DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 91, 121, 135

[Docket No. 29312; Notice No. 98–11]

RIN 2120–AG46

Terrain Awareness and Warning System

AGENCY: Federal Aviation Administration, DOT.

ACTION: Notice of proposed rulemaking.

SUMMARY: The Federal Aviation Administration (FAA) proposes to issue operating rules that would prohibit operation of turbine-powered U.S.-registered airplanes type certificated to have six or more passenger seats, exclusive of pilot and copilot seating, unless that airplane is equipped with an FAA-approved terrain awareness and warning system (also referred to as an enhanced ground proximity warning system). This proposal would affect aircraft operated under parts 91, 121 and 135. Because operators under part 125 and operators of U.S.-registered airplanes under part 129 must comply with part 91, they would also have to meet this requirement. This change is needed because there have been several accident investigations and studies that have shown a need to expand the safety benefits of ground proximity warning systems to certain additional operations. In addition, these investigations and studies have shown that there is a need to increase the warning times and situational awareness of flight crews to decrease the risk of controlled flight into terrain accidents.

DATES: Comments must be received by November 24, 1998.

ADDRESSES: Comments on this notice should be mailed, in triplicate to: Federal Aviation Administration, Office of the Chief Counsel, Attention: Rules Docket (AGC–200), Docket No. 29312, 800 Independence Avenue, SW., Washington, DC 20591. Comments may also be sent electronically to the Rules Docket by using the following Internet address: 9-nprm-cmts@faa.dot.gov. Comments must be marked Docket No. 29312. Comments may be examined in the Rules Docket in Room 915G on weekdays between 8:30 a.m. and 5:00 p.m., except on Federal holidays.

FOR FURTHER INFORMATION CONTACT: Manuel Macedo, Aircraft Engineering Division, AIR–100, Aircraft Certification Service, Federal Aviation Administration, 800 Independence Avenue, SW., Washington, DC 20591; Telephone: (202) 267–9566.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to participate in this proposed rulemaking by submitting such written data, views, or arguments as they may desire. Comments relating to the environmental, energy, federalism, or economic impact that may result from adopting the proposals in this notice are also invited. Comments that provide the factual basis supporting the views and suggestions presented are particularly helpful in developing reasoned regulatory decisions. Communications should identify the regulatory docket number and be submitted in triplicate to the above specified address. All communications and a report summarizing any substantive public contact with FAA personnel concerning this rulemaking will be filed in the docket. The docket is available for public inspection both before and after the closing date for receiving comments.

Before taking any final action on this proposal, the Administrator will consider all comments made on or before the closing date for comments, and the proposal may be changed in light of the comments received.

The FAA will acknowledge receipt of a comment if the commenter includes a self-addressed, stamped postcard with the comment. The postcard should be marked ''Comments to Docket No. 29312.'' When the comment is received by the FAA, the postcard will be dated and returned to the commenter.

Availability of the Notice

Any person may obtain a copy of this notice of proposed rulemaking (NPRM) by submitting a request to the Federal Aviation Administration, Office of Rulemaking, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267–9677. Communications must identify the notice number of this NPRM. Persons interested in being placed on a mailing list for future FAA NPRM's should request a copy of Advisory Circular No. 11–2A, Notice of Proposed Rulemaking Distribution System, which describes application procedures.

An electronic copy of this document may be downloaded using a modem and suitable communications software from the FAA regulations section of the Fedworld electronic bulletin board service (telephone: 703–321–3339). Internet users may reach the FAA's web page at http://www.faa.gov or the Federal Register's webpage at http://www.access.gpo.gov/NARA/index.html for access to recently published rulemaking documents.

Background

Beginning in the early 1970's, a number of studies looked at the occurrence of ''controlled flight into terrain'' (CFIT)-type accidents, where a properly functioning 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.

Findings from these studies indicated that many such accidents could have been avoided if a warning device called a ground proximity warning system (GPWS) was used. As a result of these studies and recommendations from the National Transportation Safety Board (NTSB), in 1974 the FAA required all part 121 certificate holders (*i.e.*, those operating large turbine-powered airplanes) and some part 135 certificate holders (*i.e.*, those operating large turbojet airplanes) to install Technical Standard Order (TSO) approved GPWS equipment (§§ 121.360 and 135.153). (39 FR 44439, December 18, 1974).

In 1978 the FAA extended the GPWS requirement to part 135 certificate holders operating smaller airplanes: turbojet-powered airplanes with 10 or more passenger seats. These operators were required to install TSO-approved GPWS equipment or alternative ground proximity advisory systems that provide routine altitude callouts whether or not there is any imminent danger (§ 135.153). (43 FR 28176, June 29, 1978). This requirement was considered necessary because of the complexity, size, speed, and flight performance characteristics of these airplanes. The GPWS equipment was considered essential in helping the pilots of these airplanes to regain altitude quickly and avoid what could have been a CFIT-type accident.

Installation of GPWS's or alternative FAA-approved advisory systems was not required on turbo-propeller powered (turboprop) airplanes operated under part 135 because, at that time, the general consensus was that the performance characteristics of turboprop airplanes made them less susceptible to CFIT accidents. For example, it was thought that turboprop airplanes had a greater ability to respond quickly in situations where altitude control was inadvertently neglected, as compared to turbojet airplanes. However later studies, including investigations by the NTSB, analyzed CFIT accidents involving turboprop airplanes and found that many of these accidents could have been avoided if GPWS equipment had been used.

Some of these studies also compared the effectiveness of the alternative ground proximity advisory system to the GPWS. GPWS was found to be superior in that it would warn only when necessary, provide maximum warning time with minimal unwanted alarms, and use command-type warnings.

Based on these reports and NTSB recommendations, in 1992 the FAA amended § 135.153 to require GPWS equipment on all turbine-powered airplanes with 10 or more passenger seats. (57 FR 9944, March 20, 1992).

NTSB Recommendations

Following the investigation of a CFIT accident south of Dulles International Airport on June 18, 1994, involving a Learjet 25D in which there were 12 fatalities, the NTSB recommended (Recommendation A–95–35) that the FAA mandate that all turbojet-powered airplanes equipped with six or more passenger seats have an operating ground proximity warning system installed. That recommendation also made reference to an earlier, similar NTSB recommendation (Recommendation A–92–055) resulting from a 1991 CFIT accident involving a Beechjet 400. Both planes were corporate jets flying under part 91 and were not required to have GPWS equipment installed.

More recently, the NTSB issued Recommendation A–96–101, based on its investigation of a CFIT accident northeast of Cali, Colombia, on December 20, 1995, involving an American Airlines Boeing 757 airplane operating under part 121, which resulted in 159 fatalities. The NTSB recommended that the FAA examine the effectiveness of enhanced ground proximity warning equipment (described in the following section), and if found effective, require all transport-category aircraft to be equipped with this equipment. Although the accident airplane was equipped with the mandatory GPWS, the GPWS did not provide the warning in time for the crew to successfully avoid the mountainous terrain.

Terrain Awareness and Warning System (Enhanced Ground Proximity Warning System)

Advances in terrain mapping technology have permitted the development of a new type of ground proximity warning system that provides greater situational awareness for flight crews. The FAA has approved certain installations of this type of equipment, known as the enhanced ground proximity warning system (EGPWS). However, in this NPRM, the FAA is using the broader term ''terrain awareness and warning system'' (TAWS) because the FAA expects that a variety of systems may be developed in the near future that would meet the improved standards being proposed in this NPRM.

TAWS improves on existing systems by providing the flight crew automatic advanced aural and visual warning of impending terrain, much earlier warning, forward looking capability, and operability in landing configuration. These improvements provide more time for the flight crew to make smoother and gradual corrective action. These functions are more fully described under ''Functions and Approval of TAWS.''

Volpe National Transportation Systems Center Studies

In recent years, the FAA commissioned several studies by DOT's Volpe National Transportation Systems Center (VNTSC) to examine the effectiveness of GPWS and EGPWS in preventing CFIT accidents in various aircraft categories and operations. These are described below.

Part 91 Study

In 1996, the FAA commissioned VNTSC to consider the installation of current GPWS or EGPWS on all part 91 turbine-powered airplanes of 6 or more passenger seats. Although NTSB Recommendation A–95–35 addressed only turbojets, the FAA expanded the study focus to include all turbine-powered airplanes because of the results of the previous studies and rulemaking discussed earlier.

