PROPULSION INTEGRITY HANDBOOK

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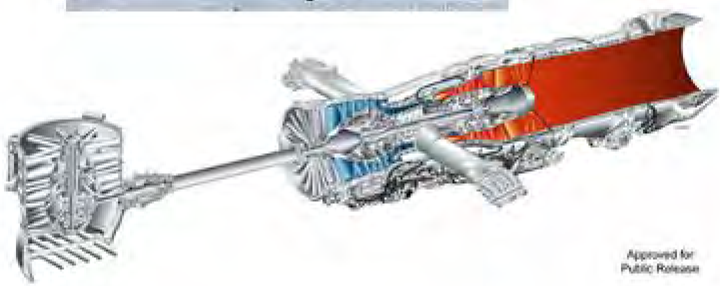

Military Aviation Authority
MAA

CERTIFICATION
MECHANICAL & PROPULSION SYSTEMS

Contents

Foreword

1. This handbook has been produced to complement RA5722, and is an Aide-Mémoire for use by personnel who are involved in the management of Propulsion Integrity (PI). It covers the salient points concerned with PI, and is offered without commitment or prejudice to the Regulation, Acceptable Means of Compliance (AMC) or Guidance Material (GM) contained in RA5722. For further advice and guidance, please refer to the MAA-Cert-MPS Branch.

2. The MAA-Cert-MPS team forms part of MAA Certification Division and are responsible for the following tasks:

a. Development of PI Regulation under RA5722.

b. Support to Project Teams' PI activities through their Propulsion System Integrity Working Groups (PSIWGs).

c. Provision of assurance to the Airworthiness Management Group on matters relating to PI.

d. Provision of advice and guidance to Project Teams on airworthiness regulation.

e. Support to the development of Ageing Aircraft Audit, Life Extension Policy and Out Of Service Date Extensions under RA5723, RA5724 and RA5725.

f. Assurance of propulsion system certification evidence in support of introduction of new aircraft, major changes and UORs, as applicable to RA1500.

g. Management of the Propulsion Airworthiness Advisory Group (PAAG) held on a six monthly basis. The PAAG is chaired by MAA-Cert-MPS at OF-4 level and includes representatives from Industry and DE&S.

Responsibilities

3. Table 1 below details the various Platforms that each Propulsion IM Desk Officer is responsible for:

MAA-Cert-MPS1a	**MAA-Cert-MPS2a**	**MAA-Cert-MPS2a1**
Fast Jets	Air Support	Rotary
BBMF	Air Transport	Qinetiq Fleet
RPAS	ISTAR	SPMAP

Table 1: IM Desk Officer Responsibilities

Abbreviations

4. **List of Abbreviations**

AAA	Ageing Aircraft Audit
ALARP	As Low As Reasonably Practicable
ATSB	Australian Transport Safety Bureau
CADMID	Concept, Assessment, Demonstration, Manufacture, In-service, and Disposal
CAMO	Continuing Airworthiness Management Organization
DE&S	Defence Equipment and Support
DO	Design Organization
DSA	Defence Safety Authority
EDIT	Engineering Development and Investigation Team
ESVRE	Establish, Sustain, Validate, Recover, Exploit
FH	Flying Hours
FLC	Front Line Command
FMEA	Failure Modes and Effects Analysis
FOD	Foreign Object Damage
MAA	Military Aviation Authority
OEI	One Engine Inoperative
OEM	Original Equipment Manufacturer
PAAG	Propulsion Airworthiness Advisory Group
PI	Propulsion Integrity
PISD	Propulsion Integrity Strategy Document
PSCL	Predicted Safe Cyclic Life
PSCDTL	Predicted Safe Cyclic Damage Tolerant Life
PSIMP	Propulsion System Integrity Management Plan
PSIWG	Propulsion System Integrity Working Group
PT1	Power Turbine
PT	Project Team
PTL	Project Team Leader
RA	Regulatory Article
RPAS	Remotely Piloted Air System
RPAV	Remotely Piloted Air Vehicle
SI	Structures Integrity
SME	Subject Matter Expert
SofS	Secretary of State for Defence
SOIU	Statement of Operating Intent and Usage
SQEP	Suitably Qualified and Experienced Person
SysI	Systems Integrity
TAA	Type Airworthiness Authority
TLMP	Through Life Management Plan

Introduction

5. Propulsion System Integrity is defined in MAA02 as ‘The ability of a propulsion system to withstand the loads, temperatures and operating environment experienced during its service life through operation in accordance with the Release To Service (RTS) and Statement of Operating Intent and Usage (SOIU)’.

6. The Propulsion System is the source of propulsive effort for the air vehicle, including the aero-engine, modules, components and accessories and is a major factor in the overall airworthiness of the aircraft. Its failure, particularly in a single engine configuration, could hazard the aircraft and lead to an accident or incident. Furthermore, the high rotational speeds and pressures achieved by gas turbine components mean that if failure does occur, the result could be an uncontained release of high-energy debris and the potential loss of the aircraft. Both of these circumstances dictate that management of PI issues is critical to the safe through-life management of military-registered aircraft. The aim of PI management is to minimise the risks to airworthiness and safety, whilst still achieving the required levels of capability, availability and cost, throughout the life cycle of the aircraft or system. PI is an essential element of airworthiness and safety, sustained by proactive management.

