Defence
Safety
Authority

Structural Integrity Handbook

Guidance Document in Support of RA 5720

Military Aviation Authority

Foreword

1. This handbook provides information on the theory and practical implementation of Structural Integrity (SI) Management and its relation to the rest of the MAA Regulatory Publications (MRP). Whilst it may be used as a repository of, and guide to further reading on the processes mandated in RA 5720. The handbook is presented in a format that also permits its use as introductory reading on SI for all staff.

2. The Aim of the SI Handbook is to give individuals a foundation of understanding necessary to successfully and efficiently manage SI. The contents are not themselves mandatory, but may instead be considered as a resource for achieving compliance with the higher level criteria set by the Regulation and elaborated within its Acceptable Means of Compliance (AMC) and Guidance Material (GM).

3. No single approach will suit every air system and RA 5720 explicitly requires individuals to act on an informed assessment of the risks under consideration for their air system. Much of this handbook expands on the AMC in the RA; but where this is not the case or where there is a choice between different approaches, it may be found that a less complex or even completely novel, technique can achieve compliance with less cost or disruption than initially thought. Advice is to be sought from MAA Cert S&ADS if alternative approaches are considered.

4. This handbook is offered without prejudice to the MRP.

5. Suggestions for improvement may be sent by e-mail to:

DSA-MAA-Cert-Structures@mod.gov.uk

Or by post to:

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The need for SI

Risk to Life (RtL)

6. The consequences of structural failure are often catastrophic. Lessons learned from decades of experience, including some high profile accidents, have led the MOD to prescribe a dedicated framework to manage the risks associated with the through-life management of air system structures. The mandated Establish-Sustain-Validate-Recover-Exploit (ESVRE) approach, which has developed over many years, cuts across both Type and Continuing Airworthiness, and RA 5720 references several essential SI-related activities covered by other similarly dedicated RAs at the same time as providing overarching regulation for SI Management.

7. The MOD, like the civil world, regulates the design and maintenance of air systems and establishes limits within which they can safely be operated. Yet experience has shown that military air systems are particularly likely to experience changes in usage and operating environment and to be operated for longer than was anticipated at the design stage. Numerous case studies illustrate how failure to adequately manage all of the variables involved can exacerbate risks to air safety.

8. Duty Holders (DHs) are legally responsible for the safe operation of systems in their AoR and for ensuring RtL are at least tolerable and ALARP. Whilst support from various stakeholders is needed to manage SI, overall responsibility is assigned to the Type Airworthiness Authority (TAA). For further detail refer to RA 1210[1].

In-service life

9. The relative ease of incorporating improvements to aircraft systems means that the operational life of an air system is usually determined by SI considerations rather than by equipment obsolescence.

Cost

10. Structural inspections and monitoring can be the most costly element of a maintenance programme. Moreover, as air systems age, the need for additional directed structural inspections, sampling, teardown, and life-extending modifications will increase.

Integrity

11. The technical and organisational uncertainties associated with military aviation contribute to a complex range of hazards and have, over time, led the MOD to develop a dedicated framework for their management through-life. At root, this concerns nothing more than the efficient management of a variety of interdependent activities related to design, maintenance and operation. In the context of airworthiness, integrity management can be thought of, as a measure of risk reduction specific to these activities. The overall activity called SI is regulated in the MRP RA 5720. Similar frameworks also exist for the management of aircraft systems (RA 5721[2]) and propulsion systems (RA 5722[3]).

Definitions

12. The following key definitions, taken from MAA02[4], apply:

a. **Structure**: Aircraft structure consists of all load-carrying members including wings, fuselage (including some transparencies), empennage, engine mountings, landing gear, flight control surfaces and related points of attachment, control rods, propellers and propeller hubs if applicable and for helicopters: rotor blades, rotor heads and associated transmission systems. The actuating portion of items such as landing gear, flight controls and doors must be subject to System Integrity Management regulation (RA 5721) as well as the Structural Integrity Management regulation (RA 5720).

[1] RA 1210 Ownership and Management of Operating Risk (Risk to Life).
[2] RA 5721 Systems Integrity Management.
[3] RA 5722 Propulsion Integrity Management.
[4] MAA02: MAA Master Glossary

b. **Structural Airworthiness**: The ability of an aircraft to maintain SI without significant hazard to the aircrew, ground crew, passengers, or to the general public over whom the aircraft is flown.

c. **SI**: The ability of an aircraft structure to retain its strength, function and shape within acceptable limits, without failure when subjected to the loads imposed throughout the aircraft's service life, by operation within the limitations of Release To Service (RTS) and to the usage described in the Statement of Operating Intent (SOI) or the Statement of Operating Intent and Usage (SOIU).

Threats

13. Compromised SI may exacerbate risks to airworthiness. Any one, or combination of, the following threats can compromise SI:

a. Overload.

b. Fatigue, fretting and wear.

c. Accidental and Environmental Damage.

d. Procedural error.

Overload

14. An air system encounters overload when subjected to forces that are above the Design Limit Load (DLL) for its structure. The DLL is either the maximum and most critical combination of loads and environmental conditions likely to occur during the life of the air system or standard airworthiness specification cases that are unlikely ever to be exceeded in service. However, this may occur in extreme atmospheric conditions (gusts and air turbulence), during heavy landings, violent manoeuvring or divergent flutter. Overload may also arise because the crew or flight control system exceed RTS limitations, or if there has been an error in defining the limits themselves, and more subtly, where the design and application of repairs or modifications bring about changes to load paths or where in-service loads are not fully understood.

15. Air systems structures are designed so that there will be no permanent deformation, loss of function or necessity for repair when loaded up to the Design Proof Load (DPL). The DPL is the product of the DLL and the proof factor, which can range from 1 for a large civil type to 1.125 for a combat air system. In the case of a type with a proof factor greater than 1, an overload event may not result in permanent deformation or structural failure; however, the overload event is to be fully investigated.

16. Air systems are subject to fluctuating loads that can be categorised as either high or low cycle. Sources of these repeated loads include:

a. High Cycle: vibration caused by acoustic loading, non-divergent flutter, manoeuvre buffet, blade passing frequencies and rotating components in an air system's dynamic systems.

b. Low Cycle: manoeuvres, gusts, the ground-air-ground cycle, cockpit or cabin pressurisations, landings, retractions, taxiing, rotor start/stop, changes in engine power, thermal changes, hydraulic/fuel system pressurisation and arrester hook use.

17. Fluctuating loads can pose a threat to SI if not adequately accounted for in design. The following paragraphs describe how fatigue, fretting and wear manifest themselves from this threat.

Fatigue

18. Fatigue is applicable to both metallic and composite structures (for guidance on composite materials, see AP 101A-0601-1[5]). It is the predominant cause of catastrophic structural failure in metallic structures and is a process of progressive, permanent structural change occurring in a material subjected to fluctuating loads below its static yield strength. Fatigue damage nucleates and grows on a microscopic scale until it manifests itself as cracking; the growth of which depends on

[5] AP 101A-0601-1 - Employment and Repair of Aircraft Composite Materials

material properties and geometry, the level, amplitude and frequency of fluctuating loads and the number of load cycles applied.

19. Fatigue damage culminates in reduced residual strength of the cracked structure; if the strength of the structure is less than the applied load, it will result in fractures. It can also develop into Widespread Fatigue Damage (WFD), which is defined as the simultaneous presence of cracks at multiple structural details that are of sufficient size and density to prevent the structure achieving its residual strength requirements. The presence of multiple fatigue cracks in the same structural element is termed multiple site damage (MSD); multiple cracks in similar adjacent structural elements is termed multiple element damage (MED). Potential locations of MSD and MED are shown in the figure below.

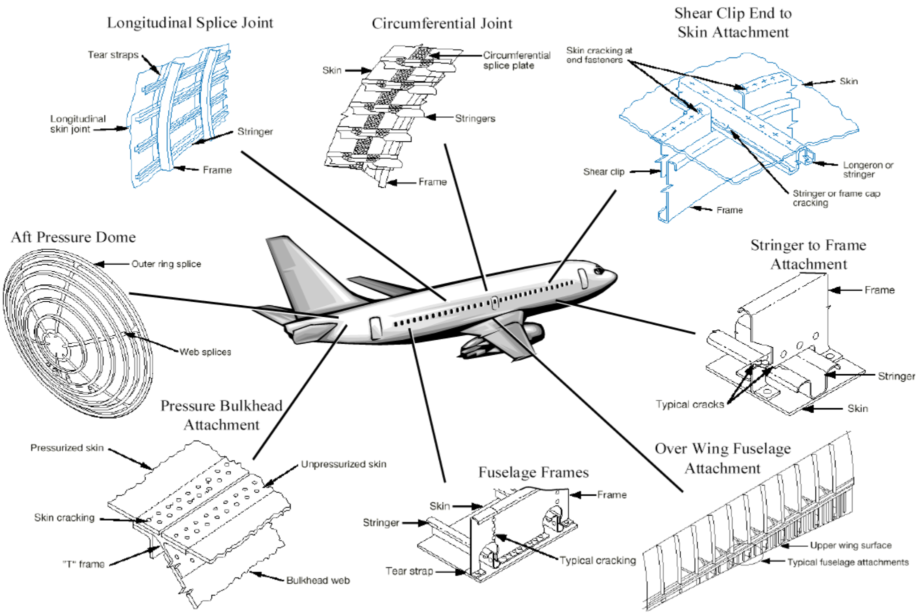

Figure 1 MSD & MED: Potential Locations

Fretting

20. Fretting is a special wear process that occurs at the contact area between two materials under load and subject to minute relative motion by vibration or some other force. In the presence of an aggressive environment, the contact movement causes wear and material transfer at the surface, often followed by oxidation of the debris and the freshly exposed surface. The oxidised debris can further act as an abrasive and such degradation is termed fretting corrosion. Fretting increases the threat of initiating fatigue cracking. This can result in so-called fretting fatigue.

Wear

21. Wear (or erosion) is the undesired cumulative change in dimensions brought about by the gradual removal of discrete particles from contacting surfaces in relative motion, usually sliding, predominantly as a result of mechanical action. Wear is not a single process, but a number of different processes that can take place independently or in a combination, resulting in material removal from contacting surfaces causing dimensional reduction through a complex combination of local shearing, ploughing, gouging, welding, tearing and other actions. The outcome of wear may result in the cumulative loss of material, and ultimately structural failure, when the residual strength of the structure falls below the applied load.

Accidental Damage (AD)

22. This is the physical alteration of an item (or its surface protection where applicable) caused by contact, impact or interaction with an object which is not a part of the air system, or by human error during manufacture, operation or maintenance of the air system. Typically AD may be caused by external impact in the air (for example: mid-air collision, bird strike, wire strike, lightning strike, severe hail, weapons release self-damage or ricochet damage) or on the ground (such as Foreign Object Damage, maintenance activities, ground handling, freight loading or vehicle movements).

23. Less obvious internal AD may arise from occupant/maintainer accidents or from overheating metallic or composite structure. AD may manifest itself as distorted, torn, punctured or otherwise distressed structure or surface protection, or as delamination or disbonding, or in less visible forms such as a change in metal heat treatment condition or 'barely visible impact damage' to composite materials such as fibre-reinforced plastics. In addition, battle damage or sabotage, although not strictly accidental, may also be considered within this category, as the effects are comparable.

Environmental Damage (ED)

24. ED is the physical degradation of structural material properties as a result of their interaction with the climate or environment. Structurally significant ED is normally caused by chemical interaction, erosion, fluid/gas absorption, thermal cycling or electro-magnetic radiation. ED may manifest itself as corrosion, stress-corrosion cracking, loss of surface finish, softening of composite material matrices (including adhesives used in laminated wood), delamination or disbonding resulting in degradation of static, fatigue or impact strength properties. For further guidance on ED refer to RA 4507[6].