Forty-four CFIT accidents that occurred between 1985 and 1994 were studied. The airplanes involved had from six to ten passenger seats and were operating under part 91. Eleven were turbojets and 33 were turboprops. Because these flights were not conducted under parts 121 or 135, GPWS was not required and none of the airplanes had GPWS installed. By using computer modeling techniques, VNTSC came to the following conclusions: (1) GPWS meeting TSO–C92 could have avoided 33 of the 44 (75%) accidents and 96 fatalities; and (2) EGPWS could have avoided 42 of the 44 (95%) accidents and 126 fatalities. The EGPWS evaluated in the Volpe studies would meet the TAWS requirements proposed in this NPRM. A more detailed analysis is included in FAA study DOT–TSC–FA6D1–96–01, Investigation of Controlled Flight Into Terrain, which is included in the public docket for this rulemaking, or can be obtained by contacting the Aircraft Engineering Division, AIR–100, Aircraft Certification Service, Federal Aviation Administration, 800 Independence Avenue, SW., Washington, DC 20591; Telephone: (202) 267–9566.

Part 121/135 Study

Later in 1996, the FAA commissioned VNTSC for a second study focusing on a retrofit of GPWS with EGPWS on airplanes operated under part 121 and part 135. This study documents an investigation of CFIT aircraft accidents involving aircraft flying under part 121 and 135 flight rules, or their foreign equivalents, and evaluating the potential for accident prevention by EGPWS.

There were over 100 fatal CFIT accidents worldwide during the study period of 1985 to 1995. A list of 47 domestic and 104 foreign accidents of aircraft with characteristics similar to those that would be covered by the proposed rule was compiled. Of these totals, 38 domestic accidents and 96 foreign accidents involved fatalities. Due to resource constraints, detailed analysis of all these accidents was not possible. The staff of the VNTSC developed a methodology and scheme for selecting a representative sample for detailed study and analysis. While not an exhaustive compilation of all CFIT accidents, it represents an effort to review the characteristics of most major CFIT accidents. From this process nine accidents were selected for detailed analysis worldwide.

Analysis showed that four of the nine accidents (44%) should have been prevented by the basic GPWS equipment that had been installed. However, in two cases the GPWS equipment was either disconnected or it malfunctioned. In the other two cases, poor flight crew coordination led to inaction following the GPWS warning, rather than decisive recovery maneuvers, until impact could not be avoided.

In contrast, EGPWS warning times would have been more than the warning time of GPWS (which was assumed by VNTSC to be 12–15 seconds) in all nine cases. In seven, warning times expected with EGPWS exceeded those of GPWS by over 20 seconds; two of these cases involved differences of over one minute. In general, EGPWS should have provided an additional margin in which flight crews could assess their situation, discover errors, regain situational awareness, and take appropriate action before impact. In only one case was an assumed EGPWS warning duration only slightly above the 12–15 second minimum. In this case it can be argued that if the visual forward looking terrain

display in EGPWS had been installed, it may have prevented the pilot's fatal wrong turn towards the mountains in the first place. Thus, it is reasonable to assume that EGPWS could probably have prevented all nine (100%) of these accidents.

VNTSC Conclusion: GPWS vs. EGPWS

The VNTSC part 121/135 study credits GPWS as a significant factor in reducing the frequency of CFIT accidents since 1975. However, these accidents have not been totally eliminated for two major reasons:

First, many of the GPWS systems currently in use are earlier generation systems, installed after the first GPWS rulemaking in the 1970's. Since that time, GPWS equipment has been improved. These advances typically involve improvements in terrain detection logic that enables increased terrain warning durations in the order of 10–15 seconds on average resulting in additional time for the pilot that can be crucial in preventing accidents. The NTSB addressed this issue by recommending to the FAA that early generation GPWS equipment be upgraded. (NTSB recommendations A–92–39 through A–92–42.)

As a result, in 1996, the FAA revised TSO–C92b and issued TSO–C92c. Specifically, this new TSO added new requirements and features to GPWS: aural warnings that would identify the reason for GPWS warnings; the inclusion of airspeed in the logic that determines GPWS warning times; altitude callouts during nonprecision approaches; and warnings based on airport location and aircraft position data.

Second, even with these added features, GPWS equipment has two important limitations: (1) GPWS does not have the capability to ''look forward,'' but instead only ''looks down,'' relying on radio altimeter data. For this reason, there is little or no warning if the terrain ahead of an airplane rises in a steep gradient. This limitation is known as the ''vertical cliff'' limitation. (2) To prevent nuisance ground proximity warnings during final approach, for an aircraft in stabilized descent on a non-precision approach (i.e., one in which lateral, but not vertical or glide slope, guidance is provided), with gear and flaps extended, all GPWS warning modes are desensitized. Thus a flight crew will receive no warning if their aircraft is not in fact lined up with a runway. This limitation is known as the ''non-precision approach (NPA) trap'' limitation.

In its conclusion, the VNTSC states that there is compelling evidence of the potential effectiveness of EGPWS in preventing CFIT accidents. EGPWS would have provided the same or increased warning durations over GPWS had each aircraft continued along the accident track, and should have provided sufficient warning to effectively prevent all nine cases studied. The study emphasized that the CFIT accident prevention in all cases would have resulted not so much from increased warning durations following system detection of terrain threats, as from the fact that flight crews, given a continuous terrain display, would have perceived these terrain threats and responded to them well before EGPWS was required to generate warnings.

Elaborating further, the study states that the continuous terrain display feature of EGPWS may be even more important than the terrain threat detection/alert/warning features in breaking the chain of decisions leading to CFIT. Flight crews lacking visual perspective are given a continuous display of nearby terrain, greatly heightening situational awareness. Rather than a ''last ditch'' warning of imminent danger, the continuous terrain display would allow crews to maneuver to avoid terrain long before it ever becomes an obstruction to their flight path. It thus represents a pivotal advance in providing flight crew terrain awareness.

The FAA agrees that the terrain situation awareness display is a valuable function and therefore proposes to mandate its use. However, the alerting functions also are critical. Because of the various piloting duties, functions and activities, a pilot does not monitor one instrument 100% of the time, and this will be the case with a terrain situation awareness display. The alerting functions provide the final safety margin that directs the pilot to take life-saving action.

While recognizing the terrain awareness benefits of the terrain display, the VNTSC study also recognizes that such a display may present a new set of challenges to pilots. The TAWS's topographical map display will offer a temptation for pilots to use it for navigational purposes. Pilot training should emphasize that other aircraft systems are intended for this purpose, and any TAWS terrain display features are intended only to provide terrain awareness, not for aerial navigation. See also Notice N8110.64, Enhanced Ground Proximity Warning System, which provides guidance on EGPWS and specifies that Airplane Flight Manuals should state that EGPWS shouldn't be used for navigational purposes.

In light of the potential savings of human life and the economic costs of destroyed or damaged aircraft, the report recommends that the FAA amend 14 CFR parts 121 and 135 to require mandatory installation in affected aircraft fleets of TAWS. A more detailed discussion and analysis is included in FAA study DOT–TSC–FA6D1–96–03, Investigation of Controlled Flight Into Terrain (For Selected Aircraft Accidents Involving Aircraft Flying Under FAR Parts 121 and 135 Flight Rules and the Potential for Their Prevention by Enhanced Ground Proximity Warning System (EGPWS)).

Functions and Approval of TAWS

Functions of TAWS

Recent technological advancements—such as more precise navigation systems, increased computer memory storage and better display technology—have allowed the development of terrain alerting and warning systems. Current systems under development have three common features: (1) Use of airplane position information from the airplane's navigation system(s), (2) an onboard terrain data base, and (3) a means of displaying the surrounding terrain. All systems currently under development function in the following same manner. Airplane position information from the airplane navigation system is fed to the TAWS computer. The TAWS computer compares the airplane's current position and flight path with the terrain data base also in the TAWS computer. If there is a potential threat of collision with terrain, the TAWS computer sends warning alerts to the airplane's audio system. The TAWS computer also inputs display data to either the weather radar, the Electronic Flight Information System (EFIS) or some other display screen on which then is shown the surrounding terrain with the threat terrain highlighted. Specific certification requirements for the TAWS is contained in TSO–C151.

