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Air Traffic Control Radar Beacon System and Mode S Transponder Requirements in the National Airspace System; Final Rule

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 43, 91, 121, 127, and 135

[Docket No. 23799; Amdt. Nos. 43-26, 91-198, 121-190, 127-41, 135-22]

Air Traffic Control Radar Beacon System and Mode S Transponder Requirements in the National Airspace System

see correction

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: This action establishes requirements pertaining to the use, installation, inspection, and testing of Air Traffic Control Radar Beacon System (ATCRBS) and Mode S transponders in U.S.-registered civil aircraft. The rule adopted continues to require a transponder for operation in each terminal control area (TCA) and in the airspace of the 48 contiguous states and the District of Columbia above 12,500 feet above ground level (AGL). Automatic pressure altitude reporting equipment, which is currently required in all of the above airspace except Group II TCA's, will be required in Group II TCA's effective December 1, 1987. The rule provides for a phased transition from ATCRBS to Mode S transponders in the National Airspace System (NAS) by limiting the manufacture and installation of ATCRBS transponders. After January 1, 1992, all newly installed transponders in U.S.-registered civil aircraft are required to meet the requirements of the technical standard order (TSO) for airborne Mode S transponder equipment. The rule also permits ATCRBS transponders already installed on that date to be used indefinitely. Projected increases in air traffic will require improved aircraft location and identification information, which will be provided by the Mode S and automatic pressure altitude reporting equipment. These requirements are an essential component of the NAS Plan. Mode S is also necessary technical prerequisite to obtain data link services which allow digital exchange of information between aircraft and the ground. The FAA will provide these services beginning on/ about 1990. This action also sets forth test and inspection requirements for the Mode S transponder and a new output power test requirement for the ATCRBS transponder.

EFFECTIVE DATE: April 6, 1987.

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SUPPLEMENTARY INFORMATION: The three kinds of aircraft equipment addressed by this rulemaking are as follows:

Air Traffic Control Radar Beacon System (ATCRBS). A radar system in which the aircraft to be detected is equipped with a radio receiver/ transmitter called a transponder. Radar pulses transmitted from the ground are received by the transponder and used to trigger a distinctive transmission from the transponder. The controller's radar receives this transmission and displays a distinct and amplified return on the radar scope.

Mode S Transponder. The Mode S Transponder is an advanced version of the existing ATCRBS transponder. The Mode S transponder is completely interoperative and compatible with the current ATCRBS system. Mode S utilizes a discrete set of radio pulses (code) for each individual aircraft, and is not limited to the maximum 4,096 possible codes of the ATCRBS transponder. Mode S also adds the capability to provide a data link between the aircraft and the ground.

Mode C (Automatic Altitude Reporting Equipment). Some transponders are equipped with a Mode C capability. Mode C is that function of a transponder which responds to specific ground interrogations by transmitting the aircraft's current altitude in 100 foot increments. This information is received by ground equipment and displayed on the controller's scope in the data block for the transmitting aircraft. Mode C may be used with both ATCRBS and Mode S transponders.

History

On October 18, 1983, the FAA published an Advance Notice of Proposed Rulemaking (ANPRM) announcing the proposed use of Mode S transponders in the NAS (48 FR 48364, Notice No. 83-16). The following was proposed to take effect by 1992 or earlier, as noted:

1. Issuance of a technical standard order (TSO) for airborne Mode S transponder equipment. With issuance, TSO authorization to manufacture ATCRBS transponders would be terminated effective in 1986.

2. Amendment of Federal Aviation Regulations (FAR) Part 43 to include tests and testing procedures appropriate to Mode S transponders.

3. Amendment of FAR Part 91 as follows:

a. Newly installed transponders in U.S.-registered civil aircraft would meet requirements of the new TSO for airborne Mode S transponder equipment.

b. Either a Mode S or ATCRBS transponder, as well as automatic pressure altitude reporting equipment, would be necessary to operate in TCA's.

c. Either an operable Mode S or ATCRBS transponder, as well as automatic pressure altitude reporting equipment, would be necessary above 12,500 feet MSL in U.S. airspace. The proposal would retain the current exception for gliders above 12,500 feet MSL and retain provisions for helicopters and air traffic control (ATC) authorized deviations.

d. Automatic pressure altitude reporting equipment would be required for operations in Group II TCA's.

4. Amendments to FAR §§ 121.345(c), 127.123(b), and 135.143(c) to be consistent with the amendments to Part 91.

Comments—Proposed Introduction of Mode S

Comments were generally favorable to the proposed introduction of Mode S in the NAS. Twelve (12) comments were received which, though generally supportive, expressed some concern in several areas.

The areas of concern centered on:

1. The ramifications to U.S. manufacturers, foreign governments, and various international users regarding early cutoff of the TSO authorization to manufacture ATCRBS transponders in 1986.

2. The need for improved accuracy of altitude data, improved automatic pressure altitude reporting equipment, and reduced quantization (i.e., smaller intervals of reported altitudes) of aircraft reported altitude in the Mode S environment.

3. The impact of the proposed installation requirement on the Department of Defense (DOD) and on general aviation aircraft owners and operators.

4. The impacts on pilot cockpit workload, awareness of other air traffic, and the vulnerability to errors in altitude reporting in an automated system.

5. The extent of U.S. airspace within which Mode S would be required.

6. The bottom-line services and benefits that Mode S offers users,

particularly general aviation users, in the NAS.

On September 17, 1985, the FAA published a Notice of Proposed Rulemaking (NPRM) (50 FR 37674, Notice 85-16) which reflected consideration of the concerns expressed in response to the ANPRM.

1. The NPRM acknowledged that an early U.S. withdrawal of the ATCRBS TSO authorization would likely have an unnecessarily disruptive and adverse economic effect on U.S. manufacturers' international sales of the ATCRBS and in addition an adverse effect on the regulatory and certification processes of foreign countries. To meet the dual objectives of permitting the continued manufacture and sale of ATCRBS transponders for foreign distribution and consumption while accomplishing an orderly domestic phase-in of Mode S transponders, the FAA proposed a schedule of installation requirements applicable only to ATC transponder equipment installed in U.S.-registered civil aircraft. The schedule was as follows:

Mode C automatic pressure altitude reporting equipment would be required in Group II TCA's effective January 1, 1992.

Transponder equipment, except equipment reinstalled in an aircraft from which it was removed for maintenance, would be required to meet TSO performance and environmental requirements in accordance with the following schedule:

1. Through December 31, 1986:

Any class of ATCRBS transponder (TSO-C74b or TSO-C74c), as appropriate; or any class of TSO-C112 (Mode S).

2. January 1, 1987, through January 1, 1992:

Any class of ATCRBS transponder (TSO-C74b or TSO-C74c) if the equipment was manufactured before January 1, 1987; or any class of TSO-C112 (Mode S).

3. After January 1, 1992:

Any class of TSO-C112 (Mode S).

As stated in the NPRM, the revised schedule was seen as providing several options to the U.S. civil aircraft operator. For example, the operator could use a previously installed ATCRBS transponder as long as it could be maintained. Through December 31, 1986, the operator could elect to replace a previously installed transponder or install a newly manufactured or used ATCRBS or a Mode S transponder meeting appropriate TSO specifications. From January 1, 1987, through January 1, 1992, the operator could elect the same options with one restriction. If the operator elects to install a new or different ATCRBS transponder, it must have been manufactured prior to January 1, 1987.

2. With respect to the concerns relative to improved accuracy of altitude data, improved automatic pressure altitude reporting equipment, and reduced quantization of aircraft reported altitude, the FAA agreed there would be benefits from greater precision in automatic altitude reporting. However, the agency maintained that each area would require separate development of the associated technology and procedures; and in each case, the FAA would seek public and industry input on the specific proposal. In addition, the existing equipment and procedures were determined to be fully adequate to support the additional reporting requirements proposed in the NPRM. For the above reasons, and because the suggested improvements were beyond the scope of the NPRM, the FAA determined it would not be appropriate to incorporate such suggestions in the Mode S NPRM. The agency did announce it would consider the institution of separate rulemaking for adoption of the requested improvements.

3. It was also recognized in the NPRM that an early cutoff of the ATCRBS TSO would adversely affect DOD equipage plans for its sizeable fleet. Accordingly, the FAA stated in the preamble to the NPRM that it proposed to permit continued manufacture of ATCRBS transponders to correspond to the DOD Mark XV implementation schedule.

4. The preamble to the NPRM also recognized the concern expressed concerning the adverse effect a "silent" Mode S data link environment would have on overall pilot traffic awareness and pilot workload in the cockpit. Again, these concerns were considered to be well beyond the scope of the NPRM. The FAA stated in the NPRM that in its implementation of data link, the agency would involve the public in its studies of all factors associated with each kind of message being considered for data link.