Procedural

25. Errors can be the result of design, manufacturing, maintenance or supply errors.

Design

26. Design errors can result from failure to adhere to recognised design standards, design best practice and qualification evidence methodology. Examples of design error include:

a. Underestimating local loads or overestimating of material properties.

b. Not addressing the potential for incorrect assembly.

c. Specifying inappropriate material and manufacturing processes.

Manufacturing

27. Manufacturing error applies to structure or an individual structural component that fails to meet the design specification. Factors leading to manufacturing error include failure to adhere to specified manufacturing drawing requirements and processes, such as:

a. Use of incorrect material.

b. Application of incorrect heat treatment.

c. Incorrect dimensioning and feature (such as holes) location.

d. Use of unauthorised or inappropriate jigs, fixtures and tooling.

Maintenance

28. Maintenance error describes an unsound maintenance process on an air system's structure. Factors leading to maintenance errors that threaten SI may include:

a. Inadequate training or supervision.

b. Inadequate resources.

c. Incorrect technical information.

Supply

29. Supply error describes the release of a component or product that does not meet the air system's current structural design specification. Factors leading to supply errors may include non-conforming components or products, those from an unknown pedigree, those from unapproved suppliers and those that are incorrectly identified or codified.

[6] RA 4507 Aircraft Environmental Damage Prevention and Control.

Establish-Sustain-Validate-Recover-Exploit (ESVRE)

30. The 5 activities within the acronym ESVRE cover the process of SI Management and represent the framework identified by the MOD as best suiting the variety of air system and procurement models represented on the Military Aircraft Register (MAR). ESVRE is intended to be as applicable to a future fighter bought from the US as to a home-grown Remotely Piloted Air System (RPAS) or a historic helicopter[7]. It is not a purely chronological framework and aspects of each ESVRE section may require action at various stages of an air system's life, as shown below.

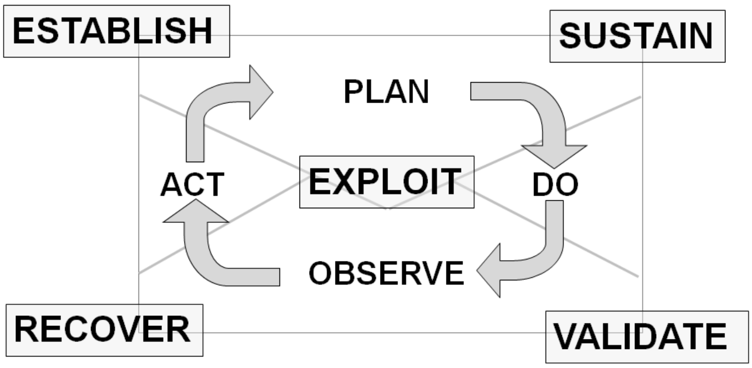

Figure 2 The ESVRE concept

31. RA 5720, which is aligned with ESVRE, is the descendant of a long series of publications and guidance that developed alongside the UK military's growing knowledge and experience in dealing with structures issues first fatigue monitoring, then corrosion control, Operational Loads and Usage Validation, structural sampling, ageing etc.

32. A great deal of this experience is also embodied in the set of standards for design and airworthiness known as Def Stan 00-970, which appeared in its earliest form in 1916. Applicants for a Military Type Certificate (RA 5810[8]) or a Change in Type Design (RA 5820[9]) are required to demonstrate compliance of Type Designs to this, or to an appropriate and equivalent, standard. Much of the initial evidence for SI is obtained during the development phase of a project, usually to support certification and qualification.

33. Fatigue testing may continue for some time after the air system enters service, to achieve full structural clearances. During the development phase, the nature and frequency of structural inspections and monitoring that will be necessary to maintain the fleet through life will also be determined.

34. Once the air system is in service, the operating conditions, usage and configuration on which the Designer based their decisions during development may change. The implications of any changes are assessed and SI evidence (usually kept in the static and fatigue Type Records) updated throughout the life of the air system type.

35. The work to gather initial SI evidence is classed as an **Establishing** activity. The actions to maintain SI through life and act on any changes to usage and operation are **Sustaining** and **Validating** activities, respectively.

36. Structural damage can be caused by any of the threats to SI or combinations thereof. More generally, failure to carry out adequate SI Management, eg Structural Configuration Control (SCC) or Usage Monitoring may undermine confidence in SI. **Recovering** activity, which may range from simple component exchange to a full Design Organisation (DO) repair or the retirement of the air system, will be required.

37. Occasionally, additional activity is needed to safely **Exploit** the inherent capabilities of the structure, to extend the Out-of-Service Date (OSD) (RA 5725[10]), for example.

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[7] 'Developing Issues in Aircraft Structural Integrity', Wg Cdr Ron Eckersley.
[8] RA 5810 Military Type Certificate (MRP 21 Subpart B).
[9] RA 5820 Changes in Type Design (MRP 21 Subpart D).
[10] Refer to RA 5725 Out of Service Date Extension Programme.

38. The crucial role played by the DO at each stage of ESVRE is explicit in RA 5720. It is not, however, limited to generating, maintaining and updating the evidence record through life. It is essential that contractual arrangements allow for the DO's participation in the exchange of information that is fundamental to in-service SI Management, such as attendance at working groups, upkeep of Usage Monitoring systems or reassessment of component lives in response to changes in air system usage.

39. It was stated earlier that the TAA is ultimately responsible for ensuring that all of these activities are carried out – this is reflected in the wording of RA 5720 – the figure below illustrates the importance of contributions from other stakeholders to achieving SI.

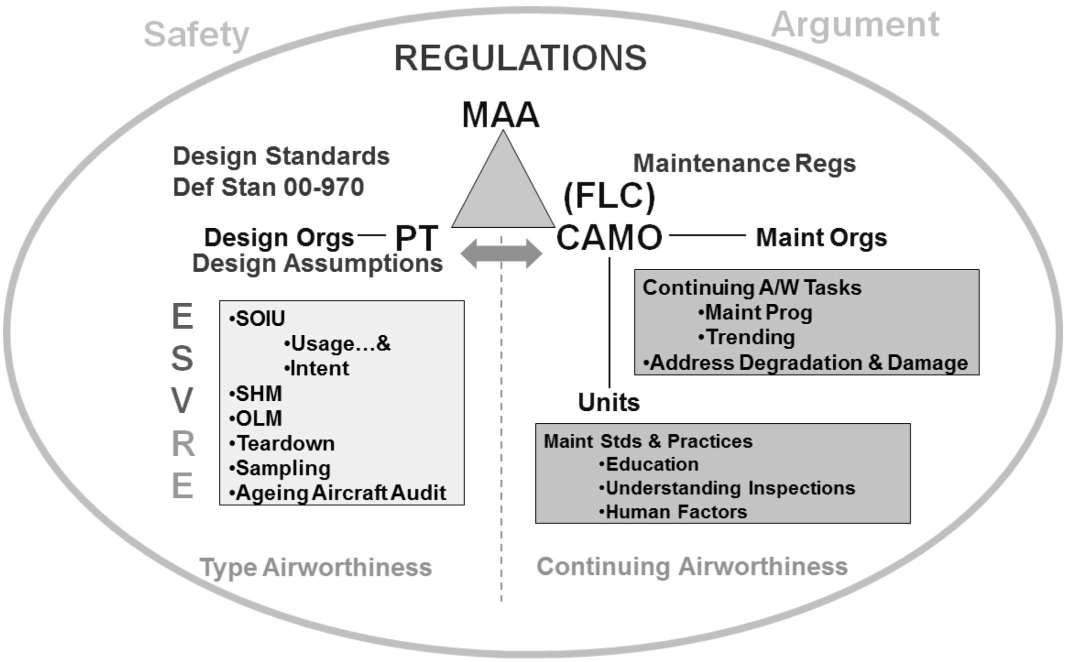

Figure 3 ESVRE in the context of Air Safety

Timing

40. Measures to assure SI are to be planned in advance and included in the air system Through Life Management Plan (TLMP), and also in any project whole life cost forecasts. Adequate funding is key to supporting the air system's SI Strategy throughout the anticipated service life of the air system.

Classification of structure

41. An air system's structure comprises assemblies, components and features (elements and details) that have traditionally been classified according to their relative contribution to the function or residual strength of their higher assembly. Various terms such as Primary Structure, Class 1 Structure, Vital Parts or 'Grade A' Parts, Principal Structural Element (PSE), Airworthiness Limitation Items, Structural Significant Items (SSIs) and Safety of Flight Structure have been used. There is no universally accepted method for selecting or identifying important structure, or commonly accepted interpretation of 'critical' or 'significant' in this context. Nevertheless, SI can be established only when all items whose failure would have an unacceptable impact on the structural airworthiness of the airframe as a whole are identified, assessed and recorded in documents that are maintained and accessible to SI stakeholders. Such items of structure are defined in the following paragraphs.

42. An SSI is defined in MAA02**Error! Bookmark not defined.** *'any detail, element or assembly, which contributes significantly to carrying flight, ground, pressure or control loads and whose failure could affect the SI necessary for the continued safe and controlled flight of the aircraft.'*

43. Selection of SSIs is pivotal to the derivation of the Preventive Maintenance programme by such methods as the Operator/Manufacturer Maintenance Development Processes, as developed by the Maintenance Steering Group Task Force (currently known as MSG-3) and published by the Air Transport Association of America[11] and Reliability Centred Maintenance (RCM) published within JAP (D) 100C-22[12]. The characteristics of SSIs have to be assessed in terms of their sensitivity and vulnerability to the threats to SI. The characterisation of Safe Life or Damage Tolerant SSIs is dependent upon a fatigue damage assessment.

SSI classification by design philosophy

44. Safe Life (specifically, either Stress Life or Strain Life) is a design philosophy that establishes a finite service life within which the probability of fatigue cracks developing and compromising residual strength is acceptably low. Safe Life SSIs are those items of structure designed to have a fatigue life at least as long as the in-service life of the air system, or those where application of a Damage Tolerant approach is not possible.

45. The Safe Life is qualified by test and analysis; Safe Life SSIs are subject to an analysis of their vulnerability to AD and ED during development of a Preventive Maintenance programme. This analysis is essential because the life of an SSI can be adversely affected by both AD and ED and thus occurrence of these threats is detected by an appropriate inspection regime.

46. Damage Tolerance (Fail Safe/Flaw Tolerant) is a design philosophy which leads to a structure that can retain the required residual strength for a period of use after the structure has sustained specific levels of detectable fatigue damage, AD or ED. Airworthiness of Damage Tolerant structure is therefore assured by a specified inspection regime. Damage Tolerant SSIs are subject to a fatigue assessment as well as AD and ED analyses.

Evidence record

47. Air systems accepted into UK military service may be designed to satisfy one of a number of different design requirements or standards, such as Def Stan 00-970, or international military or civil standards. Notwithstanding the wealth of evidence required for certification and qualification of the air system structure, the minimum evidence required to sustain the management of the air system throughout its service life is usually summarised in the static and fatigue evidence document set.

48. Static qualification evidence is usually found in the form of a Static Type Record (STR), or equivalent document. Whether an air system type is procured in accordance with the 5000 series RAs or some alternative acquisition management standard or procurement model, a Type Record is the ideal vehicle for the collation and summary of static strength evidence.

