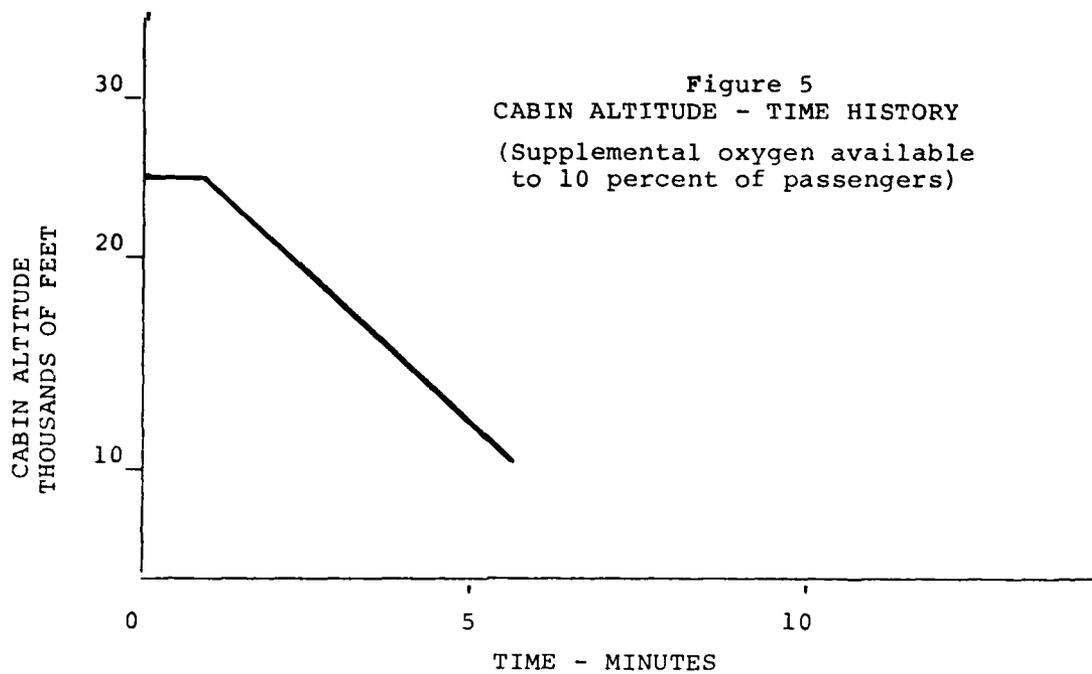
SPECIAL CONDITIONS FOR OPERATIONS ABOVE AN ALTITUDE OF 45,000 FEET



For all four figures, time starts at the moment cabin altitude exceeds 8,000' during depressurization. Areas within the actual cabin altitude-time history falls below the curve may be used to compensate, by integration, for areas wherein the actual cabin altitude-time history reasonably exceeds the curve. Time is concluded when cabin altitude returns to 8,000'.



SPECIAL CONDITIONS/OPERATIONS ABOVE AN ALTITUDE OF 45,000 FEET



AGENDA ITEM 37  
VENTILATION AND SMOKE TESTING

PROBLEM

Information item.

DISCUSSION

The Southwest Region had a position paper which was discussed earlier with FAA personnel (reference Item 24). It led to a discussion of the Multiple Expert Opinion Team, and as Bill Trammel is a member of this team, he gave a brief summary of the organization, its activities, and the purpose of it. This item was presented to the DERs as information only.

CONCLUSION

We will await the results of the MEO Team for any action.

AGENDA ITEM 38  
EQUIPMENT/INDICATOR/SENSOR INTERFACE

PROBLEM

For complex projects, appropriate configuration control is difficult.

DISCUSSION

A position paper by the Southwest Region was distributed and the subject developed into a wide ranging and lengthy discussion concerning STC procedures, FAA-industry interface, etc., summarized as follows.

The STC evaluation procedure should be equivalent to the evaluation given to the same design on a TC application. In cases where a second applicant applies for approval of an identical or similar modification, the design package required of the second applicant should be identical to the data package required from the original applicant. FAA may use the benefit of prior knowledge to decrease the amount of manpower and time required to evaluate the second package, but in principle, each STC package must be complete in itself. Different regions evaluate STC packages to differing degrees, i.e., some regions evaluate the criticality of the modification and vary the depth of their evaluation of the data in proportion to the criticality. DERs can assist FAA greatly by informing FAA where they feel additional evaluation is needed. At least one region, the Northwest Region, has a memorandum of understanding with Boeing Aircraft Company, their major TC holder, which spells out the types of installations to be evaluated due to the criticality. Boeing informs FAA of areas they find should be evaluated and FAA makes the decision whether the DER or the FAA engineer will do the evaluation. This makes it clear that different regions work in different environments and procedures must be adapted as required by the region and the applicants residing in that region.

For STC approvals, it is advisable for the approving region to contact the Type Certificate holding region when there is any question at all regarding the appropriateness of a modification. The STC in some cases references a top drawing. This permits changes to the STC via changes to the top drawing list and does not require a change in the STC itself; however, in that case, the STC should contain a phrase requiring that any installation be done to the latest FAA approved data. Some regions limit an STC to only one TC, i.e., they do not list multiple models. This seems to be a matter of regional

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policy; some regions have STCs which list a great many different models when the installation data is appropriate for all of those models. AFS-130 will study this matter and try to determine whether there is a need for national policy.

There also seems to be a problem in that some regions do not accept data from DERs residing in other regions. It is thought that in most cases there are differences in the data submitted to the second region, i.e., differences from data submitted originally to the region in which the DER resides; however, it is unclear as to whether this is always the case. It is suspected that there may be a discrepancy in this area. DERs should be afforded the same respect, responsibility, and authority in all regions, not just the one in which they were appointed. AFS-130 will investigate this in some detail and include guidance material in the forthcoming DER Handbook.

A point was made that the STC listing should include the latest amendment date of an amended STC. This listing is frequently used by the public, as well as FAA, for reference and inclusion of the latest amendment date would be useful.

A procedure for amending the STC vs. reissuing it was discussed and it appears there may be some variation in procedure. It is normally expected that a design change would constitute an amendment to the STC, while only a change in name or ownership would be reason for reissuance. It also appears that guidance is needed regarding whether a TC holder can install STC changes on the production line or whether only amendments to the TC may be incorporated.

CONCLUSION

Practices seem to vary between regions in this regard and a national policy is needed.

ATTACHMENT

Southwest Region Position Paper

Problem: After the prototype equipment approval, there ensues a continual train of changes in avionic equipment such as Sensors, Indicators, Computers, Software, etc. How should these changes be approved and documented?

