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14 CFR Part 135

Ground Proximity Warning Systems; Final Rule

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 135

[Docket No. 26202; Amendment No. 135-42]

RIN 2120-AD29

Ground Proximity Warning Systems

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: This final rule revises the operating rules for air taxi and commercial operators by requiring that all turbine-powered (rather than just turbojet) airplanes with ten or more seats be equipped with an approved ground proximity warning system. These changes are needed because studies have shown that several controlled flight into terrain accidents involving turbo-propeller powered airplanes might have been avoided had the airplanes been equipped with a ground proximity warning system. This final rule is intended to reduce the risk of airplanes being flown into terrain with no awareness by the crews that they are approaching the ground.

EFFECTIVE DATE: April 20, 1992.

FOR FURTHER INFORMATION CONTACT: Mr. Philip Akers, Aircraft Certification Service, Federal Aviation Administration, 800 Independence Avenue, SW., Washington, DC 20591; telephone (202) 267-9571.

SUPPLEMENTARY INFORMATION:

Background

A number of studies have looked at the occurrence of "Controlled Flight Into Terrain" (CFIT)-type accidents, where an airplane under the control of a fully qualified and certificated crew is flown into terrain (or water or obstacles) with no apparent awareness on the part of the crew. Some of these studies found that many such accidents could have been avoided if a warning device called a ground proximity warning system (GPWS) was used. (For detailed information on the studies, see "Investigation of Controlled Flight Into Terrain (CFIT)", Department of Transportation, Transportation Systems Center (DOT/TSC), March 1989). A copy of this study has been placed in the docket for this rulemaking.)

In 1974, the FAA required all part 121 and some part 135 certificate holders to install Technical Standard Order (TSO) approved GPWS equipment on large turbine-powered airplanes (§ 121.360). In 1978, the FAA required part 135 certificate holders operating turbojet airplanes with 10 or more seats to install TSO-approved GPWS equipment or alternative ground proximity advisory systems approved by the Director, Flight Standards Service (§ 135.153). (A TSO-approved GPWS is one that operates only when there is an imminent potential hazard; a ground proximity advisory system is usually one that provides routine altitude callouts, whether or not there is any imminent danger.)

Installation of GPWS's or alternative FAA-approved advisory systems was not originally required on turbo-propeller powered (turboprop) airplanes because, at the time, it was believed that the performance characteristics of turboprop airplanes made them less susceptible to CFIT accidents. However, later studies, including investigations by the National Transportation Safety Board (NTSB), analyzed accidents involving turboprop airplanes and found that many of the accidents could have been avoided if GPWS equipment had been used. In 1986, the NTSB recommended that § 135.153 be amended to require the installation of GPWS equipment in all turbine-powered airplanes carrying 10 or more passengers.

In response to the NTSB recommendation, the FAA requested that DOT/TSC analyze past CFIT accidents involving turbine-powered airplanes operating under part 135. The study looked at data from 41 CFIT accidents that occurred between 1970-1988. It found that of the 25 accidents that involved the type of airplane covered by this rule, and for which sufficient accident investigation data were available (covering the period 1978-1987) 16, or 64 percent, might have been avoided if the airplanes had GPWS's.

The DOT/TSC study also compared the TSO-approved GPWS to two FAA-approved alternative ground proximity advisory systems in five different operational modes. These five modes are: (1) Excessive rate of descent; (2) Excessive closure rate to terrain; (3) Altitude loss after takeoff; (4) Not in landing configuration; and (5) Deviation below glideslope. The study found equivalence in two modes (not in landing configuration and deviation below glideslope). However, there were significant performance differences in the most critical operational situation (excessive closure rate to terrain); advisory systems were found to always give automatic callouts below certain altitudes, whereas the GPWS would warn only when necessary. The GPWS would also provide maximum warning time while minimizing unwanted alarms and would use command-type warnings.

The DOT/TSC study also found that the unit cost of a TSO-approved GPWS would be comparable to that of an advisory system and therefore neither system is prohibitively expensive.

As a result of the studies discussed above, as well as a significant increase in the operation of this class of turbopropeller airplanes, the FAA issued Notice of Proposed Rulemaking (NPRM) No. 90-14 (55 FR 17358, April 24, 1990) entitled "Ground Proximity Warning Systems." The NPRM proposed the installation of TSO-approved GPWS equipment on all turbine-powered airplanes with 10 or more seats operating under part 135.

Subsequent to issuing the NPRM, the NTSB advised the FAA that six commuter airplane accidents occurred between January 1987 and January 1990. The NTSB advised that:

(1) On January 19, 1988, a Fairchild Metro III SA227-AC crashed on approach to Durango, Colorado. There were 9 fatalities and 8 survivors. The NTSB stated that "a ground proximity warning device probably would have alerted the crew to the airplane's increasing proximity to terrain and may have prevented the accident" and that "over 20 seconds of advance warning could have been provided by a GPWS."

(2) On February 19, 1988, a Fairchild Metro III SA227-AC crashed shortly after departing from Raleigh Durham International Airport due to "an excessive angle of bank initiated at an altitude that was too low." There were 12 fatalities and no survivors. The NTSB stated that "about 7½ seconds of advance warning could have been provided by a GPWS."

