U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: CERTIFICATION MAINTENANCE REQUIREMENTS
Date: 11/28/94
Initiated by: ANM-100
AC No: 25-19
Change:

1. PURPOSE. This advisory circular (AC) provides guidance on the selection, documentation, and control of Certification Maintenance Requirements (CMR's). This document also provides a rational basis for coordinating the Maintenance Review Board (MRB) and CMR selection processes in order to minimize the impact of CMR's on airplane operators. Like all advisory circular material, this AC is not, in itself, mandatory, and does not constitute a regulation. It is issued to describe an acceptable means, but not the only means, for selecting, documenting, and managing CMR's. Terms such as "shall" and "must" are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described herein is used.

2. APPLICABLE FEDERAL AVIATION REGULATIONS. Sections 25.1309 and 25.1529 of 14 CFR Part 25 of the Federal Aviation Regulations (FAR).

3. RELATED DOCUMENTS.

a. AC 25.1309-1A, System Design and Analysis.

b. Advisory Material Joint AMJ 25.1309, System Design and Analysis.

c. AC 121-22A (Draft), Maintenance Review Board (MRB) Procedures.

d. ATA Maintenance Steering Group (MSG-3), Airline/Manufacturer Maintenance Program Development Document, available from the Air Transport Association of America, 1301 Pennsylvania Avenue, Suite 1100, Washington, DC 20004-1707.

e. AC 120-17A, Maintenance Program Management through Reliability Methods.

4. BACKGROUND. CMR's have been in use since the early 1970's, when the industry began using quantitative approaches to certify systems to the requirements of § 25.1309 and other regulations requiring safety analyses. CMR's have been established on several airplanes certified in the U.S. and in other countries, and are being planned for use on airplanes currently under development.

5. CMR DEFINITION. A CMR is a required periodic task, established during the design certification of the airplane as an operating limitation of the type certificate. CMR's are a subset

of the tasks identified during the type certification process. CMR's usually result from a formal, numerical analysis conducted to show compliance with catastrophic and hazardous failure conditions, as defined in paragraph 6b, below. There are two types of CMR's, as defined in paragraph 12 of this AC.

a. A CMR is intended to detect safety-significant latent failures that would, in combination with one or more other specific failures or events, result in a hazardous or catastrophic failure condition.

b. It is important to note that CMR's are derived from a fundamentally different analysis process than the maintenance tasks and intervals that result from Maintenance Steering Group (MSG-3) analysis associated with Maintenance Review Board (MRB) activities. MSG-3 analysis activity produces maintenance tasks that are performed for safety, operational, or economic reasons, involving both preventative maintenance tasks, which are performed before failure occurs (and are intended to prevent failures), as well as failure-finding tasks. CMR's, on the other hand, are failure-finding tasks only, and exist solely to limit the exposure to otherwise hidden failures. Although CMR tasks are failure-finding tasks, use of potential failure-finding tasks, such as functional checks and inspections, may also be appropriate.

c. CMR's are designed to verify that a certain failure has or has not occurred, and do not provide any preventative maintenance function. CMR's "restart the failure clock to zero" for latent failures by verifying that the item has not failed, or cause repair if it has failed. Because the exposure time to a latent failure is a key element in the calculations used in a safety analysis performed to show compliance with § 25.1309, limiting the exposure time will have a significant effect on the resultant overall failure probability of the system. The CMR task interval should be designated in terms of flight hours, cycles, or calendar time, as appropriate.

d. The type certification process assumes that the airplane will be maintained in a condition of airworthiness at least equal to its certified or properly altered condition. The process described in this AC is not intended to establish normal maintenance tasks that should be defined through the MSG-3 analysis process. Also, this process is not intended to establish CMR's for the purpose of providing supplemental margins of safety for concerns arising late in the type design approval process. Such concerns should be resolved by appropriate means, which are unlikely to include CMR's not established via normal safety analyses.

e. CMR's should not be confused with required structural inspection programs that are developed by the type certificate applicant to meet the inspection requirements for damage tolerance, as required by § 25.571 or § 25.1529, Appendix H25.4 (Airworthiness Limitations section). CMR's are to be developed and administered separately from any structural inspection programs.