Background: The continuous flow of various equipment options for approval after the initial approval takes considerable

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engineering time if each change is evaluated, documented, inspected, and flown. On the other hand, leaving these options to the installer without an engineering evaluation could result in a non-compliance with the FARs.

Discussion: The Southwest Region generally follows the practice of evaluating all changes to the same depth as the prototype. However, being faced with typical manpower shortages and mounting backlogs, we are seeking methods of decreasing the workload, while maintaining adequate control.

Options

1. Ignore equipment changes except those of great magnitude, and require those to be evaluated by engineering.
2. Require the applicant to obtain engineering approval of all changes.

Option Analysis: Exercising option No. 1 can be risky. Option No. 2 is burdensome and often non-productive.

Recommendations: Poll the regions and let each region inform the Workshop how they handle this area of their certification program. Then arrive at a concensus of a policy for us all to follow.

## AGENDA ITEM 39

### MULTIPLE APPROVALS (AIRBORNE DRY AIR PUMPS)

#### PROBLEM

FAA has no concise, effective method for approval of some items used on many types of aircraft.

#### DISCUSSION

It was apparent that the subject was much broader than the title implies in that it pertains to approval of many different types of equipment, rather than just dry air pumps. The method of approval is really the subject. We have no method of approval at the present time that does not have drawbacks. Air pumps, and some other types of equipment, are being approved at the present time as part of the engine and the system compatibility on the aircraft must be evaluated on installation of the engine in the aircraft. The PMA approval could be used, and would give evidence of design approval as well as quality standards approval, but it is felt that a more appropriate means of approval of equipment of this nature would be via the Technical Standard Order system. At this time there is no TSO for air pumps, as there are no TSOs for many other items of equipment; therefore, the proposed "General TSO" was discussed, explained in some detail, and it seemed to be the consensus that a "General TSO" would be helpful. It was also explained that if the "General TSO" were available, and there were several approvals made for similar types of equipment under the General TSO, that information would be helpful in developing and issuing a specific TSO for that type of equipment. It was pointed out that approval of pumps and other components as part of the engine leads to some difficulty because in practice not everyone along the chain of design and approval does a proper evaluation to assure compatibility of the components with both the engine and with the aircraft systems.

#### CONCLUSION

AFS-130 will proceed with the "General TSO" and try to improve the TSO system overall.

#### ATTACHMENT

Subj: FAA approval for new models of Airborne Dry Air Pumps on numerous general aviation aircraft.

Agenda Item 39  
Multiple Approvals (Airborne Dry Air Pumps)

Background

The Airborne Manufacturing Company received approval for their basic dry air pump models through a series of thirty STCs covering a large number of U.S. certified general aviation aircraft. These STCs were set up with long aircraft lists and were frequently amended to include new models of aircraft.

In 1974, Airborne requested and was issued FAA/PMA approval for their pumps on the engine as being the type certificated product. Design approval was based on their STCs.

Discussion

PMA approval on engines alleviated the problem of numerous STC amendments because engine models generally do not change frequently and remain the same in an aircraft model series.

Recently Airborne has requested PMA for a new model dry air pump on approximately 35 engine models. Their request has been denied because FAR 33 contains no provisions for certification of an air pump as part of the engine and, furthermore, approving air pumps as part of the engine gives blanket approval for use on any airplane using that engine without regard to installation compatibility. Airborne was advised that the existing approvals would not be changed unless dictated by service experience. They are still seeking FAA approval for use of dry air pumps and other related equipment on general aviation aircraft.

Available Options

1. Field approval (337)
2. PMA for similar type aircraft
3. STCs with aircraft eligibility lists
4. General TSO (now in draft form)

Analysis of Options

Option 1. The field approval (337) is only for one aircraft. An undue waste of manpower would result if this method is encouraged because of a great number of identical installations.

Agenda Item 39  
Multiple Approvals (Airborne Dry Air Pumps)

Option 2. A PMA for similar type aircraft with adequate installation instructions would accomplish FAA approval. One negative aspect for blanket approvals is that the definition of Type Certificated Product, referred to in FAR 21.303, means a specific make and basic model number of aircraft, engine, or propeller.

Option 3. An STC for each pump model with an aircraft eligibility list would accomplish FAA approval. The major problem with a large aircraft listing is that it would require frequent updating (estimated 40 to 60 per year). New model substantiation is very difficult for Airborne because the OEMs are reluctant to give verification on parts approved as type design data. Airborne is now forced to request that the FAA verify type design approval by review of data in the various FAA regional files.

Option 4. Pump approval under a general TSO would also accomplish FAA approval and would be free of problems if the OEMs would buy the equipment with the TSO label. Aircraft owners could now replace TSOed equipment and then make a logbook entry. Installation instructions should be a key item for review prior to TSO approval.

Recommendations

For the present time Option 3. Option 4 is recommended if Part 37 of the FARs is amended to include the General TSO.

AGENDA ITEM 40  
ANGLE OF ATTACK TSO

PROBLEM

The purpose of this subject was to emphasize the need for a TSO for angle of attack.

DISCUSSION

The principle discussed relative to the previous item on dry air pumps also applies in the case of angle of attack equipment. The status of present projects being processed in Washington for the development of an angle of attack TSO was described and it was emphasized that SAE activity in this area needs more participation from the light aircraft manufacturers.

CONCLUSION

No action required.

AGENDA ITEM 41  
DIGITAL SYSTEMS CERTIFICATION

PROBLEM

Information item.

DISCUSSION

The activities of the Advanced Integrated Flight Systems Committee of FAA were briefly described and FAA plans to apply the present rules, specifically tailored to the systems to be considered for certification, were explained. It was concluded that there is nothing unique or so revolutionary about digital systems that there is any need for undue concern. Activities anticipated in the near future will involve the application of present rules in a reasonable fashion, but may also involve certain steps and considerations peculiar to digital systems which are, in effect, beyond what has been done in the past with analog systems. This is not to be regarded necessarily as additional requirements; simply application of existing requirements to the new types of systems.

CONCLUSION

It was emphasized that probably the primary concern FAA has is in the validation of correctness of the software that accompanies digital systems; that we will be particularly conscious of the need for thorough validation techniques in those systems which are considered flight critical; and that the degree of our concern and evaluation will be in proportion to the criticality of that installation.

AGENDA ITEM 42  
MASTER SWITCH ARRANGEMENT

PROBLEM

Parallel bypassing of the master switch evades the intent of FAR 23.1361.

DISCUSSION

Southern Region's proposal for a regulatory change to Part 23, which would examine and perhaps modify the present allowance of a load of up to 5 amps to bypass the master switch, was presented. After discussion, it became apparent that there is no presently known hazardous condition; however, it does seem there is potential for abuse of the intent of this regulation.

CONCLUSION

It was agreed that the next time Part 23 comes under review, the Southern Region's proposal will be considered for a regulatory change.