(3) On August 7, 1989, a DeHaviland DHC-6 flew into a mountain in Ethiopia during a flight with bad weather conditions and too low an altitude. There were 16 fatalities and no survivors. The NTSB stated that "a ground proximity warning system * * * may have prevented this accident since it can warn of a projected impact with terrain in time for corrective action by the pilot."

(4) On October 28, 1989, a DeHaviland DHC-6-300 crashed in Molokai, Hawaii. There were 20 fatalities and no survivors. In the final NTSB accident report dated September 25, 1990, the NTSB stated that "a ground proximity warning system would have provided sufficient warning for the crew to have pulled up and overflown the terrain." The NTSB determined that the probable cause of the accident was the airplane's controlled flight into terrain as a result

of the decision of the captain to continue flight under visual flight rules at night into instrument meteorological conditions, which obscured rising mountainous terrain.

(5) On December 26, 1989, a British Aerospace Jetstream 3101 crashed during its final approach to Pasco Washington; the airplane had been too high on the final approach, therefore requiring a steep descent. There were 6 fatalities and no survivors. The NTSB advised that "a high descent rate at low altitude will cause a GPWS warning."

(6) On January 15, 1990, a Fairchild Metro III SA227–AC crashed during its approach to Elko, Nevada. There were 13 injuries and no fatalities. The NTSB stated that "about 25 seconds of advance warning time could have been provided by a GPWS."

Discussion of Comments

The FAA received 17 comments in response to the proposed rule. Most of the comments received generally support the rule; however, the comments address one or more broad areas, including: ground proximity warning systems (produced by one manufacturer) vs. advisory systems (produced by at least two manufacturers); cost; timetable for compliance; false warnings; installation problems; training; and applicability of the rule. Five commenters oppose the NPRM.

Those who fully support the proposed rule are the NTSB and Sundstrand Data Control, Inc. The Airline Pilots Association (ALPA) also supports the proposal but recommends changing compliance deadlines. The General Aviation Manufacturer's Association (GAMA) comments that it cannot respond to the NPRM because it believes that the DOT/TSC report upon which it is based is "technically inaccurate." GAMA rcommends that the NPRM be delayed until the report's analysis and conclusion are made "technically correct." In addition, some commenters provide a direct response to the DOT/TSC study. All comments and FAA responses are addressed in the following section.

Ground Proximity Warning Systems vs. *Advisory Systems*

Eight commenters, including the Regional Airline Association (RAA), National Air Transportation Association (NATA), manufacturers of advisory systems such as Rockwell International and Kollsman, and part 135 operators such as Continental Express, express dissatisfaction with the NPRM's proposed requirement that only TSO-approved GPWS's be installed in part 135 turbine-powered airplanes.

Reasons for this position can be categorized into two broad areas: (1) Some believe that advisory systems are as effective as GPWS's; and (2) GPWS equipment is produced and sold by one manufacturer, creating monopolistic conditions. These two areas are described below, each with its own FAA response.

Effectiveness of Ground Proximity Warning Systems vs. *Advisory Systems.* Some commenters say that ground proximity advisory systems are as effective as GPWS's in terms of giving clear and specific warnings when the airplane is too close to terrain. For example, Continental Express asserts that the aural and visual alerts of advisory systems are no more routine than those of GPWS's and that, similar to GPWS's, they provide additional warnings which are based on the violation of "defined flight profiles". Several commenters, including RAA, recommend that the rule be expanded to allow the use of alternative systems, in addition to GPWS's.

Some commenters, e.g., Kollsman, feel that the FAA's position in the NPRM is contradictory, i.e., it is recognized (based on the DOT/TSC study) that advisory systems are functionally equivalent and provide the same safety benefit as GPWS's, yet it is considered unacceptable to allow anything that is not TSO-approved.

FAA Response: The FAA has found, in the DOT/TSC and other studies, that GPWS equipment and advisory systems are functionally equivalent in 2 out of 5 modes or warning envelopes: Mode 4 (not in landing configuration) and Mode 5 (deviation below glideslope). In the other 3 modes, there are either minor or significant differences: In Mode 3 (altitude loss after takeoff), the two systems have proximate equivalence, although the GPWS shows some superiority over advisory systems because it provides a direct warning to "pull-up"; advisory systems, in contrast, require much more integration of data on the part of the flightcrew (i.e., first receiving altitude callouts reflecting an increasing trend in altitude after takeoff, then receiving callouts reflecting decreased altitude and reversing this trend). Most importantly, in Mode 1 (excessive sink rate) and Mode 2 (excessive closure to terrain), the two systems have shown a critical difference in their performance. The FAA has analyzed accident data from many sources, including the NTSB, and has found that GPWS performance is far superior to advisory system performance in these two modes. Ground proximity warning system equipment is able to calculate the airplane descent and closure rate, compare these to the defined warning envelopes and provide a warning only if the limits are exceeded. In comparison, advisory systems either provide only one callout when the airplane enters a certain radio altimeter range and no warnings for an excessive descent rate at higher altitudes; or they provide continuous callouts below a certain altitude limit.

