U.S. Department of Transportation
**Federal Aviation Administration**

# Advisory Circular

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| **Subject:** | **ESTABLISHING THE CERTIFICATION BASIS OF CHANGED AERONAUTICAL PRODUCTS** | **Date:** | |
| | | **Initiated by:** AIR-110 | **AC No:** 21.101-1 |
| | | | **Change:** 1 |

## 1. PURPOSE.

a. This Advisory Circular (AC) provides guidance for establishing the certification basis for changed aeronautical products and identifying the conditions under which it will be necessary to apply for a new type certificate. Title 14, Code of Federal Regulations (CFR) § 21.19 identifies the conditions under which an applicant for a design change is required to make application for a new type certificate. Title 14, CFR § 21.101 requires an applicant for a change to a type certificate to meet the latest regulations except where the change is not significant, where areas of the product are not affected, where it would be impractical, or where it would not contribute materially to the level of safety of the changed product. This AC explains the criteria of §§ 21.19 and 21.101, and their application.

b. . Title14, CFR § 21.101 requires an applicant for a change to a type certificate to comply with the airworthiness requirements on the date of application for the changed product. The intent of § 21.101(a) is to enhance safety through the incorporation of the latest requirements in the certification basis of changed products. This rule applies the latest airworthiness requirements for the certification of significant design changes to aircraft, aircraft engines and propellers. Significant changes are generally distinct from the majority of major changes and are defined within this AC as product level changes. In the assessment of whether a product level change is significant, all previous relevant design changes need to be taken into consideration along with any previous updates to the certification basis. An applicant can comply with earlier amendments of the regulations based upon a finding by the Administrator that compliance with the latest regulations is impractical or does not materially contribute to the level of safety.

c. This AC and the methods illustrated in the appendices are guidance material and is one way but not the only way of showing compliance with the rule. Each change must be judged on its own merit when making the final determination of the certification basis.

d. This AC is not mandatory and is not a regulation. It outlines one method of compliance with 14 CFR. The applicant may elect to follow an alternate method, provided the alternate method is acceptable to the Administrator for compliance. Because the method of compliance presented in this AC is not mandatory, the term “must” used herein applies only to an applicant

who chooses to follow this particular method without deviation.

## 2. CONTENTS LIST.

(Table of contents to be inserted here)

## 3. APPLICABILITY.

a. This document supercedes Advisory Circular 21.101-1 dated August 8, 2001. This Advisory Circular (AC) is applicable to all major changes to type design of aircraft, aircraft engines and propellers. For the purposes of this AC an application for a change to a Type Certificate (type design) described in §21.101(a) is considered as an application for a major change. Minor changes as defined in §21.91 are considered to have no appreciable effect on airworthiness and are therefore by definition not significant. This AC applies equally to applications made for type certificate amendments, supplemental type certificates, or amended supplemental type certificates.

b. The AC is applicable to all major changes to aircraft (other than rotorcraft) of 6,000 lbs. (2722 kg) or less maximum weight, or to a non-turbine rotorcraft of 3,000 lbs. (1361 kg) or less maximum weight; unless the Administrator finds the change significant in an area, an applicant may show that the changed product complies with the regulations incorporated in the type certificate.

c. This AC is also applicable for aircraft certificated under §§21.17(b), 21.24. 21.25, and 21.27.

## 4. RELATED REGULATORY PARAGRAPHS.

- Section 21.16, Special Conditions
- Section 21.17, Designation of applicable requirements.
- Section 21.19, Changes requiring a new type certificate.
- Section 21.91, Classification of changes in type design.
- Section 21.101, Designation of applicable requirements.

**5. EXPLANATION OF TERMINOLOGY.** The following is a summary of the terminology used throughout this advisory material. Further explanations of some of these terms can be found in paragraphs 5, 6, 7, and 8.

- Certification Basis – The applicable airworthiness requirements of the Joint Aviation Requirements as established in §§ 21.17 and 21.101, as appropriate; special conditions; equivalent level of safety findings; and exemptions applicable to the product to be certified.

  **Note:** This AC is not intended for determining the applicable aircraft noise, fuel venting and exhaust requirements for changed products.

- Earlier Requirements - the requirements in effect prior to the date of application for the change, but not prior to the existing certification basis.

- Existing Certification Basis - the requirements incorporated by reference in the type certificate *of* the product to be changed.

- Latest Requirements - the requirements in effect on the date of application for the change

- Previous Relevant Design Changes – previous design changes, the cumulative effect of which could result in a product significantly or substantially different from the original product or model, when considered from the last time the latest regulations were applied.

- Product level change – a collection of changes or an individual change to the overall product configuration, method of construction, certification assumptions, operation or performance that make the product distinct from other models of the product. Product level change is defined at the aircraft, aircraft engine or propeller level of change as opposed to the component level of change.

- Substantial Change - a product level design change the extent of which is enough to require a substantially complete investigation of compliance with the applicable requirements, and consequently a new type certificate, in accordance with § 21.19.

- Significant Change - a product level change to the type certificate to the extent that it changes one or more of the following: a change in the general configuration; principles of construction; or, assumptions used for the certification criteria which are enough to require consideration of the inclusion of the latest requirements in the certification basis, but not to the extent to be considered a substantial change.

## 6. GENERAL OVERVIEW OF 14 CFR § 21.101.

a. Title 14 CFR § 21.19 specifies changes that require a new type certificate. If a new type certificate is required, §21.17 specifies the applicable certification basis for the changed product.

b. When an application for a new type certificate is not required by § 21.19, § 21.101 defines the designation of applicable requirements for determining of the certification basis for the changed product. Section 21.101, as amended by NPA 21-7, requires changed products to comply with the requirements in effect on the date of application for the change unless the Administrator accepts the applicant's justification for using earlier requirements.

c. Section 21.101(a) requires any changed type certificated product comply with the latest requirements. Section 21.101(a) allows for the exceptions identified in §§ 21.101(b) and (c). Section 21.101(b) allows the applicant to comply with earlier amendments. However, earlier amendments may not precede either the corresponding regulation incorporated in the type certificate, or any regulation in §§ 23.2, 25.2, 27.2, or 29.2. Special Conditions is allowed in accordance with § 21.101(d). This rule is also applicable to aircraft certificated under §§21.17(b), 21.24, 21.25, and 21.27 airworthiness requirements.

d. The certification basis should not be dependent on whether the type certificate holder or an applicant for a supplemental type certificate is originating the change. Where compliance with a later amendment for a significant change does not contribute materially to the level of safety, would be impractical, or is in an area not affected by the change the applicant may comply with an earlier regulations, however the applicant may not use regulations prior to those specified by the existing type certificate.

e. Section 21.101(b) pertains to changes for which earlier regulations provide adequate standards. Earlier regulations may be used when the change is not significant. In those cases where design changes that involve features that were not envisaged at the time regulations incorporated in the existing type certificate were adopted, the Administrator will review the proposed certification plan to ensure adequacy of the requirements against the proposed design change.

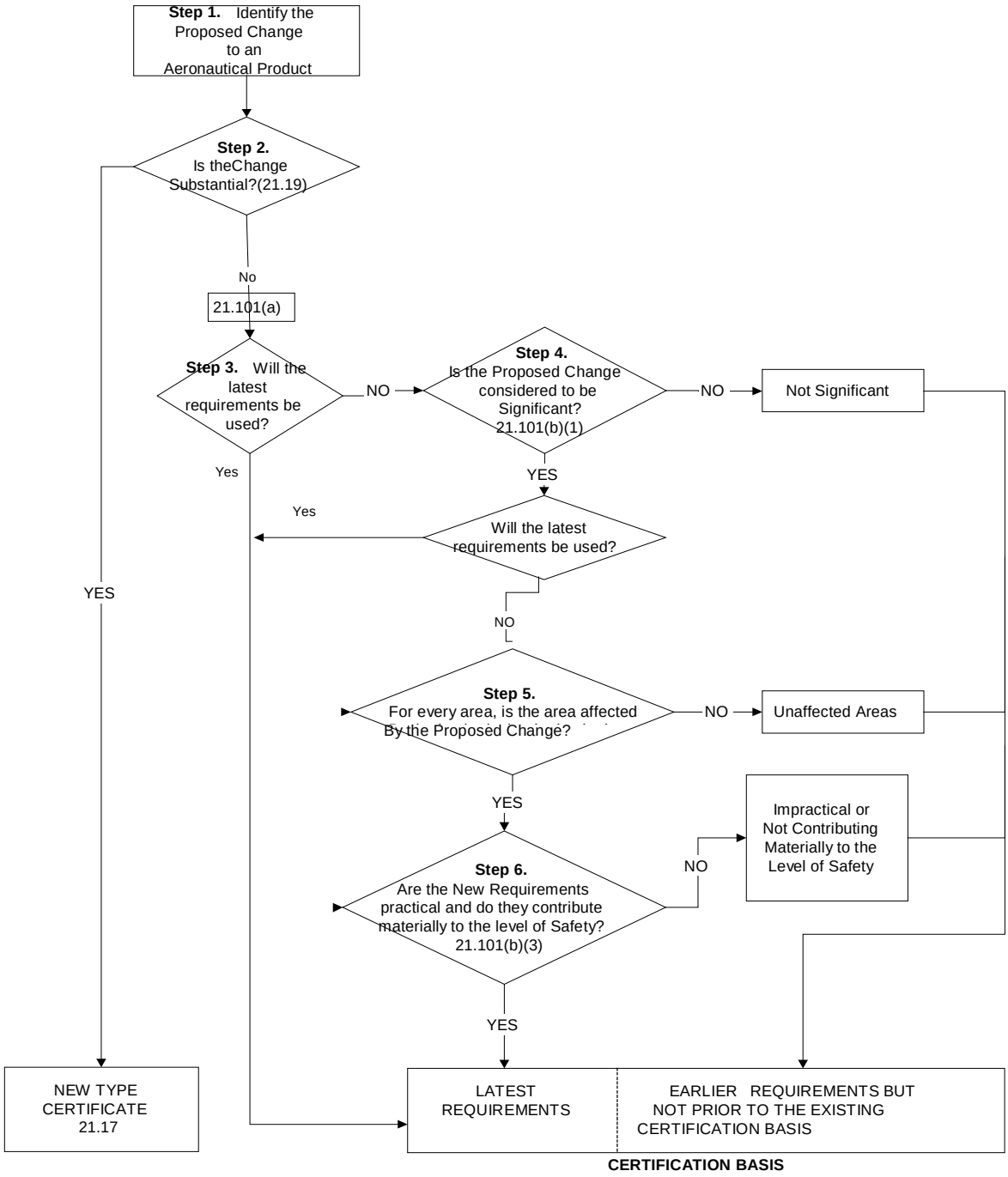
f. Section 21.101(c) provides an exception to the requirements of § 21.101(a) to meet the latest requirements for aircraft (other than rotorcraft) of 6,000 lbs. (2722 kg) or less maximum weight, or to a non-turbine rotorcraft of 3,000 lbs. (1361 kg) or less maximum weight. However, if the Administrator determines that the design change is significant, the Administrator may designate a later amendment to the regulations incorporated by reference in the type certificate. By using the process outlined in Section 6, the applicant can either comply with those later amendments, or provide substantiation that compliance with the later amendment would not contribute materially to the level of safety or would be impractical.

g. Section 21.101(d) provides for the use of special conditions when the latest regulations do not provide adequate standards with respect to the proposed change because of a novel or unusual design feature.

h. Figure 1 provides a flowchart of the process to determine the applicable certification basis for a proposed design change under § 21.101, following a determination that the proposed design change is not substantial under § 21.19.

i. As illustrated in the flowchart, a significant design change may be allowed to demonstrate compliance with earlier requirements if it can be demonstrated that an area is not affected by the change, or that compliance with the latest requirements is considered impractical or will not contribute materially to the level of safety. In this case, the applicant will propose to the Administrator a certification basis which includes earlier requirements. The applicant must provide sufficient substantiation to allow the Administrator to determine the appropriate certification basis.

**Figure 1: Establishing the certification basis for changed products**




Note 1: For excepted products under § 21.101(c) see Section 8. For conditions under 21.101(d)see Section 9.
Note 2 : In the vast majority of cases the applicant will proceed to Step 4 as the initial step in the process. See Section 6 for guidance.