ATTACHMENT

Southern Region Proposal

Background: Master switches have been bypassed with parallel power wires for high current loads, each protected by a 5 ampere circuit breaker.

Discussion: The intent of this regulation was to limit the amount of current bypassing the master switch. Therefore, the regulation should be written in those terms.

Available Options:

1. Revise the first sentence of FAR 23.1361(b) to read as follows: "Load circuits may be connected so that they remain energized after the switch is opened, if they draw 5 amperes or less."

2. Do nothing.

Analysis of Options: If we do nothing, we can still make sure that only low current loads bypass the master switch, but that is regulation by policy rather than regulation by regulations. It is preferable to make the regulations say what we want them to say.

Recommendation: Revise FAR 23.1361(b) as stated in available option number 1.

## AGENDA ITEM 43

### UNFLAGGED VERTICAL GYRO FAILURES

#### PROBLEM

The Central Region presented a position paper relating to a failure of a vertical gyro in a flight director system which permitted the rotor rpm to decrease without giving the pilot appropriate warning.

#### DISCUSSION

The Central Region recommendation is for a regulatory change to require a monitor which would warn the pilot of improper performance of the instrument in this regard. It was suggested that a change of this nature should be incorporated into the TSO; however, there is also a regulation which bears on monitoring the power input to the instrument, and if we do develop a more stringent requirement for warning the pilot, that regulation would have to be changed, also.

#### CONCLUSION

The Society of Automotive Engineers Committee A4 is working on requirements for vertical gyros and DERs and FAA should review the next draft of the proposed SAE standard carefully, with a view toward improving the warning system. It was also noted that the pilot is responsible for cross-monitoring his instruments and it is felt we should not provide warning systems that merely compensate for piloting deficiencies. On the other hand, we should improve instruments as it becomes technically and economically feasible to do so, if that will produce an improvement in the safety record.

It was also mentioned that any regulatory change and revision of the TSO must necessarily consider that laser gyros may be used in the future, and that any warning system should be keyed to warning of a faulty indication to the pilot, rather than specifically keyed to measuring rotor rpm as such.

#### ATTACHMENT

##### Central Region Position Paper

Problem: A failure in the power supplied to either phase of the vertical gyro of the Collins FS-109 system will result in improper command information with no flag to warn the pilot that a failure has occurred.

Agenda Item 43  
Unflagged Vertical Gyro Failures

Background

Investigation of an aircraft accident where the possible failure of the FD-109 system could have been a contributing factor has resulted in a test of this system to determine the effects of a failure of the power supplied to the gyro motor. Results of that test showed:

1. The flags on the flight director indicator will disappear approximately two minutes after power is applied.
2. When the flags disappear the motor RPM is still increasing.
3. When the motor has reached its running speed and power is removed command information will be proper for approximately ten minutes.
4. Approximately 18 minutes after the power is removed the flags reappear.

Examination of this vertical gyro showed that the drive motor for the gyro is 115 volt 2 phase. Single phase power is supplied to the unit and is applied to one phase of the motor directly. Power for the other phase of the motor is shifted 90° by placing a capacitor in the input to that phase. Power to the motor can be interrupted by losing the leads or brushes in either phase.

Power for the monitor flag is taken from a 15 ohm resistor located between the common connection of the stator windings and ground. EMF produced by the rotating motor will proceed energy to keep the flag removed after power is removed.

Although it has not been possible to verify, it has been verbally reported that the gyros in other manufactured systems function similar to Collins and they will also provide periods of unflagged improper information.

It has not been possible to run test on a dual FS-109 system, but we do not believe that unflagged improper information would be presented because of the comparative monitoring system used.

Agenda Item 43  
Unflagged Vertical Gyro Failures

Available Options for a Solution

Option 1. Do nothing.

Option 2. Revise airworthiness standards to require a warning flag to be presented when the gyro speed reduces to the point where improper indications are provided.

Analysis of Options

Option 1. Systems using gyro of the type discussed have been in service for some time and there have been no known failures of the type discussed that have resulted in an unsafe operation.

Option 2. This change in FAA requirements would assure that a warning flag is presented when command becomes inaccurate because of an input power failure to the gyro.

Recommendation: It is recommended that Option 2 be adopted.

AGENDA ITEM 44  
MULTIPLEXING HELICOPTER NAVIGATION  
SYSTEMS

PROBLEM

Guidance regarding multiplexing is needed.

DISCUSSION

The Southwest Region explained that an applicant in that region plans to multiplex their navigation systems.

CONCLUSION

Multiplexing is not a new concept. It is being used today in various inertial navigation systems, in air data computer systems, and in others, and there is a certain amount of technical guidance available, i.e., Mil Standard 1553A and ARINC Characteristic 429 pertaining to multiplexing the systems. The means of evaluating and approving the proposal could be the use of a failure modes and effects analysis and fault analysis to determine the criticality of system functions and the effects of the various failures, and the region could require redundancy or separation or reliability as necessary and as indicated by the criticality of failures. In addition, FAR 25.1331 does permit combining circuitry. It no longer requires separation of the pilot's instruments from other installations. This concept could be used in a helicopter. One other piece of guidance available to the regions is an engineering report, AC 213-12, on aircraft multiplex concepts, an information paper published by the Engineering Branch at the Aeronautical Center.

ATTACHMENT

Southwest Region Position Paper

Problem: A helicopter manufacturer in our region has expressed an intent to evaluate and probably propose for certification the use of multiplexing techniques. Our knowledge of the problems, hazards, and pitfalls in the use of these techniques is very limited.

Background: We do not have sufficient expertise to evaluate multiplexing techniques. Engineering Report AAC-213-12, "Aircraft Multiplex Concepts" provides some information; however, more guidance on the problems associated with the testing methods that are appropriate for, and the critical areas for the evaluation of systems utilizing these techniques, is needed.

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Multiplexing Helicopter Navigation Systems

Discussion: Since multiplexing is now a live issue, it is incumbent upon us to face it. If someone within FAA or its associates does not have the necessary experience/expertise to provide the required guidance, then the FAA should proceed to seek out those who do.

Recommendation: The Workshop attendees should discuss this topic to determine whether there is a problem, if so what is its magnitude and urgency, what is the Agency's capability, and what action do we need to take?

AGENDA ITEM 45  
COMPLEX SYSTEMS

PROBLEM

Information item.

DISCUSSION

Western Region related their experience with an integrated navigation system and emphasized that the performance and safety of the system was largely dependent upon control of the specific configuration of the system; therefore, as part of the approval, the limitations require that the approval is valid only when the configuration of the installed system is in accordance with a configuration control list which was a part of the approved design. Reference Agenda Item 17.

CONCLUSION

No action required.

