

Exemption No. 8072

**UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
RENTON, WASHINGTON 98055-4056**

In the matter of the petition of

**Embraer Empresa Brasileira de Aeronáutica
S.A. (Embraer)**

for an exemption from § 25.901(c) of Title 14,
Code of Federal Regulations

Regulatory Docket No. FAA-2002-14148

PARTIAL GRANT OF EXEMPTION

By letter dated December 11, 2002, Mr. Paulo C. Olenski, Senior Certification Manager, Embraer Empresa Brasileira de Aeronáutica S.A. (Embraer), Av. Brigadeiro Faria Lima, 2170, 12227-901 – S. José dos Campos – SP, Brazil, petitioned for an exemption from the “no single failure” criterion of § 25.901(c) of Title 14, Code of Federal Regulations (14 CFR), as it relates to “uncontrollable high thrust failure conditions.” Recent studies and service experience indicate that some existing transport category airplanes do not strictly comply with § 25.901(c) for certain uncontrollable high thrust failure conditions. The proposed exemption, if granted, would permit type certification of similarly non-compliant Embraer Model ERJ 170 series airplanes to allow installation of General Electric (GE) CF34-8E series engines.

The petitioner requires relief from the following regulation:

Section 25.901(c) requires in part that “no single failure will jeopardize the safe operation of the airplane.”

The petitioner’s supportive information follows:

As required by 14 CFR §11.25, Embraer offers the following justification in support of its petition for exemption, as well as substantiation as to how the proposed type design provides an acceptable level of safety and why granting the exemption will be in the public interest.

“1. Embraer understands the uncommanded high thrust issue and agrees that this failure mode of concern could adversely affect the airplane and should be addressed. Embraer is a member of the AIA/ AECMA SPTCM (Strategies for Protection from Thrust Control System Malfunctions)

committee, which has been tasked with developing an effective means for mitigation of uncommanded high thrust failures.

“2. All practicable actions (including maintenance practices and production processes) will be taken to address the adverse effect on safety associated with granting of the exemption from §25.901(c) for the ERJ 170/ GE CF34-8E:

“...Embraer has been assessing a design solution to the ERJ 170/ GE CF34-8E engine control system to shut down the engine on ground scenarios that could result in catastrophes. Embraer’s goal is to avoid engine shutdown in flight phases (take-off, final approach and landing) in order not to degrade the overall inflight shutdown (IFSD) rates. At this stage, too many changes to the engine control system as a result of the requirement to meet this regulation might reduce its reliability by introducing added system complexity, at least until a practicable and final design solution is identified, validated, and safely integrated into the turbine engine control system type design.

Evaluations performed using the Embraer Engineering Development Simulator (EDS) have shown that the exposure envelope for a catastrophic event from uncontrolled high thrust is limited to the final approach go-around and landing phases of flight at low altitudes. Embraer will substantiate the criticality of these failure conditions, including the critical altitude below which there is non-compliance with § 25.901(c), in Full Flight Simulator (FFS) tests with the Brazilian civil aviation authority, Centro Technico Aeroespacial (CTA).

1. “The risks associated with granting of the exemption from 14 CFR §25.901(c) for the ERJ 170/ CF34-8E propulsion system are very low, and Embraer will demonstrate that:
 - a. The risk associated with this failure scenario will be on the order of one per ten million airplane operating hours, which is less than the demonstrated average per flight hour risk for comparable existing transport category airplanes.
 - b. The ERJ 170/ CF34-8E installation will be shown to be compliant with 14 CFR §25.901(c) for any foreseeable uncontrollable high thrust failure condition, except possibly during final approach/ landing phase below 400 feet.

2. “Additionally, the CF34-8 engine control currently installed in two different airplanes (Embraer ERJ 170/ GE CF34-8E and Bombardier CRJ700/ CF34-8C) has an architecture, production processes, and maintenance practices which have resulted in a good service record. There has not been an uncontrollable high thrust malfunction in 100,000 flight hours of service.

“In summary, Embraer believes that a exemption to 14 CFR §25.901(c) is the option which best serves the public interest and which provides a level of safety which is not less than that of existing transport category airplanes. This exemption will allow the airworthiness authorities and the aerospace industry time to develop design solutions that address uncontrollable high thrust failures but do not expose the transport airplane fleet to a threat of inflight engine shutdowns.