## 7. ESTABLISHING THE CERTIFICATION BASIS FOR CHANGED PRODUCTS, § 21.101(b)(1).

a. The administrative burden for the applicant is to demonstrate and the Administrator to find that a change to a product is significant or not significant, and to determine the resulting certification basis. The certification basis can vary depending on the magnitude and scope of the change. The steps below present a streamlined approach of making this determination. In addition to assisting in the determination of significance, the guidance will help establish the appropriate amount of coordination required between the applicant and the Administrator.

b. Classifications of typical changes are provided in the tables of Appendix 1. For instructions how to use the Appendix 1 tables, proceed to step 4 below.

c. In cases where the classification in Appendix 1 is not applicable or immediately obvious for the proposed change, the following steps should be used in conjunction with Figure 1 to determine the appropriate certification basis for the changed product.

Step 1. Identify the Proposed Change to an Aeronautical Product.

(1) The applicant must, as a first step, identify the proposed change to the aeronauticalproduct. Changes to a product can include physical design changes, changes to an operating envelope, and/or performance changes. The change may be a single change, or a collection of changes. As part of identifying the change, the applicant must consider all previous relevant design changes.

(2) For each change, it is important that the effects of the change on other systems, components, equipment, or appliances of the product are properly assessed. The characteristics affected by the change are not only physical changes. The intent is to encompass all aspects where there is a need for re-evaluation, that is where the substantiation presented for the product being changed should be reviewed updated or re-written. All other areas of the aircraft are considered to be unchanged or not affected by the change.

Step 2. Is the Change Substantial?

(1) Section 21.19 requires that an applicant obtain a new type certificate for a changed product if the change in design, power, thrust, or weight is so extensive that a substantially complete investigation of compliance with the applicable requirements is required. A new type certificate could be required for either an extensive change to a previously type certificated product or for a new design derived through a series of design changes from a previously type certificated product. The need to require a new type certificate may be obvious when the change is first considered or may require a more extensive evaluation through application of § 21.101.

(2) A "substantially complete investigation" of compliance is required when most of the existing substantiation is not applicable to the changed product. This applies to the discussion and agreement of the methods of compliance together with the resulting scope of the investigation required to demonstrate compliance. The question of whether a change is extensive enough to warrant a new type certificate must be addressed at the beginning of the process. However, if at any point, while developing the certification basis, it becomes clear that the proposed change is a substantial

change, the process ceases to be an amendment process under 14 CFR part21, subpart D and becomes a new type certificate process under 14 CFR part21, subpart B.

(3) If it is not initially clear that a new type certificate is required, appendix 1 provides examples of when a new type certificate is not needed.

(4) In considering the above, a substantial change will require a new Type Certificate; § 21.19 applies. If the change is not substantial, § 21.101 applies.

Step 3. Will the Latest Requirements Be Used?

(1) In all cases where the latest requirements are used, the intent of § 21.101 has been met. Compliance requirements for major changes would follow § 21.97.

> **Note:** The applicant may elect to comply with the latest requirements. In this case § 21.101 has been met. In some cases the requirements will not have changed since he original certification (either because certification has been recent or the requirements themselves have not changed) and as such the applicant must only consider the change with respect to compliance demonstration.

Step 4. Is the Proposed Change Considered to Be Significant? Section 21.101(b)(1)

(1) Significant changes are product level changes and by their very nature, distinct from the preponderance of major changes. In general these changes are the result of a collection of major changes that make the changed product distinct from others, or occur through an isolated extensive major change. Section 21.101(b)(1) defines a significant change based on whether or not one or more of three automatic criteria applies the general configuration, principles of construction, and assumptions of certification. In most cases a significant change will involve more than one of these criteria and will, by its very nature, be obvious and distinct from other product improvements or production changes.

(2) Previous relevant design changes for the product can trigger one or more of the automatic criteria §§ (21.101(b)(1)(i) and (ii) for the proposed design change. When assessing the product level design change, either singularly or collectively, the cumulative effect of previous relevant design changes must be considered. These design changes may have been incorporated through earlier changes in the type certificate on areas related to the current proposed change and the associated areas, systems, components, equipment, or appliance. The collective result may be a product that is significantly different from the original product or model. Two examples of previous relevant aircraft design changes address those incremental increases in weight or thrust that, while individually not significant--e.g., 2%, 4%, 5% discrete increases, can, through a series of changes, achieve a significant product level change.

(3) The assessment of proposed design change together with any previous relevant design changes is based on whether any of the three criteria are triggered. Only when one or more of the three criteria is changed is the design change considered significant. The starting point to begin accumulating previous relevant design changes is the time the latest applicable regulations were applied in the affected area, system, component, equipment, or appliance.

(4) The applicant may use the tables in appendix 1 and the criteria described below as guidance to make the determination of significant.

**8. USING THE CRITERIA.**

a. Typically, significant product level changes result in a model change to the type certificate (an amended type certificate (ATC) or a supplemental type certificate that rises to the level of an ATC). It should be noted that applications for a new model not associated with hardware changes i.e., commercial considerations is not an indication of a significant change under § 21.101. All changes are considered in light of the change itself and its classification.

b. The following definitions build upon the criteria identified in the rule; they provide additional guidance on how to apply the criteria when classifying product level changes. In cases of doubt, and to ensure a consistent outcome, the applicant is encouraged to seek the advice of the Administrator.

(1) Changes Where the General Configuration Is Not Retained (Significant Change to General Configuration). A change to the general configuration at the product level that is likely to require a new designation of model because of the need to distinguish the different product with other product models, e.g. because of performance, interchangeability of major components, etc.

(2) Changes Where the Principles of Construction Are Not Retained (Significant Change to Principles of Construction). A change at the product level to the materials and/or construction methods that affects the overall product's operating characteristics or inherent strength and would require extensive re-investigation to show compliance.

(3) Changes That Invalidate the Assumptions Used for Certification (Significant Change to the Assumptions Used for Certification.) A change to the product level assumptions associated with the compliance demonstration, performance, or operating envelope that by itself is so different that the original assumptions are invalidated. Examples may include:

(a) Change of an aircraft from an unpressurized to pressurized fuselage
(b) Change of operation of a fixed wing aircraft from land based to water based
(c) Operation envelope expansions that are outside the existing design parameters and capabilities.

> **Note:** Merely operating a product to an expanded envelope for which it was originally designed is generally not a significant change. In this case, the assumptions used for certification of the basic product remain valid and the results can be applied to cover the changed product with predictable effects or can be demonstrated without significant physical changes to the product.

c. The above criteria are used to determine if a change is significant. In applying the automatic criteria and the examples in appendix 1 the applicant must concentrate on the change itself. Changes and updates to the requirements are assessed as part of the normal rule making activity and are not normally reason to trigger a classification of significance under §21.101. Appendix 1 may be used for help with the determination.

d. Appendix 1 includes tables of typical changes for transport aircraft, small aircraft, rotorcraft, and engines/propellers that meet the definition of "significant product level change" for each product line. They also include typical changes that do not achieve the significant level. The tables can be used in one of two ways: find a proposed change listed in the table, or to calibrate a classification that relies purely on the application of the criteria to the change.

e. If, based on Appendix 1 and / or the automatic criteria, the change is classified as:

- SIGNIFICANT. The applicant will comply with the latest amendments of the requirements for the certification of the changed product. The applicant can use the exceptions provided in §§ 21.101(b)(2) and/or (3) to show compliance with earlier amendments; the final certification basis may consist of a combination of the latest, and earlier or existing requirements for the change.

- NOT SIGNIFICANT (§21.101(b)(1). The applicant can apply earlier amendments to the applicable regulations as appropriate but not lower than the amendment level in the most recent certification basis. The applicant would propose and the Administrator would find the appropriate amendment levels for the regulations applicable to the change. In many cases the applicant and Administrator would agree that certain changes are not significant changes and can continue to comply with the existing certification basis.

f. Making the Classification The applicant for a change to a type certificate makes a classification of significant/non-significant (the application of § 21.101(b)(1)) in one of two ways:

(1) By delegation, where appropriate guidelines are in place to support a classification of not significant by the applicant. The Administrator may accept the not significant determination without further showing and rely on the applicant's design control system and the Administrator's oversight system to monitor and validate decisions

(2) By the Administrator accepting the determination of significance relevant to a major modification based on the applicant's submission.

g. At this point the determination of significant or not significant has been made. For significant changes, if the applicant elects to show compliance with an earlier requirement, the procedure outlined in section 7 should be used.

## 9. SHOWING COMPLIANCE WITH AN EARLIER REQUIREMENT, §§ 21.101(b)(2) AND (3).

a. For a design change that has been determined to be significant, §§ 21.101(b)(2) and (3) provide the exceptions from the requirement of § 21.101(a) to meet the latest requirements for design changes.

b. Sections 21.101(b)(2) and (3) identify conditions under which an applicant may show that the changed product complies with an earlier amendment level or with the existing certification basis and, therefore, would not be required to comply with latest requirements. The earlier amendment level with which the applicant intends to show compliance may not precede the corresponding requirements in the existing certification basis. An applicant may elect to show compliance with an earlier amendment level or with the existing certification basis for areas not affected by the change, and areas affected by the change for which compliance with the latest requirements would not contribute materially to the level of safety or would be impractical. It is incumbent upon the applicant to show that compliance with the latest requirements does not materially contribute to the level of safety, or is impractical.

c. Exceptions. The following steps should be used in conjunction with Figure 1, when an applicant wishes to comply with an earlier requirement for a significant change.

Step 5. Is the Area affected by the product level change? Section 21.101 (b)(2).

(1) A not affected area is any area, system, component, equipment, or appliance that is not affected by the proposed product level change. For a product level change, it is important that the effects of such change on other systems, components, equipment, or appliances of the product are properly assessed because areas that have not been changed may be affected. However, the applicant need not re-substantiate those areas of the product where the original substantiation has not been invalidated by the change and/or the updated certification basis.

(2) In assessing not affected areas, it may be necessary to identify secondary changes resulting from a product level change. The secondary changes may be changes in both physical aspects and/or performance characteristics that are not part of, but consequential to, the overall product level change. Secondary changes may be evaluated to the most recent certification basis for the product being changed; however, care should be taken to ensure that affected areas are not overlooked. The intent is to encompass all aspects where there is a need for re-evaluation.

(3) The following aspects of a product level change should be considered:

(a) Physical aspects. The physical aspects include, but are not limited to, structures, systems, equipment, components and appliances (physical aspects can cover both "hardware" and "software"). When evaluating the physical aspects, it is necessary to make a distinction between the product level change and the resulting secondary effects. An example of a secondary effect may be the lengthening and re-routing of the various airplane circuits as a result of the fuselage plug (this would also apply to additional seats, overhead bins, etc.) and changes to wires, distribution buses, circuit breaker, etc., where the maximum design loads are not exceeded. Another example may be the effect on crashworthiness due to an increased gross weight, not associated with fuel weight increase.

(b) Performance/functional characteristics. The less obvious aspect of the word "areas" covers general characteristics of the type certificated product such as performance features, handling qualities, emergency provisions, fire protection, structural integrity, aeroelastic characteristics, crashworthiness, etc. These characteristics may be affected by a product level change. For example, adding a fuselage plug could significantly affect performance and handling

qualities. The extension of the aircraft control cables required during the fuselage plug modification could be considered a secondary change.

(4) For areas that have been identified as not affected by the proposed design change, including secondary changes, the applicant may show compliance with an earlier requirement.

(5) All areas affected by the proposed design change must comply with the latest requirements, unless the applicant shows that demonstrating compliance with an amendment of a requirement would not contribute materially to the level of safety or would be impractical. Step 6 provides further explanation.

Step 6. Are the new requirements practical and/or do they contribute materially to the level of safety, § 21.101(b)(3)?