AGENDA ITEM 46  
COCKPIT VOICE RECORDERS

PROBLEM

FAR 25.1457 needs review and possible revision.

DISCUSSION

The Southern Region presented a position paper recommending certain detailed changes in FAR 25.1457.

CONCLUSION

It was agreed that these changes are not of sufficient importance or criticality to initiate a specific rule change at this time, but it was also agreed that when FAR 25 undergoes review, these changes will be included in the proposal.

ATTACHMENT

Southern Region Position Paper

Subj: Cockpit Voice Recorder Requirements

Background: FAR 25.1457 has always been written in a way that makes literal compliance very difficult and, in fact, maybe it has never been done. It is also written in "optimum" terminology rather than "minimum level of safety" terminology.

Discussion: The words in FAR 25.1457 do not necessarily reflect what is actually done and was inadequate to some extent. It is a matter of regulating by policy rather than regulations.

Available Options:

1. Do nothing.
2. Revise FAR 25.1457.

Analysis of Options: If we do nothing, we will still do an adequate job of evaluating and approving voice recorder installations. If FAR 25.1457 is revised, our approval methods will not change but our methods and the regulation will agree.

Recommendation: Revise FAR 25.1457 as follows.

1. The words "must be approved" should be deleted. They serve no useful purpose and, in fact, are confusing. Some people consider those words to mean that the equipment should

Agenda Item 46  
Cockpit Voice Recorders

have a TSO authorization. If that is the intent, it should be so stated. "Approved" according to FAR 1 means approved by the Administrator; this includes all the ways of approving equipment as shown in FAR 21.305. All equipment installed on an airplane must be approved in some manner.

2. FAR 25.1457(b).

a. This paragraph speaks of "microphone" in the singular. In some airplanes one area microphone is not enough. This paragraph should be reworded to say "at least one microphone," "one microphone or more," or something similar.

b. The first sentence requires the area microphone to be located in the "best" position for recording the specified communications, but this is not in accordance with the concept to regulate to the minimum and it could be costly to find the "best" location. We should require the location(s) to be adequate but not necessarily the best. In fact, that is really what happens in certification. Once an acceptable location is found, it is approved. No one is asked to show that it is the best location.

c. This paragraph also requires the area microphone to provide intelligibility as high as practicable. If an applicant shows that his area microphone is in the best position, these words say that the area microphone should be accepted since for that installation the intelligibility would be as high as practicable, even though it might not be good enough. Again, we should require that the microphone(s) provide some acceptable level of intelligibility, and not just the highest practicable with one microphone.

## AGENDA ITEM 47

### DER FORUM

#### PROBLEM

DER feedback regarding the DER system is needed to facilitate improvements in that system.

#### DISCUSSION

A proposed Agenda for a DER Forum was prepared by AFS-130 for use if time permitted. Time was limited, however, so the Agenda was given to each DER and they were requested to reply and/or comment on the Agenda items, in any informal manner, directly to AFS-130.

#### CONCLUSION

DER comments are solicited.

#### ATTACHMENT

##### AGENDA FOR THE SYSTEMS DER FORUM

#### Objectives

The views and comments received during this forum, as well as information which may follow, will be used to develop improved guidance, procedures, and lines of communication. The objective is to increase the efficiency and effectiveness of our aircraft certification programs. No attempt will be made at this forum to resolve specific issues.

#### AGENDA

##### A. ADMINISTRATIVE HOUSEKEEPING

1. DER Kit material:
  - a. Value of material received.
  - b. Delete specific items?
  - c. Add specific items?
  - d. Distribution system.
2. Communication between DERs and the Regional Office:
  - a. Was original indoctrination adequate?
  - b. Do you receive sufficient guidance? Too much?
  - c. Do you feel free to call and discuss FAA policy?
  - d. Does the region advise you of notices, ACs, etc., affecting your area

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DER Forum

3. Participation with FAA in Rule Making:
  - a. NPRM mailing list.
  - b. Submit comments directly to Rules Docket in Washington.

B. GENERAL FAA POLICY

1. DER service to the FAA:
  - a. Is there unnecessary duplication of DER work;
  - b. Unnecessary detailed checking by FAA of DER approved data?
  - c. Draft Handbook change regarding amount of review.
  - d. Are DERs providing service to reduce approval time?
2. Uniformity of FAA substantiation policy:
  - a. Extent of qualification testing required.
3. What is extent of conformity inspections on:
  - a. One-only modifications?
  - b. Purchased equipment?
4. General trust in DERs:
  - a. Do you feel a part of FAA, working with FAA?
  - b. Do you feel you have adequate authority?
  - c. Give STC number before all paperwork is in.

C. DERs' TECHNICAL AUTHORITY

1. Discussion:
  - a. How is scope of DER approval shown for technical data?
2. DERs' work with FAA inspections on field approvals.
3. Use of DERs to conduct tests.
4. Use of DERs to approve service bulletins.
5. DER appointment to additional areas.

Agenda Item 47  
DER Forum

D. OPEN DISCUSSION

1. Additional comments on previously discussed items.
2. Problems unique to consultant DERs.
3. Problems unique to company DERs.
4. Any new items.

PRESENTATION ITEMS 'A' and 'B'

A - DIGITAL FLIGHT CONTROL SYSTEMS

B - OMEGA NAVIGATION

BENDIX FLIGHT SYSTEMS DIVISION

The Bendix Flight Systems Division, Teterboro, New Jersey, responded generously to our request for briefings on two 'state of the art' subjects, Digital Flight Control Systems and Omega Navigation.

Mr. Jerry Doniger spoke on Digital Flight Control Systems, reviewing analog system architectures, digital system architectures, software, and certification issues.

Mr. Des Carey spoke on Omega Navigation, reviewing Omega system principles and describing the Bendix ONS-25 system features, configuration, operation, performance, reliability, and maintainability.

The complete Bendix presentations are not incorporated in this Workshop Report because it has not been determined that they do not include information of a proprietary nature. In addition, although the presentations are extremely informative and interesting, they are lengthy and therefore expensive to reproduce.

The FAA sincerely appreciates the fine cooperation and contribution of the Bendix Flight Systems Division.