49. An STR or equivalent document comprises a general arrangement and description of the air system, a summary of static design assumptions and criteria, a summary of critical loading, shear force, bending moment, torque and mass distributions, and a summary of static reserve factors. The static evidence contains all the relevant supporting stress and test reports and calculation files. For modern designs, evidence may have been obtained from aerodynamic and loads models (such as Finite Element Models) and so it is necessary that these models should be maintained and updated through life, in the same manner as the static evidence document itself. The scope of the static evidence document, in terms of the structural components involved, includes all SSIs.

50. Fatigue qualification evidence, usually in the form of a Fatigue Type Record (FTR) or equivalent document, is mandated for air systems designed to Def Stan 00-970 and is recommended by RA 5309[13]. Notwithstanding how an air system type has been procured, a FTR or equivalent document is the ideal vehicle for the collation and summary of fatigue qualification evidence to support the DH-facing Safety Assessment for RTS and sustain SI.

51. For multi-national or off-the-shelf designs, for both the static evidence and fatigue evidence, it may be possible to develop a multi-national fatigue evidence document or to adapt existing

[11] Now known as "Airlines for America" (A4A) as of 1 Dec 2011
[12] Refer to JAP (D) 100C-22 Guide to Developing and Sustaining Preventive Maintenance Programmes.
[13] Refer to RA 5309 Fatigue Type Record for Aircraft.

evidence to fulfil the STR/FTR requirements. However, in due course it will be necessary to develop a national fatigue evidence document to reflect the UK military as-flown usage and configuration as it develops and diverges from that of other operators.

52. The initial issue of a FTR or equivalent document generally consists of a single Part 1 (see RA 5309(1)) that comprises a statement of the fatigue principles used and a summary of fatigue and/or Damage Tolerance analyses for each item of structure. As with the static evidence document, the FTR also lists all relevant reports and may be supported by computer models.

53. Furthermore, because both usage and fatigue evidence evolve significantly over the life of a type, the fatigue evidence is to incorporate additional sections, in accordance with RA 5309:

a. A historical record of the fatigue substantiation for the aircraft.

b. A reassessment in light of service usage and fatigue test results.

c. A reassessment of inspection requirements shown to be necessary by (b).

d. A life extension document (as required).

54. SI requirements must be considered during certification activities so that applicable evidence can be captured within the Structural Integrity Strategy Document (SISD) / Platform Integrity Strategy Document (PISD) dependent on local requirement.

55. Load models, including computer modelling, are to be substantiated by test evidence and verified by an Independent Technical Evaluator (ITE) as part of certification and qualification activities.

56. Resourcing and tasking of DO support is needed to support certification (in accordance with the Military Air Systems Certification Process (MACP)) and through-life SI management. RA 5810[10] and RA 5820[11] contain regulation concerning the MACP.

57. Adequate arrangements are to be made with appropriate organisations to support computer models used to generate qualification evidence. These are then available and maintained in a usable state for the life of the platform.

58. Review of structural qualification evidence: Both the static and fatigue qualification evidence will initially have been compiled during the design and qualification of an air system type, as SI Establishing activities. However, as the as-flown configuration and usage diverge over time from that assumed during design, and as information becomes available from any on-going testing and SOIU review/Operational Loads and Usage Validation, it will become necessary, progressively, to update the qualification evidence documents.

59. Repairs, modifications or changes in usage or configuration may invalidate the original qualification. In order to assure the continued airworthiness of the fleet, there is an on-going requirement to validate and update the structural qualification evidence against measured loads data and other relevant information. The Delivery Team (DT) ensures that the DO is tasked to review and update the qualification evidence whenever it may be invalidated.

Structural Examination Programme

60. Once an air system enters service, its structure is subjected to the four main groups of threat to SI. For all SSIs, with the current state of technology, the only counter to AD/ED is to examine for and repair any damage. Furthermore, safe lives and Damage Tolerance examination thresholds and intervals are based on analysis and/or testing of structure that has not been exposed to AD/ED. Therefore, there is a need to examine for AD/ED to ensure that occurrences of these do not invalidate fatigue and Damage Tolerance clearances. In addition to the examinations for AD/ED that may be necessary for both Safe Life and Damage Tolerant structure, Damage Tolerant structures rely on examinations for cracks to counter the threat posed by fatigue (in contrast to Safe Life structures, which are not examined for fatigue cracking per se). For all structures, therefore, a Structural Examination Programme (SEP) is required.

61. The SEP is accomplished through the structures-related parts of flight servicing and scheduled maintenance procedures, and through structural sampling and teardown. In the context of the ESVRE framework, the structural elements of flight servicing and scheduled maintenance are

Sustaining activities. Structural sampling and teardown are Validating activities; see RA 5720(4). Furthermore, as air systems age, the likelihood of interaction between the different threats to SI increases. DTs ensure that procedures are in place to identify the interaction of these threats in order to enable appropriate action to be taken – see RA 5723[14]. An effective SEP, supported by structural sampling, is a key element that enables the early identification of likely threats.

62. Each SSI can be characterised in terms of its fatigue or Damage Tolerance clearance, based on the original design philosophy and will be either Safe Life or Damage Tolerant. For Safe Life components the life is determined so that the component is retired before fatigue cracks are likely to have compromised residual strength. For Damage Tolerant components, testing will have shown when a fatigue crack is likely to develop and how long the crack will take to reach a critical length. The likely time of crack initiation will determine when in the air system's life the Damage Tolerance inspections start (the examination threshold), while the rate of propagation determines the inspection periodicity.

Maintenance Schedules

63. In parallel with the above characterisation, each SSI is also assessed for its vulnerability and susceptibility to AD/ED. This is normally carried out as part of the Maintenance Schedule development process. However, typical Maintenance Schedule development processes, such as RCM or MSG-3, commonly only deal with AD or ED mechanisms acting independently. It is therefore necessary to consider the vulnerability and susceptibility of each SSI to the interaction of AD and ED (for example, the onset of corrosion following impact damage causing the breach of a corrosion protection coating) and to the interaction of AD and ED with fatigue or static loading (for example, stress-corrosion cracking or corrosion-accelerated fatigue), even though this may not be accounted for by the RCM process. The result of the assessment of vulnerability and susceptibility to AD/ED is to designate each item as either At Risk (AR) or Not At Risk (NAR) of AD/ED.

64. The Maintenance Schedule review process identifies which SSIs are AR. These items are then included in the Master Maintenance Schedule (MMS) and marked as SSIs to ensure they are examined at a suitable frequency to detect AD or ED before it becomes a hazard to SI.

65. For Safe Life items that are NAR, and Damage Tolerant items with a long threshold before inspections begin, it is possible that they may not have been included in the MMS. Therefore, to maintain SI for those items, it is necessary to validate the assumptions that led to determination of the item being NAR and determination of the Safe Life or the Damage Tolerance examination threshold. This is achieved by carrying out sample checks of the items before they reach the end of their Safe Life or first Damage Tolerance inspection. Consequently, DTs should ensure that the SSI list is cross-referred to the MMS and that SSIs that are not included in the MMS are subject to structural sampling to confirm that they do not suffer from AD, ED or fatigue damage earlier than expected.

Structural Examination – Reporting

66. The results of the Maintenance Schedule review process are promulgated in a Topic 5V (Sampling Requirements and Procedures) or equivalent, which lists all SSIs (both AR and NAR) and states the means by which they are to be examined. The list of SSIs is supported by the use of diagrams, drawings or photographs as appropriate. The Topic 5V also specifies the method for recording the result of each examination and feeding back this information to the DT; positive and negative reporting is always required to enable the DT to ensure SI is maintained.

67. The use of omnibus reporting for inspected SSIs where no structural problems are found may be considered, with detailed reporting only when a structural arising is found. The DT ensures that the inspection results are analysed to determine whether SI or availability is being compromised and whether Recovering action is required. Furthermore, the results are utilised in Maintenance Schedule reviews and Continued Airworthiness activities. The Topic 5V examinations are called up in the Topic 5A1 or equivalent Maintenance Schedule as SSI-coded activities and cross-referred or hyperlinked to the Topic 5V entry.

[14] Refer to RA 5723 Ageing Aircraft Audit.

68. For Safe Life structures, the threat posed to SI by fatigue is addressed by retiring individual airframes or major components before their probability of failure reaches an unacceptable level (typically higher than 1 in 1000). The Safe Life is derived by applying a statistical scatter factor to the predicted life (from testing or analysis), hence Safe Life methods result in the majority of structures being retired before any fatigue cracks are likely to have reached the point where the residual strength is compromised.

69. For Damage Tolerant (examination-dependent) structures, the threat posed to SI by fatigue is addressed by examining the structure for cracks. The examination threshold for Damage Tolerant structure will be defined by the DO and may be the point at which cracking is predicted to be detectable, by the selected inspection technique; which is then repeated at the prescribed inspection interval.

Statement of Operating Intent (SOI) and Usage (SOIU)

70. The SOI is the means by which the UK Services' future operating intent for a particular air system type and major mark are conveyed formally to the DO. The DO may use the information in the SOI as the basis for deriving a Design Usage Spectrum (DUS) for underpinning fatigue and Damage Tolerance clearances and associated inspections.

71. The SOI is part of the Air System Document Set (ADS) and its production is mandated for all UK military air systems. It is published as the Topic 15S within the ADS and at the earliest opportunity, but no later than the ISD.

72. The SOIU replaces the SOI when the air system has accumulated sufficient representative in-service usage data, normally within 3 years of the ISD. The SOIU describes and quantifies actual usage over a period of time including intended future air system usage.

73. SI can be highly sensitive to changes in air system usage. Continued Airworthiness assurance therefore requires regular reviews of air system usage. The SOIU formally conveys this data to the DO so that it can be analysed in comparison with original or extant usage assumptions and the implications fed into revised fatigue and damage-tolerance inspection thresholds.

74. The SOI/SOIU must be reviewed annually to check its continued validity and triennially to carry out a quantitative update, including fleet fatigue and usage data derived from Individual Air System Tracking (IAT) including but not limited to: Manual Data Recording Exercise (MDRE) , Health and Usage Monitoring Systems (HUMS), Fatigue Data Recorder (FDR), Aircraft Data Recorder (ADR), etc. The Aircraft Usage Validation Process[15] (AUVP) is the primary source of further detailed guidance on SOI and SOIU creation and the SOIU review cycle.

Usage Monitoring

75. For both Safe Life and Damage Tolerant structures, Usage Monitoring through IAT is necessary to manage the timing of either the examination or retirement of individual airframes, as appropriate. These monitoring systems have therefore been developed to identify when SSIs are to be examined or retired, as appropriate. These systems vary in the metrics used and their complexity and may include:

a. Structural Health Monitoring.

b. Health and Usage Monitoring Systems.

c. Fatigue meter and fatigue meter formula (FMF).

76. In this context, it is important to note that Usage Monitoring for IAT is primarily used only to address the threat to SI posed by fatigue. Some usage monitoring systems do have the additional ability to monitor flight parameters for potential overload conditions.

77. Fatigue lives can be dominated by high-frequency, cyclic stresses in structure. It increases with the magnitude of the stress cycle and accumulates with each application, eventually leading to initiation and growth of cracks. The severity of individual manoeuvres directly affects the fatigue consumption of components. Gentle handling should be encouraged, unless operational circumstances dictate otherwise. Excessive vibration can cause an increase in fatigue damage

[15] On the MAA website under Certification, Integrity Management, AUVP

rates and necessitate structural repairs eg fatigue damage to helicopter rotors can be reduced by avoiding a complete shutdown of the rotor during sorties.

78. Certain operational environments and roles can cause high rates of fatigue damage in excess of those suffered by the majority of a fleet. Air Staff and DTs should carefully consider the regular transfer of air systems between various roles and environments to avoid high rates of fatigue damage being concentrated upon a limited number of air systems.