6. OTHER DEFINITIONS. The following terms apply to the system design and analysis requirements of §§ 25.1309(b), (c), and (d), and to the guidance material provided in this AC.

For a complete definition of these terms, refer to the applicable regulations and guidance material (i.e., AC 25.1309-1A and/or the Joint Aviation Authorities Advisory Material Joint AMJ 25.1309). AC 25.1309-1A and AMJ 25.1309 are periodically revised by the FAA/JAA and are the controlling documents for definition of these terms. The terms listed below are derived from this guidance material and are included to assist in the use of this document.

a. Failure: A loss of function, or a malfunction, of a system or a part thereof.

b. Failure Condition: The effect on the airplane and its occupants, both direct and consequential, caused or contributed to by one or more failures, considering relevant adverse operational or environmental conditions. Failure conditions may be classified according to their severities as follows:

(1) Minor Failure Conditions: Failure conditions that would not significantly reduce airplane safety, and that involve crew actions that are well within their capabilities. Minor failure conditions may include, for example, a slight reduction in safety margins or functional capabilities, a slight increase in crew workload, such as routine flight plan changes, or some inconvenience to occupants.

(2) Major Failure Conditions: Failure conditions that would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions to the extent that there would be, for example, a significant reduction in safety margins or functional capabilities, a significant increase in crew workload or in conditions impairing crew efficiency, or discomfort to occupants, possibly including injuries.

(3) Hazardous Failure Conditions: Failure conditions that would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions to the extent that there would be:

(i) A large reduction in safety margins or functional capabilities;

(ii) Physical distress or higher workload such that the flightcrew cannot be relied upon to perform their tasks accurately or completely; or

(iii) Serious or fatal injury to a relatively small number of the occupants.

(4) Catastrophic Failure Conditions: Failure conditions that would prevent the continued safe flight and landing of the airplane.

c. Probability Terms: When using qualitative or quantitative assessments to determine compliance with § 25.1309(b), the following descriptions of the probability terms used in the requirement and in the advisory materials listed above have become commonly accepted aids to engineering judgment:

(1) Probable Failure Conditions: Probable failure conditions are those anticipated to occur one or more times during the entire operational life of each airplane. Probable failure conditions are those having a probability on the order of 1×10^{-5} or greater. Minor failure conditions may be probable.

(2) Improbable Failure Conditions: Improbable failure conditions are divided into two categories as follows:

(i) Remote: Unlikely to occur to each airplane during its total life but may occur several times when considering the total operational life of a number of airplanes of the same type. Improbable (remote) failure conditions are those having a probability on the order of 1×10^{-5} or less, but greater than on the order of 1×10^{-7}. Major failure conditions must be no more frequent than improbable (remote).

(ii) Extremely Remote: Unlikely to occur when considering the total operational life of all airplanes of the same type, but nevertheless has to be considered as being possible. Improbable (extremely remote) failure conditions are those having a probability of on the order of 1×10^{-7} or less, but greater than on the order of 1×10^{-9}. Hazardous failure conditions must be no more frequent than improbable (extremely remote).

(3) Extremely Improbable Failure Conditions: Extremely improbable failure conditions are those so unlikely that they are not anticipated to occur during the entire operational life of all airplanes of one type, and have a probability on the order of 1×10^{-9} or less. Catastrophic failure conditions must be shown to be extremely improbable.

d. Qualitative: Those analytical processes that assess system and airplane safety in a subjective, non-numerical manner, based on experienced engineering judgment.

e. Quantitative: Those analytical processes that apply mathematical methods to assess system and airplane safety.