In addition, during the DOT/TSC study, advisory system manufacturers and others were requested to submit "hard" data to substantiate the safety performance of these systems. The FAA was interested in receiving data such as accident/incident investigation reports, reconstructed accident profiles, cockpit voice recorder and flight data recorder readouts, and pilot surveys. No such quantifiable or "hard" data was made available during the DOT/TSC study, nor was any submitted for the public record during the comment period to establish the equivalence of GPWS's and advisory systems.

Therefore, the FAA continues to support a TSO-approved GPWS because it has been shown to meet minimum performance specifications in all 5 modes and provides a higher level of safety. (This TSO (TSO–C92b), in fact, incorporates by reference RTCA Document DO–161A, which was developed by a consortium of government and industry experts and addresses all 5 warning envelopes.)

In addition, the FAA has confidence in the GPWS because it has proven to be a reliable and effective system under part 121 operations.

One Manufacturer of GPWS Equipment. Some commenters, including RAA, Continental Express, Northwest Airlink, and Kollsman say that there is currently only one manufacturer of the TSO-approved GPWS (Sundstrand). As a result, this manufacturer will continue to monopolize the market on the production and sale of GPWS's destroying competition and raising prices. RAA recommends that there be at least three systems available, which would motivate manufacturers to provide an effective product at competitive prices.

FAA Response: It is the FAA's policy to encourage and support competitive sourcing of equipment. TSO–C92b incorporates both government and industry input for a GPWS which meets minimum performance specifications. The FAA will approve a GPWS from any manufacturer whose product complies with TSO–C92b.

In response to comments that it has monopolized the market for GPWS equipment, Sundstrand has informed the FAA that it has dedicated its GPWS patent (#3,946,358; glide slope boundary conditions and detection) for public use (see public docket #26202). The FAA welcomes this action and believes that it will encourage other manufacturers, who may have construed this to be a design impediment, to produce and market a TSO-approved GPWS.

Cost

There were eight comments in this area.

Six commenters, including NATA, Kollsman, and several airlines, say that the NPRM's cost estimates for a GPWS and its installation are too low, primarily because associated equipment costs, weight penalties, and installation costs are underestimated or not considered. Examples of such additional costs are: extra equipment needed to support a GPWS such as a radio altimeter and barometric rate computer; increased weight penalties due to the need for additional equipment; and installation costs resulting from the down time needed for installation.

In addition, Continental Express states that the estimated cost of a GPWS, as presented in the NPRM, is too low because the proposed system is only in the planning stage; the purchase and installation costs will most likely rise.

Two commenters say that the NPRM is incorrect in assuming that the cost of a GPWS is comparable to that of alternative systems. Kollsman presents cost data for its VTA system ($15,000) and expresses doubt that a GPWS would be available for less than that amount. RAA cites findings from the DOT/TSC study and says that the highest-cost system is 48% more than the lowest-cost system.

Virtually all commenters on this issue state that the monopolistic situation that would be created by the proposed rule (given Sundstrand's patent situation at the time of the NPRM) would undoubtedly lead to higher prices.

FAA Response: The FAA partly concurs that its cost estimates do not include certain equipment and weight penalties. In calculating GPWS costs, the FAA did include the equipment and weight costs of the radio altimeter. Additionally, the FAA did not calculate the equipment and weight costs of the barometric rate computer as an additional cost. (The barometric-rate computer is a necessary component for GPWS operation.) Since the NPRM was published, the FAA has determined that on average only one in three regional air carrier airplanes already has a barometric-rate computer. Therefore, the FAA has reestimated GPWS costs to be approximately $1000 higher to reflect this additional equipment and weight. (See the economic evaluation in this final rule document for further detail.) Additionally, Sundstrand indicates that the barometric rate function may be provided, at a much lower cost, as an option to be included with their GPWS. In terms of installation costs, the FAA did include retrofitting and down-time costs in its original calculations, just as these costs are included for any new system.

Regarding manufacturer costs, the FAA, during the course of the DOT/TSC study, asked manufacturers of advisory systems to provide "representative" cost data for their own systems and their competitors' systems. In all cases, manufacturers provided lower acquisition and retrofitting cost estimates for their own systems, as compared to what they estimated for competitors' systems. The FAA, therefore, used "own-system" estimates from each manufacturer's system presented in the DOT/TSC report and the NPRM.

In addition, Sundstrand provided the FAA the same cost estimates at least three times before their estimates were published in the DOT/TSC study and later, the NPRM. Because Sundstrand publicly reaffirmed these cost estimates several times, the FAA considers them valid unless proven otherwise.

The concern that Sundstrand's costs will rise because of a monopolistic situation created by the rule, is unjustified due to Sundstrand's opening its GPWS patent to the public. On the contrary, the FAA believes that more competition will be stimulated, which will serve to keep costs at a lower level.

Timetable for Compliance

There were two comments in this area.

Mesaba Airlines claims that the 2-year compliance date is inadequate because it would not allow enough time for system engineering and installation; much time would be needed for systems integration. In addition, down time would be needed for actual installation. It recommends that the deadline for existing airplane retrofits be extended to at least 4 years.

ALPA says that the compliance time is too lengthy, and cites the DOT/TSC study as support that CFIT-type accidents will continue until GPWS's are installed on all turbine-powered airplanes. Therefore, ALPA recommends that the time frame in which airplanes would be required to have a GPWS should be shortened as follows: Airplanes with 10 or more seats should be retrofitted within 1 year, not 2 years; airplanes with a ground proximity advisory system should retrofitted with a GPWS within 2 years.