An example of a specific TAWS currently certificated by the FAA handles the above functions as follows:

(1) Alerting Times

The function of the new proposed TAWS standard is to prevent CFIT by providing alerting times earlier than those provided by existing ground proximity warning systems manufactured in accordance with Technical Standard Order (TSO)–C92c. Typically GPWS aural and visual warnings occur about 20 seconds or less before potential impact with terrain.

The visual warning is usually a blinking light and the aural warning is usually a message through the airplane's audio system.

Studies indicate that average combined pilot and aircraft reaction time to avoid a CFIT after warning is within the 12 to 15 second range. The FAA has approved for installation a TAWS (the EGPWS) that provides an initial alert approximately 60 seconds before potential impact and another alert about 30 seconds before potential impact. These alerts are both aural and visual. These alerting times were based on data from actual CFIT accidents and were chosen by the manufacturer as the best compromise to provide timely alerts while still minimizing nuisance alarms. Human factors research and FAA experience show that, if an aural cockpit alarm sounds too often as a false alarm, the flight crew will either begin to ignore it or will be tempted to disable the system. Therefore, while the forward looking capability of TAWS could provide an alert far in advance of potential impact, the alerting time must be as short as possible, while still allowing an adequate time to avoid impact. The FAA will carefully evaluate the alerting times for each proposed TAWS, but expects that manufacturers will provide at least 20 seconds in advance of a potential impact.

(2) Forward Looking Capability

The increased alerting function is made possible by a ''forward looking'' feature. This function in turn is made possible by inputting aircraft position from the global positioning system (GPS) or a flight management system (FMS) into the TAWS computer in which a terrain database is already stored. Using aircraft position, performance and configuration data, the TAWS computer calculates an envelope along the projected flight path of the aircraft and compares that to the terrain database. If there is a potential impact with terrain, the system provides appropriate aural and visual alerts. This feature also makes possible a terrain (situational) awareness display that could be used on a dedicated TAWS display screen, a weather radar, or an EFIS display screen. Terrain within certain vertical distances of the aircraft is displayed in various color densities. The FAA would accept green, yellow and red because these are the colors currently available on the weather radar display.

(3) Terrain Clearance Floor

TAWS also provides a terrain clearance floor that adds an additional element of protection to the GPWS warning modes. The terrain clearance floor creates an increasing terrain clearance envelope around the intended airport runway directly related to the distance from the runway. The terrain clearance floor alerts are based on aircraft location, nearest runway center point position, and radio altitude. The terrain clearance floor provides an alert based on insufficient terrain clearance even when in landing configuration. This is an improvement over the current GPWS, which becomes deactivated when an airplane's wing flaps and landing gear are in landing configuration.

If an airport has glide-slope equipment that is operating, the flight crew can rely on that equipment to guide the airplane; the TAWS terrain clearance floor function may not be needed. However, if the airport does not have glide-slope equipment or it is not operating, the flight crew must perform a non-precision approach. In this case, if the flight crew is unaware of its location and comes in too low or too soon, the terrain clearance floor function would generate an aural alarm.

Approval of TAWS

Currently, the FAA approves the manufacture and installation of Ground Proximity Warning Systems through Technical Standard Orders. Sections 121.360 and 135.153 require the use of GPWS meeting TSO–C92, which has been reissued as TSO–C92a, TSO–C92b, and TSO–C92c. The FAA does not intend to revise TSO–C92c to include TAWS requirements.

Instead, the FAA is developing and will issue a new and separate TSO for TAWS. The new TSO–C151, Terrain Awareness and Warning System, is being developed through the FAA TSO process which allows for public comments. Any person desiring to review and comment on the draft TSO–C151 may obtain a copy of the draft TSO–C151 from the person mentioned in the section entitled **FOR FURTHER INFORMATION CONTACT.** This TSO would be the means to obtain FAA approval of the TAWS product. The FAA also will develop and issue a TAWS advisory circular (AC). This AC would describe an acceptable means of obtaining FAA installation approval. Notice 8110.64, Enhanced Ground Proximity Warning System (EGPWS) is the current interim guidance to be used for the installation and approval of TAWS. The FAA has issued a policy statement that states that the contents of Notice 8110.64 shall remain valid until the TSO and AC are published.

An applicant that meets the proposed requirements of TSO–C151 also will be entitled to a TSO–C92c authorization, if requested, with a TSO–C151 authorization. The performance and environmental standards of TSO–C92c are included within TSO–C151. Any equipment bearing a TSO–C151 label will meet the requirements of FAR part 121.360 and 135.153.

The Proposal

The FAA is proposing to add §§ 91.223, 121.354, and 135.154 to require the installation of FAA-approved terrain awareness and warning systems (TAWS). The FAA is also proposing to amend §§ 121.360 and 135.153 to add an expiration date of four years after the effective date of the final rule for the use of current GPWS systems, thereafter, compliance with those sections would not be allowed in lieu of the provisions proposed herein.

For operations under part 121 the proposed rule would apply to all turbine-powered airplanes. For all other operations (parts 91, 125, 129, and 135) the proposed rule would apply to all turbine-powered airplanes type certificated to have six or more passenger seats, excluding any pilot seat. The FAA proposes that, beginning one year after the effective date of the final rule, U.S.-registered airplanes manufactured after that date be equipped with TAWS. The FAA also proposes that existing turbine-powered airplanes be equipped with TAWS within four years after the effective date of the final rule. This requirement for existing airplanes would apply to all airplanes manufactured on or before one year after the effective date of the final rule. (For more discussion of the compliance dates and how they were chosen, see the Regulatory Evaluation Summary later in this preamble.)

The proposal would therefore ensure that all applicable airplanes operated under parts 91, 121, and 135 have the most up-to-date and effective equipment needed to help prevent CFIT accidents. The proposal would also ensure that operators under part 125 and operators of U.S.-registered airplanes under part 129, who must also comply with part 91, are similarly equipped in order to prevent CFIT accidents.

The FAA is also proposing that operators include in their Airplane Flight Manuals the appropriate procedures for operating and responding to the audio and visual warnings of TAWS.

The FAA is not proposing changes to current training requirements in this NPRM. However recent new training requirements on crew resource management (CRM) for flight crewmembers should provide additional

safeguards in conjunction with the use of TAWS. This requirement will apply to flight crewmembers operating under parts 121 and 135 and will take effect on March 19, 1998. (60 FR 65940, December 20, 1995).

The proposed rule would apply only to turbine-powered airplanes. The FAA specifically requests comments on whether it should require the installation of TAWS on reciprocating engine-powered airplanes. What would be the impact on safety of such a requirement? Are there technical reasons why TAWS is or is not appropriate for reciprocating engine-powered airplanes? Should TAWS be required for reciprocating engine-powered airplanes of a certain size? The FAA will study data and information submitted by commenters in response to these questions before making a determination as to whether TAWS should be required for reciprocating engine-powered airplanes. If the decision is made to require TAWS on reciprocating engine-powered airplanes it will be addressed in a separate rulemaking.

Impact of the Proposed Rule

The impact of the proposed rule on operations under parts 91, 121, and 135 would be similar to the impact of the installation of TAWS on newly manufactured airplanes, *i.e.,* installation would be required beginning one year after the effective date of the final rule. Because operators under part 125 and operators of U.S.-registered airplanes under part 129 must comply with part 91, they would also have to meet this requirement.

The requirement for TAWS on existing airplanes would impact operators under the affected parts differently. Those operators under part 91 (including operators under part 125 and operators of U.S.-registered airplanes under part 129) who are currently not required to have GPWS would, in most cases, be required to install TAWS within the four year compliance period. In those cases where GPWS was previously installed on a voluntary basis, operators would also be required to retrofit their airplanes with TAWS within four years. Retrofits would also apply in cases where part 125 operators lease part 121 airplanes that are already equipped with GPWS.

For existing airplanes under parts 121 and 135, which currently must have GPWS, operators would be required to retrofit their airplanes to install TAWS within four years. It should also be noted that the proposed rule adds to the existing part 135 requirement by requiring TAWS on an additional group of airplanes: those type certificated to have six to nine passenger seats, excluding any pilot seat. The current rule requires GPWS for airplanes with 10 or more seats under part 135. If the operators of this group of airplanes have not already installed EGPWS voluntarily, the proposed rule would require a new installation of TAWS. The FAA acknowledges that this proposal may require the retrofit of aircraft that are equipped with current generation GPWS. For example, the 1992 rule discussed earlier, required GPWS on all turbine-powered airplanes with 10 or more passenger seats. The FAA specifically requests comment on the requirement for TAWS for such airplanes. (*e.g.* Should the retrofit be required only in airplanes carrying more than a certain number of passengers?)