(1) Not contributing materially to the level of safety. Compliance with the latest requirements could be considered "not to contribute materially to the level of safety" if the change to type design and/or relevant experience provides a level of safety comparable to that provided by the latest requirements, or if compliance may compromise the existing level of safety to that particular changed product. It is incumbent on the applicant to provide sufficient justification to allow the Administrator to make this determination. This exception could be applicable in the situations described in the paragraphs below:

(a) Design. This provision gives the opportunity to consider the consistency of design. For example, when a small fuselage plug is added, additional seats and overhead bins are likely to be installed, and the lower cargo hold extended. These additional seats, bins, extended lower deck cargo and structural plug may be identical to the existing parts. Literally applying the latest requirements only to the changed parts may not contribute materially to the level of safety, as the entire design as modified may not necessarily be any safer than the original design. It also may be inappropriate to require compliance to the latest requirements for the entire fuselage, seats, bins, doors and cargo holds. For this reason, compliance of the new fuselage structure, seats, bins and cargo hold area with the requirements in effect when the original fuselage, seats, bins and cargo hold area were certified may be acceptable.

(b) However, the extent of the fuselage change may be large relative to the original structure, seats, bins, doors and cargo compartment certified, and/or the change may require essentially a new compliance substantiation that is comparable with that required for a new model airplane. Here, it would be expected that the certification basis would encompass the requirements in effect at the date of application for the entire fuselage, seats, bins, doors and cargo hold.

(c) In both examples above, it would be incumbent upon the applicant to show that compliance with the latest requirements does not materially contribute to the level of safety.

(2) Service experience.

(a) This provision permits the use of relevant service experience, such as fleet hours, to demonstrate that compliance with the latest requirements would not contribute materially to the level

of safety, and as such the use of earlier requirements may be appropriate. Appendix 3 provides additional guidance on the use of service experience, along with examples.

(b) There may be cases for rotorcraft and small airplanes where sufficient and relevant data may not be available because of the reduced utilization and the different amount and type of data available. In such cases, other service history information may provide sufficient data to justify the use of earlier requirements, such as: warranty, repair and parts usage data; accident, incident and service difficulty reports; service bulletins; airworthiness directives; or other pertinent and sufficient data collected by the manufacturers, authorities, or other entities.

(c) The service experience levels necessary to demonstrate the appropriate level of safety as they relate to the proposed design change would have to be reviewed and agreed to by the Administrator.

(d) Other exceptions. Compliance with amended requirements would not be required where the amendment is of an administrative nature and has been made only to correct errors or omissions, consolidate text, clarify an existing requirement.

d. Impractical. Compliance with the latest requirements may be considered impractical if the applicant can substantiate that it would result in additional resource requirements that are not commensurate with the safety benefits. The additional resource requirements could include those arising from design changes required for compliance and the effort required to demonstrate compliance, but would not include resource expenditures for prior product changes.

e. Substantiating data and analyses must support an applicant's position that compliance is impractical, and the Administrator must agree with this position. In evaluating an applicant's position and substantiating data regarding practicality the Administrator may consider other factors (e.g. the costs and safety benefits for a comparable new design).

f. A review of transport category projects showed that in certain cases, where an earlier amendment to applicable requirements was allowed, design changes were made to nearly comply with the latest amendments. In these cases the applicant successfully argued that full compliance would require a substantial increase in the outlay of resources with a very small increase in the level of safety. These cases reflect an appropriate application of "impracticality" to a changed product.

g. Determination of being impractical would not be necessary when the applicant can show that compliance with the latest applicable requirements for the extent of the change does not contribute materially to the level of safety. Therefore, arguments that a product design change would be impractical would be used, in most cases, where compliance with the latest requirements would contribute materially to the level of safety, but that this contribution may not be commensurate with the associated resource expenditures.

h. Appendix 2 provides additional guidance and examples for determining impracticality.

i. This completes the step by step process used in the determination of the certification basis for the changed product.

**10. EXCEPTED PRODUCTS UNDER § 21.101(c).**

a. An applicant for a change to an aircraft (other than rotorcraft) of 6,000 pounds or less maximum weight, or to a non-turbine rotorcraft of 3,000 pounds or less maximum weight may show that the changed product complies with the regulations incorporated by reference in the type certificate. The primary impact of the exception is that the starting point for determining the applicable regulations for a changed product will continue to be the regulations incorporated by reference in the type certificate, rather than the regulations in effect on the date of application for the change.

b. However, if the Administrator finds that the change is significant in an area, the Administrator may designate compliance with an amendment to the regulation incorporated by reference in the type certificate that applies to the change and any regulation that the Administrator finds is directly related, unless the Administrator also finds that compliance with the amendment or regulation would not contribute materially to the level of safety of the changed product, or would be impractical. If the Administrator agrees with the applicant's substantiation, the Administrator may allow compliance with an earlier amendment to that requirement initially designated or with the existing certification basis, depending on the proposed design change.

**11. SPECIAL CONDITIONS, §21.101(d).** Section 21.101(d) allows for the application of special conditions, or for changes to existing special conditions, to address the changed design. The objective is to achieve, for the changed product, a level of safety consistent with that provided by the requirements in effect on the date of application for the design change. The application of special conditions to a design change is not in itself a reason for it to be classified as either a substantial change or a significant change. When regulations in effect at the date of application for the change fail to provide adequate standards, the applicant must comply with special conditions to provide a level of safety equal to the established by the regulations in affect on the date of application for the change.

**12. EFFECTIVE PERIOD FOR AN APPLICATION TO CHANGE A TYPE CERTIFICATE, § 21.101(e).** Section 21.101(e) is intended to ensure that, at the time the changed product is certificated, the latest requirements in the certification basis are not more than five or three years out of date, as applicable. This is consistent with the requirements of § 21.17 for a new type certificate.

**13. OTHER CATEGORY AIRCRAFT, § 21.101(f).**

a. For aircraft type certificated under §§ 21.17(b), 21.24, 21.25, and 21.27, the certification basis for the changed product will consist of the latest amendment levels of the regulations that the Administrator finds appropriate. The provisions in § 21.101(b) and (c) apply.

b. For aircraft certificated in the restricted category, the application of the latest regulations would not normally be considered to contribute materially to the level of safety or be practical for its intended use. However, for a significant change, if the regulations incorporated by reference in the type certificate do not provide an appropriate level of safety for its intended use, the application of the latest regulations would be considered.

c. For example, the installation of turbopropeller engines in lieu of reciprocating engines either in an aircraft that was originally certificated based on satisfactory military service experience, or in an aircraft for which the original certification basis did not contain regulations for turbine engine installations would require consideration of compliance with the latest regulations as required by § 21.101(a) and (b). However, if the changed product is certified in the restricted category, earlier regulations may be accepted as providing the appropriate level of safety for its intended use. An exception to this would be if the Administrator finds that the regulation in the original certification basis is inappropriate for the special purpose for which the aircraft is being certificated and designates an alternative regulation as provided by § 21.25. However, the alternate regulation need not be the latest amendment, if an earlier amendment provides the appropriate level of safety.

## Appendix 1
## CLASSIFICATION OF CHANGES

1. The following figures present tables of typical changes that meet the definition of a significant (product level) change. The tables also include those changes that do not achieve the significant threshold. They address small airplanes in figure 1, transport airplanes in figure 2, rotorcraft in figure 3, and engines and propellers in figure 4.

a. The "Change to General Configuration", "Change to Principles of Construction" and Assumptions of Certification columns reflect the automatic criteria of §§ 21.101(b)(1)(i) and (ii). The notes column provides additional information explaining the rationale for the designation of the criteria.

b. These are examples only and the determination of significance will depend on the actual change application. Future amendments to the airworthiness requirements may affect the validity of some of the examples.

c. These are typical classifications that apply in most, but not necessarily all cases. The classification may change due to cumulative effects and/or combinations of individual changes.

**Figure 1. Table of examples of Changes for Small Airplanes**

| **Part 23 Only** | | | | |
|---|---|---|---|---|
| The following are examples for significant changes: | | | | |
| **Description of Product Level Change** | **21.101(b)(1)(i) Is there a Change to the General Configuration?** | **21.101(b)(1)(i) Is there a Change to the Principles of Construction?** | **21.101(b)(1(ii) Have the assumptions used for Certification been invalidated?** | **Notes** |
| Conventional tail to T-tail or Y-tail, or vice versa | Yes | Yes | Yes | Change in general configuration. Requires extensive structural re-investigation. Likely change in certification assumptions. Requires new AFM to address performance and flight characteristics. |

| | | | | |
|---|---|---|---|---|
| Changes in wing configuration (addition of tail strakes or change in dihedral, or changes in wing span, flap or aileron span, angle of incidence of the tail, addition of winglets, or wing sweep of more than 10% | Yes | Yes | Yes | Change in general configuration. Likely requires extensive changes to wing structure. Likely change in certification assumptions. Requires new AFM to address performance and flight characteristics. |
| Tricycle / tailwheel undercarriage change or addition of floats | Yes | No | No | Change in general configuration. Likely, at airplane level, general configuration and certification assumptions remain valid. |
| Increase in seating capacity resulting in a different certification category (e.g., from normal to commuter category where configuration or principles of construction changes or assumptions do not remain valid. | Yes | Yes | Yes | Change in general configuration. Change in principles of construction. Requires extensive construction re-assessment. Change in certification assumptions. Requires new AFM and pilot type rating. |
| Passenger to freighter configuration conversion which involves the introduction of a cargo door or an increase in floor loading of more than 20%, or provision for carriage of passengers and freight together | Yes | No | Yes | Change in general configuration affecting load paths, aeroelastic characteristics, aircraft related systems, etc. Change in design assumptions. |

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| A fuselage stretch would be considered significant if it would invalidate the existing substantiation, or would change the primary structure, aerodynamics, or operating envelope sufficiently to invalidate the assumptions of certification | Yes | Yes | Yes | Likely extensive changes to fuselage structure. Requires extensive construction re-assessment. Invalidates design & certification assumptions. Requires new AFM to address performance and flight characteristics. |
| Replace reciprocating engines with the same number of turbo-propeller engines where the operating envelop is expanded | No | No | Yes | Invalidates certification assumptions. Requires new AFM to address performance and flight characteristics. |
| Addition of a turbo-charger that changes the power envelope, operating range, or limitations. | No | No | Yes | Invalidates certification assumptions. Requires new AFM to address performance and flight characteristics. |
| The replacement of an engine of higher horsepower would be considered significant if it would invalidate the existing substantiation, or would change the primary structure, aerodynamics, or operating envelope sufficiently to invalidate the assumptions of certification | No | Yes | Yes | Invalidates certification assumptions. Requires new AFM to address performance and flight characteristics. Likely changes to primary structure. Requires extensive construction re-investigation. |

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| A change in the type of material, such as composites in place of metal (or one composite fiber material system with another (e.g., carbon for fiberglass), for primary structure would normally be assessed as a significant change. | No | Yes | Yes | Change in principles of construction. Likely change in design/certification assumptions. |
| A design change that introduces novel or unusual methods of construction for primary structure | No | Yes | No | Change in principles of construction. |
| Change involving marked increase in design speeds Vd, Vmo, Vc, or Va | No | No | Yes | Certification assumptions invalidated. Requires new AFM to address performance and flight characteristics. |
| STOL kit | No | No | Yes | Certification assumptions invalidated. Requires new AFM to address performance and flight characteristics. |
| A change in the fatigue philosophy (safe life to damage tolerance etc) | No | Yes | Yes | Changes in principles of construction and design assumptions. Requires extensive construction re-investigation. |
| A change in the rated power or thrust is likely to be regarded as significant if the design speeds are thereby changed so that compliance needs to be re-justified with a majority of requirements. | No | No | Yes | Certification assumptions invalidated. Requires new AFM to address performance and flight characteristics. |

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| Fuel state: such as compressed gaseous fuels, or fuel cells. This could completely alter the fuel storage and handling systems and possibly affect the airplane structure. | No | No | Yes | Changes in design/certification assumptions. Extensive alteration of fuel storage and handling systems. |
| A design change that alters the aircraft flight characteristics or performance from the type design would normally be significant if it appreciably changes the kinematics or dynamics of the airplane. | No | No | Yes | Certification assumptions invalidated. Requires new AFM to address performance and flight characteristics. |
| Weight increase which places the aircraft into the commuter category (i.e., above 12500 lbs) | No | No | Yes | Certification assumptions invalidated. Requires new AFM. |
| A change in the flight control concept for an aircraft, for example to fly by wire (FBW) and side-stick control, or a change from hydraulic to electronically actuated flight controls, would in isolation normally be regarded as a significant change. | No | No | Yes | Changes in design and certification assumptions. Requires extensive systems architecture and integration re-investigation. Requires new AFM. |
| Addition of cabin pressurization | No | Yes | Yes | Extensive airframe changes effecting load paths, fatigue evaluation, aeroelastic characteristics, etc. Requires extensive construction re-investigation. Invalidates design assumptions. |