79. Good practice requires a system to be in place for usage data capture and computation (either by internal agencies or external contractors), for managing overall fleet usage, for monitoring individual air system usage against safe lives or examination thresholds and intervals, and for sponsoring changes to Usage Monitoring, data capture and computation systems as and when required. Data is to be entered promptly onto electronic systems or forwarded to the appropriate agency, as directed by the DT.

80. The output of IAT systems is flight by-flight and component-by-component cumulative life data, which is used to manage examination, replacement, modification or retirement as appropriate to the individual air system/component and fatigue design philosophy. This data is therefore essential to fleet management and to allow interchangeability of lifed components. For a Safe Life airframe, the rate of consumption of fatigue life will determine the ability of the fleet to reach its OSD and the need for a life extension programme (LEP) should one be required. For a Damage Tolerant design, the rate of consumption of fatigue will determine the examination burden; this may necessitate supplemental structural examinations for very high-life air systems and will determine the economic life of the fleet. Aircraft certified to Civilian Standards (CS), will have to assess the Limit of Validity (LOV). The LOV is the period of time, expressed in appropriate units eg. Flight Hours, for which is has been shown that the established inspections and replacement times will be sufficient to allow safe operation, and in particular, to preclude development of WFD.

81. It is important for the DT to manage the consumption of fatigue to achieve the defined OSD. Occasionally, therefore, it may be appropriate to determine and promulgate a usage budget to individual air systems in conjunction with the Release to Service Authority (RTSA) and the Duty Holder (DH), where differences in operation from the rest of the fleet are significant, eg dual control or specially instrumented air systems used for trials or training exercises.

82. Modification or refurbishment programmes to mitigate fatigue can be initiated where necessary to maintain or enhance capability, achieve target OSD, or extend life (see RA 5724[16] and RA 5725).

83. The DO responsibilities are:

a. Specify for each SSI the usage parameter to be used and either the Safe Life or the Damage Tolerance examination threshold and interval, in terms of the appropriate usage metric.

b. Provide the Usage Monitoring system and implement changes to it as required.

84. Most Helicopters are fitted with Health and Usage Monitoring Systems (HUMS) in accordance with RA 4500[17] and there are opportunities for exploiting data from these systems in the IAT role. Helicopters which spend more time in unusually biased or severe flying conditions (eg heavy lift operations or mountain flying) may also load parts of the structure or rotating components considerably more severely than in the Designer’s assumptions. Unmonitored, such unusual usage could lead to structural failure of a rotating component before the predicted Safe Life has been reached. For this reason, fleet managers at all levels are to ensure that wherever possible, individual air systems experience as wide a range of roles as possible. Should it be necessary, through modification or location, to limit an airframe to one type of flying only, details are to be brought to the attention of the Designer in order that the fatigue implications can be assessed.

[16] Refer to RA 5724 Life Extension Programme.
[17] Refer to RA 4500 Health and Usage Monitoring.

85. Any period of unmonitored operation or change in usage of the air systems will threaten SI, as either can lead to air systems being operated beyond the assumptions underpinning SI. Specific threats include:

a. Inadequate validation of Sortie Profile Codes (SPCs) leading to incorrect recording of air system usage and incorrect critical part lifing assumptions.

b. Lack of monitoring or analysis of air system usage on an individual air system basis leading to inappropriate sortie profile mix and incorrect critical part lifing assumptions.

c. Change of sortie profiles.

d. Differing environments.

e. New working practices or changes to maintenance processes.

f. New operating practices.

86. Where fatigue and usage data is lost or compromised, either due to unserviceability of aircraft systems or failure of data capture or computation, fill-in data will generally be derived from mean fatigue usage data. However, this attracts a penalty factor to account for uncertainty. Since this represents a loss of available Safe Life or time to next examination, it is important that such occurrences are minimised.

Lost usage data

87. If usage data is lost or not recorded at whole air system or lifed-item level, the trigger points for retirement of Safe Life structure or examination of Damage Tolerant structure become uncertain. Conservative assumptions are therefore to be made about the missing usage data.

88. IAT programmes can be compromised by failures of monitoring equipment (such as an unserviceable fatigue meter, strain gauge, other sensor or data logger), or loss of sortie data (such as errors in post-sortie feedback recording, data corruption or transfer failure). Sorties where this occurs are classified as unmetered sorties.

89. Unmetered sorties are to be positively identified within the IAT record so that fill-in data can be applied and re-evaluated as necessary. This fill-in data is normally based on the mean usage rate for flying of a similar nature to that for which data is missing, multiplied by a standard scatter factor of 1.5. For example, for a fixed-wing air system structure lifed in Fatigue Index (FI), the fill-in FI for a missing sortie record could be based on the mean FI per flying hour rate for the same SPC, multiplied by 1.5. In most cases this factor will be conservative, resulting in a significant life penalty, but where usage is known to be highly variable, it may not be adequate. However, where more statistical evidence is available and more accurate fill-in data is required, the fatigue consumption rate equivalent to the 90th percentile of usage severity for similar sorties is to be used. Since this represents a loss of usable Safe Life, or a reduction in the time to the next Damage Tolerance examination, such loss of data is to be minimised.

90. The DT monitors the percentage of unmetered sorties and determines the extent and impact of the lost sortie information and the reason for the loss. Recovery action to prevent recurrence is to be carried out. Provided the data loss is not from the same air system or unit, or within a single or the most fatigue damaging SPC, the following percentages can be used as guidelines for the percentage of unmetered sorties on which the DT is to act:

a. <2% acceptable

b. 2-5% further investigation required

c. >5% the structural airworthiness of the fleet is to be assessed and urgent recovery action undertaken if it is found that structural airworthiness has been compromised.

91. The rate of, and recovery of, unmetered sorties is monitored by the SIWG. If the penalty fill-in life exceeds the Safe Life of the air system structure or lifed item, Exploiting measures can be employed.

Structural configuration control

92. Throughout the life of an air system there are risks to SI from changes in structural configuration. The structural configuration of an air system at the point of delivery can be expected to vary from the baseline design due to differing build standards and build concessions. Furthermore, the structural configuration of in-service air systems is likely to diverge from the as-built configuration; as individual air systems are subject to damage, repairs, modifications and Special Instruction (Technical) (SI(T)). These deviations or changes may affect air system mass, centre of gravity (C of G), internal structural layout or local structural stiffness, and may therefore alter internal load distributions. Such deviations or changes may compromise static strength, fatigue and Damage Tolerance clearances, and may jeopardise future repair, modification and life extension. Static and fatigue strength may be threatened if repairs are not adequately assessed or qualified (including static and fatigue qualification), and if the potential interaction of adjacent structural repairs is not addressed.

93. The migration of lifed structure between air systems, further complicates the problem. Furthermore, if the DO is unaware of the structural configuration of an air system, then recommendations for modification, repairs and life extension will be based upon a presumed configuration usually based on the information held in the air system master drawing set. To mitigate these risks, expensive and time-consuming whole-fleet aircraft surveys may be required if SCC has not been maintained throughout the life of the platform. SCC is a process that assists the DT to identify the cumulative risk to SI arising from deviations or changes from the build standard, and to avoid additional costs and logistics risks in the future.

94. A DT is required to take appropriate measures to ensure that a suitable system is put in place to maintain overall SCC of each air system within the fleet. Accurately recording structural arising's will assist decision-making and trend analysis for targeting appropriate husbandry or maintenance and will be further aided if the SCC system can handle graphical material. Ideally a single database should be used to maintain SCC, although it may utilise data from a range of different sources eg as a minimum, structural concessions, repairs, modifications, accidental and environmental damage for all air systems. For a legacy air system it may be necessary to carry out a structural survey of the whole fleet to establish a baseline. The database includes all relevant arisings to individual air system and is maintained for the life of the air system. The data should permit a fleet-wide assessment of structural health.

95. Key elements of the database are:

a. Build concessions.

b. The extent of damage (such as AD and ED) present before repair.

c. The condition of the material after the repair has been carried out (such as the thickness remaining after blending).

d. Repairs, which may originate from the Topic 6/Structural Repair Manual, from an approved DO or from an approved Aircraft Repair Organisation.

e. Un-repaired damage (damage within authorised limits), so as to provide a complete picture alongside embodied repairs and any further damage that may occur.

f. Modifications - DO-produced or Service-produced.

96. The regulation, including responsibilities, for technical data exploitation can be found in RA 1140[18].

97. For safe and effective operation of air systems, the weight and C of G must remain at all times within the limits specified in the RTS. If these conditions are not satisfied, the consequences may range from an increased consumption of fatigue life that will threaten SI, to failure to maintain adequate control and stability, to loss of the air system. If weight and C of G are deliberately changed through modification or change of role, then it may be necessary for the DT to initiate a

[18] Refer to RA 1140 Military Air System Technical Data Exploitation.

review of static and fatigue qualification in the light of the cumulative effects of the changes. Regulation and guidance on air system weight and C of G can be found in RA 4256[19].

Environmental Damage Prevention and Control (EDPC)

98. As air systems age, ED becomes more widespread and is more likely to occur concurrently with other forms of damage such as fatigue cracking. Similarly, air system structures will suffer from ED mechanisms such as erosion and degradation of composite material properties and surface finish.

99. ED degrades SI and, if uncontrolled, will reduce the inherent ability of the structure to sustain loads in the presence of other forms of damage. Establishment and promotion of an EDPC Programme to minimise environmental damage to the air system structure should be in place. The EDPC Programme defines the minimum requirements for preventing and controlling safety-related ED problems within the fleet (see RA 4507[8]).

Damage

100. Although damage may be detected on individual air systems, it will usually be necessary to assess whether such occurrences have fleet-wide implications. An evaluation of the extent to which damage to a single air system may indicate the potential for similar damage to be present on, or likely to be sustained by, other air systems in the fleet may need to be undertaken. For example, new arisings of AD/ED may be indicative of an emerging fleet-wide SI problem that can be addressed. For fatigue, the occurrence of unexpected cracking in an in-service air system may indicate that Safe Life, fatigue or Damage Tolerance clearances are grossly in error and a significant portion of the fleet may be at risk. Therefore, all instances of in-service fatigue cracking and damage to SSIs as identified in the Topic 5V or equivalent, plus previously unreported cracking and damage to other structure, may be brought promptly to the attention of the DT and subsequently to the DO. The DO alerts the DT to any potential read-across damage information from other operators of the same air system type.

101. Suspected structural damage that is not readily apparent may have occurred following a specific incident to an individual air system or operation of air systems in an adverse environment. Recovery actions are prompted by, and dependent upon, the following triggering events:

a. Reported overloads (including exceeding RTS operating limits).

b. Reported lightning strikes.

c. Reported bird strikes.

d. Impacts to composite structure

e. Exposure of structure (metal or composite) to any elevated temperatures that could cause degradation in material properties.

f. Exposure to corrosive substances:

(1) Caustic soda, acids, mercury, vehicle decontamination compounds, etc. (see RA 4507[Error! Bookmark not defined.]).

(2) Bodily fluids (see RA 4103[20]).

(3) Exposure to a maritime environment.

g. Operating in an environment that may invalidate the Maintenance Schedule, such as embarked operations.

102. As far as practicable, type-specific procedures are published within the ADS, detailing the action, including the appropriate inspections, to be taken following each of the events listed above. However, the impact of unusual or unexpected events will depend on the specific structure affected and specialist advice is to be sought from the DO. If the inspections confirm the presence of

[19] Refer to RA 4256 Aircraft Weighing.
[20] Refer to RA 4103 Decontamination of Aircraft after Spillage of Body Fluids

damage, the principles of recovering detected damage apply. Arisings are reported to the DT and monitored by the SIWG

Extensions

103. Fatigue safe lives and Damage Tolerance examination thresholds and intervals will normally be determined by the DO, on the basis of analysis and testing in accordance with a suitable design and qualification standard, and promulgated in the FTR. Where there is an anticipated need to extend lives, thresholds or intervals, this can be achieved through the DO via a life extension programme. However, in exceptional cases there may be an urgent need for a temporary extension of lives, or examination thresholds and intervals, of SSIs for a limited number of air systems. In such cases, the DT may consider an extension.