Regulatory Evaluation Summary

Proposed changes to Federal regulations must undergo several analyses. First Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effects of regulatory changes on international trade. Finally, the Unfunded Mandates Reform Act of 1995 requires that agencies assess the impact of regulatory changes on State, local tribal governments and private sector. In conducting these analyses, the FAA has determined that this rule: (1) Would generate benefits that justify its costs and is a ''significant regulatory action'' as defined in the Executive Order; (2) is significant as defined in DOT's Regulatory Policies and Procedures; (3) would have a significant impact on a substantial number of small entities, (4) would not constitute a barrier to international trade, and (5) would not impose a significant intergovernmental mandate on State, local or tribal governments.

Costs and Benefits for Airplanes Operated Under 14 CFR Part 121

Under the assumption that in-service airplanes must be equipped with a terrain awareness and warning system by January 1, 2003 (four years after an assumed effective date of December 31, 1998), the FAA estimates that approximately 6,000 in-service airplanes operating under 14 CFR part 121 would be affected by the proposed rule. In addition, the proposal would impact approximately 400 newly manufactured turbojet and turboprop transports delivered to part 121 air carriers per year. These estimates—which are based on Aircraft Registry records, insurance data, and proprietary forecasts—do not account for voluntary installations of TAWS equipment. Overall, the FAA projects that approximately 1,100 airplanes operating under 14 CFR part 121 would be equipped with TAWS by the year 2002 in the absence of any requirement. Adjusting these estimates to account for voluntary installations, however, would not significantly affect the conclusions since the effect would be roughly proportional on both total benefits and costs.

The FAA approves TAWS installations either through Supplemental Type Certificates issued to an applicant other than the airframe manufacturer; or, in the case of the manufacturer, either a STC or a FAA-approved type-design change. Discussions with industry indicate that a typical first-of-type certification program would cost approximately $79,000 for a part 121 turbojet airplane model and $37,000 for a part 121 turboprop airplane model. These costs include FAA engineering and administrative costs. First-of-type STC's would then be amended to cover additional model-variants. The FAA estimates that such amendments, also called ''follow-ons,'' could be developed at a cost of approximately $67,000 for turbojets and $26,000 for turboprops (again, inclusive of FAA costs).

Accurately estimating the number of STC's required by the proposed rule is problematic since flight deck equipment may differ between operators of the same model-variant. For example, several different approvals may be required for different, say, B737–400's depending on the equipment options selected by the various operators. This analysis assumes 68 first-of-type certification programs and 84 follow-on programs. It should be noted that, even when multiple firms perform retrofits on a particular model-variant, the FAA would not necessarily require multiple certification or follow-on programs: in practice, only the first entity would incur full STC development costs. Subsequent firms could then purchase the STC incurring incremental expenses associated with ground and flight testing.

The FAA estimates that total STC costs (including follow-ons) for 14 CFR part 121 operators would be approximately $8.4 million, or $7.1 million at present value (assuming that STC expenses are uniformly distributed

during the period 1999–2000, and that the discount rate is 7%).

Since ground proximity warning systems are already required for part 121 operators, equipment and installation costs associated with this proposal would include: (1) For newly manufactured airplanes, the difference in cost between current generation GPWS and TAWS, and, (2) for in-service airplanes, the cost of removing the existing ground proximity warning system and replacing it with TAWS (net the rebate value of the GPWS equipment). Since GPWS and TAWS units are approximately the same weight, and since TAWS requires no more maintenance than GPWS, incremental part 121 operating and maintenance costs associated with the proposed rule are negligible.

Retrofit costs depend on the type of equipment already in use in an affected airplane. Differences in costs can be ascribed to the relative trade-in values of various vintages of GPWS units and the fact that, in some cases, GPWS includes an integral windshear detection system. (In some cases, operators may be forced to replace both the GPWS and windshear detection systems. The analysis accounts for this additional cost where applicable.) Unit (*i.e.* per airplane) retrofit costs can be summarized as follows: (1) In-service turbojet airplanes equipped with early-generation GPWS—$59,480, (2) in-service turbojet airplanes equipped with current-generation GPWS—$64,980, (3) newly manufactured turbojet airplanes—$12,000, (4) in-service 30+ passenger turboprop airplanes equipped with early-generation GPWS—$59,480, (5) in-service 30+ passenger turboprop airplanes equipped with current-generation GPWS—$57,280, (6) newly manufactured 30+ passenger turboprop airplanes—$12,000, (7) in-service less-than-30-seat turboprop airplanes—$20,600, (8) newly manufactured less-than-30-seat turboprop airplanes—$2,000.

These unit costs include: TAWS system costs, installation kit costs, installation labor costs, an adjustment for spares and simulator installations (assumed to be 10% of TAWS systems costs), and adjustments for additional navigation equipment and displays required in some aircraft. Aside from the provision for simulator units, incremental training costs are assumed to be negligible. The FAA invites comment on these cost assumptions.

The FAA estimates that TAWS equipment and installation costs for the affected in-service 14 CFR part 121 fleet would be approximately $361.5 million, or $297.0 million at present value. Total equipment and installation costs for newly manufactured airplanes delivered to part 121 air carriers during the ten year forecast period 1999–2008 would be approximately $47.5 million, or $31.3 million at present value. Therefore, total part 121 costs—including certification costs, retrofit costs, and incremental TAWS costs for newly manufactured airplanes delivered between 1999 and 2008—would be approximately $408.9 million, or $328.3 million at present value.

The benefits of TAWS again depend on the type of GPWS unit it would replace. The risk reduction potential of TAWS when measured against an early-generation GPWS system, for example, is higher than the risk reduction potential measured against a current-generation system. Risk reduction estimates for various combinations of airplane types and GPWS vintages are based on analyses of eight CFIT accidents involving 14 CFR part 121 air carriers (this includes two part 135 air carriers now required to operate under 14 CFR part 121) which occurred during the ten-year period 1986–1995. The analyses—conducted by the Volpe National Transportation Systems Center and referred to earlier in the preamble—took into consideration, among other things, the type of GPWS equipment (if any), on-board at the time of the accident, and the relative effects of current-generation GPWS versus TAWS. On the basis of the Volpe results, the FAA estimates the following rates of CFIT risk reduction: (1) Turbojet airplanes equipped with early-generation GPWS—0.079 averted accidents per million flight hours, (2) turbojet airplanes equipped with current-generation GPWS—0.048 averted accidents per million flight hours, (3) 30+ passenger turboprop airplanes equipped with early-generation GPWS—0.079 averted accidents per million flight hours, (4) 30+ passenger turboprop airplanes equipped with current-generation GPWS—0.048 averted accidents per million flight hours, (5) less-than-30-seat turboprop airplanes—0.118 averted accidents per million flight hours.

Estimates of lifecycle benefits were calculated on a per-airplane basis and summed over all affected part 121 airplanes to obtain an estimate of the expected fleet benefits. The calculations took into consideration: (1) The passenger capacity of each airplane, (2) average load factors for various types of operations, (3) the number of flight crew, (4) the probability of fatalities given a CFIT accident, (5) the expected value of the airplane at the time of accident, and (6) the expected remaining service life of the airplane.

The FAA estimates that total lifecycle benefits for the affected 14 CFR part 121 fleet (including the lifecycle benefits accruing to newly manufactured airplanes delivered during the period 1999–2008) are approximately $5.9 billion, or $2.1 billion at present value. Therefore, the ratio of discounted benefits to discounted costs is approximately 6.5 to 1.0.

Three of the eight preventable part 121 CFIT accidents occurred during international operations of U. S. carriers. The FAA evaluated the benefits and costs of lesser requirements on operators conducting only domestic flights. This analysis, however, showed substantial benefits associated with the TAWS requirement for in-service airplanes flying only domestic routes. (See the Preliminary Regulatory Evaluation, Section VII ''Analysis of Alternatives.'')

Costs and Benefits for Airplanes Operated Under 14 CFR Part 135

The FAA estimates that approximately 1,100 in-service airplanes operating under 14 CFR part 135 would be affected by the proposed rule. Approximately 800 of these are 10–30 seat airplanes that are currently required to have GWPS, and 300 are 6–9 seat turbojets and turboprops currently not required to have GPWS. In addition, the rule would affect approximately 500 new turbojet and turboprop airplanes delivered to part 135 air carriers during the period 1999–2008. The FAA is not aware of any large scale efforts to voluntarily equip part 135 airplanes with terrain awareness and warning systems.

