# 1. OBJECTIVE

1.1 This procedure provides guidance on the selection, documentation, and control of Certification Maintenance Requirements (CMRs).

1.2 This procedure also provides a rational basis for coordinating the Maintenance Review Board (MRB) and CMR selection processes in order to ensure that premises and assumptions made during certification system safety analyses (for support of compliance with regulatory requirements) are retained in service.

1.3 This procedure describes procedures for typical projects. Unusual or complex projects may require deviations from this procedure. Early and frequent coordination with the CAAI is critical for coordinated applicant-CAAI CMR development.

# 2. GENERAL

2.1 A CMR is a required periodic task, established during the design certification of the airplane in the Transport Category as an operating limitation of the type certificate. CMRs are a subset of the tasks identified during the type certification process.

CMRs usually result from a formal, numerical analysis conducted to show compliance with catastrophic and hazardous failure conditions, as defined below.

Compliance may also result from a qualitative engineering judgment-based analysis.

2.2 CMRs are required tasks, and associated intervals, developed to achieve compliance with US 14CFR Part 25 regulations as adopted by the Air Navigation Regulations (Procedures for Documentation of Aircraft and Aircraft Parts), 1977: § 25.1309 and other regulations requiring safety analyses (such as §§25.671, 25.783, 25.901, and 25.933). 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. A CMR can also be used to establish a required task to detect an impending wear-out of an item whose failure is associated with a hazardous or catastrophic failure condition.

2.3 CMR approval activities are part of the certification effort and are performed by personnel of the CAAI Engineering Department.

*Note: The method used by CAAI for certification and inspection activities are described in CAAI procedure ENG 1.4.029. For the method used by CAAI for MRB Procedure refer to CAAI procedure ENG 1.4.039.*

2.4 CMRs have been in use since the early 1970s, when the industry began using quantitative approaches to certify systems to the requirements of 14CFR section 25.1309 and other regulations requiring safety analyses.

2.5 It is important to note that CMRs are derived from a fundamentally different analysis process than the maintenance tasks and intervals that result from

Maintenance Steering Group (MSG) analysis associated with Maintenance Review Board (MRB) activities, if this methodology is used. 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. CMRS, 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.

2.6 CMRs are designed to verify that a certain failure has or has not occurred, and do not provide any preventative maintenance function. CMRs “restart the failure clock to zero” for latent failures by verifying that the item has not failed, or initiate 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.

2.7 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 procedure 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 CMRs 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 CMRs not established via normal safety analyses.

2.8 CMRs 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, and Appendix H25.4 (Airworthiness Limitations section). CMRs are to be developed and administered separately from any structural inspection programs.

2.9 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 procedure:

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

2.9.2 **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:

2.9.2.1 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, or some inconvenience to occupants.

2.9.2.2 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.

2.9.2.3 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:

2.9.2.3.1 A large reduction in safety margins or functional capabilities;

2.9.2.3.2 Physical distress or higher workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely; or

2.9.2.3.3 Serious or fatal injury to a relatively small number of the occupants.

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

2.9.3 **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:

2.9.3.1 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 x 10-5 or greater. Minor failure conditions may be probable.

2.9.3.2 Improbable Failure Conditions: Improbable failure conditions are divided into two categories as follows:

2.9.3.2.1 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 x 10-5 or less, but greater than on the order of 1 x 10-7. Major failure conditions must be no more frequent than improbable (remote).

2.9.3.2.2 Extremely Remote: Unlikely to occur when considering the total operational life of all airplanes of the same type. Improbable (extremely remote) failure conditions are those having a probability of on the order of 1 x 10-7 or less, but greater than on the order of I x 10-9. Hazardous failure conditions must be no more frequent than improbable (extremely remote).

2.9.3.3 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 x 10-9 or less. Catastrophic failure conditions must be shown to be extremely improbable.

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

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

2.12 **Significant Latent Failures**: A failure is latent until it becomes known to the flight crew or maintenance personnel. Significant latent failures are latent failures that would, in combination with one or more other specific failures or events, result in a hazardous or catastrophic failure condition.

2.13 **Wear out**: A condition where a component is worn beyond a pre-determined limit.

*Note: For complete definition of these terms, refer to the applicable regulations and guidance material (i.e., AC 25.1309-1 and/or the ARAC draft AC 25.1309).*

# 3. Reference Material & Forms

3.1 Reference:

3.1.1 Regulation 1 of the Air Navigation Regulations (Procedures for Documentation of Aircraft and Aircraft Parts), 1977.