5. The concerns relative to the impact of Mode S on general aviation were articulated by the Aircraft Owners and Pilots Association (AOPA). AOPA's position was that the benefits of Mode S would accomplish acceptance of Mode S on a voluntary basis and that is should not be mandated. AOPA also questioned the benefits of Mode S to low altitude traffic. AOPA went on record as opposing Mode S if it were mandated above 6,000 feet. AOPA did recognize that the FAA proposal was to mandate Mode S or ATCRBS above 12,500 feet and within TCA's

FAA responded to the issues of bottom-line benefits, scope of airspace wherein Mode S is proposed, and service capabilities with a summary of the benefits of the NAS Plan. The goals of the NAS plan were broadly presented in the preamble of the NPRM as those designed to meet the pressures of increased demands for aviation services, limit costs, and provide and improve facilities. The preamble further stated that the plan for Mode S is incorporated in the NAS Plan because Mode S is considered to provide the airborne data link capability in NAS. The following excerpts from the NPRM describe in summary the NAS Plan and the role of Mode S in the NAS.

The NAS Plan is a comprehensive plan supported by large increases in automation to yield significant improvements in service and cost savings to the airspace user, the taxpayer, and the ATC system. Cost savings are expected through reductions in delays and fuel consumption due to improved traffic handling capabilities and the increased ability of the ATC system to accommodate direct, pilot-preferred routings. The effectiveness of NAS is expected to be dependent, in great part, upon a surveillance system which can provide accurate position information, relatively interference-free aircraft identify through selective addressing, and automatic pressure altitude reporting equipment. The Mode S transponder, coupled with its associated automatic pressure altitude reporting equipment, is considered a key piece of avionics necessary to participate fully in and receive the benefits of the NAS.

To summarize the role of Mode S in the NAS, Mode S is an advanced secondary radar system expected to provide improved accuracies in the surveillance of aircraft position and more interference-free identity and altitude reports to ATC.

Comments on the NPRM

The NPRM comment period expired December 16, 1985. At the request of the Air Transport Association (ATA), the comment period was reopened. The reopened period extended from February 14 to March 3, 1986 (51 FR 5686, Notice 85-16). A total of 15 commenters responded during both the original and reopened comment periods. There was general support and acceptance of the proposal. However, those in support of the proposal did express certain reservations and suggestions for improvement. Those in general support of the proposal but with comment and suggestions were the Air

Traffic Control Association (ATCA), Air Line Pilots Association (ALPA), Soaring Society of America (SSA), Experimental Aircraft Association (EAA), General Aviation Manufacturers Association (GAMA), Air Transport Association (ATA), the State of Montana, and Aerospace Industries Association of America (AIAA), Rockwell International, and Allied Bendix Aerospace. Those generally opposed to the proposed introduction of Mode S into the NAS were the Aircraft Owners and Pilots Association (AOPA), the National Business Aircraft Association (NBAA), Foster Airdata, and two private citizens.

Issues

A common element in the comments was a perception that the agency is proceeding too quickly in mandating Mode S. Many commenters stated or implied that the FAA is accelerating the Mode S transponder requirement without giving due regard to the need for allowing a reasonable acceptance period on the part of all parties affected. Those identified as being affected by an accelerated transition from ATCRBS to Mode S equipment included the manufacturers who must design, develop, produce, and market Mode S; aircraft manufacturers who design and manufacture their aircraft cockpits to accommodate installation of Mode S; installers; and general aviation owners and operators who will make the ultimate decisions to purchase and install it.

The following are the major issues and related subissues presented in the public comments.

Major Issues

a. Mode S is costly.

b. The proposed installation schedule for Mode S transponders creates problems for:

—Avionics manufactures.

—Aircraft manufactures.

—Airlines.

—Owners and operators who believe they may be forced into making two purchase decisions, an initial one for a surveillance transponder, and a subsequent purchase when added data link services become available. In addition, commenters representing general aviation believe the general aviation operators may be forced into purchasing a transponder whose benefits are questionable.

c. Data link services to be available are indefinite. FAA has made no commitment to data link, causing uncertainty as to when and what services will be available.

Other issues

There were a number of other issues and subissues raised. They are as follows:

1. There is no justification for automatic pressure altitude reporting equipment in Group II terminal control areas (TCA). On the other hand, other commenters expressed the opposite view. That view was that there is a recognizable need for automatic pressure altitude reporting equipment and its use should be required by separate rulemaking.

2. The recent decline in aviation growth does not bear out original NAS plan estimates and it makes the mandating of Mode S transponders unnecessary.

3. There are deficiencies and problems with the proposed transponder tests.

4. There are performance weaknesses and deficiencies associated with Mode S, data link, and Mode C altitude reporting equipment.

5. Use of Mode S with data link would create a "silent" environment, as opposed to today's "party line" voice communications environment. A silent environment is hazardous to flight safety.

6. The Mode S requirements may adversely affect DOD fighting capability.

7. The U.S. may be breaking International Civil Aviation Organization (ICAO) agreements if it issues a rule without international approval.

8. Issuance of Mode S requirements prior to issuance of the Mode S TSO is premature.

Discussion of major issues

a. Major issue number 1: Mode S is costly. Generally, concerns were expressed that Mode S transponders could impose a financial burden on the industry and that the FAA seems little concerned that added costs will have the greatest effect on the general aviation fleet. Major concerns associated with cost were—

(1) Mode S transponder prices, even before data link is added, will be higher, creating a smaller market, which in turn will drive the cost even higher.

The effect of higher prices would be to freeze or reduce the transponder equipage levels at the lower end of the fleet.

(2) Mode S transponders with data link will cost more because they are significantly more complicated and complex.

One commenter said that FAA's finding in its economic evaluation that the difference in cost between the ATCRBS and a basic Mode S transponder would be approximately $800 after a break-in period, was fallacious. This was said to be so because if real-time weather and automated ATC data link communications are the Mode S benefits, a surveillance-only transponder would not be very marketable. In other words, to take full advantage of data link and automation benefits, the Mode S transponder will be considerably more complicated, and therefore more costly, than a survillance-only transponder.

(3) There may be a need to make more than one buy of a Mode S transponder.

One commenter said that without any real FAA definition of what if any data link services might be available, an operator might at first buy a basic Mode S tranponder and subsequently be faced with a decision to buy another more expensive model when and if operationally effective data link services become available. On this issue, the ATA suggested that data link, at least at the basic communications level, should be required by regulatory schedule. This would permit introduction of data link for ATC purposes, without requiring replacement of the basic transponder. It would also permit reasonable investment decisions for equipment to be installed at earlier dates.

(4) Mode S transponders will have a negative cost impact on small helicopters and airplanes, and on the DOD fleet.

This commenter said the DOD would feel a great impact because of its large new fleet which would be introduced during transition to Mode S. The U.S. Army alone has nearly 10,000 helicopters now, most of which are being replaced by new helicopters which could be required to carry advanced navigational capabilities of ATCRBS and Mode S equipment. The commenter concluded that the proposed requirement seemed to be excessively redundant and expensive

Discussion of cost issue.

Under the narrow-demand, higher-price, and resultant equipage-freeze theory, the industry would produce fewer transponder options if there is a narrow base of demand, focusing on the higher end of the market (with built-in data link). FAA discussions with marketing representatives of two manufacturers of transponder equipment did not support this scenario. Both companies advised they expect to continue to produce mainly for major portion of the market. They do not expect any significant contraction in the

demand for their transponders in the 1990's in large part because of the expected existence of a substantial retrofit market. With regard to the market as a whole, although there has been a dramatic decline in the production of general aviation aircraft in recent years, the size of the total fleet and the number of hours flown have remained fairly constant or increased somewhat. Furthermore, the manufacturers have the freedom to produce basic Mode S equipment that will be upgradable or have data link capability, thereby enhancing its attractiveness to potential purchasers of smaller aircraft.

Some commenters noted that the price difference quoted in the rule between Mode S and ATCRBS transponders does not include data link and that there are very few or no advantages for a Mode S transponder without data link. The manufacturers' ability to produce basic, upgradable equipment, as expressed above, is expected to help resolve this problem.

With respect to the issue of basic Mode S advantages/disadvantages, the FAA recognizes that data link is a major benefit of equipping with a Mode S transponder. The agency also believes that most users will eventually opt to equip with data link. There are however, two basic advantages of Mode S transponders that accrue to users that derive from the capability to enhance ATC services. One is the unique address portion of the Mode S transponder which makes possible the automatic association and display of the transponder reply with aircraft registration on the ATC radar scope. The other is that when a Mode S transponder operates with a Mode S ground system, certain kinds of radio interference present in high-density traffic environments are reduced below the level experienced with an ATCRBS transponder. Not all of the garbling problems with the ATCRBS transponders and ATCRBS ground station can be eliminated by upgrading the ground station or the transponder.

There is also more to the cost issue when considered in conjunction with Mode S with data link capability. The FAA had considered a requirement that would have included some level of data link with every Mode S transponder, but rejected it for two reasons. First, the agency believes that most users desire that the device mandated by the rule be as simple as possible—a number of commenters obviously preferred a device even simpler than Mode S. Second, FAA believes that a rule mandating data link would unnecessarily limit the flexibility of manufacturers to develop a range of capabilities. That range might be described as follows. At bottom is the user who is aware of the benefit of improved ATC surveillance, but has no use for the kinds of information envisioned for data link. A middle range may be the visual flight rules (VFR) operator with a simple display device to obtain weather services through data link. At the top of the line, one might find a frequent instrument flight rules (IFR) operator needing display, a touch entry device, or even a printer to make a permanent record of data link messages to obtain weather and ATC services. By not making data link mandatory, the flexibility to meet these needs is retained as determined by the marketplace and designers' innovations.