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| Changes in types and number of emergency exits or an increase in passenger capacity in excess of maximum passenger capacity demonstrated for the aircraft type. | No | No | Yes | Emergency egress requirements exceed those previously substantiated. Invalidates assumptions of certification. |
| A change in the required number of flight crew, which necessitates a complete cockpit re-arrangement, and/or an increase in pilot workload would be a significant change. | No | No | Yes | Extensive changes to avionics and aircraft systems. Invalidates certification assumptions. Requires new AFM. |
| A marked expansion of an aircraft's operating envelope or operating capability would normally be a significant change. e.g., an increase in maximum altitude limitation, approval for flight in known icing conditions, an increase in airspeed limitations | No | No | Yes | Invalidates certification assumptions. Requires new AFM to address performance and flight characteristics. |
| A major flight deck update | No | No | Yes | Extensive changes to avionics and aircraft systems. Invalidates certification assumptions. Extensive re-assessments of systems integration, flight crew workload, handling qualities, performance evaluation are required. Requires new AFM. |
| Introduction of autoland | No | No | Yes | Invalidates original design assumptions. |

The following are examples for not significant changes:

| **Description of Change** | **21.101(b)(1)(i) Is there a Change to the General Configuration?** | **21.101(b)(1)(i) Is there a Change to the Principles of Construction?** | **21.101(b)(1(ii) Have the assumptions used for Certification been invalidated?** | **Notes** |
|---|---|---|---|---|
| Addition of wingtip modifications (not winglets) | No | No | No | A major change in airplane level. Likely, at airplane level, original general configuration, principles of construction and certification assumptions remain valid. |
| Installation of skis or wheel skis | No | No | No | A major change in airplane level. At airplane level, likely the original general configuration, principles of construction and certification assumptions remain valid. |
| Litter, berth and cargo tie down device installation | No | No | No | Not a change in airplane level. |
| Increased tire size, including tundra tires | No | No | No | Not a change in airplane level. |
| Replacement of one propeller type with another (irrespective of increase in number of blades) | No | No | No | A major change in airplane level. Likely, at airplane level, original general configuration, principles of construction and certification assumptions remain valid. |

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| Addition of a turbo-charger that does not change the power envelope, operating range, or limitations (e.g., a turbo—normalized engine), e.g., where the additional power is used to enhance high altitude or hot day performance. | No | No | No | A change in system and/or component level. |
| Replace a petrol engine with a diesel engine or approximately the same horsepower. | No | No | No | A major change in airplane level. Likely, at airplane level, original airplane general configuration, principles of construction and certification assumptions remain valid. |
| Substitution of one method of bonding for another (e.g., change in type of adhesive) | No | No | No | A change in component level only. |
| Substitution of one type of metal for another | No | No | No | A change in component level only. |
| Any change in construction or fastening not involving primary structure | No | No | No | A change in component level only. |
| A new fabric type for fabric skinned aircraft | No | No | No | A change in component level only. |
| Increase in flap speed or undercarriage limit speed | No | No | No | At airplane level, no change in general configuration, principles of construction & certification assumptions. |
| Structural strength increases | No | No | No | At airplane level, no change in general configuration, principles of construction & |

| | | | | |
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| | | | | certification assumptions. |
| Engine cooling or cowling changes | No | No | No | A change in component level only. |
| IFR upgrade involving installation of components (where the original certification does not indicate that the airplane is not suitable as an IFR platform, e.g., special handling concerns). | No | No | No | A change in system and/or component level only. |
| Fuel lines, where engine horsepower is increased but fuel flow is not increased beyond the certified maximum amount. | No | No | No | A change in system and/or component level only. |
| Fuel tanks, where fuel is changed from gasoline to diesel fuel and tank support loads are small enough that an extrapolation from the previous analysis would be valid. Chemical compatibility would have to be substantiated | No | No | No | A change in system and/or component level only. |
| Limited changes in a pressurization system, e.g., number of outflow valves, type of controller, or size of pressurized compartment, but the system must be re-substantiated if the original test data is invalidated. | No | No | No | A change in system and/or component level only. At airplane level, no change in general configuration, principles of construction & certification assumptions. |
| Install a quieter exhaust system | No | No | No | A change in system and/or component level only. |
| Changes in engine cooling or cowling | No | No | No | A change in system and/or component level only. |

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| Fuel type: AvGas to Diesel/Jet A, AvGas to Ethanol/Methanol. Changing to Multiple fuel systems containing fuel types (other than systems used for starting): such systems using as AvGas/Ethanol, or Jet A/Autogas (turbine). Unrestricted mixtures in one fuel system of different fuel types: Such as AvGas/Diesel or Jet A/Ethanol. | No | No | No | A change in system and/or component level only. At airplane level, no change in general configuration, principles of construction & certification assumptions. |
| Fuels of substantially the same type: Such as AvGas to AutoGas, AvGas (80/87) to AvGas (100LL), Ethanol to Isopropyl Alcohol, Jet B to Jet A (although Jet A to Jet B may be considered significant due to the fact that Jet B is considered potentially more explosive). | No | No | No | A change in system and/or component level only. At airplane level, no change in general configuration, principles of construction & certification assumptions. |
| Fuels that specify different levels of "conventional" fuel additives that do not change the primary fuel type. Different additive levels (controlled) of MTBE, ETBE, Ethanol, Amines, etc. in AvGas would not be considered a significant change. | No | No | No | A change in system and/or component level only. At airplane level, no change in general configuration, principles of construction & certification assumptions. |
| A change to the maximum take-off weight of less than 5% unless assumptions made in justification of the design are thereby invalidated. | No | No | No | A major change in airplane level. At airplane level, likely, original airplane general configuration, principles of construction remain |

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| | | | | unchanged. Certification assumptions remain valid. |
| An additional aileron tab (e.g. on the other wing) | No | No | No | At airplane level, no change in general configuration, principles of construction & certification assumptions. |
| Larger diameter flight control cables with no change in routing, or other system design | No | No | No | A change in system and/or component level only. |
| Autopilot installation (for IFR use, where the original certification does not indicate that the airplane is not suitable as an IFR platform) | No | No | No | A change in system and/or component level only. At airplane level, no change in general configuration, principles of construction & certification assumptions. |
| Increased battery capacity or relocate battery | No | No | No | A change in system and/or component level only. |
| Replace generator with alternator | No | No | No | A change in system and/or component level only. |
| Additional lighting (e.g., navigation lights, strobes) | No | No | No | A change in system and/or component level only. |
| Higher capacity brake assemblies | No | No | No | A change in system and/or component level only. |
| Increase in fuel tank capacity | No | No | No | A change in system and/or component level only. |
| Addition of supplement lights | No | No | No | A change in system and/or component |

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| | | | | level only. |
| Addition of an oxygen system | No | No | No | A change in system and/or component level only. |
| Relocation of a galley. | No | No | No | A change in system and/or component level only. |
| Passenger to freight (only) conversion with no change to basic fuselage structure. | No | No | No | A major change in airplane level. At airplane level, general configuration and principles of construction remain unchanged. Requires certification substantiation applicable to freighter requirements. |
| Installation of new seat belt or shoulder harness | No | No | No | A change in system and/or component level only. |
| A small increase in cg range. | No | No | No | At airplane level, no change in general configuration, principles of construction & certification assumptions. |
| IFR operations approval | No | No | No | A change in system and/or component level only. |
| APU Installation that is not flight essential | No | No | No | A major change in airplane level. At airplane level, general configuration and principles of construction remain unchanged. Requires certification substantiation applicable to APU installation |

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| | | | | requirements. |
| An alternative autopilot | No | No | No | A change in system and/or component level only. |
| Addition of Class B Terrain Awareness and Warning Systems (TAWS) | No | No | No | A change in system and/or component level only. |
| A general avionics equipment change, including installation of a new system such as Global Positioning System (GPS) for information purposes, where no credit is taken for it as an aid. | No | No | No | A change in system and/or component level only. Not an airplane level change. |

**Figure 2. Table of examples of Changes for Transport Airplanes**

| Description of Product Level Change | §21.101(b)(1)(i) Is There a Change to General Configuration? | §21.101(b)(1)(i) Is There a Change to Principles of Construction? | §21.101(b)(1)(ii) Have Assumptio-ns Used for Certification Been Invalidated? | Rationale for Determination of Significance |
|---|---|---|---|---|
| **Significant Changes** | | | | Note: All of the following changes rise to the product level such that a new certification basis for the aircraft needs to be considered. |
| Derivative model, e.g. increased passenger payload, freighter version or complete update of a certified airplane. | Yes | Yes | Yes | Multiple changes packaged into a new model. Increased payload new freighter would change the general configuration and assumptions. Updated airplane would change principles of construction. |
| Reduction in the number of flight crew (In conjunction with flight deck update). | Yes | No | No | Extensive changes to avionics and aircraft systems. Impact to crew workload and human factors, pilot type rating. |
| Modify an airplane for flight in known icing conditions by adding systems for ice detection and elimination | Yes | No | Yes | New aircraft operating envelop. Requires major new systems installation and aircraft evaluation. *Operating envelope changed.* |
| Conversion – passenger or combi to all freighter including cargo door, redesign floor structure and 9g net or rigid barrier | Yes | No | Yes | Extensive airframe changes affecting load paths, aeroelastic characteristics, aircraft related systems for fire protection, etc. Design assumptions changed from passenger to freighter. |
| Addition of leading edge slats | Yes | No | No | Requires extensive changes to wing structure, adds aircraft |

**Figure 2. Table of examples of Changes for Transport Airplanes**

| | | | | |
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| | | | | level systems, and requires a new airplane flight manual to address performance and flight characteristics. |
| Fuselage length change – lengthen or shorten fuselage | Yes | No | No | Requires extensive changes to fuselage structure, affects aircraft level systems, and requires a new airplane flight manual to address performance and flight characteristics. |
| Extensive structural airframe modification, such as installation of a large telescope with large opening in fuselage. | Yes | No | No | Requires extensive changes to fuselage structure, affects aircraft level systems, and requires a new airplane flight manual to address performance and flight characteristics. |
| Changing the number of axles or number of landing gear done in context with a product level change which involves changing the airplane gross weight. | Yes | No | No | Requires extensive changes to aircraft structure, affects aircraft level systems. |
| Primary structure changes from metallic material to composite material. | No | Yes | No | Change in principles of construction and design from conventional practices. |
| Increase in design weight of more than 10% | No | No | Yes | When it requires extensive resubstantiation of aircraft structure, aircraft performance and flying qualities and associated systems. |
| Wing changes in span, sweep, and tip designs or wing chord. | Yes | No | No | When it requires extensive changes to wing structure, adds aircraft level systems, and requires a new airplane flight manual to address performance and flight characteristics. |
| Change in type or number of emergency exits in conjunction with an increase in the number of passengers demonstrated. | No | No | Yes | The new emergency egress requirements exceed those previously substantiated. |
| Comprehensive flight | No | No | Yes | The degree of change is so |

**Figure 2. Table of examples of Changes for Transport Airplanes**

| | | | | |
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| deck upgrade | | | | extensive that it affects basic avionics and electrical systems integration and architecture concepts and philosophies. This drives a complete re-assessment of flight crew workload and other human factors issues, and requires a re-evaluation of the original design assumptions used for the cockpit. |
| Change in primary flight controls to fly by wire system | Yes | No | Yes | The degree of change is so extensive that it affects basic aircraft systems integration and architecture concepts and philosophies. This drives a complete re-assessment of flight crew workload, handling qualities, and performance evaluation, which are different from the original design assumptions. |
| Replace reciprocating with turbo-propeller engines | Yes | No | No | When it requires extensive changes to airframe structure, adds aircraft level systems, and requires a new airplane flight manual to address performance and flight characteristics. |
| Change in engine position, e.g. wing to body | Yes | No | No | When it requires extensive changes to airframe structure, adds aircraft level systems, and requires a new airplane flight manual to address performance and flight characteristics. |
| Thrust increase of more than 10% | No | No | Yes | When it requires extensive resubstantiation of powerplant installation, and has an affect on aircraft performance and flying qualities. |