The FAA estimates that total certification costs for typical 14 CFR part 135 turbojet and turboprop airplane models would be approximately $28,000 and $20,000, respectively. An estimate of total part 135 certification costs, then, is obtained by multiplying the per-certification costs by an estimate of the total number of certifications required. As in the analysis of part 121, predicting the number of required STC's for part 135 is problematic owing to potential differences between and within airplane model-variants. In some cases, more than one TAWS STC may be required per model, in other cases, one STC may cover more than one model. The FAA estimates that approximately 50 turbojet STC's and 32 turboprop STC's would be required to retrofit the affected part 135 fleet. Therefore, total fleet certification costs are approximately $2.1 million, or $1.8 million at present value (again,

assuming that certification costs are uniformly distributed during the period 1999–2000 and that the discount rate is 7%).

As noted earlier, the incremental costs (and benefits) of the rule depend in part on the type of GPWS equipment already in service. Operators who already have GPWS equipment, for example, would incur no additional operating or maintenance costs. In the absence of detailed information on which particular airplanes have or do not have GPWS, the FAA assumes that all airplanes are in compliance with current Federal Aviation Regulations—but do not exceed those requirements (that is, there is no adjustment made for voluntary GPWS installations). Thus, it is assumed that all 6–9 passenger seat turbine engine airplanes are not equipped with any type of ground proximity warning system.

Unit equipment and installation costs for affected part 135 airplanes are as follows: (1) In-service turbojet airplanes seating 6–9 passengers—$27,950, (2) newly-manufactured turbojet airplane seating 6–9 passengers—$26,475, (3) in-service turbojet airplanes seating 10 or more passengers—$24,300, (4) newly manufactured turbojet airplanes seating 10 or more passengers—$7,000, (5) in-service turboprop airplanes seating 6–9 passengers—$30,150, (6) newly-manufactured turboprop airplanes seating 6–9 passengers—$28,575, (7) in-service turboprop airplanes seating 10 or more passengers—$24,300, (8) newly manufactured turboprop airplanes seating 10 or more passengers—$7,000. (Recall that GPWS is already required for 10–30 seat airplanes. Therefore, incremental TAWS cost for newly manufactured airplanes in this group equal the difference in cost between TAWS and basic GPWS.) As before, these costs include: TAWS equipment costs, installation kit costs, GPS and display costs, and an adjustment for a radar altimeter (not present on some aircraft).

As noted above, incremental operating and maintenance costs are only associated with airplanes lacking GPWS equipment—by assumption airplanes seating 6–9 passengers. The FAA estimates that the weight of an average TAWS installation would be approximately 9 pounds for a turbojet airplane and 8 pounds for a turboprop airplane. Annual maintenance costs are approximately 5% of TAWS equipment costs, therefore annual incremental operating (fuel consumption) and maintenance costs equal $870 and $936 for 6–9 passenger turbojet and turboprop airplanes, respectively.

Total lifecycle costs for the affected 14 CFR part 135 fleet—including certification, equipment, installation, operating and maintenance costs—would be approximately $45.2 million, or $30.8 million at present value. Again, this total includes projected lifecycle costs for newly manufactured 6+ seat turbojet and turboprop airplanes delivered to part 135 operators between 1999 and 2008.

Following the procedure discussed under part 121, the estimated benefits for 14 CFR part 135 operations are a function of airplane seating capacity, load factors, annual flight hours, GPWS equipage, *etc.* Again, expected TAWS benefits for any particular airplane depend on whether or not the airplane already has GPWS and, if it does, the vintage of system installed. Risk reduction estimates are as follows: (1) Turbojet airplanes seating 6–9 passengers—0.861 accidents averted per million flight hours, (2) turbojet airplanes seating 10 or more passengers—0.036 accidents averted per million flight hours, (3) turboprop airplanes seating 6–9 passengers—2.310 accidents averted per million flight hours, (4) turboprop airplanes seating 10 or more passengers—0.091 accidents averted per million flight hours. For airplanes with 6–9 seats, risk estimates are based on analyses of approximately 40 accidents involving turbojet and turboprop airplanes operating under 14 CFR part 91. For airplanes with 10–30 seats, risk estimates are based on the service experience of similar airplanes operated under 14 CFR part 121. (At the time of this writing, the FAA has asked the Volpe center to review the part 135 CFIT accident data from the original study

Based on these results, the FAA projects that TAWS benefits—that is the value of reduced CFIT risks—for 14 CFR part 135 operators would be approximately $84.4 million, or $38.2 million at present value (including benefits accruing to affected part 135 airplanes delivered between 1999 and 2008). Therefore, the ratio of discounted benefits to discounted costs would be approximately 1.24 to 1.0.

The FAA notes that in the case of airplanes carrying fewer numbers of passengers, there is a clear overall net benefit in requiring TAWS to replace early generation GPWS. While relative benefits are lower for smaller aircraft that have only recently been retrofitted with current generation GPWS, excepting such airplanes could create a situation where the FAA would require more sophisticated equipment for noncommercial aircraft as compared with some commercial aircraft.

Costs and Benefits for Airplanes Operated Under 14 CFR Part 91

Affected 14 CFR part 91 airplanes, for the purpose of this analysis, are defined as a residual—*i.e.* the total affected fleet of U.S. registered turbine powered airplanes minus the affected 14 CFR parts 121 and 135 fleets. The part 91 residual includes general aviation aircraft (corporate, business, personal, instruction, aerial application, and other), large airplanes (having a seating capacity of 20 or more or a maximum payload capacity of 6,000 pounds or more) operating under 14 CFR part 125, and U.S. registered airplanes operating under 14 CFR part 129. Under this simple residual approach, the FAA estimates that approximately 5,500 turbojet airplanes and 5,700 turboprop airplanes (not operating under 14 CFR parts 121 and 135) would be affected by the proposed rule. The FAA estimates that an additional 220 newly manufactured turboprops and 120 newly manufactured turbojets would be affected annually.

The FAA estimates that the proposed rule would require approximately 57 STC's at a total cost of $1.3 million, or $1.1 million at present value (assuming that certification costs are uniformly distributed over the period 1999–2000, and that the discount rate is 7%).

Per airplane equipment and installation costs would be approximately $27,950 and $30,150 for typical in-service turbojet and turboprop airplanes, respectively. TAWS equipment and installation costs for newly manufactured airplanes—approximately $26,475 per turbojet airplane and $28,575 per turboprop airplane—are slightly lower reflecting lower installation costs.

Annual incremental operating and maintenance costs would be approximately $870 for turboprop airplanes and $936 for turbojet airplanes. Total lifecycle costs for the affected (residual) 14 CFR part 91 fleet, then, are approximately $642.9 million, or $415.3 million at present value. As in the analyses of 14 CFR parts 121 and 135, cost estimates include lifecycle costs for in-service airplanes and newly manufactured airplanes delivered between 1999 and 2008.

Estimates of the benefits accruing to part 91 operators are based on the Volpe accident analyses (discussed above). Of the 44 accidents, 11 involved turbojets and 33 involved turboprops. Probable cause, as determined by NTSB, was pilot error in all cases—principally through failure to maintain proper altitude, use of improper instrument flight rules or visual flight rules

procedures, or poor planning/decision-making. Volpe analyses determined that current technology ground proximity warning systems could have prevented 33 of the 44 accidents. On the other hand, TAWS could have prevented 42 of the 44 accidents; 11 turbojet airplane accidents and 31 turboprop airplane accidents. On the basis of the accident history, the FAA estimates that TAWS would prevent 2.46 turboprop airplane accidents per million flight hours and 0.86 turbojet airplane accidents per million flight hours. This translates to fleet benefits of approximately $1.5 billion, or $663 million at present value. Therefore, the ratio of discounted benefits to discounted costs is approximately 1.6 to 1.0.

The FAA invites comment on these estimates. Comments should include details such as: (1) Alternative cost assumptions, (2) alternative aircraft population forecasts, (3) the extent of voluntary industry action, *etc.*

Analysis of Alternatives

The FAA concludes that this NPRM is a significant regulatory action based on the proposal's expected cost, its potential impact on safety, and the extent of public interest in this issue. For matters determined to be significant, Executive Order 12866 requires ''an assessment, including the underlying analysis, of costs and benefits of potentially effective and reasonably feasible alternatives to the planned regulation.'' Accordingly, the FAA has considered regulatory options to identify the least intrusive and most cost-effective means of achieving the goal of reducing the probability of CFIT accidents.