Comment regarding negative cost effects of the Mode S proposal on the DOD was not submitted by the DOD, but by private citizens. The DOD did not reply to the NPRM during the comment period but has since advised that it concurs with the proposal. In any event, under the transponder installation requirements of § 91.24(a), the proposed Mode S requirements pertaining to transponder installations apply only to U.S.-registered civil aircraft.

b. Major issue number 2: the proposed installation schedule for Mode S transponders creates problems for avionics and aircraft manufacturers, airlines, and aircraft owners and operators. The major concerns expressed in this area were—

(1) Effects on avionics manufacturers. One of the proposal's alleged negative effects to avionics manufacturers was stockpiling. The NPRM proposed that an ATCRBS transponder could continue to be installed in a U.S.-registered civil aircraft after January 1, 1987, but only if it were manufactured before that date. Rockwell International commented that an effect of this requirement would be that manufacturers would have to stockpile ATCRBS transponders for 5 years (from January 1, 1987, to January 1, 1992). Stockpiling was also brought out by another commenter relative to the concerns expressed regarding production problems.

Another alleged negative effect to avionics manufacturers was that the proposal did not allow time which would be needed to design, develop, and produce Mode S transponders. Allied Bendix stated that the ATCRBS production must be moved closer to the January 1992 deadline. Since the typical product development cycle was said to be 18 to 24 months, Allied Bendix recommended that ATCRBS production cutoff for non-U.S.-registered civil aircraft should be 24 months prior to the Mode S implementation deadline. The ATCRBS production cutoff should than be December 31, 1989, if the January 1992 deadline were retained. Allied Bendix commented this would allow availability of equipment which incorporates the latest technology coincident with a market that would justify the investment required to introduce a new product. Otherwise, the company maintained it was left with the choice of either stockpiling ATCRBS transponders or foregoing this market opportunity.

In still another area of negative effect, a manufacturer said that because Mode S transponders would be more complex, they would be more expensive. Therefore, it would be more likely that ATCRBS transponders would be installed up to the 1992 deadline or until the supply of pre-January 1, 1987, transponders was depleted. A consequence of this would be that the onset of a general aviation market for Mode S transponders would be very uncertain.

(2) Effects regarding general aviation. There were several alleged negative effects of the proposal to general aviation, most of them associated with the cost/benefit issue. The NBAA maintained that owners in the lower-price end of the fleet would not equip with a transponder at all when faced with the unavailability of low priced ATCRBS transponders and no expectation of flying above 12,500 feet MSL or in TCA's.

On another related subissue, NBAA said that new hardware and software are 5 to 10 years in the future, and possibly even longer for the lower-price end of the general aviation market. Accordingly, the only foreseeable service that would convince the lower-price portion of the market to buy Mode S is improved real-time weather services.

Although not expressed in terms of specific effects to general aviation, the AOPA submitted several objections to the Mode S proposal questioning the value of Mode S primarily in terms of benefits and cost. In terms of benefits, AOPA submitted that while there may be some small incremental improvement in surveillance from use of Mode S, most, if not all, of the surveillance accuracy improvement will be attributable to the Mode S ground sensors and not the Mode S transponders. Accordingly, the FAA should permit sufficient time after Mode S ground sensors are operational for an objective evaluation of their value prior

to forcing an airborne transponder retrofit to achieve a marginal improvement in accuracy. AOPA's other concerns with the impact to general aviation owners/pilots were expressed in terms of cost. For example, AOPA reiterated the concern that Mode S transponder prices would be higher. As a result, purchases would be down, essentially freezing equipment levels in the low end of the fleet. These concerns are discussed under the cost issue above.

Comments of the SSA noted the effects of the proposal on general aviation with respect to consumer choice. SSA agreed with AOPA that service benefits of Mode S, rather than regulation, should be relied upon to motivate pilots to upgrade their equipment. Mode S services must be made available to general aviation aircraft operating below 10,00 feet MSL and not be reserved for jet-powered, high-altitude traffic. For this reason, Mode S should not be made mandatory after January 1, 1992. SSA concluded that ATCRBS should be permitted to be manufactured and installed as long as it does not interfere with either the surveillance system or services.

With respect to what was perceived as an unjustified installation requirement of Mode S transponders, the lack of consumer choice was an issue raised by two other commenters. One comment was that Mode S development will require at least 2 years from the availability of TSO-approved Mode S airborne equipment. The commenter referred to the NPRM which stated that only one Mode S ground radar is expected to be operational by 1988 at an unspecified location. Another commenter voiced a similar concern by saying that under the NPRM, users will be forced to equip with airborne Mode S before the ground stations can provide the same coverage as the older ATCRBS. The commenter's conclusion was that FAA's plan for forcing airborne Mode S equipage is premature.

(3) Effects on aircraft manufacturers. One commenter pointed out that because of technical parameters and data link capability, the Mode S transponder is not physically interchangeable with the ATCRBS transponder and, therefore, current aircraft designs cannot accept Mode S. The commenter suggested that new radio rack mounts, new control panels, new wiring, new cooling, and an additional antenna are needed to accommodate the new installation.

The problem facing manufacturers was also raised by several commenters as a retrofit problem for aircraft operators. Several commenters maintained that a formidable effect of the Mode S proposal would be the problem of retrofitting Mode S transponders in cockpits not adequately designed to accommodate the new equipment. One said that current aircraft designs do not accept Mode S. Installation design changes will be necessary and a development flight test will be required to assure antenna locations and operation characteristics are acceptable. Another suggested that retrofitting of older aircraft should remain voluntary except for aircraft operating in those areas where radar coverage is degraded by high-density traffic.

(4) Effects on airlines. The ATA advised that the proposed installation schedule would affect airlines. When a transponder is removed for maintenance, airlines routinely replace it with another unit and do not reinstall the same transponder equipment in the same aircraft each time.

The defective box is taken to the avionics shop for repair and subsequently installed in a different aircraft within the fleet. Under the proposed January 1, 1987, cutoff date associated with ATCRBS transponders, airlines would be required to retrofit all aircraft prior to the January 1, 1992, Mode S date.

Discussion of installation issues

The FAA believes that most of the concerns of and effects upon the avionics and aircraft manufacturers, owners/operators, consumers, and airlines can be alleviated by—

(a) changing the last manufacturing cutoff date for ATCRBS transponders which may be installed in U.S. aircraft from December 31, 1986, to December 31, 1989. The additional three years will provide an extended time period within which affected users may effectively plan for transition from ATCRBS to Mode S;

(b) modifying the installation requirements so that—

(1) a transponder that meets requirements of TSO C74b or TSO 74c, and that is manufactured before January 1, 1990, may be removed from an aircraft for maintenance and/or repair, and then be reinstalled on the aircraft from which it was removed. Also, a correctly functioning transponder which meets the requirements of the appropriate TSO may be installed on the aircraft temporarily while the malfunctioning transponder is being repaired.

(2) for fleet operations, a transponder that meets the requirements of TSO C74b or TSO C74c may be removed from an aircraft for maintenance and/or repair, and then be installed on either the aircraft from which it was removed or on another aircraft in the same fleet. Equipment transferred among fleet aircraft will be considered permanent equipment and not "substitute equipment" under the provision for temporary replacement sets. Accordingly, any equipment installed for the first time in an aircraft of a particular operator's fleet after January 1, 1992, must meet the requirements of TSO–C112 (Mode S).

The FAA believes that the above changes to the installation requirements which appear in the final rule may be expected to:

(i) Eliminate the problem of *stockpiling.*

(ii) Clarify onset of a Mode S market.

(iii) Allow time for aircraft manufacturers to ensure that new aircraft designs provide adequate space, wiring, etc., to accommodate Mode S equipment; and

(iv) Allow time for operators/consumers to plan for retrofitting which is not mandatory but which could take place in the 1990's as owners/operators consider replacement of ATCRBS transponders.

With respect to the issue of the reluctance to install a Mode S transponder because of associated increased costs, the FAA views as insignificant any disincentive to buy a Mode S transponder because a basic unit costs more than it does today. Most voluntary transponder equippage is due to the perceived benefit in obtaining ATC services. Those services will continue and will be enhanced with Mode S. We believe that users will see that cost as being justified. If some users do not see it as being justified, the rule provides ample time for low end users to equip with ATCRBS transponders, the life of which should extend to near the end of the century.

The proposed rule did not expressly provide for the use or installation of ATC transponders which were manufactured under TSO–C74 or TSO–C74a. The existing rule requires that transponders installed after January 1, 1974, or used after July 1, 1975, meet the requirements of TSO–C74b or TSO–C74c. However, the use of the TSO–C74 and TSO–C74a equipment after July 1, 1975, could be approved by the Administrator if the operator submitted data showing that the equipment met the performance standards of the appropriate class of TSO–C74c and environmental conditions of the TSO under which it was manufactured.