**Figure 2. Table of examples of Changes for Transport Airplanes**

| **Not Significant Changes** | | | | **Note: All of the following changes will still require formal certification, however the level of changes have been determined not to rise to the product level such that a completely new certification basis for the aircraft needs to be considered.** |
|---|---|---|---|---|
| Alternate engine installation or hush kit at same position | No | No | No | Although an airplane level change, it is not significant so long as there is not more than a 10% increase in thrust or a change in the principles of propulsion. |
| Change in type or number of emergency exits. | No | No | No | So long as the product change does not require an increase in the number of passengers normally allowed per exit, this is not a significant product level change. |
| Integrated modular avionics | No | No | No | This is not a product level change – it is a component level change since the basic functionality of the systems are unchanged. |
| Initial installation of an autopilot system | No | No | No | This is a system level change, not a product level change. |
| Installation of a complete interior in a "green" aircraft | No | No | No | Not a product level change. |
| Change from assembled primary structure to monolithic or integrally machined structure | No | No | No | Method of construction is well understood. |
| Modification to ice protection systems that could affect ice shapes | No | No | No | This is a system level change, not a product level change. |
| Brakes: design or material change, e.g. steel to carbon | No | No | No | This is a system level change, not a product level change. |
| Installation of a new or auxiliary fuel tank | No | No | No | This is a system level change, not a product level change. |

**Figure 2. Table of examples of Changes for Transport Airplanes**

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|---|---|---|---|---|
| Cargo door installation | No | No | No | By itself, this is not a significant product level change. It could be a significant change if coupled with extensive changes to the floor structure, etc. |
| Redesign floor structure | No | No | No | By itself, this is not a significant product level change. It could be a significant change if coupled with extensive changes to the number or type of cargo doors structure, etc. |
| Novel or unusual method of construction | No | No | No | By itself, this is not a significant product level change. It could be a significant change if it affects the overall product's operating characteristics or inherent strength and would require extensive re-investigation to show compliance. Or, special conditions could be required if there are no existing regulations that adequately address these features. |
| Initial installation of an APU | No | No | No | This is a system level change, not a product level change. |

**Figure 3. Table of examples of Changes for Rotorcraft**

| **Part 27/29 Only** | The following are examples of significant changes at the product level. | | | |
|---|---|---|---|---|
| **Description of Product Level Change** | **21.101(b)(1)(i) Is there a Change to the General Configuration ?** | **21.101(b)(1)(i) Is there a Change to the Principles of Construction?** | **21.101(b)(1(ii) Have the assumptions used for Certification been** | **Notes** |

| | | | **invalidated?** | |
|---|---|---|---|---|
| Comprehensive Flight Deck Upgrade | Yes | No | Yes | The degree of change is so extensive that it affects basic avionics and electrical systems integration and architecture concepts and philosophies. This drives a complete reassessment of flight crew workload and other human factor issues, and requires a reevaluation of the original design assumptions used for the cockpit. |
| VFR to first IFR approval including extensive equipment and redesign | No | No | Yes | |
| Extensive changes to equipment, systems, and installations required to support an upgrade to CATA certification approval | No | No | Yes | Engine and drive systems rating changes appropriate for CATA and rotorcraft performance requirements, and change in design requirements specific to CATA |
| Certification for flight into known icing conditions. | No | No | Yes | |
| Reducing the number of pilots for IFR from 2 to 1 with extensive equipment changes (excluding removal of equipment for second pilot) | No | No | Yes | There are different pilot configurations with different work load requirements, different certification requirements associated with single pilot IFR operations, and also extensive equipment changes. Going to single from dual pilot |

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| | | | | configuration without extensive equipment changes does not normally become a significant change. |
| (Fixed) flying controls from mechanical to fly by wire | Yes | Yes | Yes | |
| Addition of an engine; e.g. from single to twin or reduction of the number of engines; e.g. from twin to single | Yes | No | Yes | May be Substantial - depend upon project details |
| A fuselage modification that changes the primary structure, aerodynamics, or operating envelope sufficiently to invalidate the certification assumptions. | Yes | No | Yes | |
| Application of an approved primary structure to a different approved model (e.g. installation on a former model of the main rotor approved on a new model that results in increase performance | No | Yes | Yes | |
| New primary structure with extensive use of composite in lieu of metal | No | Yes | Yes | |
| Emergency Medical Service Configuration with primary structural changes sufficiently to invalidate the certification assumptions | Yes | No | Yes | Many EMS configurations will not be classified as significant. Modifications made for EMS is typically internal and the general external configuration is normally not affected. These changes should not automatically be classified as significant. |
| Skid landing gear to wheel landing gear or wheel landing to skid | Yes | No | Yes | |
| Change of the number of main rotor blades | Yes | No | No | Typically changes in the number of tail rotor blades is not significant. |

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| Change tail anti-torque device (e.g. tail rotor, ducted fan or other technology) | Yes | Yes | No | |

| **Part 27/29 Only** | The following are examples of not significant changes. | | | |
|---|---|---|---|---|
| **Description of Change** | **21.101(b)(1)(i) Is there a Change to the General Configuration ?** | **21.101(b)(1)(i) Is there a Change to the Principles of Construction?** | **21.101(b)(1(ii) Have the assumptions used for Certification been invalidated?** | **Notes** |
| Emergency floats | No | No | No | Must Comply to the specific applicable requirements for emergency floats. This installation, in itself, does not change the rotorcraft configuration, overall performance, or operational capability. Expanding an operating envelope (such as operating altitude and temperature) and mission profile (such as passenger carrying operations to external load operations, or flight over water, or operations in snow conditions) are not by themselves so different that the original certification assumptions are no longer valid at the type certificated product level. |

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| FLIR or surveillance camera installation | No | No | No | Additional flight or structural evaluation may be necessary but the change does not alter the basic rotorcraft certification |
| Helicopter Terrain Awareness Warning System (HTAWS) for operational credit | No | No | No | Certified per rotorcraft HTAWS AC guidance material |
| Health Usage Monitoring System (HUMS) for Maintenance Credit | No | No | No | Certified per rotorcraft HUMS AC guidance material |
| Expanded limitations with minimal or no design changes, following further tests/justifications or different mix of limitations (CG limits, oil temperatures, altitude, minimum/maximum weight, minimum/max external temperatures, speed, ratings structure) | No | No | No | Expanding an operating envelope (such as operating altitude and temperature) and mission profile (such as passenger carrying operations to external load operations, or flight over water, or operations in snow conditions) are not by themselves so different that the original certification assumptions are no longer valid at the type certificated product level. |
| Installation of a new engine type, equivalent to the former one; leaving a/c installation and limitations substantially unchanged | No | No | No | Refer to AC 27-1 or AC 29-2 for guidance |

| | | | | |
|---|---|---|---|---|
| Windscreen installation | No | No | No | Does not change the rotorcraft overall product configuration |
| Snow skis, "Bear Paws" | No | No | No | Must comply with specific requirements associated with the change. Expanding an operating envelope (such as operating altitude and temperature) and mission profile (such as passenger carrying operations to external load operations, or flight over water, or operations in snow conditions) are not by themselves so different that the original certification assumptions are no longer valid at the type certificated product level. |
| External Cargo Hoist | No | No | No | Must Comply to the specific applicable requirements for external loads. This installation, in itself, does not change the rotorcraft configuration, overall performance, or operational capability. Expanding an operating envelope (such as operating altitude and temperature) and mission profile (such as passenger carrying operations to external load operations, or flight over water, or operations in snow conditions) are not by themselves so different that the |

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| | | | | original certification assumptions are no longer valid at the type certificated product level. |

**Figure 4. Table of example of Changes for Engines and Propellers**

**Significant Product Level Changes**

| Part 33/Part 35 | | | | |
|---|---|---|---|---|
| **Description of Product Level Change** | **21.101 (b)(1)(i) Is there a Change to the General Configuration?** | **21.101(b)(1)(i) Is there a Change to the Principles of Construction?** | **21.101(b)(1)(ii) Have the assumptions used for Certification been invalidated?** | Notes |
| **Turbofan Engines** | | | | |
| Increase/decrease in the number of compressor/turbine stages with resultant change in performance envelope | No | No | Yes | • Change is associated with other changes that would affect performance envelope and may affect the dynamic behavior of the engine<br>•<br>• |
| | | | | • |
| New design fan blade and hub that could not be retrofitted, or a fan diameter change, either of which necessitates additional major changes to the engine. | Yes | No | Yes | • Likely change in model designation<br>• Change is associated with other changes that would affect performance envelope and may affect the dynamic behavior of the engine |
| | | | | • |

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| Hydro-Mechanical to FADEC/EEC without backup | Yes | Yes | Yes | • Change in engine control configuration<br>• Likely change in model designation<br>• Not interchangeable<br>• Assumptions used for certification may no longer be valid |
| Bladed Disk to a Blisk which necessitates additional major changes to the engine | No | No | Yes | • Change is associated with other changes that would affect performance envelope and may affect the dynamic behavior of the engine |
| A change in the containment case from hard-wall to composite or vise-versa,that is not retrofittable | No | Yes | No | • Change in methods of construction that can affect inherent strength<br>•<br>• |
| Replacement of the gas generator (core) with a different one that is associated with changes in operational limitations | No | No | Yes | • Change is associated with other changes that would affect performance envelope and may affect the dynamic behavior of the engine<br>•<br>• Assumptions used for certification may no longer be valid |
| Low bypass to high bypass with an increased inlet area. | Yes | No | Yes | • Change in configuration<br>• Likely change in model designation<br>• Not interchangeable<br>• Assumptions for certification may no longer be valid<br>Note that this change is l most likely substantial under 21.19 |
| Turbojet to Turbofan | Yes | No | Yes | • Change in configuration<br>• Likely change in model designation<br>• Not interchangeable<br>• Assumptions for certification may no longer be valid<br>Note that this change is l most likely substantial under 21.19 |
| Turbo-shaft to turbo-propeller | Yes | No | No | • Change in configuration<br>• Change in model designation<br>Note that this change is l most likely substantial under 21.19 |
| Conventional to unducted fan | Yes | Yes | Yes | • Change in configuration<br>• Change in Type |

| | | | | |
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| | | | | • <br>• Not interchangeable<br>• Assumptions for certification may no longer be valid<br>Note that this change is l most likely substantial under 21.19 |
| Conventional engine for subsonic operation to after-burning engine for supersonic operation | Yes | Yes | Yes | • Change in configuration<br>• Change in Type<br>• <br>• Not interchangeable<br>• Assumptions for certification may no longer be valid<br>• Change in operating envelope<br>Note that this change is l most likely substantial under 21.19 |
| *Piston Engines* | | | | |
| Convert from Mechanical to Electronic Control System | Yes | Yes | No | • Change in engine control configuration<br>• Likely change in model<br>• Not interchangeable<br>• |
| *Add Turbocharger that increases performance and changes in overall product* | Yes | No | Yes | ♦ Likely change in model designation<br>♦ Change in engine configuration<br>♦ Change in operating envelope |
| Propellers | | | | |
| Introduction of a different principle of blade retention | Yes | Yes | No | • Change in propeller configuration<br>• Likely change in model designation<br>• Propeller's operating characteristics and inherent strength require re-evaluation |