As noted above, the petitioner agrees to demonstrate that:

“All practicable actions (including maintenance practices and production processes) will be taken to address the adverse effect on safety associated with granting of the exemption from § 25.901(c) for the ERJ 170/ CF34-8E.”

“The risks associated with granting of the exemption from 14CFR 25.901(c) for the ERJ 170/ CF34-8E propulsion system are very low....”

Specifically, Embraer will demonstrate the following:

“The ERJ 170/ CF34-8E installation will be shown to be compliant with 14 CFR 25.901(c) for any foreseeable uncontrollable high thrust failure condition, except possibly during take-off and approach below 400 feet; and “

“The risk associated with this [uncontrollable high thrust] failure condition will be on the order of one per ten million airplane operating hours....”

The Federal Aviation Administration's (FAA) analysis is as follows:

Background

Uncontrollable High Thrust Failure Conditions

Numerous single and anticipated combinations of failures within traditional turbojet engine control systems result in losing the normal means to control thrust (i.e., control via the throttle lever, autothrottle, etc.). A subset of the resulting failure conditions may include actual thrust either increasing to higher than commanded levels and/or remaining high when low thrust is commanded. These “uncontrollable high thrust failure conditions,” and the hazards they pose, have long been inherent in transport airplane designs. In fact, the “fail-safe” states for engine controls have traditionally been chosen to protect high thrust capability and allow the flightcrew to decide when an engine shutdown is appropriate.

An initial estimate indicates that over the last 20 years the average rate of occurrence for the uncontrollable high thrust failure condition on turbofan-powered large transport category airplanes has remained relatively constant at around one every 2.5 million flight hours. This would indicate that to date an “uncontrollable high thrust failure condition” has occurred hundreds of times without resulting in a single reported serious injury.

When these failure conditions were identified during past certifications, compliance was typically based on accepting an assertion that the flightcrew will recognize and safely accommodate the loss of the normal means to control engine thrust, including shutting down the affected engine via an independent fuel shutoff as required. However, recent

engineering studies and service experience, including a 1997 Saudi Arabian Airlines Boeing 737-200 accident, indicate that this traditionally accepted assertion is not always valid. For those airplanes re-evaluated to date, the available failure recognition and accommodation time under certain anticipated operating conditions is so short and the required corrective actions sufficiently unnatural that the flightcrew cannot be relied upon to reliably and completely perform those actions before the safe operation of the airplane is jeopardized.

While the focus of this petition was on the impacts of this determination on compliance with the general objective requirement of § 25.901(c) relating to single failures, the FAA recognizes that this determination may have a similar impact on compliance with one or more specific regulations, such as §§ 21.21, 25.107, 25.109, 25.125, 25.143, 25.145, 25.147, 25.149, 25.161, 25.251, 25.571, 25.901, 25.903, and 25.1309. The FAA has concluded that, by addressing all the potential impacts of this determination on compliance with the general requirements of § 25.901(c), we will inherently cover the scope of potential impacts on all other applicable regulations. Consequently, while this documentation and the resultant granting specifically discuss only § 25.901(c), they will implicitly cover all applicable regulations impacted by this determination.

The FAA is responding to the full scope of this determination by developing a “Thrust Control Malfunction Airworthiness Program” to consistently and objectively assess and manage the existing and future transport airplane fleet risks associated with this endemic potential for non-compliance and unsafe conditions. The ultimate goal of this program will be to bring the transport airplane fleet back into compliance as quickly as practicable. The interim goal of this program will be to manage the risk associated with each instance of non-compliance so that it does not represent an unsafe condition.

For type certification the FAA has begun requesting more effective validation of any assertion that the flightcrew will recognize and safely accommodate the loss of the normal means to control engine thrust. Such a request is what led Embraer to submit the subject petition. Until practicable design solutions can be identified, validated, and safely integrated into turbine engine control system type designs, it is clearly in the public interest to continue to certificate type design improvements, even if they don’t strictly comply with the reference standard.

Embraer Model ERJ 170 Series Airplanes and GE CF34-8E Series Engines

The engine thrust control system for the GE CF34-8E series engines proposed to be installed on the Model ERJ 170 series airplane includes thrust control malfunction protection logic to mitigate uncontrollable high thrust conditions only on the ground. However, the petitioner has indicated that there are single failures in flight that can cause a CF34-8E engine to produce high thrust up to the level where the first independent limiter (governor) is encountered, while not responding to the throttle lever. Further, the petitioner has indicated that this circumstance may jeopardize the safe operation of the Model ERJ 170 airplane, if it occurs during certain conditions in the final approach and landing.