Any equipment which qualified under this provision would be more than eleven years old at this time. While the

rule adopted does not make specific provision for such equipment, the FAA will permit the continued use of any equipment manufactured under TSO-C74 or C-74a, if still in use, if that equipment meets the performance standards of TSO-C74c and the environmental standards of the TSO under which it was manufactured.

c. Major issue number 3: Data link services to be available are indefinite; they lack FAA commitment; operators do not know what data link services will be available nor when. Uncertainty in this area is also likely to be costly to consumers faced with a decision to purchase Mode S transponders (the latter part of this issue is discussed under the cost issue).

Several commenters noted that the FAA made no commitment in the proposal to data link applications, even though data link was put forth as one of the basic benefits to come from the Mode S transponder. Moreover, to obtain the benefits of data link, more equipment would be required, e.g., displays, printers, and input/output devices. This leads to cost and retrofitting problems. The AOPA commented that any forced transition to Mode S transponders should begin only after the FAA, in concert with the aviation user community, has decided what services will be provided on the data link and has created a plan which ensures that investments in equipment to obtain those services will be justified.

Discussion of the data link issue

While the FAA has not to date issued any rulemaking or technical standards specifically relating to data link, the agency is now engaged in preparation of a data link master plan and the development of a data link program. The FAA expects that informational data link services will be available within a year of the first operational Mode S sensors. In addition, the FAA agrees that there is a need to stimulate aircraft owners to purchase Mode S transponders by accelerating date link development. Data link development to date has been system oriented and has concentrated on the NAS components that are necessary for date link. Agency personnel are meeting with user groups to develop implementation priorities and a schedule which is compatible with the Mode S transponder rule schedule.

With regard to the products and services that the FAA expects to have available for users, the FAA objectives are to—

(a) Develop and implement data link applications which improve aviation safety and efficiency and stimulate Mode S transponder equipage;

(b) Provide data link services at the earliest date the equipment and data base availability permit; and

(c) Provide a focal point for all domestic and international aviation data link standards.

Weather information is currently scheduled to be the first data base available. Therefore, weather services are expected to be the first group of services offered using Mode S data link. The initial set of potential services within this group are terminal forecasts, surface observations, Automated Surface Observation System data, Automated Weather Observing System data, winds aloft forecasts, pilot reports, radar summaries, and hazardous weather advisories. The initial implementation of these services may be on a request/reply basis. As the system matures, these services can be provided to a pilot in a more automated manner.

The second group of potential services expected to be available are expanded weather and airport services. These include the Automated Terminal Information System, wind shear alerts, and runway surface winds.

The third group of potential applications expected to be available are initial ATC services. These applications include transfer of communications, altitude assignment confirmation, flight identification, minimum safe altitude warning, traffic information, and uplinking of aircraft position data.

The fourth group of potential applications expected to be available are dependent on the implementation of the advanced automation system. These applications include en route metering, automatic flight service hazardous weather, weather graphics, and clearance delivery.

Each of the above groups of services depends upon specific equipment and data base availability. The indicated order of group implementation reflects the current FAA schedules. The implementation schedule of a data link application within a group depends upon its acceptance by the users and the maturity of the concept. One of the data link program objectives is to provide the greatest number of data link services in the shortest time span.

In regard to the issue of requiring data link, the FAA had considered specifications that would have required some level of data link with every Mode S transponder, but rejected it for two reasons. The basis for rejection was that most users desire the simplest device possible; and secondly, FAA believes that a rule mandating data link would unnecessarily limit the flexibility of manufacturers to develop a range of capabilities that was described under discussion of the cost issue. In consideration of manufacturers' opinions in this area, the FAA has retained the manufacturers' flexibility to meet these needs in accordance with the marketplace and product innovations and not by regulation.

Discussion of other issues

Issue number 1: The need for automatic pressure altitude reporting equipment.

The NPRM proposed an effective date for requiring Mode C equipment in Group II TCA's of January 1, 1992. For reasons discussed below, the FAA has adopted an effective date in the final rule of December 1, 1987. The basic justification for extending the requirement to Group II TCA's remains the same. The comments which addressed the Mode C issue focused on the need for Mode C in Group II TCA's and on the inclusion of Mode S and Mode C requirements in the same rule, but not on the implementation date for the Mode C requirement.

AOPA opposed the use of Mode C in Group II TCA's saying the FAA had not provided a rationale for extending the use of Mode C transponders to additional airspace. AOPA believes there is little evidence to show that it can help to improve ATC system safety and challenged FAA claims that Mode C would increase ATC effectiveness through greater selectivity in viewing targets or that it would reduce the number of traffic advisories or avoidance vectors. AOPA said that TCA's should be considered individually, and rulemaking action should be taken if it becomes clear that a location warrants such exclusionary provisions based upon traffic volume, complexity, aircraft mix, controller workload, and frequency congestion.

In another view, two commenters said that it would be inappropriate to include two complex issues in one rule, and that Mode S and Mode C should be handled by separate rulemakings.

The FAA does not agree that the use of Mode S transponders and automatic pressure altitude reporting equipment should be separate rulemaking actions. The required use of altitude reporting equipment in Group II TCA's is not a separate issue; rather, it is an extension of its current application in Group I TCA's and above 12,500 feet MSL. Neither can its use be regarded as separate and unrelated to the use of Mode S transponders since its use will logically be required in the same airspace areas where Mode S transponders will be required.

Automatic pressure altitude reporting equipment has been required and has been in proven use in conjunction with ATC transponder equipment in Group I TCA's and above 12,500 feet MSL since 1973. The equipment has been used to provide essential aircraft identity, location, and altitude information in those airspace areas where such information provides a fundamental base in providing airspace users safe, orderly, and efficient use of available airspace.

Experience has shown that Mode C has been particularly beneficial in the higher density TCA airspace environment. It was in consideration of this environment that Task Group 1-2.1 of the National Airspace Review (NAR) recommended use of Mode C to reduce radio frequency congestion. The task group's rationale, as stated in Notice 85-16, was that this reduction was necessary to create more efficiency within the system thereby increasing capacity while providing an increased level of safety over operations with non-Mode C aircraft. In particular, the group pointed to weather conditions which cause pilots of VFR aircraft to change altitude to maintain appropriate separation from clouds. In a high density environment, this altitude change is not immediately forwarded to the controller. However, the Mode C readout on the controller's radar display does provide this information. The task group's conclusion was that in busy, complex areas with high concentrations of traffic, a continuous readout of aircraft altitude is a necessity for maintaining a continuous three-dimensional (range, azimuth, altitude) view of the traffic picture.

The FAA concurs with the finding of the NAR task group. The FAA also recognizes that the NAR task group envisioned use of Mode C equipment within a single class of TCA whose proposed establishment criteria were somewhat lower than current Group I TCA criteria and somewhat higher than current Group II criteria. Although the NAR task group related the Mode C requirements to a single class of TCA, the FAA expects similar benefits from use of Mode C in the airspace environment of today's current Group II TCA's. That environment is examined in more detail below.

The designation of a terminal area as a Group II TCA indicates that it is a higher density terminal area which presents complex air traffic conditions resulting from a mix of large turbine-powered air carrier aircraft with other aircraft of varying performance characteristics. There is no reason to believe that the complex nature of a high-density environment, as typified by a Group II TCA, will be altered by slower than expected growth in traffic or even the unlikely event of a sustained static level of traffic into the next decade and beyond. The requirements of the Group II TCA are basic to that environment and they are essentially common to the requirements of a Group I TCA. Furthermore, the requirements are generic in the sense that they could apply to any classification of airspace with similar characteristics. They are requirements designed to affort the greatest protection for the greatest number of people by providing ATC with an increased capability to provide aircraft separation service to minimize the hazardous mix of controlled and uncontrolled aircraft.

The amendment adopted prohibits operation in a Group II TCA without operating Mode C equipment, effective December 1, 1987. The requirement adopted is the same as that proposed in the NPRM except for the earlier implementation date. In consideration of the benefits of having each aircraft in TCA airspace equipped with Mode C, as discussed immediately above, the FAA believes that this requirement should not be postponed to 1992 as originally proposed. In addition, one or more other rulemaking projects under consideration by the FAA at this time would almost certainly have the effect of requiring Mode C in Group II TCA's long before January 1, 1992. These actions include:

—The establishment of a single category of TCA, in which Mode C would be required. This action was recommended by the NAR and also by a TCA Review task group established by the FAA in September 1986, and is part of the airspace reclassification rulemaking now in progress (FAA Docket No. 24455, 50 FR 5055; Docket No. 24456, 50 FR 5046, February 5, 1985).

—The requirement for use of a traffic alert and collision avoidance system (TCAS). The FAA has announced its intention to issue an NPRM by November 1987 proposing to require the installation and use of TCAS equipment by certain operators. The TCAS II system to be proposed will issue traffic alerts for conflicting aircraft equipped with transponders, but will issue conflict resolution advisories only for aircraft equipped with Mode C.