**The following changes are Not-Significant Changes**

| Part 33/Part 35 | | | | |
|---|---|---|---|---|
| **Description of Change** | **21.101(b)(1)(i) Is there a Change to the General Configuration?** | **21.101(b)(1)(i) Is there a Change to the Principles of Construction?** | **21.101(b)(1(ii) Have the assumptions used for Certification been invalidated?** | **Notes** |

| **Turbine Engines** | | | | |
|---|---|---|---|---|
| Change in the material from metal to metal of a compressor drum | No | No | No | • No change in performance<br>• No likely change in model designation<br>• Assumptions are still valid |
| Increase/decrease in the number of compressor/turbine stages without resultant change in performance envelope | No | No | No | • No change in performance<br>• Model designation may or may not change<br>• Assumptions are still valid |
| New components internal to the FADEC/EEC the introduction of which does not change the function of the system | No | No | No | • No change in configuration<br>• Retrofitable<br>• Assumptions used for certification are still valid<br>• Possible changes in principles of construction are insignificant |
| Software changes | No | No | No | No controversy-No comments |
| Rub-strip design changes | No | No | No | Component Level Change |
| A new combustor that does not change the engine performance or dynamic behavior | No | No | No | Component Level Change |
| Bearing changes | No | No | No | Component Level Change |
| | | | | |
| New blade designs with similar material that can be retrofitted | No | No | No | Component Level Change |
| | | | | |
| Fan blade re-design that can be retrofitted | No | No | No | Component Level Change |
| | | | | |
| Oil tank re-design | No | No | No | Component Level Change |
| | | | | |
| | | | | |
| Change from one hydro-mechanical control to another hydro-mechanical control | No | No | No | Component Level Change |

| | | | | |
|---|---|---|---|---|
| Change to limits on life limited components | No | No | No | Component Level Change |
| Changes to limits on exhaust gas temperature | No | No | No | No controversy-No comments |
| Changes in certification maintenance requirements (CMR) with no configuration changes | No | No | No | No controversy-No comments |
| Bump-Ratings within the product's physical capabilities that may be enhanced with gas path changes that are limited to such changes as blade re-stagger, cooling hole patterns, blade coating changes, etc. | No | No | No | No controversy-No comments |
| **Piston Engines** | | | | |
| New or redesigned cylinder head | No | No | No | No controversy-No comments |
| New or redesigned valves | No | No | No | No controversy-No comments |
| New or redesigned pistons | No | No | No | No controversy-No comments |
| | | | | |
| | | | | |
| A change in principal physical properties and mechanics of load transfer of a material of primary structure or highly loaded components. For example, change from traditional metal to either an exotic | No | No | No | Component Level Change |

| | | | | |
|---|---|---|---|---|
| alloy or a composite material on a highly loaded component | | | | |
| | | | | |
| Changes in crankshaft | No | No | No | Component Level Change |
| Changes in crankcase | No | No | No | Component Level Change |
| | | | | |
| | | | | |
| Changes in carburetor | No | No | No | Component Level Change |
| Changes in mechanical fuel injection system | No | No | No | No controversy-No comments |
| Changes in mechanical fuel injection pump | No | No | No | Component Level Change |
| No change in principles of operation of major subsystems; no significant expansion in power or operating envelopes or in limitations | No | No | No | No controversy-No comments |
| No change in basic principles of operation, or a simple mechanical change. For example, change from dual magneto to two single magnetos on a model | No | No | No | No controversy-No comments |
| No change or a change in core engine effects of subsystem change where previous analysis can be reliably extended. For example, a change in turbocharger where | No | No | No | No controversy-No comments |

| | | | | |
|---|---|---|---|---|
| induction system inlet conditions remain unchanged, or if changed, the effects can be reliably extrapolated | | | | |
| Change in material of secondary structure or not highly loaded component. For example, a change from metal to composite material in a non-highly loaded component, such as an oil pan that is not used as a mount pad | No | No | No | Component Level Change |
| Change in material that retains the physical properties and mechanics of load transfer. For example, a change in trace elements in a metal casting for ease of pouring or to update to a newer or more readily available alloy with similar mechanical properties | No | No | No | Component Level Change |
| *Propellers* | | | | |
| Change in the material of a blade bearing | No | No | No | Component Level Change |
| Change to a component in the control system | No | No | No | Component Level Change |
| Change to a de-icer boot | No | No | No | Component Level Change |

Note 1: A determination of significance under §21.101(b)(1) has no bearing on the determination of significance relative to Part 36 noise standards.

Note 2: A change that alters performance, flight characteristics, maximum altitude, maximum airspeed, external and internal loads depend on what is being changed and defined at the product level.

## Appendix 2
## PROCEDURE FOR EVALUATING IMPRACTICALITY OF APPLYING LATEST REQUIREMENTS TO A CHANGED PRODUCT

### 1. INTRODUCTION.

This Appendix provides procedural guidance that can be used as a starting point to determine the practicality of applying a requirement at a particular amendment level to a changed product. This guidance can be used for evaluating the safety benefit and resource impact of implementing the latest airworthiness requirements in the certification basis of a changed product. The procedure is generic in nature and describes the steps and necessary inputs that any applicant can use on any project to develop a position.

a. The procedure is intended to be used, along with good engineering judgement, to evaluate the relative merits of a changed product complying with the latest regulations.

b. This procedure provides a means, but not the only means, for an applicant to present its position in regards to impracticality.

c. The certification basis for a change to a product will not be at an amendment level earlier than the existing certification basis. Therefore, when determining the impracticality of applying a requirement at the latest amendment level only the increase in safety benefits and costs beyond compliance with the existing certification basis should be considered.

d. The following are steps to determine the impracticality of applying a requirement at a particular amendment level. The first step will be to identify the regulatory change being evaluated.

Step 1: Identify the Regulatory Change Being Evaluated. In this step it will be necessary to document:

(1) The specific requirement (e.g., 14 CFR § 25.365),
(2) The amendment level of the existing certification basis for the requirement, and
(3) The latest amendment level of the requirement.

Step 2: Identify the Specific Hazard that the Requirement Addresses

(1) Each requirement and requirement amendment is intended to address a hazard or hazards. In this step the specific hazard(s) is identified. This identification will allow for a comparison of the effectiveness of amendment levels of the regulation at addressing the hazard.

(2) In many cases the hazard and the cause of the hazard will be obvious. When the hazard and its related cause are not immediately obvious it may be necessary to review the explanatory note and comment/response document to the NPA. It may also be helpful to discuss the hazard with the NAA or Joint Team.

Step 3: Review the Consequences of the Hazard(s),

(1) Once the hazard has been identified it is possible to identify the types of consequences that may occur because of the presence of the hazard. More than one consequence can be attributed for the same hazard. Typical examples of consequences would include but not be limited to:

(a) Incidents where only injuries occurred,
(b) Accidents where less than 10% of the passengers succumbed to their injuries,
(c) Accidents where 10% or more passengers succumbed to their injuries, and
(d) Accidents where a total hull loss occurred.

(4) The explanatory note and comment/response document to the NPA may provide useful information regarding the consequences of the hazard the requirement is intended to address.

Step 4: Identify the Historical and Predicted Frequency of each Consequence

(1) Another input in determining impracticality is the historical record of the consequences of the hazard that led to a requirement or an amendment to a requirement. From this data a frequency of occurrence for the hazard can be determined. It is important to recognize that the frequency of occurrence may be higher or lower in the future. Therefore, it also is necessary to predict the frequency of future occurrences.

(2) More than one consequence can be attributed for the same hazard. Therefore, when applicable, the combination of consequences and frequencies of those consequences should be considered together.

(3) The explanatory note and comment/response document to the NPA may provide useful information regarding the frequency of occurrence.

Step 5: Determine How Effective Full Compliance with the Latest Amendment of the Requirement would be at Addressing the Hazard

(1) When each amendment is promulgated it is expected that compliance with the requirement would be completely effective at addressing the associated hazard. It is expected that the hazard would be eliminated, avoided, or dealt with. However, in a limited number of situations this may not be the case. It is also possible that earlier amendment levels may have addressed the hazard but were not completely effective. Therefore, in comparing the benefits of compliance with the existing certification basis to the latest amendment level it is useful to estimate the effectiveness of both amendment levels in dealing with the hazard.

(2) It is recognized that the determination of levels of effectiveness is normally of a subjective nature. Therefore, prudence should be exercised when making these determinations. In all cases it is necessary to document the assumptions and data that support the determination.

(3) The following five levels of effectiveness are provided as a guideline.

(a) Fully effective in all cases
Compliance with the requirement eliminates the hazard or provides a means to completely avoid the hazard.

(b) Considerable potential for eliminating or avoiding the hazard
Compliance with the requirement eliminates the hazard or provides a means to completely avoid the hazard for all probable or likely cases. However it does not cover all situations or scenarios.

(c) Adequately deals with the hazard
Compliance with the requirement eliminates the hazard or provides a means to completely avoid the hazard in many cases. However, the hazard is not eliminated or avoided in all probable or likely cases. Usually this action only addresses a significant part of a larger or broader hazard.

(d) Hazard only partly addressed
In some cases compliance with the requirement partly eliminates the hazard or does not completely avoid the hazard. The hazard is not eliminated or avoided in all probable or likely cases. Usually this action only addresses part of a hazard.

(e) Hazard only partly addressed but action has negative side effect
Compliance with the requirement does not eliminate or avoid the hazard or may have negative safety side effects. The action is of questionable benefit.

Step 6: Determine Resource Costs and Cost Avoidance

(1) There is always a cost associated with complying with a requirement. This cost may range from minimal administrative efforts to the resource expenditures necessary to support full scale testing or the redesign of a large portion of an aircraft. However, there are also potential cost savings from compliance with a requirement. For example, compliance with a requirement may avoid aircraft damage or accidents and the associated costs to the manufacturer for investigating accidents. Compliance with the latest amendment of a requirement may also facilitate certification of a product by a foreign aviation Administrator.

(2) When determining the impracticality of applying a requirement at the latest amendment level only the increase in costs, and safety benefits from complying with the existing certification basis should be considered.

(3) When evaluating the cost, it may be beneficial for the applicant to compare the increase in cost to comply with the latest requirements to the cost to incorporate the same design feature in a new airplane. In many cases, an estimate for the cost of incorporation in a new airplane is provided in the regulatory evaluation by the Administrator that was presented when the corresponding regulation was first promulgated. Examples of costs may include but are not limited to:

(a) Costs

1. Labor: Work carried out in the design, fabrication, inspection, operation or maintenance of a product for the purpose of incorporating or demonstrating compliance with a proposed action. Non-recurring labor requirements, including training should be considered.

2. Capital: Construction of new, modified or temporary facilities for design, production, tooling, training or maintenance.

3. Material: Cost associated with product materials, product components, inventory, kits and spares.

4. Operating Costs: Costs associated with fuel, oil, fees and expendables.

5. Revenue/Utility Loss: Costs resulting from earning/usage capability reductions from departure delays, product downtime, capability reductions of performance loss due to seats, cargo, range or airport restrictions.

(b) Cost Avoidance

1. Avoiding cost of accidents including investigation of accidents, lawsuits, public relations activities, insurance, and lost revenue.

2. Foreign Certification: Achieve a singular effort that would demonstrate compliance to the requirements of most certifying agencies, thus minimizing certification costs.

Step 7: Document Conclusion Regarding Practicality

(1) Once the information from previous steps has been documented and reviewed, the applicant's position and rationale regarding practicality can be documented. Examples of possible positions would include but are not limited to:

(a) Compliance with the latest requirement is necessary. The applicant would pursue the change at the latest amendment level.

(b) Compliance with an amendment level between the existing certification basis and the latest amendment would adequately address the hazard at an acceptable cost, while meeting the latest amendment level would be impractical. The applicant would then propose the intermediate amendment level of the requirement.

(c) The increased level of safety is not commensurate with the increased costs associated with meeting the latest amendment instead of the existing certification basis. Therefore, the applicant would propose the existing certification basis.

(d) The results of this analysis were inconclusive. Further discussions with the JAA are warranted.

**NOTE:** This process may result in a required certification basis that renders the proposed modification economically not viable.

## 2. EXAMPLE 1: §25.963 FUEL TANK ACCESS COVERS.

a. This change is part of a significant transport airplane model change that increases passenger payload and gross weight by extending the fuselage 20 feet. The model change will feature increased thrust engines, strengthened wing and fuselage, and a completely redesigned landing gear. To accommodate the higher design weights, increased braking requirements and to reduce runway loading, the applicant will change the landing gear from a two-wheel to four-wheel configuration. The new model airplane will be required to comply with the latest applicable regulations based on the date of application.

b. The wing will be strengthened locally at the side of the body and at the attachment of engines and landing gear, but the applicant would not like to alter wing access panels and the fuel tank access covers. Although the applicant recognizes that the scatter pattern and impact loading on the wing from debris being thrown from the landing gear will change, he proposes that it would be impractical to redesign the fuel tank access covers.

c. The applicant proposes to change the landing gear from a two-wheel configuration to a four-wheel configuration. This changes the debris scatter on the wing from the landing gear.

Step 1: Identify the Regulatory Change Being Evaluated

(1) The existing certification basis of the airplane that is being changed is part 25 prior to amendment 69.