104. Any temporary extension beyond the cleared fatigue Safe Life or Damage Tolerance examination threshold or interval, for a single airframe or component, required in exceptional circumstances, is authorised by an appropriate DT engineer with the necessary delegated airworthiness authority and with the agreement of the relevant 2-Star Cluster Leader (see RA 1003[21] and RA 1006[22]).

Operational Loads and Usage Validation – including OLM/ODR

105. The structural design, test and qualification and validation methodology for an air system requires the DO to make assumptions about the air system's intended usage and the associated loads acting upon the structure during its service life, as well as their frequency and magnitude of application. As an air system's role, operating patterns (including operational theatre and individual manoeuvres or SPCs) or configuration change, the relationships between flight parameters and local structural stresses may also change.

106. Therefore, as well as identifying the actual in-service air system's usage it may be necessary to identify the loads associated with this usage at regular periods throughout the air system's life, for comparison with the air system's design usage assumptions and the fatigue spectra used in test and qualification. Usually, the SOIU does not provide the level of detail required to validate all design usage and loads assumptions. Similarly, the use of simple parametric usage monitoring systems, such as those that rely simply on flying hours or 'g' counts coupled with FMF, are unlikely to provide the required level of detail. Furthermore, where an air system uses a FMF, the accuracy relies upon a known mix of sortie profiles and confirmed relationships between flight parameters and structural loads.

107. Operational Loads and Usage Validation is the preferred term for the direct or indirect measurement of representative in-service data for comparison with the assumptions supporting air system and component clearances and structural lives (see Figure). This activity, which builds upon the loads validation or flight loads survey activity undertaken during the design process, is commonly achieved using OLM, for fixed-wing air systems and Operational Data Recording (ODR) for rotary-wing air systems. The complexity of the solution chosen will be determined by the aims of the programme and existing confidence not only in actual usage, but also in the relationship between usage and the loads experienced by the air system. The TAA, in consultation with the DO, may make use of routine Usage Monitoring systems as well as existing aircraft parametric data (eg FDR or HUMS), and instrumentation systems developed especially for the task. Analysis of data captured from less complex systems may confirm a need to progress to a more complex instrumentation system.

108. The main aim of Operational Loads and Usage Validation is the substantiation of assumptions made during design, qualification and test regarding usage and associated loads. This process may comprise:

a. The validation of the fatigue usage spectrum and the assumptions used during the design, structural qualification and test of the air system, including the review of fatigue clearances as well as maintenance and inspection periodicities.

[21] Refer to RA 1003 Delegation of Airworthiness Authority and Notification of Air Safety Responsibility (DE&S)
[22] Refer to RA1006 Delegation of Engineering Authorizations

b. The validation of the air system's Usage Monitoring system, including any lifing, damage or FI algorithms.

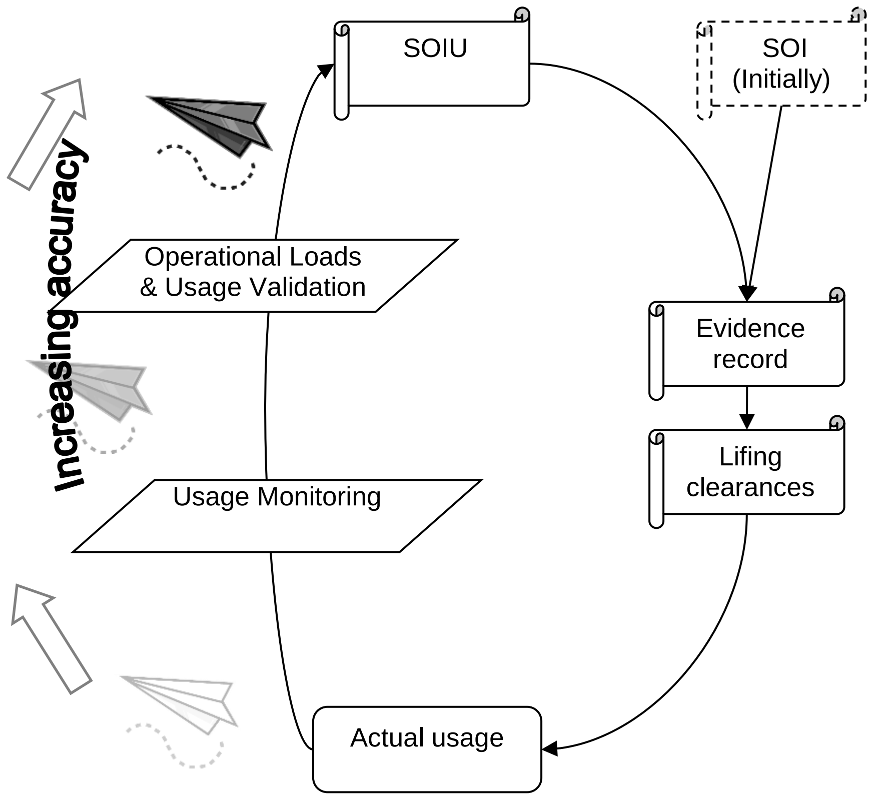

Figure 5 Flow chart – Understanding actual usage

109. The benefit of considering the Operational Loads and Usage Validation requirement during platform development is that on-board systems that meet the requirement can be included in the design (see MASAAG[23] Paper 109[24] Chapter 7 and MASAAG Paper 120[25]). This reduces the need to install the necessary instrumentation through expensive retrofits once in service, although this may be required for legacy fleets whose IAT systems fall short of the full requirement or where component/assembly-specific validation programmes (eg undercarriage or tail rotor) are required. The precise instrumentation solution, such as strain gauges or parametric systems, would then be agreed with the DO. Once installed, a permanent installation can be activated either continuously or as and when required.

110. The DT will normally task the DO to define the usage validation requirements and proposed methodology for meeting these requirements. Depending on when this task is initiated, it may be possible to obtain benefit from the knowledge and evidence gathered by the DO or Original Equipment Manufacturer during the structural design and qualification phase.

111. The complexity of Operational Loads and Usage Validation programmes and their management is such that DTs may appoint a project manager and form a dedicated working group including appropriate DO representation. Similarly, the Front Line Command may appoint the technical and operating unit project officers responsible for facilitating the programme on unit on a day-to-day basis.

112. Guidance regarding the specification of an Operational Loads and Usage Validation system can be found within Defence Standard 00-970, Part 1, Section 3, Leaflet 38. Comprehensive

[23] Military Aircraft Structural Airworthiness Advisory Group, a subgroup of the Joint Air Safety Committee hierarchy.
[24] Refer to MASAAG Paper 109 Guidance for Aircraft Operational Loads Measurement Programmes.
[25] Refer to MASAAG Paper 120 Guidance on Helicopter Operational Data Recording Programmes.

guidance for planning and undertaking an OLM programme can be found within MASAAG Paper 109 and for an ODR programme within MASAAG Paper 120[26].

Manual Data Recording Exercise (MDRE)

113. Where the method of IAT cannot adequately characterise air system usage, MDRE can be employed to record additional flight condition parameters during a representative sample of sorties. MDRE involves an additional crewmember recording the occurrence and duration of all relevant flight conditions throughout each sortie. MDRE includes a sufficient number of sorties of each kind flown by the fleet to obtain statistically significant results. In lieu of an MDRE; a suitable, automatic, means of recording usage data may be employed. It is important that the F724/725 or technical log already includes an SPC column, so that the record of usage in-service can be validated by the results of MDRE and Operational Loads and Usage Validation.

Structural Sampling Programme (SSP)

114. The SSP is part of the SEP. A properly implemented SSP helps to mitigate the unquantified risk of critical structural failure from unanticipated causes. Sampling is applicable to all SSIs that are not otherwise examined during flight servicing or scheduled maintenance. Predominantly these will be items that have been sub-classified as ‘Not At Risk’ from AD/ED and demonstrated, by test or analysis, to be free from fatigue cracking during the expected service life of the air system.

115. Where there are also ‘At Risk’ SSIs and parts of AR structure that are not normally accessible for inspection, such as the inside surfaces of hollow flying control rods or torsion boxes, it is most important that these are be sampled regularly through the life of the fleet. Structural sampling, combined with the feedback from scheduled examinations, validates the scheduled examination element of the SEP.

116. Furthermore, by examining the actual condition of all critical structure, the SEP validates the assumptions used to forecast, for the lifetime of the air system, the effects of usage and exposure to AD/ED, including the interaction of the different threats to SI. If structural sampling uncovers unexpected damage, Recovering, and/or Exploiting activities are employed. Unexpected damage may also indicate a lack of understanding of local in-service loading that could be addressed by OLM/ODR including targeted instrumentation to improve understanding and inform the development of effective repair or modification action. Non-SSI components are considered for sampling where failure would result in unacceptable economic or operational impact.

117. To achieve the necessary SI Validating objectives, the DT actively manages structural sampling so that the necessary sampling information is gathered and interpreted and any necessary follow-up action completed. Policy for sampling programmes is detailed in the Support Policy Statement of the air system’s Topic 2(N/A/R)1 and sampling activities, plus the resulting corporate knowledge gained from sampling, is to be captured in the SI Strategy and the air system’s Topic 5V or equivalent. Where the SSP highlights significant deviation between expected and actual in-service damage, this information is to be fed back to the DO.

118. Structural sampling is planned so that by the time the fleet leader reaches 80% of its original design life or revised lives if less, examples of all parts of all SSIs have been examined either through scheduled maintenance or sampling. Where it is not possible to examine all parts of all SSIs, alternative approaches can be explored in conjunction with the DO to assess the condition of the SSIs. For example, if it is physically impossible to access and inspect an SSI, the DO may be tasked to assess the risk associated with not being able to carry out inspection and propose alternative analyses or mitigations, including teardown. Some of the threats to SI, if not correctly anticipated by the RCM analysis, could result in indications early in the air system’s life (such as AD and ED), whereas others would not be apparent until late in the air system’s life.

119. Therefore, it may be appropriate to sample at both points. The decision on how much further sampling is required will need to be determined through a regular review of the sampling results and the level of risk. Such analysis and decisions are examined periodically by the SI Working Group (SIWG) (see SIWG Page 31). It is advisable to continue the sampling process right up to the OSD,

[26] Refer to MASAAG Paper 120 Guidance on Helicopter Operational Data Recording Programmes (See References and Further Reading).

as the cumulative exposure to damage from AD, ED and the probability of unexpected fatigue cracking increases towards the end of the air system's life. Creeping deferment of fleet OSDs has, in the past, also exposed shortfalls in the lifing of, for example, older modifications, which could have been picked up by sampling.

120. Candidate air systems for structural sampling inspections are selected carefully to maximise the probability of finding any unanticipated damage that could affect the fleet. The probability of damage increases with exposure to the threats to SI. Therefore, air systems that lead the fleet in terms of flying hours, FI, age, maintenance time or exposure time in corrosive or dusty environments, or environments significantly different from that assumed during development (eg, embarked ops), or that have experienced the worst combination of these factors, are selected for sampling.

121. For example, corrosion arising rates by tail number may indicate the environmental exposure level. A statement describing how representative the chosen air systems are of the fleet as a whole may provide useful evidence that thought has been given to where this relatively small sample size lies in the overall air system population. It is also useful to have a number of alternative candidate air systems on standby to take full advantage of the available sampling opportunities. For removable components, the history and usage of the component is considered, since it may differ from the usage of the air system to which the component is currently fitted.