Also, the FAA has received separate petitions for rulemaking, from the Air Line Pilots Association and the Air Transport Association, requesting that the requirements for Mode C equipment be extended to additional terminal areas and other airspace. The FAA has not acted on either petition at this time. Finally, language included by the House Committee on Appropriations in the report on a recent spending resolution (H.J. Res. 730) stated the committee's intent that the FAA substantially expand the airspace in which Mode C equipment is required.

Requiring Mode C equipment in Group II TCA's effective December 1, 1987, rather than January 1, 1992, advances the date by which some operators must acquire Mode C but does not otherwise alter the requirement proposed in the NPRM. The equipment required is common avionics equipment now installed on the aircraft used by most Part 121 and Part 135 operators and many general aviation operators. An adjustment in the implementation date from 1992 to 1987, therefore, does not present any new issues with respect to availability of equipment or costs to operators.

In summary, the FAA believes the benefits of a Mode C requirement in Group II TCA's clearly support the implementation of that requirement at the earliest practical time. An effective date of December 1, 1987, will provide affected operators sufficient time to acquire the Mode C equipment if necessary. The issues related to the expanded Mode C requirement were presented and discussed in the NPRM and the comments received, and the agency has determined that further notice is not required.

Issue number 2: There has been a decline in aviation growth that does not bear out NAS estimates and which makes the mandating of Mode S transponders unnecessary. AOPA said it is clear that the traffic projections upon which the NAS Plan was based in 1980 substantially exaggerate the growth and density of aircraft in the U.S. fleet. The increases suggested will not happen, and any transponder mandate based on those forecasts is misguided at best.

The initial estimate that 19.9 billion in cost savings or benefits over the years 1981-2000 is expected to result from NAS improvements was derived on the basis of a 1981 equivalent system. In other words, the improvements of the NAS were quantified by estimating the cost savings expected to result from a reduction in delays, improved fuel-efficient routing, reduced accidents, and reduced operating and maintenance costs, using as a baseline for comparison the higher expected costs of operating and maintaining the 1981 system in a manner to provide the same level of service to more aircraft. The extent of these benefits was estimated on the basis of the projected increase in traffic levels over the years 1981-2000, which in turn are based on projected increases in the active fleet. The benefits of Mode S estimated in the

initial economic evaluation were based on fleet projections made in early 1985 rather than in 1980–81, as the commenter apparently believes was the case. The 1987 projection, which was just released, takes account of declining production trends in general aviation aircraft over the past 5 years as it forecasts a total of 219,300 airplanes in this category as of the year 1998, which is about 40,000 lower than last year's projection. The 1986 estimate of NAS improvement benefits has been reduced to 16 billion mainly to reflect the lower forecasts of aviation activity. The reduction in the fleet of about 15 percent is considerably less than the 50 percent decrease cited by one commenter and has had a proportionately smaller downward effect on the magnitude of expected benefits. In any case, the benefits of an upgraded NAS that were estimated 1 year ago are likely to be realized eventually even if the underlying forecast may have been too optimistic, because the total civil aviation fleet is still expected to increase over the foreseeable future if at a slower pace.

Issue number 3: There are deficiencies and problems with transponder tests. Several concerns were raised in this area. One commenter said there would be increased reliance placed on future transponders, especially on data link; therefore, there is a question whether the frequency with which ATC transponders are required to be tested is adequate.

In reference to the proposed additional testing of transponder output power, another commenter said that unless the FAA can demonstrate that inadequate output from current transponders is causing a degradation in system performance, this part of the rule should not be adopted.

AOPA stated that while it supports the transponder test requirements, the length of time between inspection and test could easily be extended from 24 to 36 months. Inspections conducted at that interval would assure proper operation, but would offset the increased cost of performing the more complex tests both for Mode S and ATCRBS devices.

The current transponder tests and inspection requirement are based on the experience gained with the ATCRBS transponders. At this time, the FAA has no data to substantiate either increasing or reducing the frequency of transponder tests and inspections. Prior to the implementation of the data link, the FAA expects sufficient experience with the Mode S transponder to determine if the frequency of testing should be changed.

The FAA believes that the additional testing of the transponder output power is necessary because it is obvious that inadequate output from transponders degrades the air traffic control system performance. If a transponder does not have sufficient output power to respond to an interrogation, the ATC system does not obtain identification of the aircraft.

The FAA does not concur with the AOPA suggestion that the length of time between inspection and tests could be extended from 24 to 36 months. The FAA has no data to support such a change. Older transponders, without solid-state output, tend to degrade in performance over time. Increasing the length of time between tests and inspection could result in some transponders being out of tolerance for longer periods of time.

Issue number four: There are performance weaknesses and deficiencies associated with Mode S, data link, and Mode C altitude reporting equipment.

Commenters alleged several technical deficiencies and weaknesses with the equipment with respect to both Mode C and Mode S equipment. One commenters said that the current trend to monopulse secondary surveillance radar (SSR)/monopulse ATCRBS may be jeopardized by the addition of any form of Mode S transponders in the airspace using the same ICAO radio channels, because, according to an in-depth British study, angular errors will increase. Another commenter said the Mode S proposal includes the likelihood of a degradation of the primary function of the radar beacon system in its mission of air traffic monitoring and ATC operations. The data rate of message exchanges is restricted by the radar antenna sweep rate which will limit message exchange windows to 120 milliseconds duration at 12 second intervals for en route and 40 milleseconds for terminal radars. Another commenter believes the FAA should defer the Mode S issue until it is proven that the ATCRBS/SSR Mode C, using monopulse techniques now being developed in Europe in the interest of greater accuracy, can no longer meet the national ATC needs.

Concerning the accuracy of Mode C altitude reporting equipment, AIA stated that there is a major problem with altitude reporting accuracy that has not solved by Mode S; i.e., barometric altitude. Another commenter recommended that the FAA undertake, on a high priority basis, a research and development project to develop an accurate altimetry system to ensure that altitude reports by either ATCRBS or Mode S users will in fact be accurate altitudes. The commenter went on to say that to mandate a whole new system based on present altimetry techniques is premature and a shameful waste of money.

With respect to data link, one commenter maintained that data link hardware for the cockpit is yet to be determined. The packaging and human factors features are not specified. Manufacturers must determine how data will be uplinked and downlinked. Questions remain unanswered. In slightly different language, the ATA said that even though the characteristics of the Mode S transponder are reasonably well defined, the extent to which the data link functions may impact the hardware design is less clear. ATA concluded that it seems appropriate that FAA adjust the dates for transition to Mode S until the airborne architecture for Mode S data link has been firmed up.

Concern regarding need for improved accuracy of altitude data and improved automatic pressure altitude reporting equipment was one of the issues to surface from the original ANPRM. As stated in the NPRM and repeated earlier in the preamble to this rule, the FAA agreed there would be benefits from greater precision in automatic altitude reporting. However, this increased precision would require separate development of the associated technology and procedures. In each case, the FAA would seek public and industry input on the specific proposal. This continues to be the agency position on this issue. Also, in accordance with the previous position on this matter, the FAA believes the existing equipment and procedures are fully adequate to support additional reporting requirements proposed in this notice. The agency will consider the institution of separate rulemaking in the future for adoption of the requested improvements.

The introduction of Mode S transponders is not expected to affect adversely the introduction of monopulse ATCRBS or the angular measurement accuracy of air traffic monitoring operations. The compatibility of ATCRBS with present and future enhancements was considered by the International Civil Aviation Organization (ICAO) in its Secondary Surveillance Radar (SSR) Improvements and Collision Avoidance System Panel (SICASP). The panel approved a recommendation at its first meeting recognizing that compatibility had been demonstrated to exist between Mode S and ATCRBS. The panel further

recommended that ICAO ensure the maintenance of compatibility of future SSR enhancements in the formulation of standards relating to these enhancements. The recommendation was subsequently accepted by ICAO.

With regard to data link concerns, the FAA believes that the revised Mode S installation schedule will also help provide for a longer transition period to develop and test equipment and procedures, validate benefits, and implement associated data link applications and procedures. Concerns regarding the uses, systems, practices, or procedures involving data link will be addressed through the appropriate procedures of FAA's data link program as evaluation data becomes available. These concerns therefore will not be addressed here since they are beyond the scope of this rule which is limited to the use, testing, and installation of ATCRBS/Mode S transponders.

Issue number 5: Use of Mode S with data link would create a "silent" environment, as opposed to today's "party line" voice communications environment.

According to one commenter, a silent environment is hazardous to flight safety. The commenter said the silent nature of the Mode S data link can lead to sending a message in error which, if undetected, can lead to a fatal accident. Currently, all pilots hear ATC instructions to all other proximate pilots and can catch inconsistent instructions to different aircraft in the same area. The party line would be lost if this rulemaking takes effect.