FAA Response: The FAA has considered these alternative timetables and maintains that the proposed timetable is the most reasonable one for installing GPWS equipment. There is concern, however, on having all airplanes meet the compliance dates in an orderly manner. In previous instances involving rules requiring equipment installation, there have been cases where delays could have been avoided by installing the equipment during the periodic maintenance cycle of the airplane. Certificate holders have made an unacceptable number of requests to extend compliance dates. To alleviate this problem, an installation schedule was included in several recent amendments to the FAR's. Because an installation schedule was not proposed in this rulemaking, and because issuing a supplemental notice of proposed rulemaking would add further delays, FAA principal airworthiness inspectors will be monitoring part 135 operators to ensure that an acceptable transition to the GPWS is made.

Increased compliance time would very likely result in more lives lost from CFIT-type accidents. As stated in the background, the NTSB found, in its preliminary investigations of six other accidents (beyond those which were documented in the DOT/TSC report) that GPWS "may have prevented the accident" or provided "advance warning." NTSB also stated that, for all six accidents, the GPWS at least could have been a factor to prevent the accident. Alternatively, a reduction in compliance time is unrealistic, considering the amount of time needed to retrofit each airplane, including scheduling and the ordering and availability of equipment.

The FAA expects airplane operators affected by this rule to make a "good faith" effort in complying with the timetable established for installation of the GPWS. While the final rule does not contain an installation schedule, affected operators are expected to begin the approval process as soon as possible so that they will not be faced with last minute scheduling problems. The FAA assumes that planning will begin at the time of publication of the rule.

At this time, the FAA knows of no circumstances under which it would consider granting an extension of the compliance date unless an operator can present evidence of good faith efforts to

secure the equipment and installation services. Examples of such evidence include purchase orders and contracts dated in 1992 to indicate a plan to ensure implementation within the 2-year compliance period.

The FAA considers its proposed timetable a middle ground between the need to reduce CFIT-type accidents as quickly as possible and practical considerations of installing GPWS equipment on all airplanes affected by the rule. Therefore, part 135 operators affected by this rule are required to comply with the proposed timetable for installing GPWS equipment on their airplanes. Additionally, the FAA considers compliance date extensions to be unwarranted, since GPWS equipment is available and can be installed within the time required by the rule.

False Warnings

There were three comments in this area.

Rockwell International, Conquest Airlines, and Continental Express claim that the GPWS has been found to give frequent and unnecessary false warnings, which pre-conditions crewmembers to ignore the warnings and also interferes with crew communications; in some cases, the GPWS is deactivated, thus negating its usefulness.

FAA Response: The GPWS requirements were refined by amendments in 1975 and 1976. (See 40 FR 19638, 42183, 50707, 55313, and 41 FR 35070.) One of the major considerations at that time was the transition from TSO–C92a to the current standard, TSO–C92b, which resolved the problem of false or nuisance alarms. Since the effective dates of the amendments listed above, there have been only rare occasions of GPWS false alarms. These were mostly attributed to non-standard approaches with unusually high glide slope angles or terrain closure rates, and have been resolved on an individual basis. Operating experience has demonstrated that false/nuisance GPWS warnings are minimal and are no longer a problem.

Installation Problems

Mesaba Airlines says that it will be difficult to install GPWS's on many airplanes due to limited rack and panel space.

FAA Response: The FAA has consulted with Sundstrand who has developed a new GPWS model for smaller turbine-powered airplanes. This manufacturer has informed the FAA that the new model is smaller than the existing system now used in part 121 operations and that it is specifically designed for installation in the commuter type airplane. Use of this or a similar model for airplanes that have limited rack and panel space is recommended.

Training

There were three comments in this area.

ALPA stresses the importance of an appropriate and quick response to GPWS warnings and recommends training for pilots in how to use GPWS equipment.

Conquest Airlines is against requiring GPWS's in commuter airplanes, stating that the GPWS can interfere with crew communication emergencies; it recommends instead, improved training for flight crews (e.g., Line-Oriented Flight Training [LOFT] and Cockpit Resource Management [CRM]) to enhance safety.

Similarly, Rockwell International says that the DOT/TSC report does not evaluate the interrelationship between GPWS's and other warning systems (e.g., windshear) and how this affects crew performance.

FAA Response: The rule (§ 135.153(d)) requires GPWS training by stating that operators' Airplane Flight Manuals must contain appropriate procedures for the use of GPWS equipment by flight crews. The FAA, however, is not specifying the contents of this type of training due to the diversity of Part 135 operations. As was the case with previous rulemaking concerning new equipment, the FAA expects each operator to develop GPWS training to fit its own operations and to meet the requirements of § 135.153(d).

In addition, the FAA believes that GPWS equipment will not impede crew communications or interfere with other warning devices because the interference problem created by false alarms has been virtually eliminated. The GPWS equipment helps, rather than hinders crew communications, because it produces fewer warnings (compared to advisory systems) resulting in less confusion in the cockpit.