The petitioner intends to demonstrate that any combination of failures that could jeopardize safe operation complies with § 25.901(c) in that they are not “probable combinations.”¹ Conversely, the petitioner does not intend to demonstrate that those single failures that could jeopardize safe operation comply with § 25.901(c). Compliance with § 25.901(c) requires that each identified single failure be assumed to occur under all anticipated combinations of airplane operating and environmental conditions. While the single failures themselves must be assumed to occur regardless of their probability,² probability can be considered when determining what combinations of operating and environmental conditions are anticipated to occur in the fleet life of the airplane type. Single failures do not need to be assumed to occur under conditions that are in and of themselves not expected to occur. Nonetheless, the proposed design is known to have single failures that will cause uncontrollable high thrust.

Uncontrollable high thrust under certain anticipated takeoff and landing conditions is expected to jeopardize the safe operation of the proposed airplane. Consequently, in order to certificate the installation of the GE CF34-8E series engines on the Model ERJ 170 series airplanes, the petitioner must either obtain this exemption or substantially modify the engine control system design to mitigate the noted failure conditions in flight. As delineated in the petitioner’s supporting information, the petitioner has concluded that the exemption is the option which best serves the public interest.

FAA Analysis - Introduction

To obtain this exemption, the petitioner must show, as required by § 11.81(d), that granting the request is in the public interest, and, as required by § 11.81(e), that the exemption will not adversely affect safety, or that a level of safety will be provided that is equal to that provided by the rules from which the exemption is sought.

FAA Analysis - Public Interest

The petitioner has committed to demonstrate that all practicable actions have been taken to minimize the adverse effect on safety associated with granting of the exemption from § 25.901(c) for the Model ERJ 170 series airplanes with GE CF34-8E series engines. Embraer has indicated that it intends to implement the thrust control malfunction protection logic on the ERJ 170 models equipped with CF34-8E engines to ensure that

¹ The term “probable,” as used in § 25.901(c), has a very different meaning from the same term as subsequently used in association with § 25.1309(b) compliance. As used in § 25.901(c), “probable” means “foreseeable.” In § 25.1309(b) terms, this means the subject failure conditions are “anticipated to occur” (i.e., they are not “extremely improbable”).

² While probability has been an acceptable means of supporting a finding that a particular “combination” of failures are not “probable,” any single failure where the physics of the failure can be identified is typically “anticipated to occur,” unless that occurrence within the relevant exposure can be clearly and acceptably ruled out, as is the case for those structural failures specifically exempted by the rule itself.

compliance with the “single failure” criterion of 14 CFR 25.901(c) is met for all uncontrollable high thrust failure conditions which occur on the ground. If the FAA is to certify the ERJ 170/ CF34-8E airplanes, making this commitment a condition of the exemption assures that granting the exemption will be in the public interest. That is, any risks associated with non-compliance must be eliminated or further reduced, wherever the FAA finds that to do so is technologically feasible and cost beneficial for the public. This has traditionally been accepted as the level of safety that is “in the public interest.” Furthermore, if bringing the airplane into compliance were found to be a “practicable action,” then this exemption would in effect be self-eliminating.

In consideration of the above, the FAA concludes that granting this petition is in the public interest.

FAA Analysis - Effect on Safety

The petitioner has committed to demonstrate that the exposures and failure rates of ERJ 170/ CF34-8E airplanes are such that the airplane should not exceed the known average per flight hour risks of comparable existing transport category airplanes. Making this commitment a condition of this exemption, in combination with the condition to minimize that risk, means that granting this exemption should not adversely affect and, in fact, should improve the average per flight hour risk within the current transport airplane fleet.

For those existing transport airplanes re-evaluated to date, the conditions under which an uncontrollable high thrust failure may jeopardize the safe operation of the airplane are limited to specific aborted takeoff or approach and landing scenarios. Given that these scenarios occur, there is still a low probability that a serious injury will result. This limited exposure, in conjunction with the historically low occurrence rates, makes this a relatively low per flight hour risk. This assessment is supported by the fact that the 1997 Saudi Arabian Airlines Boeing 737-200 accident is the only one attributed to these types of failures, and there were no serious injuries in that accident.