Contrary to the commenter's perception, the "party line" would not be lost as a result of this rulemaking. Though presented as a major benefit, data link is not being mandated by this rule. This same concern was expressed in response to the original ANPRM and responded to in the subsequent NPRM. These concerns were considered to be well beyond the scope of the NPRM. The FAA stated in the NPRM that in its implementation of data link, it would involve the public in its studies of all factors associated with each kind of message being considered for data link. This continues to be the FAA's position. The FAA recognizes there are advantages and disadvantages to both the party line and data link messages. The benefits to any data link service must outweigh the disadvantages before implementation. One of the objectives of the FAA's data link applications program will be to investigate the feasibility and desirability of providing some of the "party line" information which currently serves to congest voice frequencies over data link. Frequency changes are an example. If frequency changes were removed, voice channels are expected to be less congested, providing more time for users to better monitor other party line information.

Issue number 6: The Mode S requirements may adversely affect DOD fighting capability.

Two commenters believed that the DOD's fighting capability would be diminished by the Mode S rule. The impact of the Mode S transponder rule on the DOD was discussed earlier in this preamble under the major issue of cost. In that discussion, it was stated that comment regarding negative cost effects of the Mode S proposal on the DOD was submitted by private citizens. Even though the proposal did not apply to military aircraft, the DOD has advised the FAA that it concurs with the proposal and is voluntarily incorporating Mode S in its Mark XV transponder. In summary, the DOD has expressed no concerns that mandating Mode S transponders would adversely affect its mission.

Issue number 7: The U.S. may be breaking ICAO agreements if it issues a rule without international approval.

A commenter said that it appears from study of the ICAO charter, to which the U.S. has agreed, that no nation will unilaterally impose rules regarding avionics in its airspace which is available via bilateral ICAO agreement with at least 50 other nations. Another commenter stated that the U.S. should defer implementation of a Mode S requirement until there is full agreement in the ICAO that Mode S is essential and that states are permitted to mandate its use for aircraft of all nations. The U.S. cannot afford an ICAO confrontation.

In regard to the ICAO issue—

(a) There will be no conflict with ICAO. The installation requirement pertains only to U.S.-registered civil aircraft.

(b) If ICAO believes Mode S is unnecessary, it may consult with the U.S., possibly through SICASP, and make a recommendation.

Issue number 8. Issuance of Mode S requirements prior to issuance of the Mode S Technical Standard Order is premature. This point was made by seven commenters before the December 16 comment deadline date for the Mode S NPRM. At that time, the FAA had not as yet issued a Mode S TSO. However, on February 5, 1986, the FAA issued the Mode S TSO, TSO–C112, "Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment."

Economic Evaluation

The following is a summary of the regulatory evaluation associated with this rule. The complete evaluation is in the public docket for inspection.

This rule involves some costs and benefits. There are three aspects of the rule which may have potential economic impacts:

1. The requirement for use of automatic pressure altitude reporting equipment in Group II TCA's after December 1, 1987.
2. The basic Mode C and Mode S transponder and maintenance requirements.
3. The change to maintenance tests for the ATCRBS transponder.

Group II TCA Requirement

The proposal for altitude reporting equipment within Group II TCA's has an effective date of December 1, 1987. Current regulations require only a 4096 code transponder (ATCRBS) within Group II TCA's. The basic transponder does not have the automatic altitude reporting capability associated with Mode C, which is an add-on piece of avionics compatible with nearly all transponders currently in use. There has been a steady trend toward increased equipage in the general aviation fleet with both ATCRBS transponders and Mode C capability over the past decade. FAA national data reveal that by 1984, about 80 percent of the general aviation (including the commuters and air taxies) was equipped with an ATCRBS transponder and that about one-half of these transponders had Mode C capability. In estimating the cost of this new requirement, the FAA assumed that only those aircraft which presently operate in Group II TCA's and are not equipped with Mode C would be affected. The FAA determined that the cost (discounted) of equipping the 2,368 aircraft that would be affected by this requirement would amount to $1.9 million. In addition, the incremental testing costs associated with Mode C are expected to amount to about $333,500 over the next five years. None of the major air carriers would be affected by this requirement.

There are safety and efficiency benefits associated with the proposal, but they are not quantifiable. Those benefits would result from improved aircraft control within Group II TCA's. Although there is no realistic method for allocating a portion of the overall NAS benefits ($16 billion) to the Mode C regulatory proposal, one can reasonably conclude that the likely benefits would far exceed the associated one-time costs

of $1.9 million and recurring cost of $335,000 in view of the central role envisioned for Mode C in the overall NAS Plan.

Mode S Transponder Requirements

The regulatory cost of the Mode S proposal can be developed by estimating Mode S installations and multiplying this forecast by an estimate of the net cost of compliance.

Forecast of Installations

Installations of Mode S transponders are forecast to begin in 1988, with only 10 percent of new installations being Mode S that year, but increasing to 100 percent in 1992. Total transponder installations are estimated as the net annual increase in active aircraft in forecast years, plus 3 percent of the previous year's active aircraft. Using FAA forecasts for future years (FAA Aviation Forecast, February 1987), installations of Mode S transponders would exceed 6,000 in 1992 and average approximately 6,500 a year for the decade from 1991 to the year 2000.

Net Cost of Installation

The added cost per unit for a Mode S transponder, compared to projected transponder equipage in the absence of this regulation, is expected to be approximately $600, installed. This cost estimate assumes installation of a Mode S surveillance transponder with data link connectors, but not the cost of data link processing or display capability. Data link capability could be integrated into the transponder or added later. The price for a Mode S transponder will be about $1,000 more than for an ATCRBS Transponder for about 4 years to account for recovery of development costs.

Based on these assumptions, the regulatory cost of the Mode S proposal for the period 1988 thru 2000 is $21.2 million on a discounted cost basis.

Benefits of Mode S

Mode S is a major component of the NAS Plan. There are many benefits of Mode S, and all are associated with the benefits of the NAS Plan implementation. The benefits of the NAS Plan implementation have been estimated at almost $16 billion in cost savings through the year 2000, due to system operations and maintenance costs, as compared to the "1981 equivalent" systems. There is no reasonable way to allocate a portion of the overall NAS benefits to the Mode S regulatory proposal, but Mode S is considered necessary to successful implementation of the NAS Plan.

Transponder Maintenance Tests

There are additions to Appendix F of Part 43 which provide for tests appropriate for Mode S tranponders. There is also an added power output test required for ATCRBS transponders. This test should not involve significant additional costs. The Mode S inspection costs are expected to be moderately higher. Assuming the cost of the Mode S biennial test will be moderately higher than today's tests, any offsetting benefits are in the same general category of general NAS benefits and cannot be specifically allocated to Mode S.

Conclusion

Estimated costs of the Mode C requirement in Group II TCA's are $1.9 million for equipment and approximately $333,500 over the next five years for testing. Estimated cost of the Mode S transponder requirement from the year 1988 through the year 2000 is $21.2 million on a discounted cost basis. Additional costs of required periodic testing of the Mode S transponder will not be significant. The benefits of the Mode C, Mode S, and associated testing requirements adopted in this rule are difficult to quantify, but all are essential components of the NAS Plan. Implementation of the Plan is estimated at almost $16 billion in cost savings through the year 2000. In addition, if one midair collision involving a medium size airliner is prevented by any of the requirements adopted, the additional benefit would be approximately $61,506,000 on a discounted cost basis (based on an accident involving 110 fatalities). Therefore, the FAA has concluded that the benefits of the rules adopted substantially exceed the regulatory costs of those rules.

For the reasons set forth in the above regulatory evaluation summary, the FAA has determined that the rule does not involve a major rule under Executive Order 12991. The Department of Transportation has determined that the rule is considered a significant rule under DOT Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). A copy of the Regulatory Evaluation prepared for this action is contained in the regulatory docket, and a copy may be obtained by contacting the person identified under the caption, "FOR FURTHER INFORMATION CONTACT."

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress in order to insure, among other things, that small entities are not disproportionately affected by Government regulations. The RFA requires agencies to review rules which may have a "significant impact on a substantial number of small entities." For purposes of RFA, small entities are considered to include small businesses, non-profit organizations, and municipalities but not private individuals. As discussed above under "Economic Evaluation," the FAA concludes that the number of small entities affected by this rule will not be substantial in relation to all aviation-related small entities. In addition, the impact on most such small entities will be substantially less than the threshold for significant impact under agency guidelines. Therefore, I certify that, under the criteria of the Regulatory Flexibility Act, this rule will not have a significant impact on a substantial number of small entities.

Summary of FAA Actions

Consistent with FAA's plan to modernize the NAS, and the planned role of the Mode S surveillance system in the NAS, the FAA is taking or has taken the following actions:

1. *Issue a TSO for airborne Mode S Transponder.* Concurrently, TSO authorization to manufacture ATCRBS transponders will continue in effect. The intent of continuing the ATCRBS TSO is to allow continued manufacture of ATCRBS transponders for foreign sale and for installation in aircraft destined for foreign countries and to accommodate the DOD.

Issuance of the TSO's is not accomplished through rulemaking and, therefore, the Mode S TSO is not a regulatory portion of this rulemaking package. However, consistent with FAA practice, the proposed TSO for Mode S was made available for public comment. All issues generated by public comment were resolved and TSO-C112 was issued February 5, 1986.