7. The effectiveness of any military force and its operational readiness is dependent on the integrity of the various systems, sub-systems and components that make up the total platform. PI Management is an organised and disciplined approach to the design, analysis, certification, production and life management of aero-engines. This will ensure the engine has adequate structural characteristics to perform the required operation for the required design life.

8. Modern military aircraft engines are often operated at high power settings for extended periods of time and this places a large emphasis on continuing reliability. An aero engine today must provide definite life for definite cost so quality and reliability must be considered. Therefore, PI concerns are paramount. Propulsion Systems are becoming increasingly complex, which further increases the potential for a system to fail. The subject of PI and the potentially catastrophic consequences associated with its failure should not be underestimated.

9. All platform Project Teams (PTs) must recognise the importance of PI by the inclusion of various management plans and working groups. PI is considered as a through-life activity with the inclusion of a Propulsion Integrity Strategy Document (PISD), a Propulsion System Integrity Management Plan (PSIMP) and a Propulsion System Integrity Working Group (PSIWG) as part of the Platform Through Life Management Plan (TLMP). The interaction of these various elements are detailed in the PI Management section of this handbook, starting on page 16.

PI Failure Examples

10. A number of high profile civil and military accidents have highlighted the potential impact PI failure can have, and serve to demonstrate why PI is so important.

11. **Tucano T1: Engine Failure leading to wheels up landing (Jan 13).** Tucano ZF349 was on a Partial Test Flight (PTF) from RAF Linton-on-Ouse, following maintenance to investigate an Exhaust Gas Temperature (EGT) over-temp. During the PTF, the pilot is required to carry out Engine Electronic Control (EEC) checks in both Normal and Manual operation. In Normal operation, the EEC maintains Turbine EGT and Engine Torque, whilst in Manual, the pilot is required to monitor the engine instruments to ensure the engine limits are not exceeded. There is also a propeller governor that, in Normal operation, provides a

constant engine RPM to the propeller drive shaft. In Manual operation it is mechanically set to provide 100.5% RPM.

12. During the EEC Manual checks, the pilot noticed abnormal torque indications and decided to end the sortie and return to Linton. On reselecting the EEC to Normal, the aircraft experienced a loss of thrust and a large increase in drag. The pilot suspected an engine failure, shut down the engine and attempted an emergency landing. The undercarriage was lowered but, due to the undercarriage requiring hydraulic pressure to positively lock down and the engine driven hydraulic pump no longer being able to provide sufficient pressure due to lack of engine drive, the aircraft landed wheels up and travelled 3700ft along the runway and onto the grass. Both of the pilots exited the aircraft unharmed.

Figure 1: Tucano ZF349

13. A Service Inquiry (SI) was convened to establish the cause of the accident and it was soon apparent that the aircraft had suffered engine failure, and it was on this area that the Inquiry focussed. Initial investigation centred on the Engine, EEC and propeller governor. No leaks or damage was evident on the engine and both the EEC and propeller governor passed test and were assessed as serviceable. Investigation then moved to the Fuel Control Unit (FCU) which controls fuel flow to the engine in both Normal and Manual operation, thus controlling engine torque and EGT.

14. Within the FCU is a Torque Motor (TM) which, using P3 engine air acting on a sealed bellows unit, controls the fuel flow to the engine via a flapper valve. The FCU failed test and was stripped for further investigation and testing. This testing found the TM was unserviceable and an x-ray examination was carried out on the TM. This x-ray examination showed that the bellows were deformed and not seated correctly within the housing. Further strip and inspection showed that the epoxy resin sealing the bellows to the housing had failed, meaning the bellows had become unseated and blocked the flapper valve, reducing the flow of fuel to the engine and, subsequently, reducing engine RPM.

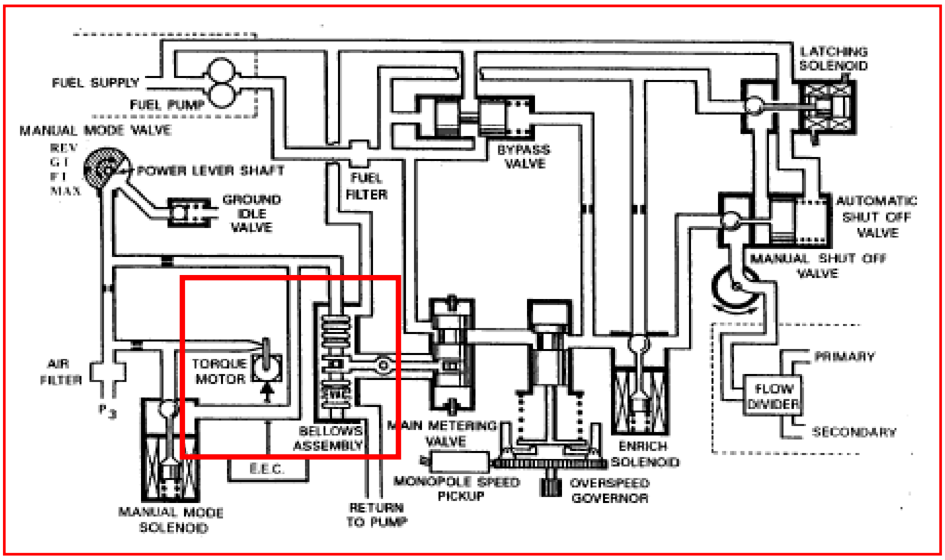

Figure 2: Fuel Control Unit Schematic

15. The SI Panel determined that the cause of the accident was due to the failure of the epoxy resin in the TM. The de-bonding of the epoxy resin on the TM bellows within the FCU resulted in the bellows becoming lodged against the flapper valve, thereby reducing engine fuel flow and a corresponding decay in engine RPM. The Panel also concluded that age and environmental degradation was the most likely reason that the de-bonding occurred.