3.1.2 US 14CFR (FAR) Sections 25.1309 and 25.1529.

3.1.3 European Aviation Safety Agency (EASA) Acceptable Means of Compliance (AMC) 25.1309 - System Design and Analysis.

3.1.4 ATA Maintenance Steering Group (MSG-3) - Airline/Manufacturer Maintenance Program Development Document.

3.1.5 CAAI Procedure ENG 1.4.029 – Type Certification.

3.1.6 CAAI Procedure ENG 1.4.038 – Supplemental Type Certification.

3.1.7 CAAI Procedure ENG 1.4.039 – Maintenance Review Board Procedure.

3.1.8 FAA AC 120-17A - Maintenance Program Management through Reliability Methods.

3.1.9 FAA AC 25.1309-1A - System Design and Analysis.

3.1.10 FAA AC 25-19A - Certification Maintenance Requirements.

3.1.11 FAA Aviation Rulemaking Advisory Committee (ARAC) recommended draft AC 25.1309 - Arsenal, System Design and Analysis (dated 6/10/2002).

3.2 Forms: None.

## 4. System Safety Assessment (SSA)

4.1 14CFR 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 with this section 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.

4.2 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 CAAI 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.

4.3 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 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 and the ARAC draft Arsenal AC 25.1309.*

## 5. Design Consideration of Candidate CMRs

5.1 A decision to create a candidate CMR should follow the guidelines given in AC 25.1309-1A and Appendix 1 of this procedure (i.e., the use of candidate CMRs 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)).

5.2 A practical failure monitoring and warning system is one that is considered to be within the state of the art.

5.3 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.

5.4 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.

## 6. Overview of the scheduled Task development process

The following 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 CMRs are detailed below.