PRESENTATION ITEM 'C'

ADVANCED INTEGRATED FLIGHT SYSTEMS (AIFS)

E. M. Boothe  
ARD

As generally discussed in the Advanced Integrated Flight Systems (AIFS) Planning Group Meeting, September 27, 1977, the following tentative schedule for workshops is presented:

1. National Aeronautics and Space Administration (NASA/Dryden Flight Research Center - Draper Laboratory

This workshop relates to the NASA/Ames "Simulation Methods" program and is described by the August 26 letter/proposal for NASA/DFRC Supplemental Task. Per Section 2.3, Task III, of the enclosed work statement, it is planned that the workshop will provide a summary of the report plus an opportunity to be exposed to actual F-8 digital fly-by-wire simulations. The workshop will be conducted by NASA/DFRC and Draper Laboratory for designated Federal Aviation Administration (FAA) Flight Standards Service (AFS) and Systems Research and Development Service (ARD) and NASA personnel:

Date: June 1978 (detailed dates to be negotiated)  
Length: 3 days maximum  
Where: Dryden Flight Research Center, California  
Attendance: Estimate maximum 20

2. NASA/Ames Research Center - Phase I Contract(s)

The NASA/ARC program "Industry Perspective on Simulation Methods and Research for the Validation and Failure Effects Analysis of Advanced Digital Flight Control/Avionics" has at least three contractors; two for CTOL and one for helicopter, which will participate in the Phase I study efforts. The Phase I effort will obtain in depth industry perspective relative to experience in methods (analysis, simulation, flight) for the validation and failure effects analysis of digital flight control and avionics. Identification of those potential digital flight control and avionics candidates for pre and post 1985 will be included. Within 2 months after conclusion of the Phase I contract efforts, each contractor will conduct a 3 day workshop in the contractor's local FAA region for FAA AFS/ARD and NASA personnel, followed by a 3 day workshop at NASA/ARC. The following preliminary information is provided for organizational planning purposes:

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a. FAA Region Workshops

Dates: September to October 1978 (tentative)  
Length: 3 days (each) maximum  
Where: ASO, ANE, and AWE Region Offices  
Attendance: Estimate maximum 20

b. NASA/ARC Workshops (with FAA attendance)

Dates: October to November 1978 (tentative)  
Length: 3 days (per ea. contractor) maximum  
Where: Ames Research Center, California  
Attendance: Estimate maximum 30

3. NASA/FAA "Symposium for Industry/Government"

NASA/ARC is proposing to conduct a national forum of industry and Government experts which will report on status, progress, and program results to date of NASA, Department of Defense (DOD), and industry programs in key subject areas. These include analysis, simulation, and flight methods for validation and failure effects analysis, reliability assessment, software validation, etc. This will be an opportunity to transfer timely research information to industry and Government technical personnel:

Symposium Date: Spring or Summer 1979 (guesstimate)  
Length:  
Where: Ames Research Center (most likely) or mid-USA

4. NASA/ARC/FAA Workshops (Phase IV Simulation Methods Study)

A CTOL and helicopter real-time systems/mission "hands on" demonstration and tutorial workshops using advanced flight hardware and software will be conducted by each (2) contractor at NASA/ARC. The NASA contracts presently require a 20 hour class session, 4 hours per day, 5 days a week, with a total of 8 classes anticipated over two 2 week periods. It is planned that two FAA AFS/ARD personnel (one pilot and one engineer) and one NASA engineer will constitute a "class:"

CTOL Schedule: Late 1979 through 1980  
Helicopter: Late 1980 through 1981  
(Detailed dates not identified)

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5. Others

NASA/Langley Research Center

Presently discussing with NASA/LaRC the conduct of workshops or training sessions relative to the advanced flight control and avionic system onboard the TCV B-737, fault-tolerant hardware and software activities, software validation, and other program related efforts. No firm proposals are available at this time.

As the schedules become firm, you will be notified. During the course of the next few months, if you have any inputs, suggestions, or requirements which may be of benefit to our long-range planning, we would appreciate your support.

/s/ Ed Boothe

(Enclosure 1)

Correspondence from NASA/Ames Research Center, CA, (Doug Doane, Avionics Systems Branch), August 26, 1977

Subj: DFRC-CSDL Fly-By-Wire Methodology Study Project

Attached are two (2) copies of the proposal submitted by Charles Stark Draper Laboratory to NASA-DFRC as part of their joint project to review, document, assess, and recommend validation, reliability prediction/assessment, and failure effects analysis methods for fly-by-wire hardware and software. This project has been funded and initiated.

Periodic schedule and progress reports will be supplied to you as they are received.

/s/ Doug Doane

(Enclosure 2)

Proposal for NASA/DFRC Supplemental Task

1.0 Introduction

The development of the procedures and policies for the validation and certification of aircraft with a fly-by-wire systems will be one of the most important tasks which must be accomplished before the considerable advantages of the systems can be realized. It will be necessary to develop the

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validation methods as early as possible so that the designers of digital fly-by-wire control systems will fully understand the reliability requirements and the means that will be necessary to demonstrate that reliability. The regulatory authorities will also need to be aware of what is being developed and anticipate the data and testing they will require to demonstrate compliance with the regulations. The authorities will be very reluctant to certify a new system for which there is no precedent without ample assurance that flight safety can be assumed. On the other hand, airframe companies and the airline customers will be reluctant to commit to the use of a fly-by-wire system, in spite of large potential advantages, unless flight safety can be assumed and there are no large risks and unreasonable costs in obtaining certification. In order to give both the users and the regulatory authorities the necessary confidence, it is necessary for the validation methods to be developed along with the development of the systems themselves.

The Charles Stark Draper Laboratory (CSDL) is in an excellent position to assist in the development of these validation methods based on the experience gained in the development of operational fly-by-wire systems, particularly the NASA F-8 Digital Fly-By-Wire system. The following sections outline the proposed program technical approach and the program plan.

2.0 Technical Approach

The majority of the proposed effort is divided into two tasks. First is a review of the existing experience of NASA-Dryden Flight Research Center and CSDL in the validating of fly-by-wire systems in order to document this experience, evaluate the effectiveness or ineffectiveness of the methods used, and determine how this experience might apply to future commercial systems with alternative configurations. The second major task is to review the adequacy of existing methods and recommend areas where research is necessary to improve the validation methods. The results of these studies would be compiled into a report and then presented to FAA and NASA as a workshop.

2.1 Task I - Review, Assess, and Document Methods for the Validation, Reliability Prediction/Assessment and Failure Effects Analysis of Fly-By-Wire Hardware and Software.

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The first task will be to review the experience of NASA-DFRC and CSDL in the methods for validating, predicting and assessing the reliability and performing Failure Modes and Effects Analysis (FMEA) of fly-by-wire hardware and software. This experience will be evaluated and documented to provide a basis for the remainder of the effort. The methods that prove to be most productive will be identified as well as those that were not effective. Examples of methods include (a) analytical ground-based computer analysis, (b) real time simulation, and (c) flight test. The roles, benefits, limitations, etc. of each method and how they complement each other will be described. The reliability criteria used in past and present research systems at DFRC will also be discussed. Possible alternate future digital fly-by-wire configurations will be described particularly those applicable to civil aircraft. The applicability of the current experience to these configurations will be indicated. The reliability criteria and the validation and FMEA methods that appear most promising to apply to future civil digital fly-by-wire systems will be described. The problems and benefits of using this technology as it influences operational reliability and maintenance procedures will be described. The broader benefits of fly-by-wire, such as more efficient airframe structure, improved aircraft performance and resulting fuel economy which are not directly related to flight safety, high reliable, fault tolerant design are beyond the scope of this study and are not included. Block diagrams illustrating sensors, computer, actuator, cockpit configuration, etc. are included.