(2) Amendment 25-69 added the requirement that fuel tank access covers on transport category airplanes be designed to minimize penetration by likely foreign objects, and be fire resistant.

Step 2: Identify the Specific Hazard that the Regulation Addresses

(1) Fuel tank access covers have failed in service due to impact with high-energy objects such as failed tire tread material and engine debris following engine failures. In one accident, debris from the runway impacted a fuel tank access cover, causing its failure and subsequent fire, which resulted in fatalities and loss of the airplane. Amendment 25-69 will ensure that all access covers on all fuel tanks are designed or located to minimize penetration by likely foreign objects, and are fire resistant.

Step 3: Review the History of the Consequences of the Hazard(s)

(1) Occurrences with injuries, and with more than 10% deaths

Step 4: Identify the Historical and Predicted Frequency of Each Consequence

(1) In 200 million departures of large jets,

- 1 occurrence with more than 10% deaths, and
- 1 occurrence with injuries.

(2) There is no reason to believe that the future rate of accidents will be significantly different than the historical record.

Step 5: Determine How Effective Full Compliance with the Latest Amendment of the Regulation would be at addressing the Hazard

(1) Considerable potential for eliminating or avoiding the hazard. Compliance with amendment 25-69 eliminates the hazard or provides a means to completely avoid the hazard for all probable or likely cases. However, it does not cover all situations or scenarios

Step 6: Determine Resource Costs and Cost Avoidance

(1) Cost Avoidance:

(a) There were 2 accidents in 200 million departures. The applicant believes that it will manufacture more than 2000 of these airplanes or derivatives of these airplanes. These airplanes would average 5 flights a day. Therefore, statistically there will be accidents in the future if the hazard is not alleviated. Compliance will provide cost benefits related to avoiding lawsuits, accident investigations and public relation costs.

(b) There are cost savings associated with meeting a single certification basis for FAA and foreign regulations.

(2) Cost:

(a) For a newly developed airplane there would be minor increases in labor resulting from design and fabrication.

(b)There would be a negligible increase in costs related to materials, operating costs, and revenue utility loss.

Step 7: Document Conclusion Regarding Practicality

(1) It is concluded that compliance with the latest regulation increases the level of safety at a minimal cost to the applicant. Based on the arguments and information presented by the applicant through the issue paper process, the Administrator determined that meeting the latest amendment would not be impractical.

## 3. EXAMPLE 2: § 25.365 PRESSURIZED COMPARTMENT LOADS.

a. For the product change described in Example 1, the lengthened fuselage affects the size of the main deck passenger compartment and the lower center cargo compartment. The applicant plans to comply fully with the latest pressurized compartment loads except for one interior partition for which the applicant believes compliance would be impractical.

b. The applicant proposes to increase the length of the fuselage by installing fuselage plugs. This change affected the size of the main deck passenger compartment and the lower center cargo compartment.

Step 1: Identify the Regulatory Change Being Evaluated

(1) The existing certification basis of the airplane that is being changed includes § 25.365 at amendment 25-54. The initial release of § 25.365 required that interior structure of passenger compartments be designed to withstand the effects of a sudden release of pressure through an opening resulting from the failure or penetration of an external door, window, or windshield panel, or from structural fatigue or penetration of the fuselage, unless shown to be extremely remote.

(2) Amendment 25-54 revised § 25.365 to require that the interior structure be designed for an opening resulting from penetration by a portion of an engine, an opening in any compartment of a size defined by § 25.365(e)(2), or the maximum opening caused by a failure not shown to be extremely improbable.

(3) Amendment 25-71 extended the regulation to all pressurized compartments, not just passenger compartments, and to the pressurization of unpressurized areas. The later regulation had previously been identified as an unsafe feature under § 21.21(b)(2).

Step 2: Identify the Specific Hazard that the Regulation Addresses

(1) The hazard is a catastrophic structure and/or system failure produced by a sudden release of pressure through an opening in any compartment in flight. This opening could be caused by an uncontained engine failure, an opening of a prescribed size due to the inadvertent opening of an external door in flight, or by an opening caused by a failure not shown to be extremely improbable. The opening could be produced by an event that has yet to be identified.

Step 3: Review the History of the Consequences of the Hazard(s)

(1) Occurrences with injuries, less than 10% deaths, and more than 10% deaths

Step 4: Identify the Historical and Predicted Frequency of Each Consequence

(1) In 200 million departures of large jets,

- 2 occurrences with more than 10% deaths,

- 1 occurrence with less than 10% deaths, and
- 1 occurrence with injuries.

(2) There is no reason to believe that the future rate of accidents will be significantly different than the historical record.

Step 5: Determine How Effective Full Compliance with the Latest Amendment of the Regulation would be at addressing the Hazard

(1) Fully effective in all cases.
Compliance with amendment 25-71 eliminates the hazard or provides a means to completely avoid the hazard.

(2) Considerable potential for eliminating or avoiding the hazard.
Compliance with amendment 25-54 eliminates the hazard or provides a means to completely avoid the hazard for all probable or likely cases. However, it does not cover all situations or scenarios.

(3) Adequately deals with the hazard.
Compliance with the original certification basis eliminates the hazard or provides a means to completely avoid the hazard in many cases. However, the hazard is not eliminated or avoided in all probable or likely cases. Usually this action only addresses a significant part of a larger or broader hazard.

(4) Design changes made to the proposed derivative airplane bring it nearly into compliance with § 25.365 amendment 25-71. Analyses show that one interior partition would fail when subjected to the pressure differential defined by the latest regulation. However, its failure would not have an impact on continued safe flight and landing. This is because none of the critical or essential systems are affected by failure of this partition and its failure would not present a hazard to a crewmember. Design solutions were considered for this partition, including structural reinforcement and additional venting area, but all were found to require substantial changes. With this design the applicant believes that most of the safety benefits have been achieved and that no appreciable increase in safety would be achieved by complying fully with amendment 25-71.

Step 6: Determine Resource Costs and Cost Avoidance

(1) Cost Avoidance

(a) There were 4 accidents in 200 million departures. The applicant believes that it will manufacture more than 2000 of these airplanes or derivatives of these airplanes. These airplanes would average 5 flights a day. Therefore, statistically there will be accidents in the future if the hazard is not alleviated. Compliance will provide cost benefits related to avoiding lawsuits, accident investigations and public relation costs.

(b) There are cost savings associated with meeting a single certification basis for FAA and foreign regulations.

(2) Cost:

(a) For a newly developed airplane there would be a significant increase in costs related to labor and capital to comply with amendment 25-71 instead of the original certification basis.

(b) There would be a negligible increase in costs related to materials, operating costs, and revenue utility loss.

(c) There would be savings in both labor and capital costs if compliance were shown to amendment 25-54 instead of amendment 25-71.

Step 7: Document Conclusion Regarding Practicality

(1) The design is in compliance with §25.365 amendment 25-54, and nearly in full compliance to amendment 25-71. The design would adequately address the hazard at an acceptable cost. Therefore, based on arguments of impracticality discussed in an issue paper, the Administrator accepts the applicant's proposal to comply with §25.365 amendment 25-54.

## 4. EXAMPLE 3. § 23.562 EMERGENCY LANDING DYNAMIC CONDITION.

**NOTE:** This example is taken from a UK certification, so references are made to BCAR sections and amendments.

a. The applicant proposes to increase the length of the fuselage by installing fuselage plugs to increase passenger capacity. The general configuration is not retained because the additional fuselage length is a sufficiently large that it would invalidate the existing substantiation, or would change the primary structure, aerodynamics, or operating envelope sufficiently to invalidate the assumptions of certification.

b. The latest regulations appropriate to this class of aircraft at the date of application for approval of the modification are Part 23 (11 March 1994). The original basis of certification is BCAR Section K. Performance aspects of the later code were applied but this example covers only the (structural) dynamic seat requirements, which were not in the original certification basis of the airplane.

Step 1: Identify the Regulatory Change Being Evaluated

(1) The existing certification basis of the airplane that is being changed includes BCAR Section K. At the time of application for approval of the modification the appropriate code was Part 23 (initial issue dated 11 March 1994) which includes § 23.562.

Step 2: Identify the Specific Hazard that the Regulation Addresses

(1) The hazard is catastrophic structural failure and occupant injury/fatality associated with dynamic conditions during emergency landing.

Step 3: Review the History of the Consequences of the Hazard(s)

(1) While the service record of public transport operations of the type within the UK is known, such details of the worldwide fleet are not available. No fatal accidents have occurred on the type while operating on the UK register. Other accidents proving fatal have involved other factors such as ditching in cold water.

Step 4: Identify the Historical and Predicted Frequency of Each Consequence

(1) The type has over 30 years of operation, over 1500 aircraft have been built and the lead aircraft has over 30,000 hours. In broad terms, the type has a respectable service record in spite of being operated in a rugged environment, and capability of passenger survival passenger survival of emergency landings has been demonstrated.

(2) There is no reason to believe that the future rate of accidents will be significantly different than the historical record.

Step 5: Determine How Effective Full Compliance with the Latest Amendment of the Regulation would be at addressing the Hazard

(1) The aircraft is designed for service in a rugged environment, with good handing at low speed. Capability of passenger survival passenger survival of emergency landings has been demonstrated with the existing design and compliance with the later requirement would not eliminate the hazard.

Step 6: Determine Resource Costs and Cost Avoidance

(1) Cost Avoidance: Foreign certification agencies may find it straightforward to accept compliance with later requirements.

(2) Costs: The cost of re-designing the seats and entire fuselage to be able to withstand dynamic seat loads would be great, and the entire fuselage would be affected, as well as all of the other seats on the airplane not in the areas of the fuselage plug. Costs would include test article fabrication, test set up and execution, and reporting, plus the cost to redesign the seats and the supporting structure, and production line and jigging changes would be very large and it would no longer be possible to convert earlier variants to the later standard. The weight would also increase and this would at best reduce margins of compliance with other requirements, or at worst render this impossible.

Step 7: Document Conclusion Regarding Practicality

(1) The applicant believes that the design complies with latest BCAR requirements in this area, and while appropriate flight aspects were re-assessed to Part23, it is deemed that with respect to the dynamic seat requirements the increased level of safety may not be commensurate with the increased costs. Subsequently, the application of dynamic seat requirements as being impractical may be presented to the Administrator for consideration, provided the submission is supported by relevant cost benefit analysis.

## 5. EXAMPLE 4. § 27.561 EMERGENCY LANDING CONDITION.

a. The applicant proposes to install a rotor system that has been previously approved and certificated to Part 27 at Amendment 27-28 (equivalent to Part 27 Change 0) on a rotorcraft approved to Part 27, Amendment 27-25. This results in a rotorcraft that has a marked improvement in the overall reliability and the vibration characteristics. For marketability purposes, the applicant proposes an amendment to the type certificate with a unique model designation. The Administrator and applicant are in agreement that this is a significant change and the regulations in effect on the date of application are the appropriate basis for certification. The applicant has reviewed the proposed changed rotorcraft and has eliminated and reached agreement with the Administrator on affected and not affected areas. For the affected areas, the applicant has reviewed each regulation applicable to the affected areas and is in agreement with the Administrator that the appropriate certification basis for the changed product is the applicable regulations effective on the date of application except for the cabin area overhead crashworthy requirements.

Step 1. Identify the Regulatory Change Being Evaluated.

(1) Section 27.561. Emergency Landing Conditions, specifically § 27.561(c).

(2) The existing certification basis of the rotorcraft that is being changed is Part 27 at Amendment 25.

(3) Amendment 27- 32 increased the load factors for supporting structure above and/or behind the crew and passenger compartment.

Step 2. Identify the Specific Hazard that the Regulation Addresses.

(1) To prevent injuries to an occupant if the supporting structure above and/or behind the occupied space came loose in an emergency landing. The hazard is catastrophic structural failure and occupant injury/fatality associated with dynamic conditions during emergency landing.

Step 3. Review the History of the Consequences of the Hazard(s).

(1) Occurrences with injuries, less than 10% deaths, and with more than 10% deaths

Step 4. Identify the Historical and Predicted Frequency of Each Consequence.