The alternatives considered fall under two general groupings: (1) require different levels of TAWS or GPWS technologies for different subsegments of the regulated population, and (2) impose different compliance deadlines on different subsegments of the regulated population.

Different Levels of TAWS or GPWS for Different Subsegments of the Regulated Population

One group of alternatives consists of options that would require different levels of TAWS or GPWS technologies for different subsegments of the regulated population (including the option of *not* requiring GPWS or TAWS equipment at all). There are three broad classifications of TAWS/GPWS technologies: (1) Early-generation GPWS, (2) current-generation or upgraded GPWS (with improved capabilities and a lower probability for nuisance warnings), and (3) TAWS. It is possible to identify several regulatory alternatives, then, based on these technology levels.

One alternative would be to exclude certain types of airplanes or operators from a TAWS or GPWS requirement altogether. Based on its evaluation of benefits and costs, the FAA does not consider this to be the best option. Excluding operators of 6–9 seat airplanes, for example, would run contrary to a significant body of analyses—by the DOT, FAA and NTSB—that indicates that a TAWS requirement would result in substantial reductions in CFIT casualties and property losses.

Another alternative would be to require GPWS without regard to technology. Under this option, any vintage of GPWS—even the oldest systems—would be compliant. Approximately 95% of the world's commercial airline fleet are equipped with some form of ground proximity warning system. Also, anecdotal evidence suggests that there are some other, non-air carrier operators who have voluntarily installed GPWS. This alternative, therefore, would primarily affect general aviation operators and commercial operators of 6–9 seat turbine powered airplanes. There are two drawbacks to this option. First, a detailed analysis shows that the greatest potential for CFIT fatality reductions is produced by requiring TAWS in commercial airplanes *that are already equipped with GPWS*. For 14 CFR part 121, for example, TAWS is expected to reduce the accident rate by up to 0.079 per million flight hours. The FAA's analysis of part 135 carriers—most of whom already have current generation GPWS technology—also shows that significant benefits, which more than justify the costs, can be realized by requiring TAWS retrofit. Second, this option would effectively force on-demand air taxi and other general aviation operators to a higher standard than that required for the largest commercial carriers. This follows since early generation GPWS systems are no longer being produced for installation in the United States. This option would therefore require small operators to install upgraded GPWS or TAWS while many part 121 operators could legally continue to use technology developed over 20 years ago.

A third alternative would be to require current technology GPWS only. This alternative would also reduce the number of affected airplanes. The FAA estimates that approximately 3,200 airplanes operating under 14 CFR part 121, and 1,100 airplanes operating under 14 CFR part 135 already have upgraded GPWS equipment (or will have such equipment by the projected effective date of the proposed rule). Under this alternative, these airplanes would not require retrofit. In addition, incremental costs associated with the purchase of newly manufactured airplanes would be zero for part 121 operators and many part 135 operators. (Again, this follows since early generation GPWS units are no longer being produced for installation in the United States.) Limiting the requirement to upgraded GPWS would also marginally reduce compliance costs for some affected operators since upgraded GPWS would be less expensive than TAWS in some cases. A variant of this alternative would be to except smaller aircraft that may have been required to, or have voluntarily been equipped with current generation GPWS. The FAA concludes, however, that this exception may result in requiring more sophisticated equipment on certain noncommercial aircraft relative to some commercial aircraft.

There are safety and cost-effectiveness concerns with this alternative. It clearly provides a lower level of safety than the proposed rule; moreover, although this option is substantially cheaper than the proposed rule, ironically its costs do not justify its benefits for some types of operations. For example, in some cases the limited risk reduction potential would not justify replacing early-generation GPWS with upgraded current-generation systems. For airplanes that currently lack any GPWS, the FAA concludes that requiring only upgraded GPWS is a suboptimal strategy based on the relatively small difference in cost between upgraded GPWS versus TAWS combined with the relatively large differential in risk reduction potential between the two systems. Finally, significant safety benefits would be foregone for those airplanes already equipped with current-generation GPWS.

Clearly, there are dozens of combinations of the two previous alternatives involving different subsegments of the U.S. registered fleet. In general, they include: (1) Exempting, or imposing reduced requirements on, in-service aircraft, (2) exempting, or imposing reduced requirements on, domestic operations; (3) exempting, or imposing reduced requirements on, non-part 121 operations; (4) exempting, or imposing reduced requirements on, operations not involving the carrying of passengers for compensation or hire.

The FAA does not favor options requiring TAWS installation only for newly manufactured airplanes. While it is true that this alternative would

significantly reduce compliance costs (indeed, some manufacturers are, or will soon be, offering TAWS as standard equipment), 30 or more years would elapse before the entire non-TAWS fleet is retired and replaced with TAWS-equipped airplanes. The foregone benefits—reduced fatalities, injuries, and property loss—associated with such a strategy are serious disadvantages of this alternative.

The FAA also considered options that would combine TAWS installations for certain newly manufactured airplanes, with a GPWS requirement for in-service airplanes equipped with no, or early-generation, GPWS. While less costly than the proposed rule, such alternatives would actually be less cost-effective: significant safety benefits associated with replacing upgraded GPWS with TAWS would be foregone, and, as noted earlier, in many cases it does not make economic sense to replace early-generation GPWS systems with upgraded systems.

The accident history shows that substantial benefits can be achieved by requiring TAWS on international flights. An obvious alternative, then, would be to require TAWS retrofit only for airplanes conducting international operations, and impose lesser requirements for the remainder of the U.S. registered fleet (for example, require TAWS on newly manufactured airplanes only). Under this strategy, operators conducting only domestic flights would incur little or no costs. While the FAA acknowledges that a greater-than-proportional share of CFIT fatalities involving U.S. registered airplanes involve international operations, analyses (see the discussion of DOT Volpe National Transportation Systems Center analysis in the preamble, for example) show that substantial reductions in CFIT risks can be achieved by also requiring TAWS for domestic operations.

As part of its analysis, the FAA estimated the domestic CFIT rate for 14 CFR part 121 carriers. This study showed that the discounted TAWS benefits—considering the domestic CFIT accident rate alone—would exceed discounted costs—associated with retrofitting the entire turbine-powered part 121 fleet—by approximately 50%.

Finally, the FAA considered the option of requiring TAWS only on aircraft carrying passengers for compensation or hire. Accident analyses by the NTSB and DOT, however, show that a TAWS requirement would provide substantial safety benefits—that justify TAWS costs—for non-commercial, general aviation airplanes.

Different Compliance Deadlines for Different Subsegments of the Regulated Population

Economic and safety considerations complicate the selection of a meaningful compliance period. With too long a period, important safety benefits may be foregone; with too short a period, the cost burden on industry becomes excessive. For in-service airplanes, the compliance alternatives can be summarized as follows: (1) Select a compliance period shorter than 4 years, (2) select a compliance period longer than 4 years, (3) different combinations of compliance years and equipment requirements.

Shortening the compliance period for TAWS installation, while beneficial from the standpoint of reduced CFIT risk, would raise important economic and technical problems. First, in the absence of technical standards and a substantial body of TAWS installation/retrofit experience—particularly for general aviation airplane types—approximately 200 STC's (or STC follow-ons) or type design change programs would have to be undertaken by industry and processed and approved by the FAA. Substantially shortening the compliance period for TAWS retrofit could impinge on other modification or repair work (which may also have safety implications) and could necessitate a reallocation of FAA resources and disrupt other FAA projects.

Second, production information provided by the manufacturer of the only existing TAWS-compliant system indicates that building a sufficient number of units to accommodate a shorter deadline would be problematic. Theoretically, the FAA could grant extensions, but widespread use of this authority would result in inefficiencies—to modification centers, operators, and the FAA—and, in the end, result in no sooner achieving full fleet compliance than simply selecting a more appropriate compliance deadline in the first place.

Other costs associated with a shorter deadline include: (1) Increased probability of service disruption, (2) decreased likelihood of the availability of competing TAWS products, and (3) difficulties in drafting and approving FAA technical standards for TAWS technology.