16. The SI Panel found that a lack of a rigorous lifing policy was considered to be an ‘Other’[1] factor in the accident. Differences were found between the overhaul life stated by Honeywell, the engine Design Organisation and the published ‘Engine and Ancillaries Lifing Policy’ and engine critical components were not clearly identified. There was also a poor paperwork trail detailing the control of critical components and the Panel were unable to fully identify which components from build were still fitted to the engine.

17. The inability for the Original Equipment Manufacturer (OEM) to identify a failed TM through the FCU Standard Serviceability Test was also cited by the panel as an ‘Other’ factor. The TM was not routinely tested as a separate component and this lead to a number of FCUs being returned serviceable as No Fault Found.

18. The Panel observed that the Mean Time Between Failure (MTBF) of the TM had reduced significantly since 2009, from 12696 flying hours to 1449 flying hours in 2012. This is indicative of an ageing component and this reduction in MTBF should have lead to increased monitoring of the TM.

19. **Merlin Mk1: Turbine Disc failure (Jan 10).** On 13 Jan 10, a Merlin Mk1, was undergoing a rotors turning ground run at RNAS Culdrose for a fault on the No 3 engine. After approximately 10 minutes, the No 1 engine suffered a major failure and the No 2 engine also shut down. Initial investigation showed that there had been an uncontained release of all the blades on the 1st Stage Power Turbine (PT1) as shown in Figure 3.

[1] Factors that were noteworthy in that they may cause, contribute to, or aggravate future accidents.

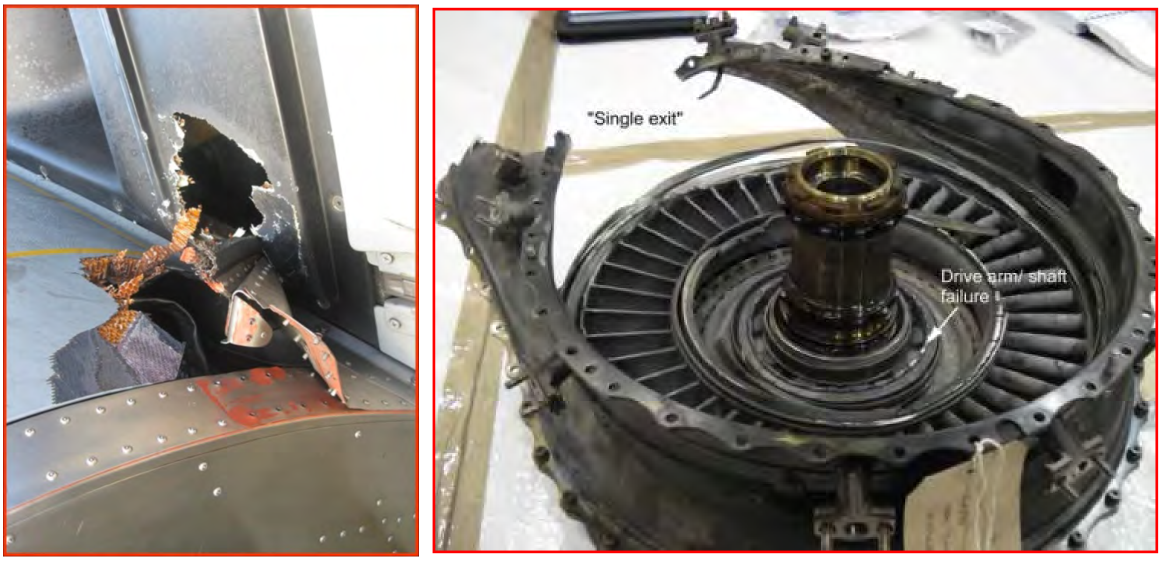

Figure 3: RTM322 Disc Failure

20. The RTM322 Engine Control Unit (ECU) is fitted to all marks of Merlin (fitted with 3 ECUs) and to the Apache (2 ECUs) so this failure was to have a large impact on flying operations. Immediately following the incident, One Engine Inoperative (OEI) flying was restricted with OEI training prohibited. The Merlin aircraft was also prohibited from carrying out twin Engine Cruise.

21. The ECU had been built by RR in Nov 98 and initially fitted to the ac in Apr 99. It completed ≈333 flying hours (FH) and was then removed to storage in Sep 00. In Jun 06 the ECU was fitted another ac in Jun 06, then moved to the subject ac in Nov 08 when it had completed ≈830 FH. At the time of the incident, the ECU had completed ≈1150 Flying Hrs (FH) and ≈840 starts.

22. Investigation by MIG revealed that the failure of the turbine disc had been caused by an oil leak from the Interduct Feed tube joint (Figure 4) starting a fire which caused the PT1 disc to overheat.