In terms of improved training for flight crews, the FAA has already required or recommended such training in recent amendments to parts 121 and 135, as well as in advisory circulars on LOFT and CRM. The FAA has also established procedures for a voluntary alternative training program called the "Advanced Qualifications Program" (AQP). A key element of this program is cockpit resource management training, which teaches crewmembers how to operate as a team through effective communication and decision-making. Whether a commuter airline continues to employ current training methods or implements an AQP, there are provisions in place for providing training in the proper use of GPWS's in the flightcrew environment.

Applicability of the Rule

There were six comments in this area, three of which say that certain categories of airplanes should be exempt from the proposed requirement.

Chalk's International Airlines and Ketchikan Air Service, Inc. are against requiring GPWS's for their seaplanes and floatplanes that are engaged only in daytime, VFR operations. They state that GPWS's would add no further safety benefit for VFR operations, as opposed to IFR operations, and therefore, they recommend that certain day VFR operations be exempted from the rule.

NATA is against requiring GPWS's for on-demand air charter operations; it states that such operations should be distinguished from commuter operations. NATA notes that the NPRM does not make this distinction; thus, it concludes that the proposal discriminates against charter operations. Therefore, NATA recommends that turbo-prop airplanes used for charter operations by on-demand part 135 operators be exempted from the rule and that new airplanes (turbine-powered with 10 or more seats) be equipped with a GPWS 2 years after the adoption of the rule.

Two other commenters (Mesaba Airlines and United Express) recommend that airplanes already in service be exempt from a retrofit installation and that a GPWS be installed only on newly manufactured airplanes.

An individual commenter states that, if the FAA is to require GPWS's for air taxi and commercial operators, it should be required for all airplanes; this would "give a much better economic scale for the avionics manufacturers," i.e., GPWS's would cost less since more would be produced.

FAA Response: In considering whether to grant the above-requested exceptions, the FAA studied the extent to which these operations had a history of CFIT-type accidents and fatalities. The FAA found that both VFR and charter operations did, indeed, have a history of CFIT-type accidents and fatalities. The DOT/TSC study reports that between 1978 and 1988, VFR operations had 3 CFIT-type accidents with 18 fatalities; all were Mode 2 (excessive closure rate to terrain) situations. In this same time period, charter operations had 13 CFIT-type accidents with 21 fatalities. Operating

experience demonstrates that GPWS equipment is necessary as a safety component for these operations; therefore, they are not being excluded from the rule.

The FAA does not concur with commenter recommendations to require GPWS equipment only on newly-manufactured airplanes. The NPRM and this final rule document have cited studies showing a significant number of CFIT-type accidents involving commuter airplanes not equipped with a GPWS. Operating experience clearly indicates that GPWS equipment is superior to advisory systems. Since many airplanes already in use will remain in operation for many years, the FAA has concluded that it is crucial that all commuter airplanes be required to have GPWS equipment as soon as feasible in order to prevent more CFIT accidents.

The recommendation to extend the requirement for GPWS to airplanes that are not operated under part 135 is outside the scope of this rulemaking.

Comments on the DOT/TSC Report

The FAA received some comments which respond directly to the DOT/TSC report. In particular, Rockwell International and Continental Express state that DOT/TSC conclusions, based on the study's analysis of NTSB accident data, are faulty in terms of the following: (1) A GPWS warning may not have been activated in some accidents; if there was a warning, it may not have provided enough reaction time or been heeded by the flight crew; and an advisory system may have been able to perform as effectively as a warning system; (2) Other contributing factors could have caused some of the accidents (e.g., windshear, flight crew stress); GPWS equipment may not have helped in these cases.

In addition to faulting DOT/TSC's analysis of NTSB data, these commenters state that some of the study's information is inaccurate. For example, a table that is supposed to list only accidents involving turbine-powered airplanes also lists those involving piston-engine airplanes. Also, some of the cost/benefit information is faulted, for example, installation costs for GPWS equipment should be higher than quoted because of the need to connect it to other airplane systems; and advisory systems provide the same level of benefit as does GPWS equipment.

FAA Response: All comments regarding the DOT/TSC report have been reviewed. In addition, DOT/TSC has thoroughly reviewed all relevant NTSB accident data and exercised the best possible judgment in determining the effectiveness of GPWS equipment in preventing accidents. In some cases, DOT/TSC has made judgments based on the available data, and the conclusions reached in these cases are sound.

DOT/TSC agrees that, in a few instances, there were minor errors in exhibiting the data; however, the errors did not affect the ultimate conclusions reached in the study. For example, even though the table described above lists two accidents involding piston-engine airplanes, the remaining 25 accidents comprise 22 involving turboprop airplanes and 3 involving turbojet airplanes; thus, the study's conclusion that turboprop airplanes should have approved GPWS equipment remains.

Regarding these commenters' arguments that the study's cost data is inaccurate, the FAA reiterates that each manufacturer provided the cost data for its own system, as well as its competitor's systems and that the latter cost data was biased upwards. Therefore, the cost data used in the study was based on estimates from the respective manufacturers. The FAA considers these estimates to be valid. While each type of system achieves benefits which exceed its costs, the FAA has determined that GPWS is most beneficial from a safety standpoint.

Commenters' arguments that installation costs were not included in DOT/TSC estimates are not valid because these costs were included in GPWS cost calculations presented in the study; this data was subsequently reflected in the NPRM and is explained in the cost section and the economic evaluation of this final rule document.