2.2 Task II - Review, Assess, and Recommend Research for Improving the Validation, Reliability Prediction/Assessment, and Failure Effects Analysis of Fly-By-Wire Systems.

The analytical, simulation, and flight test methods that exist now or that are being considered for future digital fly-by-wire hardware and software systems will be reviewed. The problems and deficiencies of these methods will be identified and discussed and any necessary further research will be recommended for improving the validation, reliability prediction/assessment, and FMEA methods, particularly as it applies to the certification of future digital fly-by-wire concepts for civil use.

The CSDL will participate in the review at the present NASA/FAA "Simulation Methods for Validation and Failure Effects Analysis of Digital Flight Control and Avionic Systems" program. Recommendations will be made on data that should be

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obtained, analytical simulations or flight experiments that should be performed, government (FAA/NASA) actions or government sponsored research required for improving the validation and FMEA methods of fly-by-wire hardware and software.

- 2.3 Task III - Conduct a Workshop at NASA-DFRC for the FAA and NASA. Review, discuss, and demonstrate methods for the validation, reliability prediction/assessment, and failure effects analysis of fly-by-wire systems.

A 2 to 3 day workshop will be conducted for FAA flight standards, systems research and development service personnel, and NASA research personnel covering methods for validation and failure effects analysis of fly-by-wire systems. The workshop will cover the material in the final report in sufficient detail and use step-by-step problem examples, actual simulation demonstration, and other teaching so that personnel of the technical methods level in FAA flight standards can understand the role, benefits, and limitations of the various (analytical, simulation, and flight) methods applicable to fly-by-wire concepts.

- 2.4 Task IV - Document Methods/Rationale

A Final Report will be produced covering Tasks I-III. One reproducible copy and 50 copies will be provided to the Ames Research Center two months prior to the workshop. This report will be of sufficient detail to explain the methods and techniques with examples so that FAA flight standards personnel can obtain a good understanding of the role, benefits, limitations, etc. of the various methods.

PRESENTATION ITEM 'D'

FM/TV INTERFERENCE

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During this presentation, I'd like to give you my opinion of the conclusion this project will have, what the project was to accomplish, the tests that were conducted and the results of the tests, possible future applications of intermodulation interference prediction techniques, and what recommendations we would like to make, based on the limited knowledge we currently have. I would really like to spend another year running tests on the subject and the material that we've already spent a year with, but I don't know whether that will be possible.

Intermodulation is common, it's widespread, and it occurs to both Com and Nav receivers. The voice and music interference you are accustomed to hearing, perhaps, when you've just contacted departure or approach control coming into a terminal, is not the only type of intermodulation interference that occurs. There's another type which we call motorboating. It's a sound that might be equivalent to an outboard motor at a trolling speed, or even the high speed sound you get when you're pulling a skier. It runs not only from the sound you get, but also in your Nav receivers by deflection of the CDI. The interference is not rejected by TSO receivers, nor by those receivers meeting the RTCA standard for VHF receivers.

It is possible to predict intermodulation interference, but not in all cases. There needs to be more work done on it. The most serious and most severe interference comes to low cost receivers. The interference occurs in the terminal areas and at low altitudes. It's not a high altitude type of interference. It is also made worse by certain ELTs. Normally, the antenna of the ELT is connected to the ELT. The final stage of the ELT may be a transistor. When the high power FM signal hits that transmitter, it is modulated, slope detected, or what have you, and you get a re-radiated signal which is picked up in both Com and Nav receivers. Depending on the coupling of antennas, and the manufacturer of the ELT, you will get interference, and much of my data has to do with what we have found in the laboratory relative to the ELT.

Again, to emphasize, most of the comments received deal with communications interference by FM stations. Much of the interference is received by the navigation equipment. You'd expect it. It's in that band between 108 and 118, and the FM band is 88 to 108. The present TSO for receivers is not written to

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prevent intermodulation interference. The general complaint is against the Com receiver, but we've found that it's also present in the Nav receiver and we feel there needs to be more work to definitely examine the extent and the effect of this interference by using position measuring equipment which will be quite accurate.

In NAFEC's project, the items have all been worked on to determine the type of interference, the extent, procedure, and preventive procedures. The one area we haven't gone into is the solution area when it deals with hardware. We have not yet done our laboratory experimentation nor flight tests adequately to deal with hardware solutions to this intermodulation interference. The project activities were divided into these several parts, and under the screen room tests we had a preliminary series of tests to obtain information about which receivers were subject to intermodulation interference and how much FM signal it took to cause this interference. Then we did comprehensive laboratory tests where we studied the effect of the FM signal on receiver selectivity and sensitivity.

The flight tests were divided into two parts. We flew in a Convair 580 initially for an exploratory flight into the Southern Region, and flew around the area of Miami. The second phase of the flight testing was a flight which took us out through the Eastern and Central Regions to the Rocky Mountain Region, down into the Southwest Region, and back to NAFEC. We got a great deal of data on that activity.

We have published one letter report dealing with FM interference at Topeka, Kansas. The final report for this project was put into our report processing section last week, so within the next two months, depending on how many reviews we go through and how successful we are in getting through these reviews, we will have a report out on that activity. Our analysis on the work we've been doing is also fast coming to a close.

The laboratory tests dealt in the preliminary stage with just a very cursory look at receivers. When we got into the comprehensive tests, we spent quite a lot of time testing a number of receivers. The findings dealt with sensitivity and selectivity, and the FM effects on TSO receivers and on the ELT. Included in this particular activity were antenna tests for avionic antennas. In the laboratory we set up a configuration which allowed us to have three FM signal generators inputting