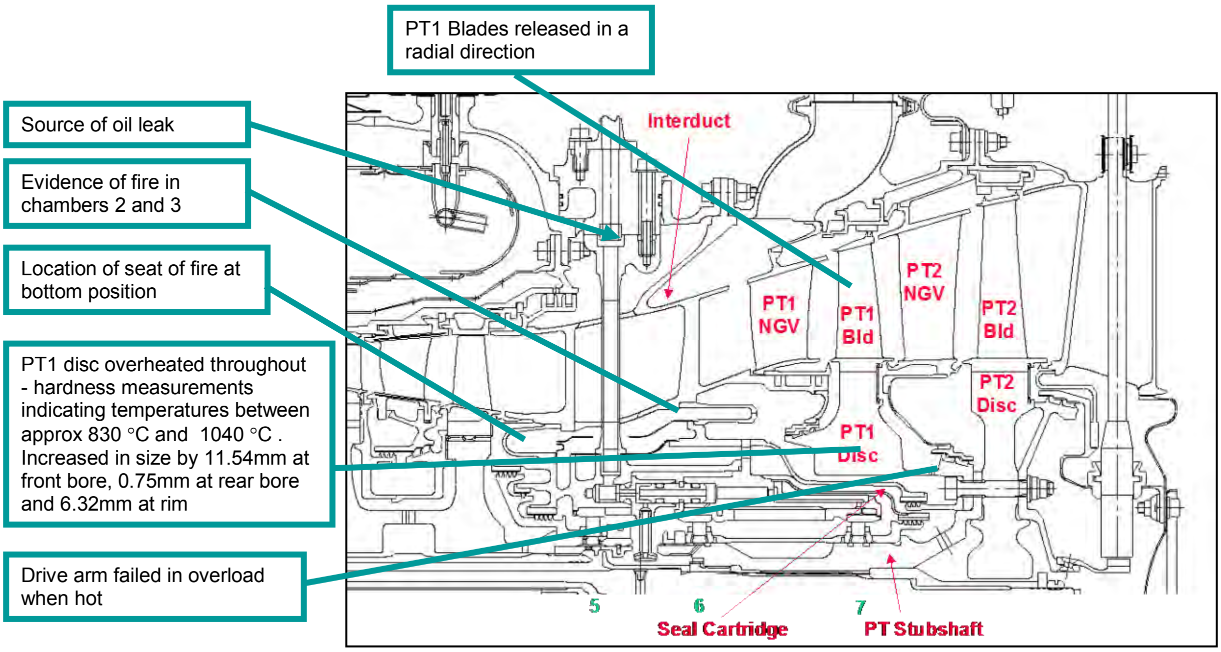

Figure 4: Source of Failure

23. This leak was caused by the torque loading on the joint not being sufficient to create a seal with the gasket that was fitted. A modification was developed to change the seal and to increase the torque loading of the clamp from 4.8Nm to 7.8Nm. Routine borescope inspections of the oil feed/drain/vent adaptors were introduced and the allowable oil consumption rate was lowered to 0.2 litre/hour to act as a warning for any possible failure. This example shows how PI was compromised by a Procedural Design Error due to incorrect calculations for the torque loading of the clamp.

24. **Airbus A380-842: Uncontained engine failure (Nov 10).** On 4 Nov 10, a Qantas Airbus A380-842 aircraft departed from Changi Airport, Singapore for Sydney. On board were 5 flight crew, 24 cabin crew and 440 passengers. Following a normal take-off the crew reported that, while maintaining 250 kts in the climb and passing 7,000 ft, they heard two 'loud bangs', followed shortly after by indications of a failure of the No 2 engine. The crew were forced to make a successful and safe emergency landing back at Changi Airport.

25. The subsequent Australian Transport Safety Bureau (ATSB) investigation[2] indicated that fatigue cracking had taken place in an engine high pressure/intermediate pressure bearing structure, oil feed stub pipe within the No 2 engine. This resulted in oil leakage followed by an oil fire in the No 2 engine (Figure 5).

Figure 5: Trent 900 – Uncontained Turbine Disc

26. The fire led to the release of the Intermediate Pressure Turbine IPT) disc. The IPT disc released three different high energy fragments, resulting in structural and systems damage. The investigation report indicated that segregated wiring routes were cut by two of the three individual pieces of disc debris, and as a result led to difficulties in the shutting down of No 1 engine after landing. The findings of the report were determined to be a "critical safety issue" and the ATSB recommended immediate inspections of all in-service Trent 900 engines. On 8 Dec 10 the ATSB reported that 45 Trent 900 engines had been inspected, and 3 of these engines had failed inspection and had been removed from service.

27. As a result of this occurrence, a number of safety actions were immediately undertaken by Qantas, Airbus, Rolls-Royce plc and the European Aviation Safety Agency (EASA). On 1 Dec 10, the ATSB issued a safety recommendation to Rolls-Royce plc in respect of the Trent 900 series, in addition the Civil Aviation Safety Authority issued a Regulation 38 maintenance direction that addressed the immediate safety of flight concerns in respect of Qantas A380 operations with the Trent 900 series engine.

28. Investigations into the uncontained engine failure have so far showed that the root cause of the failure was a manufacturing defect in an oil feed pipe (Figure 6), which in turn caused fatigue cracking due to the pipe wall being too thin. The crack led to an oil leak and

[2] http://www.atsb.gov.au/publications/investigation_reports/2010/aair/ao-2010-089.aspx

internal oil fire that weakened the engine's IP turbine disk, which separated from the turbine shaft and punctured the engine case and wing structure.