Regulatory Evaluation Summary

This section summarizes the full regulatory evaluation prepared by the FAA that provides more detailed estimates of the consequences of this regulatory action. This summary and the full evaluation quantify, to the extent practicable, estimated costs to the private sector and anticipated benefits.

Executive Order 12291, dated February 17, 1981, directs Federal agencies to promulgate new regulations or modify existing regulations only if potential benefits to society for each regulatory change outweigh potential costs. The order also requires the preparation of a Regulatory Impact Analysis of all "major" rules except those responding to emergency situations or other narrowly defined exigencies. A "major" rule is one that is likely to result in an annual effect on the economy of $100 million or more, a major increase in consumer costs, or a significant adverse effect on competition.

The FAA has determined that this rule is not "major" as defined in the executive order; therefore, a full regulatory analysis has not been prepared. Instead, the agency has prepared a more concise document termed a regulatory evaluation. In addition to a summary of the regulatory evaluation, this section contains a regulatory flexibility determination required by the 1980 Regulatory Flexibility Act (P.L. 96-354), a regulatory flexibility analysis, and an international trade impact assessment. If more detailed economic information than is contained in the summary is desired, the reader is referred to the full regulatory evaluation in the docket.

The rule will amend Part 135 such that 2 years following its effective date, no person may operate a multiengined turbine-powered airplane having a passenger seating configuration, excluding any pilot seat, of 10 seats or more unless it is equipped with an approved GPWS. Airplanes already equipped with a previously approved alternative "advisory" system may continue to be operated with that system until 4 years after the effective date of the rule.

Much discussion and documentation of costs and benefits of this rule were provided in the DOT/TSC study. The costs and benefits presented in this regulatory analysis reflect, to a large degree, both the findings in that study and the comments responding to the NPRM.

Analysis of Costs

The unit cost of each GPWS, including installation, as reported by the manufacturer, amounts to $14,600. The FAA estimates that within the 10-year-period 1993-2002, a total of 887 airplanes operating under Part 135 will require a GPWS at a total cost of $13.0 million. Approximately 725 of 837 airplanes that are currently operating under Part 135 and affected by this rule will need to be equipped with a GPWS within 2 years after the effective date of the rule. About 60 airplanes operating under Part 135 (not included in the above total of 887) are already equipped with GPWS approved for operations under Part 121, and another 52 airplanes have advisory systems that will need to be replaced within 4 years following the effective date of the rule. In addition, newly manufactured multiengine turbine-powered airplanes with 10 or more passenger seats will be affected by this rule and must be equipped with GPWS. The FAA anticipates that in each of the first 10 years after this rule is in effect (1993-2002) 11 new turbine-powered

airplanes in the 10 to 19 passenger seat size will be added to the fleet operating under Part 135 that would not contain GPWS's unless otherwise required.

The manufacturer also provided cost data for compatible radio altimeters and barometric-rate computers that will be needed on-board to accompany the GPWS. The estimated cost per airplane is $7,000 for an altimeter and $975 for a computer, including installation. The FAA estimates that 326 existing airplanes are equipped with acceptable radio altimeters, and that 225 existing airplanes are equipped with barometric rate computers (leaving 511 and 612 airplanes to be equipped with a radio altimeter and barometric rate computer, respectively). Among newly-manufactured airplanes, 73 will require altimeters and 88 will require computers during the 10-year period. This assumes that a similar percentage of such airplanes as currently exists would be equipped with these instruments in the absence of this rule. Total outlays for radar altimeters and barometric rate computers for the years 1993–2002, are estimated at $4.1 million and $0.7 million, respectively.

The total estimated equipment and installation costs for all airplanes affected is estimated to be $17.7 million.

The manufacturer estimates annual maintenance costs to be 5 percent of total equipment costs. Therefore, annual maintenance costs for an airplane needing all three pieces of equipment would be .5×($14,600+7,000+975)=$1,129. The average cost per airplane will be somewhat less since not all airplanes will require the same amount of new equipment to comply with this rule. Total fleet maintenance costs will increase from year-to-year as more airplanes become equipped with GPWS and related instruments. Maintenance costs during the 10-year analysis period will total $8.3 milion.

Each additional pound of weight added to a turbine-powered airplane operating under Part 135 is estimated to consume an additional 8.55 gallons of fuel annually. Applying the current jet fuel cost of $1.82 per gallon, the annual cost per pound of additional weight is about $15.56. The total additional weight per airplane associated with the GPWS, altimeter, and barometric rate computer is estimated to be 5.6 pounds. Because some airplanes are already equipped with one or more of these instruments, the average additional weight per airplane is estimated to be about 4 pounds. Therefore, total annual weight penalty costs are estimated to be $62.24 per airplane. Total additional fleet fuel costs are estimated to be $0.5 million over the 10-year period.