2. *Amend the FAR.* The following changes to the FAR are adopted by this amendment:

FAR Part 43, Appendix F. ATC transponder test and inspection requirements apply to both ATCRBS and Mode S transponders. Test areas include radio reply frequencies, suppression, receiver sensitivity, radio frequency, and output power. Those tests applicable only to Mode S transponders include Mode S diversity transmission channel isolation, Mode S address, Mode S formats, Mode S all-call interrogations, ATCRBS-only all-call interrogations, and squitter. The reference to § 91.177 is corrected to refer to § 91.172. The existing requirement for recordkeeping will be retained.

FAR Part 91, Section 91.24(a). For operations not conducted under Parts 121, 127, or 135, ATC transponder equipment installed (or in fleet operations, equipment introduced into the fleet inventory) within specific time periods must meet the performance and environmental requirements of the TSO's specified in the rule. The requirement to meet the Mode S TSO after January 1, 1992, does not apply to—

(a) A transponder which met the requirements of the rule when originally installed, and which is removed from an aircraft for maintenance and then reinstalled on the aircraft from which it was removed.

(b) A transponder which meets the requirements of TSO C74b or TSO C74c and is temporarily installed on an aircraft when the permanent transponder is removed for maintenance.

(c) A transponder which met the requirements of the rule when originally installed in a fleet aircraft, which is removed from the aircraft for maintenance/repair, and which is then installed on either the aircraft from which it was removed or on another aircraft in the same fleet.

Section 91.24(b). All aircraft operated in the airspace areas below are required to have either a combination ATCRBS or Mode S transponder and automatic pressure altitude reporting equipment. The new requirement applies as follows:

1. in Group I TCA's;
2. in Group II TCA's; and
3. in all controlled airspace of the 48 contiguous States and the District of Columbia, above 12,500 feet MSL, excluding the airspace at and below 2,500 feet AGL.

Automatic pressure altitude reporting (Mode C) equipment is required in Group II TCA's.

Exceptions to the rule are as follows:

1. Operations of helicopters in TCA's at or below 1,000 feet AGL under a letter of agreement.

2. Operations of gliders above 12,500 feet MSL but below the floor of positive control area.

No Group III TCA's exist or are planned.

An editorial change has been made to substitute the word "operating" for the word "operable" in § 91.24(b). Substitution of the word "operating" for the word "operable" is made to reflect the requirement that transponders must be turned on.

Section 91.90(b)(2)(iii). Aircraft operating in Group II TCA's are required to be equipped with automatic pressure altitude reporting equipment effective December 1, 1987.

The following FAR sections are amended to make transponder requirements under those sections consistent with the amended transponder installation requirements of Part 91:

1. FAR Part 121, § 121.345(c);
2. FAR Part 127, § 127.123(b); and
3. FAR Part 135, § 135.143(c).

List of Subjects

14 CFR Part 43

Air transportation, Aircraft, Aviation safety, Safety.

14 CFR Part 91

Aviation safety, Safety, Aircraft, Air traffic control, Pilots, Airspace, Air transportation, Airports.

14 CFR Part 121

Aviation safety, Safety, Air traffic control, Air transportation, Aircraft, Airplanes, Airports, Airspace, Transportation.

14 CFR Part 127

Aircraft, Airworthiness, Air traffic control, Helicopters, Airspace.

14 CFR Part 135

Aviation safety, Safety, Air transportation, Airworthiness, Aircraft, Transportation, Helicopters, Air traffic control, Airspace, Airplanes.

Adoption of the Amendments

For the reasons set forth above, Parts 43, 91, 121, 127, and 135 of the Federal Aviation Regulations (14 CFR Parts 43, 91, 121, 127, and 135) are amended as follows:

PART 43—MAINTENANCE, PREVENTIVE MAINTENANCE, REBUILDING AND ALTERATION

1. The authority citation for Part 43 is revised to read as follows:

Authority: 49 U.S.C. 1354, 1421 through 1430; 49 U.S.C. 106(g) (Revised Pub. L. 97-449, January 12, 1983).

2. Appendix F to Part 43 is revised to read as follows:

Appendix F—ATC Transponder Tests and Inspections

The ATC transponder tests required by Section 91.172 of this chapter may be conducted using a bench check or portable test equipment and must meet the requirements prescribed in paragraphs (a) through (j) of this appendix. If portable test equipment with appropriate coupling to the aircraft antenna system is used, operate the test equipment for ATCRBS transponders at a nominal rate of 235 interrogations per second to avoid possible ATCRBS interference. Operate the test equipment at a nominal rate of 50 Mode S interrogations per second for Mode S. An additional 3 dB loss is allowed to compensate for antenna coupling errors during receiver sensitivity measurements conducted in accordance with paragraph (c)(1) when using portable test equipment.

(a) Radio Reply Frequency:

(1) For all classes of ATCRBS transponders, interrogate the transponder and verify that the reply frequency is 1090±3 Megahertz (MHz).

(2) For classes 1B, 2B, and 3B Mode S transponders, interrogate the transponder and verify that the reply frequency is 1090±3 MHz.

(3) For classes 1B, 2B, and 3B Mode S transponders that incorporate the optional 1090±1 MHz reply frequency, interrogate the transponder and verify that the reply frequency is correct.

(4) For classes 1A, 2A, 3A, and 4 Mode S transponders, interrogate the transponder and verify that the reply frequency is 1090±1 MHz.

(b) Suppression: When Classes 1B and 2B ATCRBS Transponders, or Classes 1B, 2B, and 3B Mode S transponders are interrogated Mode 3/A at an interrogation rate between 230 and 1,000 interrogations per second; or when Classes 1A and 2A ATCRBS Transponders, or Classes 1B, 2A, 3A, and 4 Mode S transponders are interrogated at a rate between 230 and 1,200 Mode 3/A interrogations per second:

(1) Verify that the transponder does not respond to more than 1 percent of ATCRBS interrogations when the amplitude of P_2 pulse is equal to the P_1 pulse.

(2) Verify that the transponder replies to at least 90 percent of ATCRBS interrogations when the amplitude of the P_2 pulse is 9 dB less than the P_1 pulse. If the test is conducted with a radiated test signal, the interrogation rates shall be 235±5 interrogations per second unless a higher rate has been approved for the test equipment used at that location.

(c) Receiver Sensitivity:

(1) Verify that for any class of ATCRBS Transponder, the receiver minimum triggering level (MTL) of the system is −73±4 dbm, or that for any class of Mode S transponder the receiver MTL for Mode S format (P6 type) interrogations is −74±3 dbm by use of a test set either:

(i) connected to the antenna end of the transmission line;

(ii) connected to the antenna terminal of the transponder with a correction for transmission line loss; or

(iii) utilized radiated signal.

(2) Verify that the difference in Mode 3/A and Mode C receiver sensitivity does not exceed 1 db for either any class of ATCRBS transponder or any class of Mode S transponder.

(d) Radio Frequency (RF) Peak Output Power:

(1) Verify that the transponder RF output power is within specifications for the class of transponder. Use the same conditions as described in (c)(1) (i), (ii), and (iii) above.

(i) For Class 1A and 2A ATCRBS transponders, verify that the minimum RF peak output power is at least 21.0 dbw (125 watts).

(ii) For Class 1B and 2B ATCRBS Transponders, verify that the minimum RF peak output power is at least 18.5 dbw (70 watts).

(iii) For Class 1A, 2A, 3A, and 4 and those Class 1B, 2B, and 3B Mode S transponders that include the optional high RF peak output power, verify that the minimum RF peak output power is at least 21.0 dbw (125 watts).

(iv) For Classes 1B, 2B, and 3B Mode S transponders, verify that the minimum RF peak output power is at least 18.5 dbw (70 watts).

(v) For any class of ATCRBS or any class of Mode S transponders, verify that the maximum RF peak output power does not exceed 27.0 dbw (500 watts).

Note: The tests in (e) through (j) apply only to Mode S transponders.

(e) Mode S Diversity Transmission Channel Isolation: For any class of Mode S transponder that incorporates diversity operation, verify that the RF peak output power transmitted from the selected antenna exceeds the power transmitted from the nonselected antenna by at least 20 db.

(f) Mode S Address: Interrogate the Mode S transponder and verify that it replies only to its assigned address. Use the correct address and at least two incorrect addresses. The interrogations should be made at a nominal rate of 50 interrogations per second.

(g) Mode S Formats: Interrogate the Mode S transponder with uplink formats (UF) for which it is equipped and verify that the replies are made in the correct format. Use the surveillance formats UF=4 and 5. Verify that the altitude reported in the replies to UF=4 are the same as that reported in a valid ATCRBS Mode C reply. Verify that the identify reported in the replies to UF=5 are the same as that reported in a valid ATCRBS Mode 3/A reply. If the transponder is so equipped, use the communication formats UF=20, 21, and 24.

(h) Mode S All-Call Interrogations: Interrogate the Mode S transponder with the Mode S-only all-call format UF=11, and the ATCRBS/Mode S all-call formats (1.6 microsecond P_4 pulse) and verify that the correct address and capability are reported in the replies (downlink format DF=11).