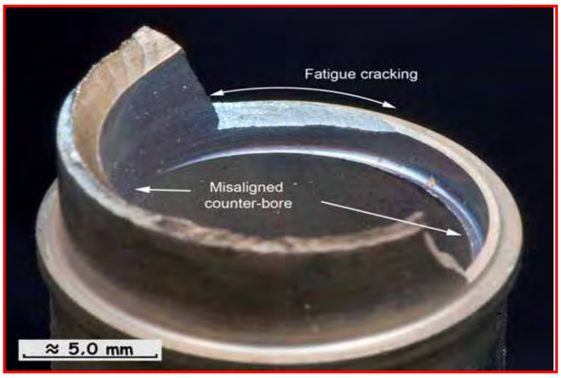

Figure 6: Stub pipe showing misaligned counter-bore.

29. On 18 May 11, the ATSB released an interim factual report which stated that 53 Trent 900 engines were removed from service; 11 of which were due to out-of-tolerance oil-feed stub pipes with a misaligned counter-bore, leading to an incorrect pipe wall thickness, and 42 due to lack of measurement records relating to the oil-feed stub pipe. Therefore, PI had been compromised from the outset due to a Manufacturing Error. It is important to recognise PI can be compromised in many ways. PI threats are discussed further in the following section.

Threats to PI

30. **Introduction.** PI may be threatened at any stage of a Propulsion System or aircraft's life cycle by any number of threats, including:

a. Component degradation.

b. Change in usage or unmonitored operation.

c. Fatigue and creep.

d. Overload.

e. Lack of Configuration Control.

f. Accidental Damage and Environmental Deterioration.

g. Procedural error.

h. Obsolescence.

i. Legislation change.

j. Fuel and fuel system hazard.

k. Human Factors.

31. Unless managed, any one or a combination of these threats could lead to an incident or accident. Furthermore, the presence of more than one threat will serve to compound the situation and introduce an added complication.

32. **Component Degradation.** Over time, components are subject to deterioration, which ultimately impacts on their ability to perform their required function. Such deterioration may include the following:

a. **Mechanical wear.** The undesired cumulative change in dimensions brought about by the gradual removal of discrete particles from contacting surfaces in motion, usually sliding, predominantly as a result of mechanical action. The consequence of this may be the lack of load-carrying ability of the material, play in moving components, or the inability to complete the expected movement cycle.

b. **Other ageing effects.** Including stress corrosion[3] cracking, repeated repairs or modifications and long term un-rectified environmental, maintenance and /or handling damage.

33. **Change in usage or unmonitored operation.** Any period of unmonitored operation or change in usage of Propulsion Systems will threaten PI, as either can lead to them being operated outside of the regimes of the PI assumptions. Specific threats include:

a. Inadequate validation of sortie profile codes, leading to incorrect recording of usage and critical part[4] lifing assumptions.

b. Lack of monitoring or analysis of usage.

[3] Corrosion Handbook - AP119A-0201-1
[4] Def Stan 00-970 Pt 11

c. Change in sortie profiles.

d. Differing operating environments.

e. New working practices or changes to maintenance regimes.

f. New operating practices.

34. **Fatigue.** Fatigue is defined as a fracture of a material due to cyclic application of a load. Fracture usually occurs in a three-step process:

a. Nucleation of the crack.

b. Slow, cyclic propagation of the crack.

c. Catastrophic failure of the material.

35. Figure 7 below shows an example of how Propulsion Systems are prone to fatigue. Foreign Object Damage (FOD), has generated a stress concentration that has caused an increase in the vibratory stress amplitude in the rotor blades. This has led to High Cycle Fatigue failure of the disk.

Figure 7: Pegasus Fan Rotor Fatigue Cracking.

36. **Creep.** Creep (sometimes called cold flow) is the tendency of a solid material to move slowly or deform permanently under the influence of mechanical stresses. It can occur as a result of long-term exposure to high levels of stress that are still below the yield strength of the material. Creep is more severe in materials that are subjected to heat for long periods, and generally increases as they near their melting point. Creep always increases with temperature.

37. **Overload.** Overload may occur within the Propulsion System when an element of the system exceeds one or more of its design parameters. Since the Propulsion System is designed to work close to the limits of material integrity, the consequence of overload can be severe. Examples of Propulsion System overload include over-speed, over-temperature, over-torque, accidence of aero-engine ‘g’ limits and over-stress of engine mounting components.

38. **Lack of Configuration Control.** Configuration Control is necessary to support the aircraft Safety Case and to inform airworthiness decision-making, which will assist in ensuring confidence in PI. Design Organizations (DO) may make life extension, modification and

repair recommendations based on presumed configuration that does not match the as-flown configuration as a result of a lack of Configuration Control.

39. **Accidental Damage.** Accidental Damage is the physical alteration of an item caused by any unintentional influence, contact or impact on a system or component. An example of this is highlighted in Figure 8. Battle damage and sabotage, although not strictly accidental, may also be considered within this category, as the effects are comparable.

Figure 8: Compressor damage due to FOD.