Two manufacturers estimate that 40 man-hours will be required to install all equipment associated with the GPWS. Although installation is likely to coincide with other scheduled maintenance activity, the loss of the use of an airplane for 40 man-hours, or 5 workdays, typically equates to a loss of 18 revenue hours for Part 135 airplanes, assuming an average of 3.6 revenue hours or block hours per day. The value of this lost revenue is estimated to be $180 per hour. Therefore, 18 hours of down-time due solely to installation of a GPWS and related equipment will cost an operator $3,240 per airplane. However, $3,000 per airplane is used for the purpose of this analysis since it is likely that installation of such equipment will coincide to some extent with other scheduled maintenance. Such costs will occur in 1993 (or sooner) for most affected airplanes, and in 1995 (or sooner) for airplanes that are currently equipped with approved advisory systems. Total fleet down-time costs are estimated to be $2.3 million over the 10-year period.

The total 10-year cost of this rule for all equipment, installation, maintenance, additional fuel consumption, and down-time costs is estimated to be $28.9 million, or $20.7 million discounted present value.

Analysis of Benefits

Twenty-five accidents involving turbine-powered airplanes occurred during the 10-year period (1978–1987) for which NTSB accident investigations revealed that it was highly improbable that the flight crew had any prior awareness of an impending impact with terrain. None of the airplanes involved in these accidents was equipped with a GPWS, and only one was equipped with an advisory system. The March 1989 DOT–TSC study of CFIT's scrutinized the circumstances of each of these accidents. The study determined that four of the accidents most likely would not have been prevented if a GPWS had been in use. In five other accidents the airplanes involved would have received a GPWS alert if such a system had been in use, but with questionable time provided for recovery. The other 16 accidents involved airplanes that would have had a GPWS alert activated with sufficient time for recovery. The casualties in the 16 accidents that the study considered preventable with the use of a GPWS included 56 fatalities and 7 serious injuries.

Comparable levels of accidents and casualties can be expected in the future if GPWS's are not installed on multiengined, turbine-powered airplanes operating under Part 135. In order to provide the public and government officials with a bench mark comparison of the expected safety benefits of rulemaking actions over an extended period of time with estimated costs in dollars, the FAA currently uses a minimum value of $1.5 million to statistically represent the value of a human fatality avoided (in accordance with guidelines issued by the Secretary of Transportation dated June 22, 1990). A value of $640,000 is used to statistically represent a serious injury prevented. In addition, the DOT–TSC study determined that the value of the average dollar loss for the 10 airplanes destroyed and 6 airplanes substantially damaged, was $550,000 and $180,000, respectively. Applying these values against the estimated potential losses provides an estimate of the total benefits of the rule over a 10-year period. The savings in human casualties total $88.5 million ((56×$1.5 million)+(7×$640,000)). The savings in destroyed and substantially damaged airplanes total $6.6 million ((10×$550,000)+(6×$180,000)). Total benefits amount to $95.1 million, or $53.1 million when discounted at 10 percent over the 10-year period.

There have been at least six more commuter airplane accidents occurring since the 1978–1987 study period. Preliminary findings indicate that they may have been prevented if the airplane had been equipped with a GPWS. These accidents have not been included in the estimate of benefits attributable to this rule because the NTSB has not completed its investigations or made final recommendations on all of them. Therefore, it would be inappropriate to attribute a specified number of accidents prevented if this rule had been in effect. However, one of the six accidents in which the NTSB did complete its investigation is mentioned here as further evidence of the merits of this rule. That particular accident occurred on October 28, 1989, in Molokai, Hawaii, and resulted in the deaths of all 20 people aboard the airplane. The NTSB concluded that a GPWS might have prevented the accident and reiterated its stance on the need for use of GPWS's in turbine-powered airplanes operated under part 135.

Comparison of Benefits and Costs

The anticipated discounted present value of the benefits of this rule ($53.1 million over 10 years) far exceed the estimated discounted present value of the costs ($20.7 million over 10 years). Although there is no way to know how many accidents and deaths actually will be prevented, if the rule is only 40

percent as successful as expected in preventing CFIT accidents, it will be cost-beneficial.

International Trade Impact

This rule will have little or no impact on trade opportunities for U.S. firms doing business overseas or foreign firms doing business in the United States. If foreign nations do not adopt U.S. standards, their airplane operators may be at a disadvantage in the U.S. market. However, the impact is expected to be slight. The maximum annualized cost of this rule per airplane over the 10-year period 1993 to 2002 is estimated at $3,772 ($2,800 discounted present value) but the average will be somewhat less. Such costs should not create an economic disadvantage to either domestic operators or foreign carriers operating in the United States.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities are not unnecessarily and disproportionately burdened by government regulations. The RFA requires agencies to review rules that may have a "significant economic impact on a substantial number of small entities."

For air carriers, a small entity is defined as one that owns, but does not necessarily operate, 9 or fewer airplanes. The FAA's criteria for a "substantial number" is a number that is not less than eleven and that is more than one third of the small entities subject to the rule. The FAA's criteria for a "significant impact" is at least $4,200 per year (1991 dollars) for an unscheduled carrier and $60,300 per year for a scheduled carrier operating a fleet that includes small airplanes, which have 60 or fewer seats.

An unscheduled small entity carrier with at least 2 airplanes will incur a significant economic impact because the annualized present value cost of $5,600 for 2 airplanes exceeds the $3,700 criteria used by the FAA. Such carriers represent approximately 37 percent of all small entities subject to the rule. Therefore, as required by law, a regulatory flexibility analysis follows.

Regulatory Flexibility Analysis

As required by sections 603(b) and (c) of the Regulatory Flexibility Act, the following analysis deals with the rule as it relates to small entities.