7. SYSTEM SAFETY ASSESSMENTS (SSA). Section 25.1309(b) provides general requirements for a logical and acceptable inverse relationship between the probability and severity of each failure condition, and § 25.1309(d) requires that compliance be shown primarily by analysis. In recent years there has been an increase in the degree of system complexity and integration, and in the number of safety-critical functions performed by systems. This increase in complexity has led to the use of structured means for showing compliance with the requirements of § 25.1309.

a. Sections 25.1309(b) and (d) specify required safety levels in qualitative terms, and require that a safety assessment be made. Various assessment techniques have been developed to assist applicants and the FAA in determining that a logical and acceptable inverse relationship exists between the probability and the severity of each failure condition. These techniques include the use of service experience data of similar, previously approved systems, and thorough qualitative analyses.

b. In addition, difficulties had been experienced in assessing the acceptability of some designs, especially those of systems, or parts of systems, that are complex, that have a high degree of integration, that use new technology, or that perform safety-critical functions. These difficulties led to the selective use of rational analyses to estimate quantitative probabilities, and the development of related criteria based on historical data of accidents and hazardous incidents caused or contributed to by failures. These criteria, expressed as numerical probability ranges associated with the terms used in § 25.1309(b), became commonly accepted for evaluating the quantitative analyses that are often used in such cases to support experienced engineering and operational judgment and to supplement qualitative analyses and tests.

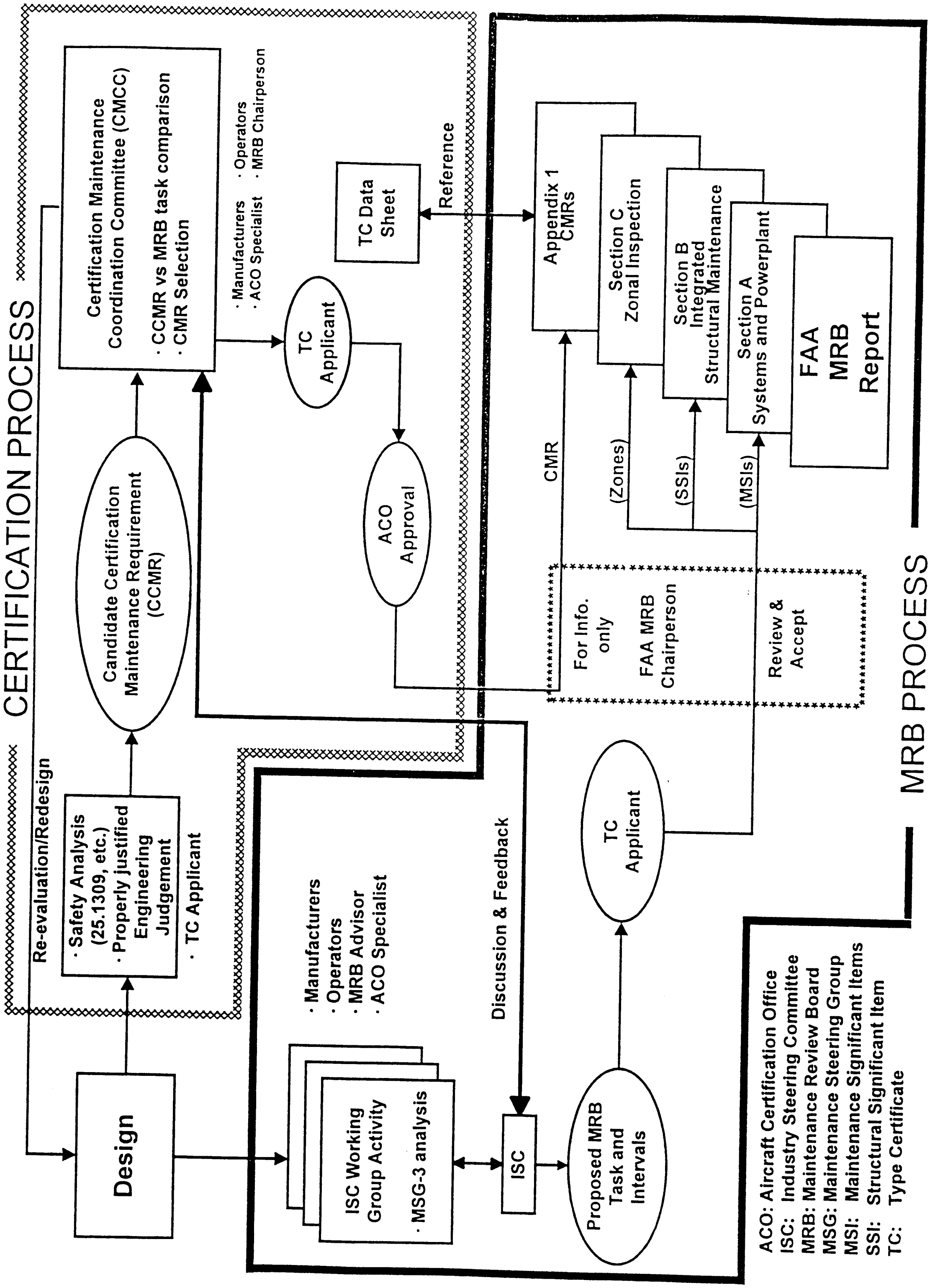
NOTE: See Advisory Circular 25.1309-1A, System Design and Analysis, for a complete description of the inverse relationship between the probability and severity of failure conditions, and the various methods of showing compliance with § 25.1309.