It is the specter of this low per flight hour risk accumulating indefinitely on many, if not most, existing and future transport airplanes that is the primary concern driving development of the FAA’s “Thrust Control Malfunction Airworthiness Program.” To date, corrective actions under 14 CFR part 39 have been considered warranted only when the uncorrected risks for a particular type design were considered significantly greater than the known average risks within the transport fleet. Since the conditions and limitations of this exemption require that the Embraer Model ERJ 170 series airplane with a CF34-8E engine be expected to have an uncontrollable high thrust failure rate over three times better than the current fleet average, the impact of adding the fleet hours of the Model ERJ 170 series airplane with CF34-8E series engines to the overall transport fleet exposure should be insignificant. Furthermore, if as part of the “Thrust Control Malfunction Airworthiness Program,” the FAA determines that additional generally applicable precautions must be taken, including perhaps some future introduction of a

compliant design, these will further minimize any cumulative risk impact of granting this exemption.

This exemption inherently implies a somewhat greater hazard than full compliance with § 25.901(c). This is why the FAA intends to bring the transport fleet back into full compliance as soon as practicable. Nevertheless, the fact that the per flight hour risks associated with this non-compliance are low allows us to develop a well considered recovery program to assure that we don't introduce a worse problem than we are trying to solve and that this recovery program is clearly in the public interest.

In consideration of the above, the FAA concludes that granting this petition will not adversely affect safety.

Conclusion

In consideration of the foregoing, I find that a partial grant of exemption is in the public interest and will not adversely affect safety. Therefore, pursuant to the authority contained in 49 U.S.C. 40113 and 44701, delegated to me by the Administrator, Embraer Empresa Brasileira de Aeronáutica S.A. (Embraer) is granted an exemption from § 25.901(c) to the extent necessary to allow type certification of the Model ERJ 170 series airplanes with CF34-8E series engines and without an exact showing of compliance with the requirements of § 25.901(c) as they relate to single failures resulting in uncontrollable high thrust conditions. For the Model ERJ 170 series airplanes, this exemption is subject to the following conditions and limitations:

1. Embraer must demonstrate, in accordance with an FAA-approved “Airworthiness Assessment and Risk Management Plan,” that all practicable actions have been taken to minimize the adverse effects on safety associated with granting this petition. These must include, but are not limited to, practical actions to eliminate or further reduce the risks by improving designs, procedures, training, and instructions for continued airworthiness. Based on the proposed incorporation of the thrust control malfunction logic to ensure compliance with § 25.901(c) for all failure conditions on the ground, Embraer must therefore demonstrate that extending the existing thrust control malfunction protection to eliminate the inflight failure conditions during the final approach/ landing phase would either require a substantial modification or result in an overall net increase in “risk” due to the increased risk of multiple inflight shutdowns (IFSD).
2. Embraer must demonstrate, in accordance with an FAA-approved “Airworthiness Assessment and Risk Management Plan,” that the risks associated with exempting the “uncontrollable high thrust failure condition” from the single failure provisions of § 25.901(c) are no greater for the proposed Model ERJ 170 series airplanes with GE CF34-8E series engines than those generally known to exist for comparable airplanes within the current transport fleet. Acceptable risk for this provision can be characterized as:

- a. The airplane complies with § 25.901(c) for any foreseeable uncontrollable high thrust failure conditions in flight, except possibly during final approach/landing below 400 feet; and
 - b. The expected frequency of occurrence of the uncontrollable high thrust failure condition is less than once per ten million airplane operating hours.
3. The following “Note” will be added to the airplane Type Certification Data Sheet for any airplane certificated under this exemption:

The FAA has concluded that the occurrence of any uncontrollable high thrust failure condition or any of the associated causal failures listed within Embraer Document (reference tbd) are reportable under §§ 121.703 (c), 125.409 (c), and 135.415(c).

In support of this “Note,” Embraer must develop and obtain FAA approval of the Embraer document referenced in the “Note,” prior to customer delivery. This document lists those failures that can contribute to or cause an uncontrollable high thrust failure condition covered by this exemption. This document shall then be made available as part of the instructions for continued airworthiness. Further, the failures listed within this document shall be added to the list of reportables under § 21.3 for any airplane certificated under this exemption.

4. The granting of this partial exemption does not relieve any regulatory obligation to identify and correct unsafe conditions related to uncontrollable high thrust failure conditions.

Note: Additional background and guidance regarding these provisions are provided in FAA Letter 02-112-02, dated October 19, 2001.

Issued in Renton Washington on June 11, 2003.

s/s Kalene C. Yanamura
Acting Manager
Transport Airplane Directorate,
Aircraft Certification Service