(1) Notice No. 87-4, Docket No. 25287 [Federal Register: June 3, 1987 (Volume 52, Number 106)(Page 20938)] provided the following information:

> NTSB and FAA data collected between 1975 and 1979 indicated that normal category rotorcraft have 14.3 accidents per 100,000 flight hours.

(2) The Applicant believes that this rate will be lower for their rotorcraft based on their current accident data for the existing design. Additionally, the fuselage structure used for this modification has an excellent safety record and redesigning the roof structure to comply with the increased load factors for the overhead structure (main rotor) would not significantly increase the level of safety.

Step 5: Determine How Effective Full Compliance with the Latest Amendment of the Regulation would be at addressing the Hazard.

(1) The occupant survival of emergency landings has been demonstrated with the existing design and compliance with the later requirement would not eliminate the hazard.

Step 6: Determine Resource Costs and Cost Avoidance

(1) Cost Avoidance: There is little cost avoidance associated with this change in that the current configuration has an excellent safety record and it is anticipated these improvements will only enhance the safety and reliability of the rotorcraft.

(2) Cost: The additional changes to the proposed design to fully comply with Amendment 27-32 would result in a significant increase in costs related to labor and capital. Due to the added weight necessary to fully comply with Amendment 27-32 there would be an increase in operating costs and a consequent loss in revenue.

Step 7: Document Conclusion Regarding Practicality.

(1) It is demonstrated that application of the latest amendment level of Part 27 would be impractical on the following basis:

(a) Re-substantiation of the rotor and upper airframe supporting structure to the latest amendment level would require further demonstration of compliance for these components.

(b) Additional, extensive re-design and substantiation of the rotor support structure and cabin overhead structure would also be required for Part 27 at Amendment 27-32.

(c) The additional demonstration of compliance noted in 1 and 2, above, provides a minimal increase in safety to the overall rotorcraft.

(d) The increased effort required to substantiate 1 and 2 at the latest amendment of Part 27 would incur costs that would make the project economically unfeasible and would not be commensurate with the limited increase in safety to be gained.

(e) The reinforcement of the roof supporting structure would not add to the safety of the rotorcraft, as other unaffected areas of the rotorcraft remain compliant with the earlier amendment of the crashworthiness requirements.

(2) The Administrator agreed with the applicant position of impracticality.

**Appendix 3**

**THE USE OF SERVICE EXPERIENCE IN THE CERTIFICATION PROCESS**

**1. INTRODUCTION.** Service experience may be utilized to support the application of an earlier certification basis if the earlier certification basis in conjunction with the applicable service experience and other compliance measures provides a level of safety comparable to that provided by the latest requirements. It is incumbent on the applicant to provide sufficient substantiation to allow the Administrator to make this determination. A statistical approach may be used, subject to the availability and relevance of data, however sound engineering judgement must be used. For service history to be acceptable, the data must be both sufficient and pertinent. The essentials of the process involve:

a. A clear understanding of the requirement change and the purpose for the change;
b. A determination based on detailed knowledge of the proposed design feature; and
c. The availability of pertinent and sufficient service experience data.
d. A comprehensive review of that service experience data.

**2. GUIDELINES.** The Certification Review Item (CRI) procedure would be used and the applicant should provide documentation to support the following:

a. The identification of the differences between the requirement in the existing basis and the requirement as amended, and the effect of the change in the requirement.

b. A description as to what aspect of the latest requirements the proposed changed product would not meet.

c. Evidence showing that the proposed certification basis for the changed product, together with applicable service experience, provides a level of safety consistent with complying with the latest requirements.

d. A description of the design feature and its intended function

e. Data for the product pertinent to the requirement:

(1) Service experience from such sources as the following
-Accident Reports
-Incident Reports
-Service Bulletins
-Airworthiness Directives
-Repairs
-Modifications
-Flight hours/cycles for fleet leader and total fleet
-World Airline Accident Summary (WAAS) Data
-Service Difficulty Reports
-NTSB Reports
-Warranty, repair and parts usage data

(2) Show that the data presented represents all relevant service experience for the product, including the results of any operator surveys, and is comprehensive enough to be representative

(3) Show that the service experience is relevant to the issue.

(4) Identification and evaluation of each of the main areas of concern, with regard to:

-Recurring and/or common failure modes
-Cause
-Probability, by qualitative reasoning
-Measures already taken and their effects

(5) Relevant data pertaining to aircraft of similar design and construction may be included

(6) Evaluation of failure modes and consequences through analytical processes. The analytical processes should be supported by:

-A review of previous test results; and
-Additional detailed testing.

f. A conclusion that draws together the data and the rationale.

g. These guidelines are not intended to be limiting, either in setting required minimum elements or in precluding alternative forms of submission. Each case may be different, based on the particulars of the system being examined and the requirement to be addressed.

## 3. FIRST EXAMPLE: TRANSPORT AIRPLANES.

a. Transport Airplanes: § 25.1141(f) Auxiliary Power Unit (APU) Fuel Valve Position Indication

NOTE: This example is taken from a FAA certification, so references are made to aviation regulation sections and amendments.

This example comes from a new generation model transport airplane where extensive changes where made to the main airframe components, engines and systems. The baseline airplane has an extensive service history. The purpose of the example is to show how the use of service experience is used to support a finding that compliance with the latest regulation would not contribute materially to the level of safety, and that application of the existing certification basis (or earlier amendment) would be appropriate. The example is for significant derivatives of transport airplanes with extensive service history. It is provided to illustrate the process, following the guidelines in this Appendix, but does not include the level of detail normally required.

(1) The differences between the regulation in the existing certification basis and the regulation as amended, and the effect of the change in the regulation.

The existing certification basis of the airplane that is being changed is the initial release of part 25. Amendment 25-40 added the requirement §25.1141(f) that power-assisted valves must have a means to indicate to the flight crew when the valve is in the fully open or closed position, or is moving between these positions.

(2) What aspect of the latest regulations the proposed changed product would not be met.

The proposed APU fuel valve position indication system does not provide the flight crew with fuel valve position or transition indication, and therefore does not comply with the requirements of §25.1141(f).

(3) Evidence that the proposed certification basis for the changed product, together with applicable service experience and other compliance measures provide an acceptable level of safety.

The APU fuel shut off valve and actuator are unchanged from those used on the current family of airplanes, and have been found to comply with the earlier amendment 25-11 of §25.1141(f). The existing fleet has achieved approximately xx flights during which service experience of the existing design has been found to be acceptable. If one assumes a complete APU cycle, i.e. start up and shutdown for each flight, the number of APU fuel shut off valve operations would be over $10^8$ cycles, which demonstrates that the valve successfully meets its intended function and complies with the intent of the regulation. In addition, the system design for the changed product incorporates features, which increase the level of functionality and safety.

(4) A description of the design feature and its intended function.

The fuel shut off valve, actuator design, and operation is essentially unchanged, with the system design ensuring that the valve is monitored for proper cycling from closed to open at start initiation. If the valve is not in the appropriate position (i.e. closed) then the APU start is terminated, an indication is displayed on the flight deck and any further APU starts are prevented. Design improvements using the capability of the APU Electronic Control Unit (ECU) have been incorporated in this proposed product change. These design changes ensure that the fuel valve indication system will indicate failure of proper valve operation to the flight crew, albeit the system does not indicate valve position as required by §25.1141(f).

(5) Data for the product pertinent to the regulation.

An issue paper was coordinated which included data, or referenced reports, documenting relevant service experience that has been compiled from incident reports, fleet flight hour/cycle data, and maintenance records. The issue paper also discussed existing and proposed design details, failure modes, and analyses showing to what extent the proposed airplane complies with the latest amendment of §25.1141. Information is presented to support the applicant's argument that compliance with the latest amendment would not materially increase the level of safety. Comparative data pertaining to aircraft of similar design and construction are also presented.

(6) Conclusion drawing together the data and rationale.

The additional features incorporated in the APU fuel shut off valve will provide a significant increase in safety to an existing design with satisfactory service experience. The applicant proposes that compliance with the latest amendment would not materially increase the level of safety, and that compliance with §25.1141 at amendment 25-11 would provide an acceptable level of safety for the proposed product change.

## 4. SECOND EXAMPLE: ROTORCRAFT.

a. Rotorcraft Example; §29.865,Cargo Hook Installation

Step 1. Identify the change:

An applicant proposes to amend their type certificate with a new model designation for an improved version of an existing certificated rotorcraft. The new model rotorcraft will have a new and improved rotor system that includes an increase in the number of main rotor blades from three to five blades and tail rotor blades from two to five blades. Additionally, there will be a new flight deck area that include changes from analog to digital and removal of one pilot seat and pilot control system to allow more cabin space for utilization of tie down cargo. Additionally, the existing external cargo hook is replaced by an increased load capacity cargo hook. The Administrator and applicant are in agreement that this is a significant change and the regulations in effect on the date of application are the appropriate basis for certification. The applicant has reviewed the proposed changed rotorcraft and has eliminated and reached agreement with the Administrator on affected and not affected areas. For the affected areas, the applicant has reviewed each regulation applicable to the affected areas and is in agreement with the Administrator that the appropriate certification basis for the changed product is the applicable regulations effective on the date of application except for the replacement of the cargo hook.

Step 2. Identify details of the change:

Replacement installation of cargo hook with a similar hook with an increase in the load capacity still within the rotorcraft maximum gross weight. Class A, B and C load combinations. Local reinforcement of the airframe structure and attachment to accommodate the installation of the new cargo hook.
Replace primary and manual quick release systems with like systems.
Cockpit controls not affected
No flight manual changes except for max allowable hook load

Step 3. Identify the effects of the design change

Increased airframe loads
Verify flight and handling characteristics

Step 4. Identify requirements affected.

Amendment 29-12 adopted Dec. 13, 1976 revised the rule to preclude the necessity of considering the application of an external load at angles that will not be obtained in service. This cargo hook will meet the 30-degree requirements of 14 CFR part 29.865, amendments 29-12 and/or amendment 29-43.

Amendment 29-30 adopted February 12, 1990 revised the rule to allow use of a design factor less than 2.5 g's, provided the lower load factor is not likely to be exceeded by virtue of the rotorcraft characteristics and capability. This cargo hook will meet the requirements of 14 CFR part 29 (limit static load equal to 2.5g's), amendments 29-12 and/or 29-43.

Amendment 30 also requires a fatigue evaluation of the cargo attaching means if failures result in a hazard to the rotorcraft. Evaluation of available, pertinent, service data has shown that failures of the cargo attaching means have not occurred during the use of this cargo attaching means on other installations. There is no hazard to the rotorcraft in the event of a failure to any part of the cargo attaching means, as there are two independent means of releasing the load from the cargo hook thus rendering the load to be a "non-hazard". Due to the failsafe features of the design, and the maintenance instructions, no failure is deemed to pose a hazard to the rotorcraft.

Amendment 29-43 Adopted October 5,1999 revised the rule to include requirements for human external cargo and electromagnetic interference. This installation has no change to previously approved electrical features that could be influenced by EMI. The installation will not be used for human external cargo.

The replacement cargo hook will meet the requirements of 14 CFR part 29 Amendment 29-12 and partially Amendment 29-43.

Installation of external rotorcraft accessories, typically do not change general configuration or principles of construction of the rotorcraft and the assumptions used for certification of the cargo hook are still valid.

Step 5 Data for the product pertinent to the regulation.

An issue paper was coordinated which included data, or referenced reports, documenting relevant service experience that has been compiled from incident reports, accident reports, and maintenance records. The issue paper also discussed existing and proposed design details, failure modes, and analyses showing to what extent the proposed rotorcraft complies with the latest amendment of §29.865. Information is presented to support the applicant's argument that compliance with the latest amendment would not materially increase the level of safety. Comparative data pertaining to aircraft of similar design and construction are also presented.

Step 6 Conclusion drawing together the data and rationale.

The features incorporated in the cargo hook installation will provide a significant increase in safety to an existing design with satisfactory service experience. The applicant proposes that compliance with the latest amendment would not materially increase the level of safety, and that compliance with §29.865 at Amendment 29-12 would provide an acceptable level of safety for the proposed changed product.

Subsequently, the applicant requested with submission of the above data, the Administrator accept the data and make an alternate determination that the existing certification basis for §29.865 at Amendment 29-12 provides an acceptable level of safety for the proposed change.

The Administrator agreed with the applicant.