Why Agency Action is Taken

The reasons for agency action are detailed in the preamble to the rule. Briefly, the amendment will improve safety involving Part 135 operations by reducing controlled flight into terrain accidents involving turbine-powered airplanes. The FAA estimates that 16 such accidents could have been prevented during the 10-year period of 1978 through 1987 if the airplanes had been equipped with the ground proximity warning systems required by this rule. The rule addresses an NTSB recommendation and is supported by studies concluding that installation of a GPWS will contribute to prevention of CFIT accidents.

Objective of and Legal Basis for the Rule

The objective of the rule is to improve the operating safety of part 135 airplanes by preventing controlled flights into terrain. The objective is more thoroughly discussed in the preamble to the rule. The legal basis of the rule is sections 313, 314 and 601 through 610 of the Federal Aviation Act of 1958, as amended (49 U.S.C. 1354, 1355, and 1421 through 1430) and the Department of Transportation Act (49 U.S.C. 106(g)).

Description of the Small Entities Affected by the Rule

The small entities affected by the rule will be unscheduled carriers operating under part 135 of the Federal Aviation Regulations having more than one, and fewer than nine airplanes.

Compliance Requirement of the Rule

Compliance with the amendment will be mandatory for all turbine-powered multiengine airplanes with 10 or more seats operating under part 135. Those turboject airplanes that are currently using alternative warning systems approved by the FAA will be required to replace those systems within 4 years of the effective date of the rule.

Alternatives to the Rule

As part of the rulemaking action, the FAA considered several alternative approaches to the problem addressed by this rule.

Alternative One: Let the market decide. The airline would be free to choose whether it should install GPWS's as recommended. This alternative would allow the public to select an airline based on competitive factors including those of a safety nature. This is an alternative applicable to all safety regulations and, in the view of the FAA, would not assure a safe U.S. air transportation system.

Alternative Two: Delay development of the rule pending additional information that could be obtained during further government and industry reviews. This alternative is also rejected. The current rule is supported by adequate investigations and studies.

Alternative Three: Reduce costs to the industry by allowing operators to install either a GPWS or a ground proximity "advisory" system. Advisory systems provide a full complement of five warning envelopes and are available for less than the cost of a GPWS. The FAA rejects this alternative because the most effective advisory systems available are comparable in price to a GPWS, but not in effectiveness. The FAA has found, in the DOT/TSC and other studies, that GPWS equipment and advisory systems are functionally equivalent in only 2 out of 5 modes or warning envelopes. Only the TSO-approved GPWS meets minimum performance specifications in all 5 modes and provides the highest level of safety possible.

Federalism Implications

The regulations adopted herein will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this final rule will not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

This rule is significant under Department of Transportation Policies and Procedures (44 FR 11034, February 26, 1979) and, if adopted, the FAA certifies that it may have a significant negative economic impact on a substantial number of small entities under the criteria of the Regulatory Flexibility Act; however, no other feasible alternatives were identified. The annual cost that would be imposed on part 135 operators to install a ground proximity warning system on turbine-powered airplanes would exceed the $3,700 siginificant impact criteria per year for unscheduled air carriers. The FAA has determined that this notice involves a rulemaking action that is not a major rule under Executive Order 12291. A final regulatory evaluation of the proposal, including a final regulatory flexibility analysis and international trade impact analysis has been placed in the docket. A copy may be obtained by contacting the person identified under "**FOR FURTHER INFORMATION CONTACT.**"

List of Subjects in 14 CFR Part 135

Ground proximity warning systems.

The Amendment

Accordingly, the Federal Aviation Administration (FAA) amend 14 CFR Part 135 of the Federal Aviation Regulations (FAR) as follows:

PART 135—AIR TAXI OPERATORS AND COMMERCIAL OPERATORS

1. The authority citation for part 135 continues to read as follows:

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

2. Section 135.153 is revised to read as follows:

§ 135.153 Ground proximity warning system.

(a) Except as provided in paragraph (b) of this section, after April 20, 1994, no person may operate a turbine-powered airplane having a passenger seating configuration, excluding any pilot seat, of 10 seats or more, unless it is equipped with an approved ground proximity warning system.

(b) Any airplane equipped before April 20, 1992, with an alternative system that conveys warnings of excessive closure rates with the terrain and any deviations below glide slope by visual and audible means may continue to be operated with that system until April 20, 1996, provided that—

(1) The system must have been approved by the Administrator;

(2) The system must have a means of alerting the pilot when a malfunction occurs in the system; and

(3) Procedures must have been established by the certificate holder to ensure that the performance of the system can be appropriately monitored.

(c) For a system required by this section, the Airplane Flight Manual shall contain—

(1) Appropriate procedures for—

(i) The use of the equipment;

(ii) Proper flight crew action with respect to the equipment; and

(iii) Deactivation for planned abnormal and emergency conditions; and

(2) An outline of all input sources that must be operating.

(d) No person may deactivate a system required by this section except under procedures in the Airplane Flight Manual.

(e) Whenever a system required by this section is deactivated, an entry shall be made in the airplane maintenance record that includes the date and time of deactivation.

Issued in Washington, DC, on March 17, 1992.

Barry Lambert Harris,

Acting Administrator.

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