The principle objection to lengthening the compliance period is that the flying public would forego significant safety benefits without a substantial decrease in costs. The FAA's analysis indicates that delaying the compliance deadline beyond the current proposal would not result in lower downtime or certification costs. Rather, cost savings would equal the modest return to capital (that would be spent on TAWS equipment) that would be realized during the short time that the operator could postpone retrofit. It is true that a longer compliance period would permit some airplanes to be retired without retrofit. However, these airplanes would have to be replaced with TAWS compliant aircraft (either through purchase or lease), therefore the net cost savings is negligible.

The FAA also considered a hybrid two-stage approach designed to: (1) Give operators of older airplanes a cheaper compliance option, and (2) require quicker fleet installation of at least a current generation GPWS unit. In this approach, all U.S. registered turbine-powered airplanes with 6 or more passenger seats would be required to have a minimum of upgraded GPWS within an initial compliance period (*e.g.* 1 year); and an FAA-approved terrain awareness and warning system by a second compliance period (*e.g.* 5 years). Theoretically, costs for many operators would be lower due to lower GPWS costs and the availability of GPWS STC's for most affected airplane models. There are two problems with this approach

First, this proposal increases the likelihood of service disruptions. The two-stage approach only makes sense if the initial and secondary compliance deadlines are sufficiently far apart. If the initial and secondary deadlines were only separated by one or two years, for example, it is unlikely that any operator would choose to install an upgraded GPWS system. Delaying the secondary (TAWS) deadline is unacceptable to FAA for the safety reasons cited above. Thus, the initial deadline—affecting all airplanes with no or early-generation GPWS equipment—would have to be relatively early. Depending on the specific date chosen, the initial deadline could require retrofit of over 12,000 airplanes (with current generation GPWS) within a one or two year period.

Second, FAA's analysis of the affected airplane population indicates that a large number of operators of airplanes that would need to be retrofitted by the initial deadline would choose to have TAWS equipment (primarily because they would expect these airplanes to be in-service after the secondary deadline). As noted above, it is unlikely that TAWS production will be able to accommodate this demand. Thus, operators who could not obtain TAWS would have to install upgraded GPWS and then retrofit TAWS approximately five years later. That is, the FAA would

compel some operators—most likely smaller operators with little market influence—to retrofit twice within five years.

Third, as noted above, it is difficult to justify retrofitting upgraded GPWS in place of an existing early-generation system. The cost difference between GPWS and TAWS is relatively small—especially in consideration of the trade-in value of the existing unit (in some installations upgraded GPWS may be more expensive than TAWS)—but the difference in risk reduction is substantial. A preliminary analysis (of a compliance alternative that would require upgraded GPWS within one year and TAWS within five years) showed that the projected reduction in the part 121 CFIT accident rate associated with replacing early GPWS with TAWS was three times the rate reduction associated with replacing early GPWS with upgraded GPWS.

The FAA invites comment on the alternatives discussed in this section and suggestions or other regulatory alternatives that have not been considered. Submitted alternatives should include an analysis of the issues discussed here, including: (1) Technical feasibility, (2) economic considerations (*e.g.* TAWS production constraints, probability of service disruption, supplier competition), and (3) public safety impacts.

Initial Regulatory Flexibility Determination and Analysis

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. Specifically, the RFA requires federal agencies to prepare an initial regulatory flexibility analysis for any proposed rule that would have a ''significant economic impact on a substantial number of small entities.'' The purpose of this analysis is to ensure that the agency has considered all reasonable regulatory alternatives that would minimize the rule's economic burdens for affected small entities, while achieving its safety objectives.

Entities potentially affected by the proposed rule include manufacturers of transport category airplanes, manufacturers of TAWS/GPWS systems, and air carriers. In addition, the rule would affect many other types of small entities which operate turbine-powered airplanes seating six or more passengers under 14 CFR part 91 (*e.g.* small business, governments, and other private or public organizations). There are thousands of operators of such airplanes and, therefore, potentially thousands of entities representing hundreds of industries, organizations, and institutions. The FAA acknowledges, therefore, that a substantial number of small entities could be significantly affected by the proposed rule.

As noted above, the proposed rule is the culmination of an analysis of a number of alternatives (in fact, the FAA has ruled out several alternatives that would have imposed more costly requirements on small entities). Three cost-reducing compliance options were considered for small entities specifically: (1) Exclude small entities, (2) extend compliance deadline for small entities, and (3) establish lesser technical requirements for small entities.

The FAA's analysis indicates that the option to exempt small entities from the requirements of the proposed rule is not justified. In fact, as noted in the preamble, the accident history of part 91 operators (many of whom are small entities) forms the basis of the NTSB's recommendation to require ground proximity warning systems on smaller turbojet and turboprop airplanes.

The FAA also considered options that would lengthen the compliance period for small operators. The requirement as proposed, however, would place a modest burden on small entities with respect to time constraints. Small entities—by definition operating small numbers of airplanes—would have four years from the effective date of the rule to complete retrofit work. As noted earlier, delaying the compliance deadline beyond the current proposal would not result in lower downtime or certification costs. Rather, cost savings would equal the modest return to capital (that would be spent on TAWS equipment) that would be realized during the short time that the operator could postpone retrofit. On the other hand, lengthening the compliance period would expose airplane occupants to significant safety risks for a longer period of time.

Finally, the FAA's analysis indicates that compliance options that would permit non-TAWS technologies are not cost-effective. For airplanes not equipped with any ground proximity warning system, TAWS units would provide up to 23% greater CFIT risk reduction over current-generation GPWS at very little additional cost. (In fact, in some installations, upgraded GPWS may be more expensive than TAWS.) In cases where aircraft already have GPWS, VNTSC and FAA analyses indicate that the safety benefits of TAWS outweigh the costs of retrofit.

The FAA invites comments on its analysis of small entity impacts and alternatives. Comments should include: (1) Compliance issues that are specific to small entities (*e.g.* cost and technical feasibility), (2) public safety impacts, and (3) other small entity compliance alternatives not considered here.

International Trade Impact Assessment

Recognizing that nominally domestic regulations often affect international trade, the Office of Management and Budget directs Federal Agencies to assess whether or not a rule or regulation will affect any trade-sensitive activity. The proposed rule could potentially affect international trade by burdening domestic businesses or air carriers with requirements that are not applicable to their foreign competitors. In general, the FAA concludes that the potential international trade impacts associated with the proposed rule would be negligible. Many domestic and foreign air carriers are already voluntarily installing TAWS equipment in recognition of the substantial safety benefits. A summary of potential impacts follows.

There is only one line of FAA-approved systems that meets the requirements of the proposed rule. The proposed requirement could give the manufacturer of this product line a competitive advantage relative to foreign and domestic competitors by creating a substantial and immediate demand for enhanced GPWS units. Monopolistic control of this large market, in turn, may permit the manufacturer to take advantage of scale economies and learning curve effects—advantages that would be unavailable to other potential manufacturers who have not yet developed TAWS equipment. This production cost advantage may permit the dominant manufacturer to set prices so as to exclude market entry, but maintain economic profits. (''Economic profits'' in the sense that they are above the standard return for that particular industry.)

The FAA's analysis indicates that the proposed rule would have a negligible effect on the competitive position of domestic airframe manufacturers. Under the proposed rule, domestic manufacturers, could continue to offer basic GPWS units on airplanes sold to foreign customers (if the airplane is not U.S. registered). Foreign airframe manufacturers, on the other hand, would be required to equip airplanes sold to U.S. customers (operating under 14 CFR parts 91, 121, or 135) with TAWS.

Domestic firms leasing aircraft to foreign operators may be adversely

affected by the part 91 provisions of the proposed rule. Domestic leasing companies, for liability reasons or to position themselves to lease to both 14 CFR part 121 and foreign carriers, often choose to maintain U.S. registered fleets. Thus, their lease prices would have to reflect TAWS retrofit costs while the prices of foreign competitors would not (in some cases, the lessee is directly responsible for modifications required by airworthiness directive or regulations—but in either case the disincentive effect is the same). Given the small cost of TAWS relative to average airplane values, the FAA concludes that the potential international trade impact would be small. Also, TAWS equipped airplanes would be safer and thus more attractive to potential lessees—and their passengers. Increased patronage attributable to the operation of safer airplanes would also partially offset the costs of compliance.