122. Where possible, sampling should be done within a scheduled maintenance activity, and should include feedback directly into the RCM analysis. The following opportunities are worth considering for implementing the structural sampling plan:

a. Planned sampling may be carried out concurrently with scheduled maintenance on the selected air system, when access to the structure to be sampled is improved by the scheduled maintenance activity.

b. Opportunities for sampling inaccessible structure may arise from modification programmes and extensive repairs. DTs can take full advantage of those occasions when air system are sufficiently stripped to enable examination of normally inaccessible structure, or when an individual air system, their assemblies or major components are scrapped following major damage or life expiry. Although the air system concerned may not be the highest lifed within the fleet, value may still be obtained from opportunity sampling of these airframes. This may be in addition to, or instead of, sampling on the originally selected air system. A simple process to consider structural sampling requirements should be considered for inclusion in the instructions for repair scheme applications. Structural sampling opportunities should also be considered as part of the modification authorisation process. Unless absolutely necessary, SSP should not be undertaken in a first-line environment.

c. If there is no suitable maintenance opportunity for the selected candidate air system within the required timeframe and no emergent opportunity afforded by modification, incident or accident, it may be necessary to undertake sampling by directed inspections using an SI(T). Due to the large amount of preparatory work likely to be required to access the structure to be sampled, this option is likely to have the greatest adverse impact on air system availability.

123. Finally, there is little fundamental difference between sampling of critical structure and critical systems and consideration can be given to harmonising these policies where possible, to avoid duplication of effort.

Teardown

124. A Teardown (also known as sampling and forensic examination) is defined as a progressive, detailed, controlled and destructive examination of an air system structure. The teardown of a full-scale fatigue test specimen airframe, at the conclusion of testing is normally required for completion of fatigue and Damage Tolerance qualification and is therefore an SI Establishing activity. Teardown as part of the structural sampling programme involves teardown of the whole or selected parts of an ex-service air system or teardown of removable components or sub-assemblies. This may be the only way to achieve some of the structural sampling requirements and may be done on an opportunity basis. However, the same level of consideration as to where to focus the teardown is required as it is for structural sampling. Teardown may also be used to examine in detail,

particular areas of SI concern on an airframe and to develop and validate examination techniques. Teardown can also be used to provide on-going confidence in repairs by removing them and inspecting the underlying damage site for evidence of any damage growth. Teardown of high-life air system is a useful tool to support life extension activities (see RA 5724(1) & (2)[16]).

125. Detailed guidance on the conduct of structural sampling and teardown can be found in MASAAG Paper 105[27] and the Teardown Handbook produced by the Technical Co-Operation Program (TTCP). Details of potential structural sampling areas, based upon the SSI list, are detailed in the Topic 5V or equivalent.

Maintenance Schedule review

126. The structural elements of the Maintenance Schedule for an air system type will normally be reviewed in the course of the Maintenance Schedule review; see RA 4351[28] for regulation on the conduct and timing of these reviews. The structural element of this review is an SI Validating activity. In-service SI arising's and changes of operating intent and usage are to be taken into account when reviewing the SEP elements of the Maintenance Schedule.

127. In reviewing the structural elements of the Maintenance Schedule, in-service SI arising's (including those from Topic 5V or equivalent reporting) and failures, results of sampling and teardown, plus the implications of major changes in fleet disposition, operating environment, roles and usage, are to be taken into account. It is essential that schedule changes generated by the MOD or contracted schedule review body do not extend examination intervals derived from fatigue and Damage Tolerance analyses, unless supported by the DO. Moreover, it is also recognised that, for any scheduled structural examinations driven by fatigue considerations, historical examination results will be of very limited predictive value and therefore do not provide a sound basis for increased examination intervals; the absence of cracking to date may not indicate that it would be safe to adjust examination intervals. A further consideration is that schedule review activity is to be managed to ensure continuity in trend monitoring of SI arising's both before and after a schedule is revised. For example, Schedule Identification Numbers (SINs) for directed examinations of individual SSIs are usually left unchanged; however, if the SINs are changed, pre-and post-review SINs are to be tracked.

Ageing Aircraft Programme

128. Ageing Aircraft aspects should be considered a continuous through life programme with consideration given to ageing within the SI Strategy. The Ageing Aircraft Programme Working Group (AAPWG) meet on a twice yearly basis to discuss Ageing Aircraft issues, regulation and other guidance. For regulation on the Ageing Aircraft Audit see RA 5723[14]. Other relevant reading on the subject can be found on the MAA website in the form of AAPWG Paper 10. For any further guidance contact DSA-MAA-Cert-Struct4.

Recovery

129. The need for repairs to meet extant design standards is especially relevant for ageing air systems and for air systems with multiple adjacent repairs. The repair of detected damage to individual air system will be affected by undertaking repairs detailed within the ADS or schemes provided by either the Aircraft Repair Organisation (see RA 4815(2)[29]) or the DO; these processes are outside the scope of SI management and this RA. However, in order that structural configuration control is maintained, the extent of the damage and its repair is to be recorded on a suitable database. Refer to RA 4403[30] and RA 4815(2).

Changes to clearances due to Validating activities

130. Validation activities such as SOIU reviews and Operational Loads and Usage Validation may introduce changes to fatigue formulae or fatigue and Damage Tolerance clearances that may reduce available Safe Life or render Damage Tolerance examinations overdue. In the short term, such reductions may indicate that the risk of fatigue failure is higher than originally thought and, in

[27] MASAAG Paper 105 Teardown Inspections – Guidance and Best Practice.
[28] Refer to RA 4351 Production and Maintenance of Maintenance Schedules.
[29] Refer to RA 4815(2) Procedures for Good Maintenance Practices.
[30] Refer to RA 4403 Expedient Repair.

extreme cases, that safe lives have been over-flown. Action is then required to recover SI to restore risks to As Low as Reasonably Practicable (ALARP) levels.

131. Once adverse lifing revisions have been verified, it is essential that the DT re-evaluate the position of the fleet in relation to Safe Life and/or Damage Tolerance clearances. Subject to the results of this re-evaluation, it will be necessary to quantify risk and generate recovery options. Options for Recovering of SI may include early retirement of the fleet or individual airframes, transfer to a Damage Tolerance (examination dependent) regime, additional testing, modification, repair or replacement, or the imposition of operating restrictions. These options are, as far as possible, to be based on quantitative analyses by the DO. In all cases, it is important that the risk presented is thoroughly assessed and the acceptance/mitigation endorsed by the SIWG and then accepted by the appropriate Letter of Airworthiness Authority holder. Furthermore, it will be important to address the understandable, intuitive reaction to under-estimate risk when there is a lack of physical damage on in-service air systems.

Fatigue conservation

132. The rate of fatigue usage of an airframe will determine when the Safe Life is reached (for retirement or embodiment of a structural modification) or, for Damage Tolerant designs, the point at which the airframe becomes uneconomic to examine and repair. These safe or economic lives are frequently the constraint on the useful calendar life of a type and are therefore managed to achieve the required airworthiness, availability and capability until the required OSD. Whereas fatigue budgeting is an SI Sustaining measure, fatigue conservation is an SI exploitation measure that may be required if the fatigue budget would be insufficient to achieve the necessary OSD.

133. Fatigue-damaging loads on the life-limiting structure of fixed-wing air systems are driven by key parameters such as normal acceleration, ground-air-ground cycle, pitch and roll accelerations, mass properties and time spent in buffet conditions. Life may be prolonged by identifying and avoiding, or only undertaking when absolutely necessary, particularly damaging manoeuvres or configurations. For a helicopter, the loading situation is more complex, involving high-cycle loading (from the rotating assemblies) and a low-cycle element (similar to fixed-wing manoeuvring and exposure to gusts); as a result, the accuracy of the SPC is critical. Knowledge of the design spectra or MDRE, ODR/HUMS data along with accurate SPC recording will provide operating advice for fatigue conservation purposes.

134. The following procedure is to be used to implement fatigue conservation measures on a fleet or individual air system:

a. Identify shortfall in required fatigue budget.

b. Identify the most damaging manoeuvres/operations/role fits using, for example, the following information and techniques:

(1) Analyse Operational Loads and Usage Validation data, HUMS data and results from MDRE, as available, to identify the most significant contributors to structural life consumption.

c. In consultation with the DH, identify means of reducing or eliminating fatigue-damaging operating methods.

d. DH: promulgate and enforce the revised operating methods.

e. Review the effectiveness of the revised operating methods.

Cleared life

135. The potential requirement for an air system LEP should be identified in the SI Strategy and Plan from their inception. A decision point is to be marked and reviewed periodically so that any LEP work can be started and completed before the current planned OSD. Practically, it can take ten years between starting a major LEP and getting the evidence to give the required life clearances. The FTR and supporting technical reports are used as evidence for this activity. RA 5724[16] and Def Stan 00-970 Part 1 Section 3 (Structure) Leaflet 39 (Fatigue Life Extension) provides a good template for structures LEP activity, regardless of the design standard originally used for the air system.

SI Strategy

136. Establishing the Strategy allows all SI stakeholders to underwrite the intended approach while maintaining visibility of the actions required. Moreover, the SI strategy will form part of an air system's Safety Assessment evidence and TLMP. It is essential that development of a SI strategy to meet this Regulation is considered early in the acquisition cycle and well before the In-Service Date.

137. The SI Strategy should be published in the form of a Strategy Document (either Structural or as part of the Platform Integrity) and cover the following aspects:

a. Details of overarching strategy: the measures considered necessary to support the fleet throughout its life and to address ESVRE activities, and details of any necessary deviations from MOD regulation.

b. Details of strategy implementation: an introduction, implementation of the strategy to ESVRE principles, the SI meeting strategy including frequency and membership, the SI Plan and a record of historic SI activities and decisions.

138. Compromised SI can affect an air system's airworthiness, capability, availability and associated whole-life costs at any point in its service life. The aim in sustaining an SI Strategy is to maintain and promulgate the DT's intended approach to implementing the required acquisition cycle and through-life SI management activities for an air system in terms of methodology, timescale and financial commitment. To achieve this, a DT develops an SI Strategy to ensure that there is a clear understanding across all SI Stakeholders of what is to be achieved and what the short and long-term objectives are in meeting the vision. Sustaining the strategy allows all SI Stakeholders to continue to update and underwrite the intended approach while maintaining visibility of the actions vital to maintaining structural airworthiness.

139. The strategy released in the form of a SISD will include relevant items such as design philosophy, verification and validation approach, major modification and capability upgrade programmes, integration of new stores, change in fleet disposition, fleet draw-down and OSD plans. This communication is particularly important as it will form part of the platform's Through Life Management activities and ultimately the associated Safety Assessment, and will also act as a record of the evidence and rationale behind the SI decisions, such as termination of full-scale fatigue testing, taken throughout the life of the air system. Therefore, this document outlines the strategy and details the activities required to implement and maintain UK MOD SI regulation.

140. The SI Plan needs to be integrated within the SISD and the TLMP. The SI Plan may incorporate all elements of the ESVRE framework or equivalent for SI management, identifying all of the SI activities planned to achieve the necessary Structural Airworthiness, capability, availability and cost, until the funded OSD. It may be useful to mirror the RA headings of RA 5720 plus selected relevant additional line items such as major modification and capability upgrade programmes, integration of new stores, changes in fleet disposition, fleet draw-down and OSD plans. Accordingly, the SI Plan is owned by the DT and made available to all SI Stakeholders.