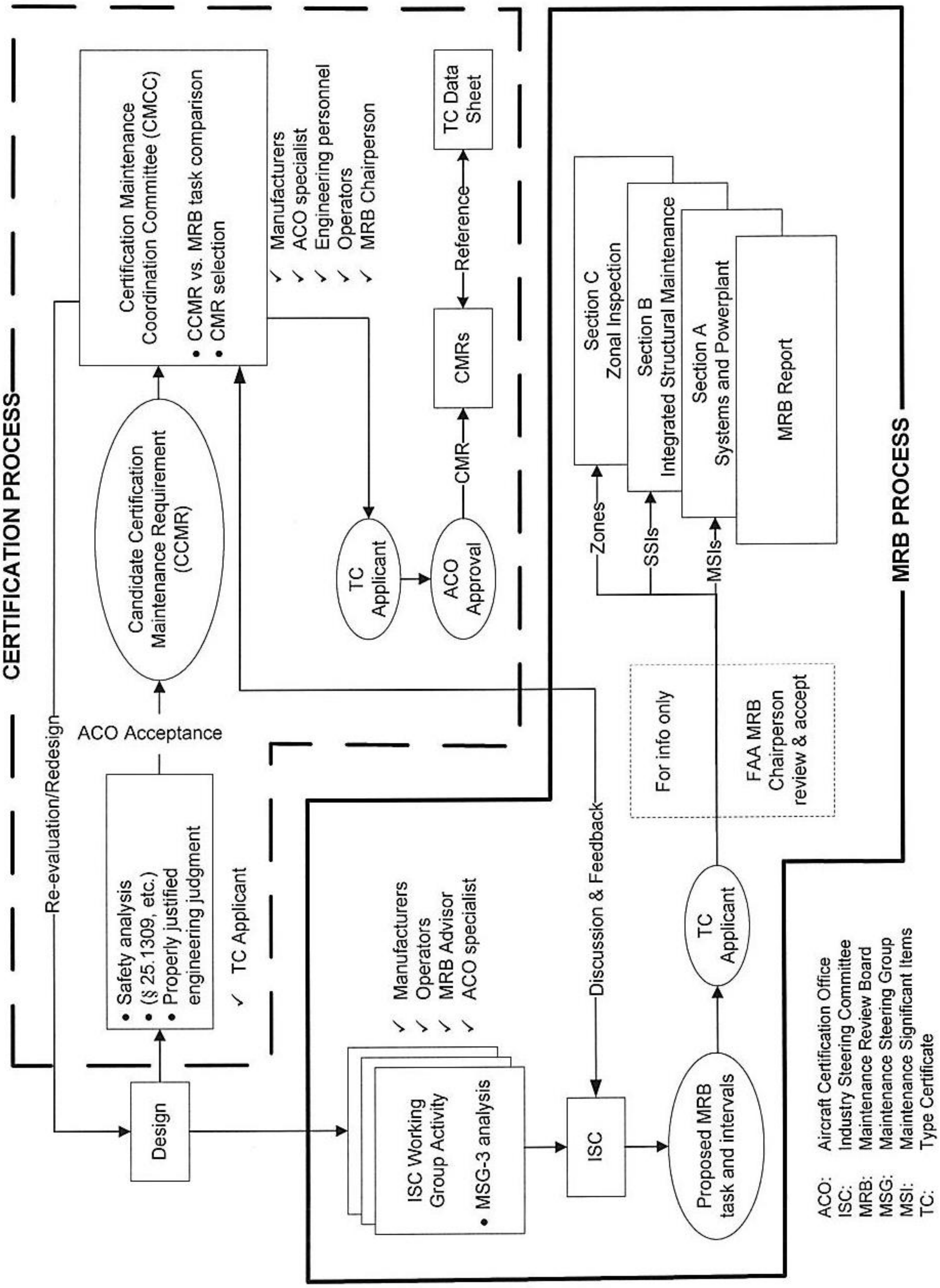


Figure 1. Scheduled Maintenance Task Development

# 7. Identification of Candidate CMRs (CCMRs)

7.1 Tasks that are candidates for selection as CMRs usually come from safety analyses (e.g., SSA), and other requirements (such as §§ 25.671, 25.783, 25.901, and 25.933). The SSA should identify as CCMRs the maintenance tasks intended to detect latent failures that would, in combination with one or more specified failures or events, lead to a hazardous or catastrophic failure condition. Tasks may also be selected from those intended to inspect for impending failures due to wear out.

The CCMR should identify the failure mode to be detected, the failure condition of concern, the check interval, and the maintenance task.

7.2 All Significant latent failures should be addressed in the SSA. In some situations, a failure condition might meet the quantitative probability objective, yet contain a component that, per the analysis, does not require inspections to meet that objective (i.e., could be left latently failed for the life of the airplane). In that situation, inspections in the life of the airplane are necessary to avoid undue exposure to catastrophic or hazardous "single failure" situations. Therefore, a qualitative assessment to determine the required maintenance before end of airplane life is necessary.

7.3 As the safety analysis may be qualitative or quantitative, some task intervals may be derived in a qualitative manner. Per the advisory material regarding 25.1309, numerical analysis supplements, but does not replace, qualitative engineering and operational judgments. Therefore, other tasks that are not derived from numerical analysis of significant latent failures, but are based on properly justified engineering judgment, can also be candidates for CMRs. The justification should include the logic leading to identification as a candidate CMR, and the data and experience base supporting the logic.

7.4 As §25.1309(b) regulates catastrophic, hazardous, and major failure conditions, CMRs may also be identified for latent failures that would, in combination with one or more specified failures or events, lead to a major failure condition that is not identified and assigned a task via the MSG-3 process. Experience has shown these cases are rare.

# 8. Certification Maintenance Coordination Committee (CMCC)

8.1 In order to grant air operators of aircraft an opportunity to participate in the selection of CMRs and to assess the candidate CMRs 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 aircraft manufacturers, potential operator representatives designated by the Industry Steering Committee (ISC) Chairperson, CAAI Engineering Department Specialists, and the MRB Chairperson.

8.2 As early as possible in the design phase of the airplane program, and at necessary intervals, the CMCC should meet to review candidate CMRs, 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.

8.3 The CMCC would function as an advisory committee for the TC applicant. The results of the CMCC (proposed CMRs to be included in the type design definition and proposed revisions to MRB tasks and/or intervals) should be forwarded by the TC applicant to the ISC for its consideration. Revisions to proposed MRB tasks and/or intervals accepted by the ISC will be reflected in the MRB report proposal, while 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 CAAI Engineering Department for final review and approval.

# 9. CMR Selection

9.1 The candidate CMRs should be reviewed by the CMCC and a determination should be made as to whether it should be a CMR. The TC applicant should provide sufficient information to the CMCC to enable an understanding of the failure conditions and the failure or event combinations that result in the CCMR. CCMRs are evaluated in the context of the failure conditions in which they are involved, e.g., whether the latent failure is part of a dual failure, or a more complex failure condition.

9.2 The CMR designation should be applied in the case of catastrophic dual failures where one failure is latent. The CMR designation should also be applied to tasks that address wear out of a component involved in a catastrophic failure condition that results from two failures. The interval for the CMR task should be chosen such that the system safety analysis assumptions are protected in service, while allowing flexibility for the airplane operators to manage their maintenance programs. In cases where the system safety analysis does not specify an interval, the CMCC may establish an interval that is less than the life of the airplane considering factors that influence the outcome of the failure condition, such as the nature of the fault, field experience, or the task characteristics.