40. **Environmental Deterioration.** Environmental Deterioration is the physical deterioration of material properties as a result of their interaction with the climate or environment. Chemical interaction, erosion, fluid/gas absorption, thermal cycling or radiations are typical causes of Environmental Deterioration. It may manifest itself as corrosion, loss of surface finish, and could include electrical insulation deterioration, softening of composite materials and other component deterioration.

41. Environmental Deterioration is becoming more common-place as the frequency of deployments to areas with harsh environmental conditions increases, particularly if this was not originally factored into the design. As shown in Figure 9, extreme environmental conditions can have an adverse impact on aircraft engines as well as other aircraft systems.

Figure 9: Presence of sand on components post operations in Afghanistan.

42. **Procedural error.** Procedural errors in maintenance take a variety of different forms, involve many different types of documents and can be attributed to both document deficiencies and user errors. Furthermore, procedural errors can be the result of design, manufacturing, maintenance or supply errors.

a. **Design error.** Describes the result of failure to adhere to recognised design standards, design best practice and qualification evidence methodology. Examples of design error include:

(1) Failure to generate sufficient evidence of material properties.

(2) Potential for incorrect assembly.

(3) Specifying inappropriate material and manufacturing processes.

(4) Failure to design an assembly so that it can correctly perform its required functions.

(5) Failure to produce error-free software.

b. **Manufacturing error.** Describes the outcome or the performance of a system or component that fails to meet the design specification. Factors leading to manufacturing error include failures to adhere to manufacturing drawing requirements and processes, such as:

(1) Use of incorrect material.

(2) Application of an incorrect process or loss of process control.

(3) Use of incorrect parts or components.

(4) Use of unauthorised jigs, fixtures and tooling.

(5) Incorrect routing or assembly of components, cable ducts, pipes or looms.

(6) Human Factors.

c. **Maintenance error.** Describes the unsatisfactory outcome or performance of a maintenance process on an aircraft system. Factors leading to maintenance errors that threaten PI may include:

(1) Inadequate instruction, training or supervision.

(2) Inadequate resources.

(3) Incorrect technical information.

(4) Use of unauthorised jigs, fixtures and tooling.

(5) Human Factors.

d. **Supply error.** Describes the supply of a component or product that does not meet the current specification and therefore does not satisfy the aircraft’s airworthiness requirements. Factors leading to supply errors may include:

(1) Non-conforming components, products or software.

(2) Those from an unknown pedigree.

(3) Those from unapproved suppliers.

(4) Those that are incorrectly identified and/or codified.

43. **Obsolescence.** Obsolescence is the loss, or impending loss, of the manufacturers or suppliers of items or shortages of raw materials. Failure to manage obsolescence may result in reduced availability of components, systems or aircraft and increased through-life costs. PTs are therefore required to maintain an obsolescence management plan as part of their TLMP to indicate what contingencies are in place to deal with such a problem.

44. **Legislation change.** Throughout the life of a system or aircraft, legislation changes may impact upon PI. It is the PT's responsibility to ensure the effects of legislation changes are addressed for their platform and systems.

45. **Fuel and fuel system hazard.** Even with fire barriers, major fuel leaks around the propulsion unit can be a major hazard to the aircraft. It is the responsibility of the PT to check that fuel and oil lines associated with the propulsion unit have been correctly categorized in terms of their safety criticality. Although not strictly a direct threat to PI, fuel contamination is a major threat to Propulsion System operation and requires pro-active management. Fuel contamination exists in the form of absorbed water, incorrect fuel types, oils, foreign particulates, FAME (Fatty Acid Methyl Esters) and microbiological organisms. The PT is responsible for maintaining an authorized list of fuels for use on the platform and progressing clearances of new or updated fuel specifications. Further information in respect of aviation fuel requirements can be found in RA4515: Fuels, Lubricants and Associated Products and MAP-01 Chapter 11.11.

46. **Human factors.** PI can be influenced by Human Factors throughout the life of an aircraft or engine in many different ways. All maintenance and operating procedures should make allowance for the likelihood of human error and be as detailed as required to ensure there is no ambiguity. Organizations should also put in place Human Factors training to ensure that its personnel are aware of their own limitations as well as those of others.

PI Management

47. The overall responsibility for PI should rest with the Type Airworthiness Authority (TAA), however, other Defence Equipment and Support (DE&S) staff, Front Line Commands (FLCs), operating Stns/Ships/Units and contracted organizations also have essential roles in managing PI.

48. **Establishing, Sustaining, Validating, Recovery and Exploiting (ESVRE) Framework.** RA5722 specifies those activities required to achieve and maintain PI for aircraft operated within the MAE from their inception through to their eventual disposal. The ESVRE framework is the MOD's approach to managing integrity (Structures, Systems and Propulsion) for in-service aircraft and the key elements should be costed through the platform TLMP. ESVRE is a framework around which essential management processes for effective and continued PI are built. The framework itself comprises of 5 elements and, as such, the Regulation pertaining to PI is structured as follows:

a. **E**stablishing Propulsion Integrity – see RA5722(2)

b. **S**ustaining Propulsion Integrity – see RA5722(3)

c. **V**alidating Propulsion Integrity – see RA5722(4)

d. **R**ecovering Propulsion Integrity – see RA5722(5)

e. **E**xploiting Propulsion Integrity – see RA5722(6)

49. Applied together, these elements comprehensively cover all necessary activities to satisfy the As Low As Reasonably Practicable (ALARP) risk principles. The regulation is intended to underpin the Air Safety Management System (ASMS) (RA1200) for all military aircraft projects and it aims to:

a. Enable an aircraft and its associated systems to be operated at an acceptable level of safety throughout its service life.

b. Ensure a high level of availability by minimising inspections, maintenance activities and modifications.

c. Minimise costs associated with airworthiness activities whilst adhering to the ALARP principle.

d. Maximise efficiency of the aircraft and associated systems in terms of capability, maintainability and airworthiness.