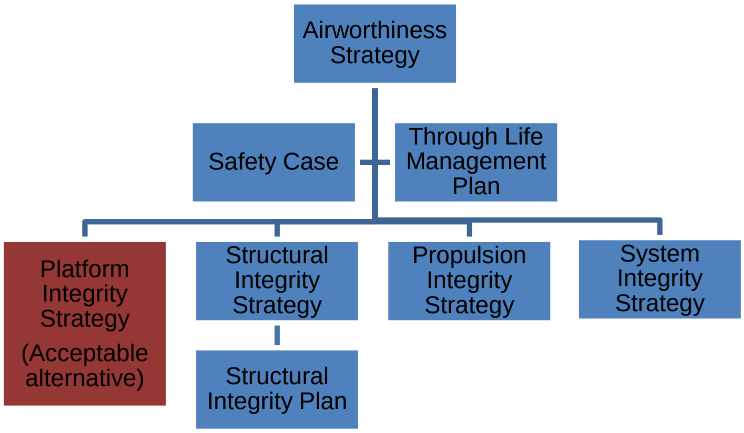

Figure 6 SI document hierarchy

141. The SI Strategy and SI Plan are living documents and should be reviewed periodically by structures specialists in the SIWG. They should incorporate all elements of the ESVRE framework for SI Management, broken down into individual programme, recurring and one-off activities, key milestones and decision points, as appropriate to the position of the air system type in the project life cycle. Detailed guidance on the content and approach required of the S/PISD may be found in the DE&S PISD Template[31]. SI planning is a continuous activity that ensures that all SI-related activities are: captured, coordinated and adequately resourced.

SIWG

142. The SIWG forms a fundamental part of the governance of the through-life safety management of the air system. At the top level, the SIWG should keep in mind questions that define its aim:

a. Is there sufficient evidence to prove that, at current and forecast usage rates, the platform will safely achieve its OSD? If not, what do we need to do to address this?

b. How do we ensure that risks to air safety arising from the four main threats to SI are managed, tolerable and ALARP?

143. The DT is to have processes that enable it to monitor, measure and sustain SI. The effectiveness of these processes is ratified at the SIWG. Although executive airworthiness responsibility rests with the TAA, there are a number of stakeholders in SI Management who will contribute to the SI decision-making process. A SIWG is a suitable forum for discussing a SI Strategy, structural issues and risks.

144. A SIWG should be initiated by the DT at an appropriate time prior to the In-Service Date and in consultation with MAA Cert S&ADS. The SIWG should be sufficiently ahead of higher level meetings (Project Safety Panel, etc.) to allow SI risks to be raised at these forums. In multi-national projects, although multi-national forums may be established to progress SI issues common to the partner nations, it is likely that a UK only SI meeting structure will also be necessary to progress national issues associated with UK configuration, usage, operating practices and SI standards.

145. Current risks to Structural Airworthiness are to be discussed by all SI stakeholders in sufficient detail to allow the Letter of Airworthiness Authority (LoAA) holder to understand the current level of risk. Risks are to be formally recorded in order to provide an audit trail for SI decisions. Any Structural Airworthiness risk identified that is potentially generic in nature or broad-based is to be raised by the DT at the appropriate Airworthiness Management Group.

146. An 'Aide-Memoire' is provided at Annex A for generic guidance only. The DE&S Airworthiness Team (DAT) should be contacted for an up to date IM scorecard.

Suggested SI training

147. The following training courses may be suitable for staff involved in SI Management. Applications can be made via the MAA website (www.gov.uk/maa).

a. Aircraft Structural Integrity Course (ASIC) (MAA).

b. Airworthiness of Military Aircraft Course (AMAC)

References and further reading

148. MAA regulation and further reading on SI can be found on the MAA website at www.gov.uk/maa or as listed below:

a. AAPWG Paper 10 – A Framework for Ageing Aircraft Audits.
b. AAPWG Paper 11 - Guidance on the Conduct of Aircraft Zonal Hazard Analysis (ZHA).
c. AAPWG Paper 12 - Understanding the Corrosion Threat to Ageing Aircraft.
d. ASG - Acquisition System Guidance for further information on Through Life Management Plan, Risks and Hazards (Via the Defence Intranet (Formerly AOF)).
e. Aircraft Topic 15S – Statement of Operating Intent and Usage.
f. Aircraft Topic 5V – Sampling Requirements and Procedures.

[31] DE&S Platform Integrity Strategy Document Template (SPT02b).

g. Aircraft Usage and Validation Programme (AUVP).
h. AP 101A-0601-1 – Employment and Repair of Aircraft Composite (Defence Repository - TDOL).
i. AP 101A-1500-0 – Joint Service Aircraft Battle Damage Repair Manual (Defence Repository - TDOL).
j. Def Stan 00-970 Pt 1 Sect 3 Lft 36 (Structural Inspection Programme)
k. Def Stan 00-970 Pt 1 Sect 3 Lft 37 (Ensure Fatigue Qualification Testing covers fleet usage to OSD).
l. Def Stan 00-970 Pt 1 Sect 3 Lft 38 (Conduct a continuous or periodic OLM/ODR programme throughout aircraft life).
m. Def Stan 00-970 Pt 1 Sect 3 Lft 38 (Fatigue and Usage Monitoring and HUMS. Assess Fleet Leader status and need for budgeting).
n. Def Stan 00-970 Pt 1 Sect 3 Lft 38 (SOIU Review).
o. Def Stan 00-970 Pt 1 Sect 3 Lft 39 (Life extension measures).
p. Defence Standard 00-970 – Design and Airworthiness Requirements for Service Aircraft.
q. DE&S Airworthiness Team - Platform Integrity Strategy Document Template (DAT Library No. SPT02b).
r. Handbook of Best Practice in Teardown of Aircraft Structures, Second Edition, TTCP, Sep 2011.
s. JAPD-100C-20 – Preparation and Amendment of Maintenance Schedules.
t. JAPD-100C-22 – Procedures for Developing Preventive Maintenance.
u. MAA02: MAA Master Glossary.
v. MASAAG Paper 104 – Recommendations for the future shape of the Ageing Aircraft Structural Audit.
w. MASAAG Paper 105 – Teardown Inspections - Guidance and best practice
x. MASAAG Paper 106 – Repair Assessment Programme for Military Transport Aircraft
y. MASAAG Paper 109 – Guidance for Aircraft Operational Loads Measurement Programmes
z. MASAAG Paper 116 – Widespread fatigue damage in military aircraft
aa. MASAAG Paper 118 – The Interaction of Corrosion and Fatigue in Aircraft Structures
bb. MASAAG Paper 120 – Guidance on Helicopter Operational Data Recording Programmes (Not yet released – For information contact DSA-MAA-Cert-Struct4-Gen)
cc. MASAAG Paper 123 – Development, Validation, Verification and Certification of Structural Health Monitoring Systems for Military Aircraft
dd. RA 1003 Delegation of Airworthiness Authority and Notification of Air Safety Responsibility (DE&S)
ee. RA 1006 Delegation of Engineering Authorizations
ff. RA 1140 Military Air System Technical Data Exploitation
gg. RA 1210 Ownership and Management of Operating Risk (Risk to Life)
hh. RA 4103 Decontamination of Aircraft after Spillage of Body Fluids
ii. RA 4201 Maintenance Policy - Composite Materials
jj. RA 4256 Aircraft Weighing
kk. RA 4350 Through Life Management of Technical Information
ll. RA 4351 Production and Maintenance of Maintenance Schedules
mm. RA 4403 Expedient Repair
nn. RA 4500 Health and Usage Monitoring
oo. RA 4507 Aircraft Environmental Damage Prevention and Control
pp. RA 4815(2) Procedures for Good Maintenance Practices (MRP 145.A.65(b))
qq. RA 5309 Fatigue Type Record for Aircraft
rr. RA 5720 Structural Integrity Management
ss. RA 5721 System Integrity Management
tt. RA 5722 Propulsion Integrity Management
uu. RA 5723 Ageing Aircraft Audit
vv. RA 5724 Life Extension Programme
ww. RA 5725 Out of Service Date Extension Programme
xx. RA 5810 Military Type Certificate (MRP 21 Subpart B)
yy. RA 5820 Changes in Type Design (MRP 21 Subpart D)

Classic articles (available to ASIC delegates, contact DSA-MAA-Cert-Structures):

a. Managing an Ageing Aircraft Fleet, Wg Cdr Andy March.
b. Developing Issues in Aircraft Structural Integrity, Wg Cdr Ron Eckersley, (Ex WC SSG).
c. Helicopter Fatigue and Qualification Case History, M Overd, Westland Helicopters Ltd.
d. Helicopter Structural Integrity, Sqn Ldr D Thomas.
e. Fibre-reinforced Polymer Composites, Dr D Bray, DSGT, RAFC Cranwell.
f. The Hawk Life Extension Programme, Wg Cdr M J Kilshaw (adapted from original articles).
g. Future Fatigue Monitoring Systems, Sqn Ldr S Armitage, (ex SM17b (RAF)) and D M Holford, DERA.
h. Fatigue Management – Current RAF Practice, the Future and some Case Studies, Sqn Ldr S Armitage.
i. Tornado Structural Integrity, Sqn Ldr M A Sibley (adapted from original paper).
j. Eurofighter Typhoon – Production Major Airframe Fatigue Test (PMAFT), M.D. Greenhalgh, BAE Systems.
k. Structural Airworthiness Requirements for Aircraft Fatigue Design, Alison Mew, QinetiQ(F).
l. Ageing Aircraft in Military Service, Sqn Ldr N Lea.
m. Economic Benefits of Usage monitoring in UK Military Rotary Wing Aircraft Sqn Ldr L Sumner.
n. Aviation Occurrence Reporting CAL Boeing 747 Accident Report (ASC-AOR-05-02-001) – Executive Summary, ASC.
o. Repairs to Damage Tolerant Aircraft, T Swift (FAA).
p. Safe Life Scatter Factors – Their Origins, Applicability and Opportunities for Exploitation, Sqn Ldr T Bleakley.
q. The Structural Audit – A Positive Contribution To The Sustainment Of Airworthiness And Safety, M J Duffield – Systems & Structures Airworthiness – Structural Integrity (Large Aircraft) QinetiQ(F).
r. Nimrod Review 2009 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/229037/1025.pd