(i) ATCRBS-Only All-Call Interrogation: Interrogate the Mode S transponder with the ATCRBS-only all-call interrogation (0.8 microsecond P_4 pulse) and verify that no reply is generated.

(j) Squitter: Verify that the Mode S transponder generates a correct squitter approximately once per second.

(k) Records: Comply with the provisions of Section 43.9 of this chapter as to content, form, and disposition of the records.

PART 91—GENERAL OPERATING AND FLIGHT RULES

3. The authority citation for Part 91 continues to read as follows:

Authority: 49 U.S.C. 1301(7), 1303, 1344, 1348, 1352 through 1355, 1401, 1421 through 1431, 1471, 1472, 1502, 1510, 1522, and 2121 through 2125; Articles 12, 29, 31, and 32(a) of the Convention on International Civil Aviation (61 Stat 1180); 42 U.S.C. 4321 et seq.; E.O. 11514; 49 U.S.C. 106(g) (Revised Pub. L. 97-449, January 12, 1983).

4. In § 91.24, paragraphs (a) and (b) are revised to read as follows:

§ 91.24 ATC transponder and altitude reporting equipment and use.

(a) *All airspace: U.S.-registered civil aircraft.* For operations not conducted under Parts 121, 127, or 135 of this chapter, ATC transponder equipment installed within the time periods indicated below must meet the performance and environmental requirements of the following TSO's

(1) *Through January 1, 1992:* (i) Any class of TSO–C74b or any class of TSO–C74c as appropriate, provided that the equipment was manufactured before January 1, 1990; or

(ii) The appropriate class of TSO–C112 (Mode S).

(2) *After January 1, 1992:* The appropriate class of TSO–C112 (Mode S). For purposes of paragraph (a)(2) of this section, "installation" does not include—

(i) Temporary installation of TSO–C74b or TSO–C74c substitute equipment, as appropriate, during maintenance of the permanent equipment;

(ii) Reinstallation of equipment after temporary removal for maintenance; or

(iii) For fleet operations, installation of equipment in a fleet aircraft after removal of the equipment for maintenance from another aircraft in the same operator's fleet.

(b) *Controlled Airspace: All aircraft.* Except for persons operating helicopters in terminal control areas at or below 1,000 feet AGL under the terms of a letter of agreement, and except for persons operating gliders above 12,500 feet MSL, but below the floor of the positive control area, no person may operate an aircraft in the controlled airspace prescribed in paragraphs (b)(1) through (b)(3) of this section, unless that aircraft is equipped with an operating coded radar beacon transponder having either a Mode 3-A 4096 code capability, replying to Mode 3/A interrogations with the code specified by ATC, or a Mode S capability, replying to Mode 3/A interrogations with the code specified by ATC and intermode and Mode S interrogations in accordance with the applicable provisions specified in TSO–C112, and that aircraft is equipped with automatic pressure altitude reporting equipment having a Mode C capability that automatically replies to Mode C interrogations by transmitting pressure altitude information in 100-foot increments. This requirement applies—

(1) In Group I Terminal Control Areas governed by § 91.90(a);

(2) In Group II Terminal Control Areas governed by § 91.90(b) except as provided therein; and

(3) In all controlled airspace of the 48 contiguous States and the District of Columbia, above 12,500 feet MSL, excluding the airspace at and below 2,500 feet AGL.

* * * * *

5. In § 91.90, paragraph (b)(2)(iii) is revised to read as follows:

§ 91.90 Terminal control areas.

* * * * *

(b) *Group II terminal control areas.*

* * * * *

(2) *Equipment requirements.*

* * * * *

(iii) The applicable equipment specified in § 91.24, except that for operations conducted prior to December 1, 1987, automatic pressure altitude reporting equipment is not required for any operation within the TCA. A transponder is not required for IFR flights operating to or from an airport outside of but in close proximity to the TCA when the commonly used transition, approach, or departure procedures to such airport require flight within the TCA.

* * * * *

PART 121—CERTIFICATION AND OPERATIONS: DOMESTIC, FLAG, AND SUPPLEMENTAL AIR CARRIERS AND COMMERCIAL OPERATORS OF LARGE AIRCRAFT

6. The authority citation for Part 121 is revised to read as follows:

Authority: 49 U.S.C. 1354(a), 1355, 1356, 1357, 1401, 1421–1430, 1472, 1485, and 1502; 49 U.S.C. 106(g) (Revised, Pub. L. 97–449, January 12, 1983).

7. In § 121.345, paragraph (c) is revised to read as follows:

§ 121.345 Radio equipment.

* * * * *

(c) ATC transponder equipment installed within the time periods indicated below must meet the performance and environmental requirements of the following TSO's

(1) *Through January 1, 1992:* (i) Any class of TSO–C74b or any class of TSO–C74c as apporpriate, provided that the equipment was manufactured before January 1, 1990; or

(ii) The appropriate class of TSO–C112 (Mode S).

(2) *After January 1, 1992:* The appropriate class of TSO–C112 (Mode S). For purposes of paragraph (c) (2) of this section, "installation" does not include—

(i) Temporary installation of TSO–C74b or TSO–C74c substitute equipment, as appropriate, during maintenance of the permanent equipment;

(ii) Reinstallation of equipment after temporary removal for maintenance; or

(iii) For fleet operations, installation of equipment in a fleet aircraft after removal of the equipment for maintenance from another aircraft in the same operator's fleet.

PART 127—CERTIFICATION AND OPERATIONS OF SCHEDULED AIR CARRIERS WITH HELICOPTERS

8. The authority citation for Part 127 is revised to read as follows:

Authority: 49 U.S.C. 1354(a), 1421, 1422, 1423, 1424, 1425, 1430; 49 U.S.C. 106(g) (Revised Pub. L. 97–449, January 12, 1983).

9. In § 127.123, paragraph (b) is revised to read as follows: Section 127.123 Radio equipment.

* * * * *

(b) ATC transponder equipment installed within the time periods indicated below must meet the performance and environmental requirements of the following TSO's

(1) *Through January 1, 1992:* (i) Any class of TSO–C74b or any class of TSO–C74c as appropriate, provided that the equipment was manufactured before January 1, 1990; or

(ii) The appropriate class of TSO–C112 (Mode S).

(2) *After January 1, 1992:* The appropriate class of TSO–C112 (Mode S). For purposes of paragraph (b)(2) of this section, "installation" does not include—

(i) Temporary installation of TSO–C74b or TSO–C74c substitute equipment, as appropriate, during maintenance of the permanent equipment;

(ii) Reinstallation of equipment after temporary removal for maintenance; or

(iii) For fleet operations, installation of equipment in a fleet aircraft after removal of the equipment for maintenance from another aircraft in the same operator's fleet.

PART 135—AIR TAXI OPERATORS AND COMMERCIAL OPERATORS

10. The authority citation for Part 135 is revised to read as follows:

Authority: 49 U.S.C. 1354(a), 1355(a), 1421 through 1431, and 1502; 49 U.S.C. 106(g) (Revised Pub. L. 97–449, January 12, 1983).

11. In § 135.143, paragraph (c) is revised to read as follows:

§ 135.143 General requirements.

* * * * *

(c) ATC transponder equipment installed within the time periods indicated below must meet the performance and environmental requirements of the following TSO's

(1) *Through January 1, 1992:* (i) Any class of TSO–C74b or any class of TSO–C74c as appropriate, provided that the equipment was manufactured before January 1, 1990; or

(ii) The appropriate class of TSO–C112 (Mode S).

(2) *After January 1, 1992:* The appropriate class of TSO–C112 (Mode S). For purposes of paragraph (c)(2) of this section, "installation" does not include—

(i) Temporary installation of TSO–C74b or TSO–C74c substitute equipment, as appropriate, during maintenance of the permanent equipment;

(ii) Reinstallation of equipment after temporary removal for maintenance; or

(iii) For fleet operations, installation of equipment in a fleet aircraft after removal of the equipment for maintenance from another aircraft in the same operator's fleet.

Issued in Washington, DC on January 29, 1987.

Donald D. Engen,

Administrator.

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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 43, 91, 121, 127, and 135

[Docket No. 23799; Amdt. Nos. 43-26, 91-198, 121-190, 127-41, 135-22]

Air Traffic Control Radar Beacon System and Mode S Transponder Requirements in the National Airspace System

Correction

In rule document 87-2033 beginning on page 3380 in the issue of Tuesday, February 3, 1987, make the following corrections:

1. On page 3382, in the third column, after paragraph numbered (4), in the first paragraph, insert a period at the end of the last line.

2. On the same page, in the same column, in the third line from the bottom of the column, insert "a" between "for" and "major".

3. On page 3383, in the third column, in the fourth line, "than" should read "then".

4. On page 3385, in the second column,

in the second line, "the" should read "that".

PART 43, APPENDIX F—[CORRECTED]

5. On page 3390, in the third column, in Appendix F, in paragraph (b)(2), in the sixth line, "rates" should read "rate".

6. On page 3391, in the first column, in Appendix F, in paragraph (g), in the ninth line, "identify" should read "identity".

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