8. DESIGN CONSIDERATIONS RELATED TO CANDIDATE CMR's. A decision to create a candidate CMR should follow the guidelines given in AC 25.1309-1A (i.e., the use of candidate CMR's in lieu of practical and reliable failure monitoring and warning systems to detect significant latent failures when they occur does not comply with §§ 25.1309(c) and (d)(4)). A practical failure monitoring and warning system is one that is considered to be within the state of the art. A reliable failure monitoring and warning system is one that would not result in either excessive failures of a genuine warning, or excessive or untimely false warnings, which can sometimes be more hazardous than lack of provision for, or failures of, genuine but infrequent warnings. Experienced judgment should be applied when determining whether or not a failure monitoring and warning system would be practical and reliable. Comparison with similar, previously approved systems is sometimes helpful. Appendix 1 outlines some design considerations that should be observed in any decision to create a candidate CMR.

9. IDENTIFICATION OF CANDIDATE CMR's (CCMR's).

a. Figure 1 illustrates the relationship between the certification process and the MRB process in establishing scheduled maintenance tasks. Those tasks related to the certification process, as well as those derived through MSG-3 analysis, must be identified and documented as illustrated. The details of the process to be followed in defining, documenting, and handling CMR's are given in paragraphs 9b through 12 below.

Figure 1: SCHEDULED MAINTENANCE TASK DEVELOPMENT



b. Candidate CMR's.

(1) Tasks that are candidates for selection as CMR's usually come from safety analyses (e.g., System Safety Assessments (SSA), which may establish the need for tasks to be carried out periodically to comply with § 25.1309, and other requirements requiring this type of analysis). Tasks may be selected from those intended to detect latent failures that would, in combination with one or more specific failures or events, lead to a hazardous or catastrophic failure condition.

(2) Other tasks, not derived from formal safety analyses but based on properly justified engineering judgment, may also be candidates for CMR's. The justification must include the logic leading to identification as a candidate CMR, and the data and experience base supporting the logic.

10. CERTIFICATION MAINTENANCE COORDINATION COMMITTEE (CMCC).

a. In order to grant operators of the airplane an opportunity to participate in the selection of CMR's and to assess the candidate CMR's and the proposed MRB tasks and intervals in an integrated process, the type certificate (TC) applicant should convene a Certification Maintenance Coordination Committee (CMCC) (see Figure 1). This committee should be made up of manufacturers, operator representatives designated by the Industry Steering Committee (ISC) Chairperson, FAA Aircraft Certification Office (ACO) Specialists, and the MRB Chairperson.