The potential impact to air carriers is, again, a function of the aircraft registration. Foreign air carriers operating U.S. registered airplanes would be required to install TAWS as would U.S. air carriers. To this extent, operators of U.S. registered airplanes would have costs not applicable to non-U.S. registered competitors.

Conversely, CFIT accidents are a leading cause of commercial aviation fatalities worldwide. It is likely that knowledgeable passengers would be more than willing to pay the small difference in price to travel on an airplane equipped with TAWS. Voluntary industry initiatives to install enhanced ground proximity warning systems are consistent with the view that TAWS benefits far exceed its costs, and could have beneficial effects for domestic airlines competing for international passenger traffic.

Unfunded Mandates Reform Act Analysis

Title II of the Unfunded Mandates Reform Act of 1995 (the Act), enacted as Pub. L. 104–4 on March 22, 1995, requires each Federal agency, to the extent permitted by law, to prepare a written assessment of the effects of any Federal mandate in a proposed or final agency rule that may result in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year. Section 204(a) of the Act, 2 U.S.C. 1534(a), requires the Federal agency to develop an effective process to permit timely input by elected officers (or their designees) of State, local, and tribal governments on a proposed ''significant intergovernmental mandate.'' A ''significant intergovernmental mandate'' under the Act is any provision in a Federal agency regulation that will impose an enforceable duty upon State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million (adjusted annually for inflation) in any one year. Section 203 of the Act, 2 U.S.C. 1533, which supplements section 204(a), provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, the agency shall have developed a plan that, among other things, provides for notice to potentially affected small governments, if any, and for a meaningful and timely opportunity to provide input in the development of regulatory proposals.

The FAA has determined that the proposed rule would likely have an economic impact *on the private sector* exceeding $100 million in certain years; and that the economic impact to State, local, and tribal governments would be far less than this threshold. Since the proposed rule does not impose an enforceable duty upon State, local, and tribal governments in the aggregate, of $100 million (adjusted annually for inflation) in any one year, the FAA concludes that it does not constitute a significant intergovernmental mandate as defined in the Act.

Federalism Implications

The regulations proposed herein would 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 rule does not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Paperwork Reduction Act

As required by the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)), the FAA has submitted a copy of these proposed sections to the Office of Management and Budget for its review. The agency is not collecting information. This NPRM proposes to mandate a Terrain Awareness and Warning System for all turbine powered airplanes of 6 or more passenger seating. TAWS is a passive, electronic, safety device located in the avionics bay of the airplane. TAWS alerts pilots when there is terrain in the airplanes' flight path. Since there is not an actual collection of information, we cannot estimate a burden hour total. However, for the purpose of controlling this submission, we will assign a one hour burden to the package. There is a total cost estimate of 140 million dollars per year, for installation of the passive, electronic, safety device.

Organizations and individuals desiring to submit comments on the information, billing, and collection requirements should direct them to the Office of Information and Regulatory Affairs, OMB, Room 10202, New Executive Office Building, Washington, DC 20503; Attention: Desk Officer for Federal Aviation Administration. These comments should reflect whether the proposed collection is necessary; whether the agency's estimate of the burden is accurate; how the quality, utility and clarity of the information to be collected can be enhanced; and how the burden of the collection can be minimized. A copy of the comments also should be submitted to the FAA Rules Docket.

OMB is required to make a decision concerning the collection of information contained in this NPRM between 30 and 60 days after publication in the **Federal Register**. Therefore, a comment to OMB is best assured of having its full effect if OMB receives it within 30 days of publication. This does not affect the deadline for the public to comment on the NPRM.

International Compatibility

The FAA has reviewed corresponding International Civil Aviation Organization international standards and recommended practices and Joint Aviation Authorities requirements. TAWS is a new system recently developed by American industry. The FAA intends to work through the ICAO process to harmonize this rule with the international community.

List of Subjects

14 CFR Part 91

Aircraft, Aviation safety.

14 CFR Part 121

Aircraft, Aviation safety, Safety.

14 CFR Part 135

Aircraft, Aviation safety.

The Proposed Amendment

For the reasons discussed above, the Federal Aviation Administration proposes to amend 14 CFR parts 91, 121, and 135 as follows:

PART 91—GENERAL OPERATING AND FLIGHT RULES

1. The authority citation for part 91 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40103, 40113, 40120, 44101, 44111, 44701, 44709, 44711, 44712, 44715, 44716, 44717, 44722, 46306, 46315, 46316, 46502, 46504, 46506–46507, 47122, 47508, 47528–47531.

2. Section 91.223 is added to read as follows:

§ 91.223 Terrain awareness and warning system.

(a) *Airplanes manufactured after [one year after the effective date of the final rule].* No person may operate a turbine-powered U.S.-registered airplane type certificated to have six or more passenger seats, excluding any pilot seat, unless that airplane is equipped with an approved terrain awareness and warning system, including a terrain situational awareness display, that meets the requirements of TSO–C151.

(b) *Airplanes manufactured on or before [one year after the effective date of the final rule].* No person may operate a turbine-powered U.S.-registered airplane type certificated to have six or more passenger seats, excluding any pilot seat, after [4 years after the effective date of the final rule] unless that airplane is equipped with an approved terrain awareness and warning system, including a terrain situational awareness display, that meets the requirements of TSO–C151.

(c) *Airplane Flight Manual.* The Airplane Flight Manual shall contain appropriate procedures for—

(1) The use of the terrain awareness and warning system; and

(2) Proper flight crew reaction with respect to the terrain awareness and warning system audio and visual warnings.

PART 121—OPERATING REQUIREMENTS; DOMESTIC, FLAG, AND SUPPLEMENTAL OPERATIONS

3. The authority citation for part 121 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 40119, 44101, 44701–44702, 44705, 44709–44711, 44713, 44716–44717, 44722, 44901, 44903–44904, 44912, 46105.

4. Section 121.354 is added to read as follows:

§ 121.354 Terrain awareness and warning system.

(a) *Airplanes manufactured after [one year after the effective date of the final rule].* No person may operate a turbine-powered airplane unless that airplane is equipped with an approved terrain awareness and warning system, including a terrain situational awareness display, that meets the requirements of TSO–C151.

(b) *Airplanes manufactured on or before [one year after the effective date of the final rule].* No person may operate a turbine-powered airplane after [four years after the effective date of the final rule], unless that airplane is equipped with an approved terrain awareness and warning system, including a terrain situational awareness display, that meets the requirements of TSO–C151.

(c) *Airplane Flight Manual.* The Airplane Flight Manual shall contain appropriate procedures for—

(1) The use of the terrain awareness and warning system; and

(2) Proper flight crew reaction with respect to the terrain awareness and warning system audio and visual warnings.

5. Section 121.360 is amended by adding paragraph (g) to read as follows:

§ 121.360 Ground proximity warning—glide slope deviation alerting system.

* * * * *

(g) This section expires on [four years after the effective date of the final rule].

PART 135—OPERATING REQUIREMENTS: COMMUTER AND ON-DEMAND OPERATIONS

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

Authority: 49 U.S.C. 106(g), 40113, 44701–44702, 44705, 44709, 44711–44713, 44715–44717, 44722.

7. Section 135.153 is amended by adding paragraph (f) to read as follows:

§ 135.153 Ground proximity warning system.

* * * * *

(f) This section expires on [four years after the effective date of the final rule].

8. Section 135.154 is added to read as follows:

§ 135.154 Terrain awareness and warning system.

(a) *Airplanes manufactured after [one year after the effective date of the final rule].* No person may operate a turbine-powered airplane type certificated to have six or more passenger seats, excluding any pilot seat, unless that airplane is equipped with an approved terrain awareness and warning system, including a terrain situational awareness display, that meets the requirements of TSO–C151.

(b) *Airplanes manufactured on or before [one year after the effective date of the final rule].* No person may operate a turbine-powered airplane type certificated to have six or more passenger seats, excluding any pilot seat, after [insert date 4 years after the effective date of the final rule], unless that airplane is equipped with an approved terrain awareness and warning system, including a terrain awareness and warning system, that meets the requirements of TSO–C151.

(c) *Airplane Flight Manual.* The Airplane Flight Manual shall contain appropriate procedures for—

(1) The use of the terrain awareness and warning system; and

(2) Proper flight crew reaction with respect to the terrain awareness and warning system audio and visual warnings.

Issued in Washington, DC, on August 19, 1998.

Thomas E. McSweeny,

Director, Aircraft Certification Service.

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