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through a splitter to a receiver and an ELT. We recorded the AGC output of the receiver and used one of the signal generators to drive the X amplifier of an XY plotter. We tested to find out the effect of spacing between these two antennas. This test was conducted in a large screen room in the laboratory at NAFEC, so it isn't an airplane configuration; but from 3-1/2 inches to 60 inches, it didn't make a lot of difference in spacing between the ELT antenna and the Collins 137X. We chose a space, which appeared to be worse to us, of four feet between the antennas and we ran our tests with this configuration. To help us with this, we also developed a computer program which would allow us to find what FM frequencies combine to produce an intermodulation interference frequency for an FAA assigned frequency. It's a very simple equation which uses just the frequencies of the FM stations:  $F_1 = AF_1 + DF_2 - CF_3$ .  $F_1$  is the intermod frequency, or it could be the assigned frequency;  $F_1, 2,$  and  $3$  are radiated FM frequencies;  $A, B,$  and  $C$  are coefficients from 0 to  $N$  integers; and the maximum in our program was three, so you can have an inter-mod frequency generated by  $3F_1 + 1F_2 - 3F_3$ . That would subtract out and you would get a frequency in the VHF band. Our program is a little different from the program that's available to all the frequency management officers in that we put a tolerance factor in this equation which allows us to say we'll take an  $F_1$  of 122 and our tolerance can be as much as 14 mega ohms. That means we can go down to 108 and up to 136, and we can get all the possible intermods between 108 and 136 for a set of FM frequencies that we've put in. We might put in 20 FM frequencies. Taking three at a time for all the possible combinations, three at a time, of 20 FM frequencies, explains why we have to have a computer program and it was used to help us pick out the frequencies we wanted to use in our tests.

On this viewgraph, the top set of curves came down to here. The lowest one was generated using a minus 60 DBM on frequency AM signal and the top curve in this set is up here at a minus 100 DBM. The receiver is an Edoaire. We measured here the distortion we got for this input signal at 60 minus 60; we had a 9% distortion at minus 90; 10% at 115; and 16% at 105. We found that things get pretty bad when your distortion level reaches 15%. It's difficult to understand and deal with a signal which exceeds that.

For the next set of curves we took the same receiver, put in two FM signals, and we still had our AM signal input. We shifted the baseline down for clarity, but you can see that the space between here and the bottom is much less than the space below the baseline on the other, so you've had a

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general AGC increase with the input of the two signals. The distortion now for -60 is 10%, but what happens at 90 is that you go to a 25% distortion as opposed to 10% up here, and at 100 it's 34%. By the way, the ELT was also connected during this test. The signal levels are, I think, -20 and -11 for the FM interference. In this lowest set of curves, we go to zero at 2 dBm and this is what happens to the selectivity of the receiver with a very strong FM input signal. Two dBm is not an impossible level to get, as we have recorded in our aircraft tests.

On the next slide, we have three FM inputs to the receiver, without the ELT connected. These three inputs - we have 36, 29, 25, 25, and then down to 11 for -20, -30, -20 input of the FM signal. That's without the ELT; it's just the FM signals for this particular intermod going in. When we connected the ELT, for similar levels we started out at 90% distortion and dropped to 24% at 20/20/20 - up here it's 25/25. The thing about that is usually the effect of the ELT drops out between 0 and -5 dBm, so at that point you don't have the effect, but above this level, here, you're seeing a lot of effect due to the ELT. You'll never get above, say, a 30% distortion, or maybe a 40% distortion, from just the FM signal, but with the ELT in there, distortion really goes wild.

I won't go into this slide in any depth. This is for a Genave Alpha 10 receiver. The same type situation prevails wherein the interference becomes very severe as the level of signal drops and the FM signal rises. Curves 1, 2, and 3 are plotted without the ELT connected, and there's not much spacing between them; then curves 4, 5, and 6 above are with the ELT connected. Curves 8 and 9 are with ELT, 10 and 11 are without ELT, and the effect is pretty dramatic there.

This slide is for the King 195. This is a TSO receiver. The first two lines are 46% distortion with the ELT, the third line is without the ELT - the same input as line 2, but with 0% distortion. Lines 1 and 4 should be compared. They are with and without. One is 46% distortion and the other is 11%. The 7th line and the last line reflect the dropping of power of interfering signals. At this level, here, we drop from -13 dB to -16 dB. At -13 we had 44% distortion, but when we dropped to -16, we got 0% distortion - it was just an immediate change due to a reaction of the ELT.

The receiver sensitivity response is best reflected, perhaps,

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by this next viewgraph. The No. 1 line up there is with a -85 dBm input. The No. 6 line is -65 dBm input. We've got a 20 dB separation between No. 6 and No. 1. You have lost, in effect, 10 dB sensitivity on this receiver by the introduction of that signal.

The next slide is the same type of test. In this case, the effect has changed so that -85 is line 6 and when we put in the -10 dB signal, it goes to line 4, so we've lost only about 2 to 3 dB on this receiver. This is a King 195. On this curve, here, I simply want to show you the effect when we have two FM signals being put in. We sweep one signal for 88 to 108, that signal generator 2, then we added a third FM signal here, No. 3, and for the first two there were only two, so these two curves, here, reflect - the first one, down here, is without the ELT, the second one is with the ELT. This curve, here, is three FM signals with ELT. This one is without the ELT. Now these curves, here, are at 118. The next set of curves, two curves up, are at 127. This set of curves is at 135. I'm simply saying that this chart reflects a condition which is general, where the amount of interference decreases as you go up in the frequency. At 118 where all your terminal assignments are, and where all your interference is, your interference is worst.

If you're thinking that any two FM signals will cause the distortion we've been seeing, that's not the case. For two signals, a -60 on frequency signal with FM signals of -6, -2, -6 signals get a 13% distortion. When you raise that to -90, it was 15%, but when you go to two frequencies which were not intermod frequencies to the on frequency signal of 122.8, distortion drops to 0.

Interference to the ILS receiver as shown here gives full scale left 25 microamps, so for a -10 - +10 dBm input, this is what we're getting. By the time we've dropped the level to -40 zero 60 held the same, we are now down to 7 microamps, so we're declining. As the level of the interfering FM signal keeping the on frequency VOR simulator signal constant at -60, we dropped the interfering signals to 40 and -10. Now we're down to about 3 microamps. This is the type of interference you can get from even low level FM signals from this receiver. We boosted the FM signal to zero at 5 and now we're back to 25 microamps, full scale deflection on the CDI. Those were with the ELT. Without the ELT, the last three lines, here, reflect what's happened. Zero -5 -8 -9 60 and 75, no ELT and we're getting 25 microamps, then we drop to 18, then down to 10 on the last, so even without the ELT, you get a very significant error.

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For antenna tests, we have a range at NAFEC, and we tested some of the avionic antennas on this range. A sample VOR antenna could be taken on this slide by this solid black line. It drops to minimum at 120, then it starts to rise sharply at 110. The only Com receiver we have monitored here comes back, starts rising at 120, flattens out, comes across, and goes back up again, but once it's at about 100 megahms, it starts to rise comparably with the Nav antennas. There's not a big difference in the rejection of the FM band, but for that reason there's not much difference between the FM Com antennas as we use these two antennas in our calculations for receiver power interference.