50. The principles and procedures outlined in the MAA Regulation Publications (MRP) are applicable to aircraft designs of any origin and to all procurement models. Although aligned approximately with the acquisition cycle for new types, the ESVRE framework should also be retrospectively applied to legacy types, including Historic Aircraft. Where a PT seeks to deviate from the ESVRE framework, it should first consult the MAA-Cert-MPS Team to ensure that the efficacy of any other proposed system in maintaining an auditable process of PI management is judged to result in appropriate propulsion airworthiness.

51. As Figure 10 shows, the ESVRE framework does not fit against the Concept, Assessment, Demonstration, Manufacturing, In-Service and Disposal (CADMID) format or any other procurement cycle. Consequently, elements of ESVRE can and will be re-visited throughout the life of the aircraft.

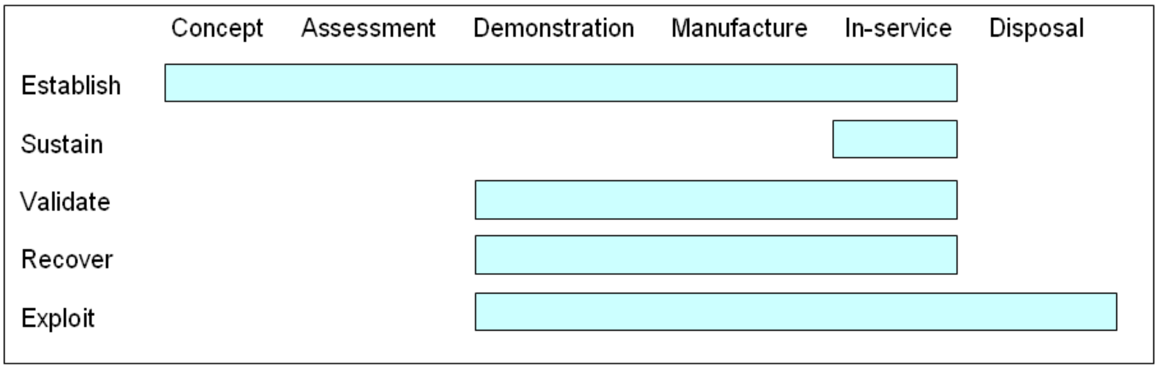

Figure 10: ESVRE Through Life Concept

52. In many respects, the ESVRE approach to PI does not introduce anything that is fundamentally different from the CADMID process. However, it does introduce a formalized management process in which PI issues can be identified and dealt with accordingly.

53. **PI Management Process**. In order to effectively manage PI, the TAA is required to put in place 3 processes that, together, will ensure all stakeholders involved in PI will be able to understand the threats to PI and what measures are in place to minimize these risks. These 3 processes detail the ***'What'***, ***'How'*** and ***'When'*** of how PI is going to be managed throughout the life of the aircraft. The PI management strategy for an Air System should be scoped at the earliest opportunity, ideally during initial certification activity for the Platform. As Figure 11 shows, all 3 processes are intrinsically linked and all should be in place for PI to be managed safely.

Figure 11: PI Management Cycle

54. **Propulsion Integrity Strategy Document (PISD).** The PISD details the ***'What'*** and ***'How'*** of PI management. It is a living document that is owned by the TAA and is used to communicate the PI strategy to all key stakeholders. The PISD forms part of the Platform Through Life Management Plan and acts as a record of the evidence and rationale behind decisions made to maintain PI. The ESVRE format provides an example of a structure and framework that may be used to clearly capture the requirements contained within RA5722. The PISD is to be reviewed and endorsed by all stakeholders at each PSIWG. In order to facilitate this review, the documents, including any amendments are to be sent to stakeholders with the PSIWG calling notice to allow them to view the documents and make

comments as required at the PSIWG. Even if the documents have not been amended, they should still be sent to stakeholders for comment as required. There is no requirement for a full rewrite to be carried out on PISDs, once written only amend as required to reflect the current state of the platform. Further information on the PISD can be found at Annex A.

55. **Propulsion System Integrity Management Plan (PSIMP).** The PSIMP details the ***'What'*** and '***When'*** of PI management. It may mirror the ESVRE format and contain all the headings of the PISD. It should contain meeting dates, one off and recurring activities (AAA[5], document reviews, etc), major modification programmes, changes to fleet disposition and any other key milestones. It can also be used to track PSIWG actions as required. The PSIMP should be reviewed by all key stakeholders prior to each PSIWG. A suggested PSIMP layout can be found at Annex B.