9.3 The CMR designation may not be necessary if there is an equivalent MSG-3 task, or an approved procedure in the Flight Manual (AFM), to accommodate the CMR. The following criteria are used in making this determination:

9.3.1 The SSA allows the failure to be latent for the life of the airplane, or

9.3.2 Latent failures leaving the airplane one failure away from hazardous failure conditions, or

9.3.3 A wear out failure mode that directly or in combination with another failure, leads to a hazardous failure condition.

9.4 In all the above cases, the CCMR is satisfied by:

9.4.1 A MSG-3 task provided it meets all of the following criteria:

9.4.1.1 It is a Failure Effect Category 8 task (FEC8) for latent failure, or FEC5 task for evident failure due to wear out (See the ATA document referenced above for definitions of FEC5 and FEC8). Note that because the MSG-3 logic may not consider a failure condition containing three or more failures, it is possible that there is no MSG-3 task identified for a CCMR.

9.4.1.2 The FEC8 or FEC5 task interval is shorter than the interval that would be required for the CMR.

For example, some applicants have applied, and authorities have accepted, a factor of one half of the CMR interval as a margin to guard against potential escalation of FEC8 task intervals beyond the intervals specified by the CMR.

9.4.1.3 The applicant has procedures in place (e.g. tagging of MSG-3 tasks to identify those derived from the safety analysis) so that the FEC8 or FEC5 task would not be susceptible to escalation beyond the interval that would otherwise be required by a CMR. For example, due to difficulty in accessing the item, a task may not be conducted at the required interval. Engineering judgment indicates when a CMR is appropriate rather than a MSG-3 task.

9.4.2 Tasks covered by the approved aircraft flight manual (AFM) procedures.

9.5 In complex failure conditions (e.g., a combination of three or more failures) the SSA may identify more than one CCMR. Equivalent and compatible MSG-3 tasks (if they exist) may be used to satisfy some of those CCMRs. The rationale for the disposition of each CCMR should be presented to the CAAI Engineering Department for approval.

# 10. CMR Documentation

10.1 CMRs should be listed in a document referenced in the Type Certificate Data Sheet. CMR document revisions should be controlled by a CAAI approved log of pages. In this way, changes to CMRs following certification will not require an amendment to the Type Certificate Data Sheet. CMRs are functionally equal to Airworthiness Limitations. An acceptable means is to include CMRs in the Airworthiness Limitation Section of the Aircraft Maintenance Manual.

10.2 All minimum initial scheduled maintenance tasks and CMRs 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 the first appendix (1 or A) 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).

10.3 Since CMRs are based on statistical averages and reliability rates, an exceptional short-term extension for a single CMR interval may be made on one aircraft for a specific period of time without jeopardizing safety. Any allowable extensions to CMR intervals must be defined and fully explained in the CMR document, and require CAAI approval before implementation.

10.3.1 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. These exceptional extensions must be CAAI approved prior to implementation.

10.3.2 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.

10.3.3 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.

10.3.4 The CMR document should state that CAAI must approve, prior to its use, any desired extension not explicitly listed in the CMR document.

# 11. Post Certification Changes to CMRs

11.1 Any post-certification changes to CMRs should be reviewed by the CMCC, and must be approved by the CAAI Engineering Department.

11.2 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, a CMR task change or interval escalation could only be made if world fleet service experience indicates that certain assumptions regarding component failures rates made early during the engineering analysis were too conservative and a re-calculation of system reliability with revised failure rates of certain components reveals that the task or interval may be changed.

11.3 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 as during the original certification of the aircraft, in order to allow the operators to manage their own maintenance programs.

11.4 In the event that data provides sufficient basis for a relaxation of a CMR (less restrictive actions to be required), the change may be documented by a revision to the CMR document and approved by CAAI Engineering Department.

11.5 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).

11.6 After initial aircraft certification, the only basis for adding a new CMR is in association with the certification of design changes. A new CMR created as part of a design change should be part of the approved data for that change, and added to the CMR document.

# APPENDIX 1 – Guidance for CMR definition

1. The underlying goal of any system design should be an absolute minimum number of CMRs, with none as the goal. However, the final determination of system design, and ultimately the number of CMRs, after safety and reliability are assured, should be based on the total cost of ownership of the system (or the aircraft), 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.
2. 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:

   2.1 What is the magnitude of changes to the system and/or aircraft required to add a reliable monitoring or warning device that would expose the hidden failure?

   2.2 What is the cost in added system complexity?

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

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

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

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

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

   2.8 Is the proposed CMR task labor intensive or time consuming? Can it be done without having to “gain access” and/or without work stands? Without test equipment? Can the CMR task be performed without removing equipment from the airplane? Without having to re-adjust equipment? Without leak checks and/or engine runs?

   2.9 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?

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

   2.11 Have all alternatives been evaluated?