In Florida we didn't get much in the way of interference, although we expected to. Within that red circle on this slide we have about 2 million watts of FM power being radiated. Here is Opalaka, there's North Peary, right here off the circle is Fort Lauderdale - that's a five mile compass - and then down here is Miami International. We went back and retested at a later date and found the interference we expected, but we were flying at too high an altitude, about 2,500 feet, and we also found we had more signal loss in our antenna-to-receiver arrangement, so we had to change that as a result of our test.

We can crank in maybe 30 FM stations without too much problem. It just takes longer in our computer program. The computer program said if you had FM stations of these frequencies, you would get interference on this FAA frequency. Well, if these FM stations were spread far apart, you might not get the interference, so let's go to the VIN diagram approach where we make certain assumptions about the FM stations. The FM station was assumed to be omni directional and uniform in its radiation. For interference, we had to have two or more interfering signals. And we computed the level of power which would cause a receiver to experience interference. For our purpose, we decided -10 dBm was the level required for interference to overcome the Com receiver and -20 was necessary to break through on the Nav receiver, so if you had two signals for interference, one had to be the high level, the other one could be lower. For the Com receiver, one had to be at -10, but the other one could be at -30 dBm and you would get interference from that combination. We computed the range to the level of -10, -20, or -30 dBm. For -30, this outer circle, our range, varied between 4 and 40 miles; for -20 dBm, the range varied between 1-1/2 to 12 miles; and for -10 dBm, from .4 to 1-1/2 miles for Com receivers and .4 to 3.7 miles for

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Nav receivers. So, in order to get interference, we said that a receiver had to be within this circle, here, and have a second signal which overlaid it.

You would get a situation of the sort shown on this next slide where you have FM station A and within the -10 dBm level you have another interfering signal overlaying it with a -30 level. The area of potential interference is shown by this cross-patched area and out here, again - this is station B at the -10 level, but overlaid by the -30 level from Station A, so you have a potential interference area there also.

Another particular arrangement, a different configuration, shows up like this next slide. On the basis of this type of prediction, we had an idea of where we might find our interference in the field. We have found that this works out pretty well in our analysis of data from Topeka. We also found it was true in the Atlantic City area. One of the possibilities for applying this is to have the data assembled at a facility with the necessary data base in a computer. We would have to know the FM station data, its power, the location for the receiver, the transmitter sites, the FAA supported facilities - all the information commonly held by the Office of Telecommunications, Department of Commerce, or by ECAC. The requirement would then be to develop a program to use this information and plot the potential interference areas on all of the 150 or so applications from the FCC that come in every month and send this material out to the field and say, 'Hey, is this going to give you a problem?'

We did our comprehensive flight tests to determine the prevalence of the interference, how frequently it is encountered, to confirm the signal levels of our lab tests, the type of interference we found, and to find out how accurate our prediction for interference location was. We used these receivers: the King 195B and Com 11A, the Genave, an ARC Nav 400, Mark 12, and the Genave 110. In our aircraft we also had a spectrum analyzer. We started out using a Polaroid camera to record the spectrum analyzer, but that didn't work out too well - the frequency changed too rapidly, particularly when we were flying over the antennas, so we went to a Vidicom to record it continuously. That worked better, but it really plays hob when you try to photograph the Vidicom output for reports. Then, on the last flight, we went to a camera and Vidicom combination, so we already have the photographs and that gives us a lot of data to work with. We also had a strip chart recorder for recording CDI deflection and the AGC and we used a 14

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channel audio recorder to record the audio from the receivers.

On this slide, we have two antennas on top of the Convair 580 fuselage at stations 500 and 560. I guess that's 55 feet and 56 feet from the nose. About a foot and a half forward of the station 560 antenna, we installed an ELT, the Sharc 7. We tested the NARCO 10 and the Sharc 7, and gave up on the NARCO 10 because we couldn't get any interference out of it, but the Sharc 7 is the ELT we've used throughout these tests and it has given us real, live action every time we've used it.

This next slide is a photograph of a map which shows the location of FM stations in the Atlantic City area. Between this station and this station over here, we expected to get interference on a frequency of 110.5. This station is a 20 KW station, this one is a 50 KW station. This is a 20 dB level - or -20 dB level, and this is also a -20 dB level, so we expected to get that interference within that set of circles. We did get that interference, pretty closely conforming to the size of those circles. Out in Topeka, however, we weren't as fortunate in getting consistent results because we found we were getting interference not from the Topeka area, but from about 30 miles away - far outside the radius. What I'm saying is that while the effective radiated power is nice for calculating these circles, it doesn't always let you know when you're going to get interference. The result of the flight test was that interference is extensive. We found interference at the frequencies we monitored using our computer program and we listed all the FM stations for the cities we went to. We went to Kansas City, Topeka, Indianapolis, Denver, Albuquerque, Houston San Antonio, Dallas, and then to the Miami area. In each of these locations we found interference on the frequencies we monitored. The flight test reported different interference types than we had anticipated. We found that if you go off frequency for FM stations, you get this motorboating sound, it's not the music and the voice that you frequently associate with interference, it's not the good music or the country music stations that come through. It can be just this motorboating sound. The point of the interference coming from a more distant station than had been calculated was already made. The interference we did find when we compared with the spectrum analyzer signal level occurred at the levels we anticipated in the laboratory, and the ELT increased the amount of interference that occurred when we were flying. We could be flying in an area getting no interference, connect the ELT, and right away we'd have interference.

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The frequency assignment is made so that the low frequency for the Com band is assigned to the terminal area. Much of the interference could, perhaps, be relieved if things were reversed so that the frequency assignment for the terminal areas were made from the high end of the band. Everybody screams when this is said, and I can understand the problems associated with it, but that appears to be the case. The assignment of educational channels currently is made at the low end of the FM band, the 88 MegaHertz end. It would improve things if those assignments were made at the high end of the band, partly because the FM channels and transmitters are lower power, usually, than the high end of the FM band. The high end of the FM band consistently has 100 KW transmitters. That would relieve the problem somewhat. It would also relieve the problem greatly if they kept the high end of the band away from airports, away from the ILS and the VOR approaches and the low altitude flying.

We know that this can create interference, we know that can cause variations from the normal on a great many navigation receivers. We need to know something about the spectrum level in the FM band in the ILS space and the space around airports that is critical to communications. We need to modify the TSO for the ELT so that it will eliminate this re-radiation in the future. There was only one ELT that we found particularly bad, but it's a TSO ELT. The final item here is to reduce the couplings between the Com/Nav receivers and the ELT. That's one way of doing it. Every aircraft, of course, is going to be different; if you get an ELT four feet away on one aircraft, it might have a 30 dB to the communication Nav antennas, whereas on another you might have close coupling. Finally, there appears to be a definite need to revise the TSO for Com and Nav receivers because the present TSO does not provide for adequate rejection of intermodulation interference.

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