b. As early as possible in the design phase of the airplane program, and at intervals as necessary, the CMCC should meet to review candidate CMR's, their purpose, criticality, and other relevant factors. During the CMCC's discussions, participants' experience may suggest alternatives to a given CMR that would satisfy the intent of the CMR, while allowing reduced operational impact. In addition, where multiple tasks result from a quantitative analysis, it may be possible to extend a given interval at the expense of one or more other intervals, in order to optimize the required maintenance activity. However, if a decision is made to create a CMR, then the CMR task interval shall be based solely on the results of the safety analysis.

c. The CMCC would function as an advisory committee for the TC applicant. The results of the CMCC (proposed CMR's to be included in the type design definition and proposed revisions to MRB tasks and/or intervals) would be forwarded by the TC applicant to the ISC for their consideration. Revisions to proposed MRB tasks and/or intervals accepted by the ISC will be reflected in the MRB report proposal. Revisions to proposed MRB tasks and/or intervals rejected by the ISC will result in CMR tasks. Subsequent to the ISC's consideration, the TC applicant will submit the CMR document to the responsible ACO for final review and approval.

11. SELECTION OF CMR's.

a. The candidate CMR's should be reviewed by the CMCC and a determination made as to whether or not CMR status is necessary and, if so, whether to categorize the CMR as One Star or Two Star, as defined in paragraph 12 of this AC. To reach this decision, the following should be considered by the CMCC:

(1) CMR status does not need to be applied if the CCMR is satisfied by:

(i) Maintenance actions considered to be routine maintenance activity (MRB tasks) based on engineering judgment and experience on similar airplane types; or

(ii) Tasks included in the approved Airplane Flight Manual.

(2) CMR's remaining after application of paragraph 11a(1) should be categorized as either One Star or Two Star CMR's. The following should be considered in assigning One Star or Two Star status:

(i) The degree of conservatism taken in the classification of the failure condition consequences.

(ii) The degree of conservatism taken in the individual failure rates and event occurrence rates used.

(iii) The margin between safety analysis calculated maximum interval and the interval selected through the MRB process.

(iv) The sensitivity of the failure condition probability to interval escalation.

(v) The proximity of the calculated maximum interval to the airplane life.

b. For operators with approved escalation practices or an approved reliability program, data collection and analytical techniques are used to make adjustments to an operator's maintenance program. It has been demonstrated that the management of a maintenance program does not give rise to undue escalations. Therefore, escalation of Two-Star CMR task intervals within an operator's maintenance program ensures that Two-Star CMR's will be properly managed by the operator with adequate controls.

12. DOCUMENTATION AND HANDLING OF CMR's. CMR's should be listed in a separate CMR document, which is referenced in the Type Certificate Data Sheet. The latest version of the CMR document should be controlled by an FAA-approved log of pages. In this

way, changes to CMR's following certification will not require an amendment to the Type Certificate Data Sheet. The CMR document should clearly identify the two types of CMR tasks, which are handled as follows:

a. One Star CMR's (*) - The tasks and intervals specified are mandatory and cannot be changed, escalated, or deleted without the concurrence of the responsible ACO.

b. Two Star CMR's (**) - Task intervals may be adjusted in accordance with an operator's approved escalation practices or an approved reliability program, but the task may not be changed or deleted without prior ACO approval.

c. All minimum initial scheduled maintenance tasks, and CMR's, should reside in an MRB report to ensure that the operator's maintenance planning personnel are aware of all requirements. The CMR document should be included as Appendix 1 or A (the first appendix) to the MRB report. The MRB report should include a note indicating that the CMR document is the controlling document for all CMR tasks. When a CMR task corresponds to an MRB task, whatever the respective intervals, this fact should be highlighted, for example, by flagging the task in the CMR appendix of the MRB report.

d. Since CMR's are based on statistical averages and reliability rates, an exceptional short-term extension for a single CMR interval may be made on one airplane for a specific period of time without jeopardizing safety. Any extensions to CMR intervals (both one star and two star) must be defined and fully explained in the CMR document. The local regulatory authority (e.g., a Principle Maintenance Inspector) must be notified as soon as practicable if any short-term extension allowed by the CMR document has taken place.