Annex A - STRUCTURAL INTEGRITY WORKING GROUP - AIDE MEMOIRE

1 Introduction	a. Introduction. b. Actions arising from previous minutes and not covered under agenda items.	The SIWG forms a fundamental part of the governance of the through-life safety management of the air system. At the top level, the SIWG should keep in mind 2 questions that define its aim: a. Is there sufficient evidence to prove that, at current and forecast usage rates, the platform will safely achieve its OSD? If not, what do we need to do to address this? b. How do we ensure that risks to air safety arising from the 4 threats to structural integrity are managed, tolerable and ALARP?
2 Fleet Planning	c. Fleet Statistics.	Check on consumption statistics (eg FI/1000hr, landings/hr – whatever is important for that type of platform) looking for significant changes. Stats need to include historic or design assumptions for comparison. Average data can be misleading if fleets-within-fleets issues exist.
	d. Fleet Size.	Review of how many aircraft there are in the fleet and how they are operated – does this reflect design assumptions or has Designer been made aware of variations.
	e. Fleet Disposition.	Identification of fleets-within-fleets issues. Identification of changes in bases or operations (eg rough strip).
3 Establishing SI	f. SI Strategy Document and SI Plan.	Do SI Plan and Strategy exist? Make sure you have read the Plan and Strategy. Are they just repeats of the template or have they been thought about? Has the Designer been consulted / included in the Strategy / Plan? Post-RTS and after the SI Strategy and SI Plan have both been established this agenda item may be moved to Sustaining SI, where the discussion should focus on when the Strategy and the Plan were last updated and whether they still deliver a regulatory compliant and suitably safe outcome (eg in light of updated or new regulation, or in light of in-service findings necessitating a change to the strategy).
	g. SOI.	Has the SOI been produced? Alternatively, when is it planned to be published? Has Requirements Manager been heavily involved in SOI development. Has the Designer

		been tasked to review and identify implications for lives. This agenda item can be marked as N/A if the SOI has been updated to become an SOIU.
	h. Release to Service – SI aspects.	This should cover both the initial RTS, with specialist advice from the SI Advisor, and ongoing RTS amendments (with implication for SOI/U). Looking for significant issues or shortfalls (eg limited clearances or envelope restrictions – looking for coherent plan to get to full RTS). Also are there any RTS issues that will require validation in service? For example, probabilistic gust or birdstrike analysis will require validation from in-service data.
	i. Structural Design Certification:	What is the structural design certification basis for the aircraft (eg stress-life, strain-life, damage tolerance)? Where is this defined and recorded (eg designed / certified to Def Stan/EASA/FAA/BCAR/JSGS etc)?
	(1) Classification of Structure & review of SSI list.	Does the platform have a clearly identified SSI list (or eqivalent) that has credibility and has been reviewed, involving Designer? If not, what plans are in place to develop list? SSIs are required for developing RCM-based maintenance schedules.
	(2) Static Type Record.	Does the platform have an up-to-date and credible STR? If not, what documents constitute the equivalent and are they identified and controlled in the same way. Are processes in place to ensure that modifications likely to affect the STR or equivalent are identified and STR amendments actioned?
	(3) Fatigue Type Record.	Does the platform have an up-to-date and credible FTR? If not, what documents constitute the equivalent and are they identified and controlled in the same way. Are processes in place to ensure that modifications likely to affect the FTR or equivalent are identified and FTR amendments actioned? What plans are in place for incorporating OLM/ODR/IAT results into the FTR (or equivalent) to move from design assumptions to actual usage for lifing.
	j. Fatigue Test Clearances.	What are the fatigue clearances for the fleet? Where are they promulgated and how are they managed in service. What plans are in place to take interim fatigue clearances to meet the life-time requirements. Are adequate plans in place for ongoing fatigue tests or tests likely to be needed to generate lifing evidence?
	k. SARC Assessment.	Red/Amber/Yellow/Green. Review previous meeting's score (and the reasons for that score if not green) to ensure consistency and to monitor progress of long-running issues.
4 Sustaining SI	l. Usage Monitoring – method of Individual Aircraft Tracking (IAT); fatigue	Does platform have a clear plan for usage monitoring / IAT/ HUMS? This has been an area of weakness on many platforms. Often too much focus on 'fitting systems' and

	monitoring/budgeting/formulae; structural and transmission Health and Usage Monitoring Systems.	not enough on what is going to be done with the data and through life management of the system, data and results and what are the aims of IAT/HUMS ? Where FMF are used how are they validated and reviewed? This should include measures to identify when the IAT has been compromised (eg excessive un-metered rates or system failures) and plans to rectify the situation if this occurs. Is there sufficient fatigue life (however it is calculated) remaining to see the fleet through to its OSD?
	m. Structural Examination Programme (SEP) (to include discussion on structural examination to counter threat posed by hazardous incidents, corrosion, erosion and other environmental degradation).	How has the SEP been developed? Was RCM used in conjunction with an up-to-date SSI list? How is the DT going to review the SEP and ensure that it is fit for purpose? – reliance on F765s alone is not sufficient.
	(1) SEP Reporting Process (Topic 5V).	Does a Topic 5V exist? If not are there plans in place to develop one, in conjunction with Designer? How will it be done and how does the DT intend to exploit the 5V to support SI (eg sampling opportunities)? Also did the 5V development identify any shortfall in existing SEP (eg hard to inspect or un-inspectable at risk SSIs)?
	(2) Scheduled maintenance plan (Topic 5A1).	How has the maintenance schedule been developed? Has the Designer been fully involved in its development? Also ensure that mechanism is in place to ensure that structural inspections are undertaken by authorised tradesmen (MAP-B473).
	n. Structural Configuration Control.	Historically this has been a challenging issue. What measures are in place to retain configuration control and how are these measures going to be validated to ensure they are working (eg periodic mod and repair checks at deep maintenance)?
	o. OSD.	What is the declared OSD for the platform, how does this relate to the Design Service Goal (DSG) and when will any potential LEP requirements be identified? Creeping life extension should be avoided.
	p. Obsolescence Management Plan	Are there any structural materials or coatings used on the ac type that are obsolete/obsolescent? If so, how are repairs to structural items made from obsolete/obsolescent materials going to be performed and what plans are in place for identifying and approving new coatings.
	q. SIWG Frequency and Composition	Does the SIWG take place twice yearly? Are the key stakeholders noted in RA 5720(3) present? Does the Chairperson's LOAA allow him/her to chair SIWGs?
		Red/Amber/Yellow/Green. Also review previous meeting's score (and the reasons for that score if not green) to ensure consistency in the scoring and to monitor progress of

	r. SARC Assessment.	long-running issues.
5 Validating SI	s. SOIU Review.	When were the last annual and triennial SOIU reviews started and, therefore, when are the next reviews due to begin? What plans are in place for the next reviews? Are adequate data collection and analysis tools in place to collate the data for 3-yearly review? What calendar period does the usage data come from? Does the review also include updating the 'Intent' element? What mechanisms are in place for Designer to analyse the revised SOIU and report back on lifing implications in context of the DSG?
	t. OLM/ODR/MDRE.	What OLM/ODR/MDRE is planned or underway? This section should include reports from OLM/ODR/MDRE Working Groups. Encourage identification of likely OLM/ODR/MDRE validation requirements early in the programme. Additional OLM/ODR/MDRE requirements may still be required for ac with strain gauge-based monitoring systems due to incomplete coverage (eg landing gear). May also require validation of RTS assumptions if not possible by other means (eg time at flight-level for bird strike or gust risks).
	u. Structural Sampling.	What sampling has been done and what is planned? Opportunity sampling can prove extremely valuable and does not have to be restricted to Cat5 aircraft. What can be done alongside mod programmes? Use Topic 5A1 to identify candidates. Particular focus should be on any 'at risk' SSIs that are not inspectable (eg inside flying control rods).
	v. Teardown.	As per structural sampling. Invaluable particularly for validation of corrosion protection / prevention. Successful programme requires careful thought as to targeted areas. Requires Designer involvement and also benefitted by involvement from other users (particularly if older fleets exist elsewhere).
	w. Maintenance schedule review (Including Topic 5V returns).	What plans are in place for review of the schedule? How will the schedule review be done? What data are available and is the data considered for purpose? Is the Designer heavily involved in this process and are fatigue-life related schedule elements clearly identified.
	x. Review of Type Records.	What plans are in place for the review of type records (or documents identified as meeting these requirements)? Should be linked in with fatigue test completion, OLM/ODR programmes, mod programmes etc. STR sometimes forgotten as in-service focus is on fatigue – care needs to be taken over mass growth (often incremental).

	y. NDT Technique Review	NDT review should be about both whether the techniques are still required, and whether they are still appropriate. Techniques are often introduced rapidly in response to an in-service or fatigue test arising and should be reviewed if they are going to be part of a longer-term SI measure.
	z. Ageing Aircraft Measures.	When was previous AAA started and when is next planned? How are issues identified by AAA managed within the platform and what measures are in place to ensure the completion of remedial measures is endorsed by the SIWG? Again important that the Designer is involved in this process (see RA 5723 for background information).
	aa. SARC Assessment.	Red/Amber/Yellow/Green. Also review previous meeting's score (and the reasons for that score if not green) to ensure consistency in the scoring and to monitor progress of long-running issues.
6 Recovering SI	a. Structural Problems.	
	(1) Review Contents of Structural Arising Database.	Identification of structural issues and recovery plans.
	(2) Review EDPC WG/Database.	Report from EDPC WG. Should include issues taken on by SIWG and directives back to EDPC WG. Confirm that there is an ED Prevention and Control Programme in place and that this has been reviewed by SMEs at SIWG (including Designer) and that issues and progress are tracked by SIWG.
	b. Modifications with SI implications.	Review of recent modifications to confirm that SI implications have been identified and addressed (eg mass growth (global or local), changes in flight control system, reduced access for maintenance etc.).
	c. Special Instructions Technical SI(T) with SI implications.	Review of tech instructions issued to ensure SI implications identified and addressed (eg removal of surface finish, making access for inspections).
	d. Repair Assessment Programme (MASAAG 106)(mandatory for large ac only).	Where applicable, what RAP surveys have been undertaken and what is planned? How is the information being preserved and updated? Has the Designer reviewed the RAP reports and have remedial actions been implemented (eg fatigue analysis of repairs undertaken and inadequate repairs replaced with adequate repairs)? What measures have been implemented to prevent reoccurrences in the future (eg revised procedures, cancellation of inadequate repair instructions or removal of inadequate repairs from the Topic 6).
	e. Compromised IAT.	

	f. SARC Assessment.	It is likely that an IAT system will be compomised at some time during the life of the fleet, particularly (but not exclusively) with modern electronic structural health monitoring systems. What is the percentage of compromised IAT data? Are there any trends that could identify a significant issue for collecting IAT data (eg large percentage of compromised IAT data from a single airframe)? What is the gap-filling method and does it comply with the regulation? Red/Amber/Yellow/Green. Also review previous meeting's score (and the reasons for that score if not green) to ensure consistency in the scoring and to monitor progress of long-running issues.
7 Exploiting SI	g. Review of Structural Hazards or Risks. h. Fatigue Conservation Measures. i. Exploiting In-service experience. j. Life/OSD Extension Programme. k. Exploitation of OLM/ODR/HUMS/SHM /MDRE data.	Identify if any of the discussions during the meeting invalidate the structural hazards/risks that already comprise the loss model, meaning that those hazards/risks need to be reconsidered in light of new evidence, or whether new hazards need to be considered. If it has been identified that there is insufficient fatigue life (however it is calculated) remaining until the OSD, what measures could be introduced to ameliorate the situation? For example, VC10 adjusted the aileron upset angle to reduce wing bending. RW platforms could extend cleared safe lives of some rotables by reducing the time spent in hover. Historically measures have been introduced too late and they have been less successful than anticipated. Therefore this should include methods of monitoring fatigue conservation measures. Should include any relavant experience from other users or similar types. Reports from User Groups on SI issues can be highly relevant. Identification of plans for LEP. Historically often identifed too late. Significant LEP should be idenfied 10 years before OSD. Deadlines for decisions should be identified in Strategy/Plan. Often an issue for elevation above SIWG. Data can be essential in meeting OSD or in LEP. Plans to exploit data to convert from design assumed usage to actual usage should be identified.
8 Ac Disposal Plan	l. Aircraft Disposal Plan	Potential source of structural sampling / teardown to support remaining fleet.
9 AOB	m. AOB	

10 SARC Score	n. Overall SARC Assessment.	Red/Amber/Yellow/Green. Also review previous meeting's score (and the reasons for that score if not green) to ensure consistency in the scoring and to monitor progress of long-running issues.
11 New SI Risks	o. Consideration of new SI Risks that should be registered within Risk Management system	Formal pull through of SI issues identified as structural issues in the SIWG into the risk register (where not already identifed as entries)
12 Upward Reporting	p. Actions from and reports to *HAMG/CA AMG/AS AMG*	Should include significant risks (technical and programme (eg LEP)) and significant non compliances with RA
13 Next Meeting	q. Arrangements for next meeting	