(1) The term "exceptional short-term extension" is defined as an increase in a CMR interval that may be needed to cover an uncontrollable or unexpected situation. Any allowable increase must be defined either as a percent of the normal interval, or a stated number of flight hours, flight cycles, or calendar days. If no short-term extension is to be allowed for a given CMR, this restriction should be stated in the CMR document.

(2) Repeated use of extensions, either on the same airplane or on similar airplanes in an operator's fleet, should not be used as a substitute for good management practices. Short-term extensions must not be used for fleet CMR escalation.

(3) The CMR document should state that the cognizant ACO must approve, prior to its use, any desired extension not explicitly listed in the CMR document.

13. <u>POST-CERTIFICATION CHANGES TO CMR's</u>. Any post-certification changes to CMR's should be reviewed by the CMCC, and must be approved by the ACO that approved the type design.

a. Since the purpose of a CMR is to limit the exposure time to a given significant latent failure as part of an engineering analysis of overall system reliability, instances of a CMR task repeatedly finding that no failure has occurred may not be sufficient justification for deleting the task or increasing the time between repetitive performances of the CMR task. In general, One- Star CMR's are not good candidates for escalation under an operator's reliability program. A One-Star CMR task change or interval escalation could only be made if world fleet service experience indicates that certain assumptions regarding component failure rates made early during the engineering analysis were overly conservative, and a re-calculation of system reliability with revised failure rates of certain components reveals that the task or interval may be changed.

b. The introduction of a new CMR or any change to an existing CMR should be reviewed by the same process used during initial certification. It is important that operators be afforded the same opportunity to participate they received during the original certification of the airplane, in order to allow the operators to manage their own maintenance programs.

c. In the event that later data provide sufficient basis for a relaxation of a CMR (less restrictive actions to be required), the change may be documented by an FAA-approved change to the CMR document.

d. If the requirements of an existing CMR must be increased (more restrictive actions to be performed), the new requirements will be mandated by an airworthiness directive (AD).

e. After initial airplane certification, the only basis for adding a new CMR is in association with certification of design changes.

f. A new CMR created as part of a design change should be a part of the approved data for that change, and added to the CMR document.

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APPENDIX 1

GUIDANCE FOR THE USE OF CMR's

The underlying goal of any system design should be an absolute minimum number of CMR's, with none as the goal. However the final determination of system design, and ultimately the number of CMR's, after safety and reliability are assured, should be based on the total cost of ownership of the system (or the airplane), with due regard to weight, reliability, initial, and recurring costs. If the cost of adding practical and reliable monitoring and/or warning to a system is large, and the added maintenance burden of a CMR is small, addition of a CMR may be the solution of choice for both the type certificate applicant and the operator.

A decision to create a CMR should include a rigorous trade-off of the cost, weight, or complexity of providing an alerting mechanism or device that will expose the latent failure, versus the requirement for the operator to conduct a maintenance or inspection task at fixed intervals. The following points should be considered in any decision to create a CMR:

a. What is the magnitude of the changes to the system and/or airplane needed to add a reliable monitoring or warning device that would expose the hidden failure? What is the cost in added system complexity?

b. Is it possible to introduce a self test on power-up?

c. Is the monitoring and warning system reliable? False warnings must be considered, as well as a lack of warnings.

d. Does the monitoring or warning system itself need a CMR due to its latent failure potential?

e. Is the CMR task reasonable, considering all aspects of the failure condition that the task is intended to address?

f. How long (or short) is the CMR task interval?

g. Is the proposed CMR task labor intensive or time consuming? Can it be done without having to "gain access" and/or without workstands? Without test equipment? Can the CMR task be done without removing equipment from the airplane? Without having to re-adjust equipment? Without leak checks and/or engine runs?

h. Can a simple visual inspection be used instead of a complex one? Can a simple operational check suffice in lieu of a formal functional check against measured requirements?

i. Is there "added value" to the proposed task (i.e., will the proposed task do more harm than good if the airplane must be continually inspected)?

j. Have all alternatives been evaluated?

*U.S. G.P.O.:1995-387-549:86