56. **Propulsion System Integrity Working Group (PSIWG).** The PSIWG is the opportunity for all key stakeholders to understand threats to PI and to put in place the action to ensure risks remain ALARP. Meetings are to be held every 6 months and should be timed to allow any issues to be escalated to the next higher meeting as required. The PSIWG is to be chaired by the TAA, or an LoAA holder of at least OF4/B2 level. Key stakeholders include the TAA, DO, PT desk officers involved in PI, prime supporting contractors, Platform safety manager and the CAMO[6]. Other personnel such as the MAA, Independent Safety Advisors, EDIT, aircrew, maintainers, OEMs and FLCs should also be invited as required. It is important that all attendees at the PSIWG are SQEP for their area and empowered to make decisions/take actions for their area of responsibility. .

57. **Integrity Management Airworthiness Regulation Compliance Scorecard (IMARCS).** PTs are required to score themselves in order to report their compliance with the Integrity Management (IM) RA series. This is done using the IMARCS process detailed in DATIN 2015/05. This scoring gives an individual score for each area of ESVR (Exploiting is not scored) and an overall compliance score for Propulsion. This Propulsion score is combined with the Structures and Systems score to give an overall Platform IM compliance score.

58. **Summary**. The principles of PI should not differ widely between platforms and lessons should be learnt from more established platform PTs by the newer aircraft teams. For further detail regarding PI management, reference should be made to RA5722. Guidance on any part of this process can be obtained from the MAA-Cert-MPS Team

[5] Ageing Aircraft Audit RA5723
[6] Continuing Airworthiness Management Organization RA4947

Engine Lifing – Process and Methodology

59. This section has been produced for personnel directly involved in the management and lifing of Propulsion Systems. The information contained within this section has been compiled to provide additional background information for the Propulsion desk officer. The information has been collated from a number of legacy MOD propulsion policy publications that have since been withdrawn from circulation.

60. **Life Declaration for Major Rotating Parts.** There is a mandatory requirement to establish and monitor component lives for both rotating and non-rotating critical parts[7] (as identified in the FMEA), which are subject to significant fatigue. This is achieved by implementing a lifing policy.

61. When a lifing procedure is identified for a platform, and subsequently implemented, it should have been agreed with the Authority and referenced in the Engine Model Specification. The structural integrity of the part will be determined such that the probability of individual failure of any critical part in service is at an acceptably low level. This will be achieved by establishing the service duty of the part, determining its capability to meet that duty and ensuring consistent product quality by manufacturing control. Periodic reviews of the service environment and investigation of service arisings, as required by RA5722, will be carried out to confirm the predictions concerning duty and the capability will be made.

62. **Life Declaration Figures**. It is beholden upon the DO to make the life declaration figures available to the TAA. The format of the Life Declaration may take the format detailed below. Additionally, it may be accompanied by a sketch indicating the position of the critical areas
.

a. Version control of document.

b. Previous life statement number if applicable.

c. Reason for change if applicable.

d. Engine and marks.

e. Engine operational limitations reference.

f. Assembly and/or component.

g. Part numbers.

h. Diagram of potential critical areas.

i. Material – common name and spec code.

j. SN curve ref.

k. Engine reference stresses (before and after correction to equivalent 0 – max cycle and kt if appropriate) and temperatures and time-points in cycle.

l. Reference cycle documentation reference.

m. Exponent used.

[7] Definition contained in CS-E.

n. Temperature normalisation parameter used.

o. Test references and whether results were cracked or not.

p. Failure Investigation References.

q. Over-stresses.

r. List of critical areas and calculated critical area safe lives.

s. Predicted Safe Cyclic Life (PSCL).

t. Approval signatures.

Procedures for Life Declaration

63. **Safe Life.** There are a number of ways in which the life of a critical part may be determined with some approaches being more conservative than others. One such procedure for determining service life, *the Safe Life Approach*, is detailed below:

a. Stage 1 - Using relevant engine stresses, temperatures and material properties, MOD accepted databank or by test on a new part:

(1) The Area Safe Cyclic Lives (Ar) for each identified critical area are identified.

(2) Applying the appropriate Mission Exchange Rate, the lowest Critical Area Safe Cyclic Life from the identified critical areas is determined.

(3) Relevant stress and life factors are applied as appropriate to arrive at the PSCL. (Def Stan 00-970 Pt 11, Annex A can provide additional information on this activity).

(4) Consequently, Service Cyclic Life (Sr) is declared as being equal to PSCL with a life management plan or equal to a proportion of the PSCL.

(5) In this case, the Service Life itself is declared as equal to $\frac{Sr}{\text{Exchange Rate } (\beta)}$

b. Stage 2 - From all knowledge accumulated, the PSCL value can be confirmed or re-evaluated (if the experience warrants it). The new Service Cyclic Life or current values can be confirmed accordingly.

c. Stage 3 - Stage 2 is repeated as service experience accumulates.

64. **Calculation of Service Usage Rates.** The Operator is ultimately responsible for the collection of data and the monitoring of aircraft usage over a representative range of missions, for the purpose of re-establishing exchange rates. This is reflected within RA5722 accordingly, under the area of ‘Validation’. The section below describes one method of calculation of Service Usage Rates that may applied. This method may be implemented where cyclic usage rates are to be based on a sample of recorded flight tapes.

a. The recorded flight data is used to develop a database of Cyclic Exchange Rates (CERs) against various parameters such as Sortie Pattern Codes (SPC), base, flight date using algorithms and constants supplied and validated by the Engine OEM. These CERs are analysed in families of sortie profiles for example. The analysis may employ Weibull, Log Normal or any other distribution shown to accurately characterise the data. Where there is a reasonable number of data points a good description line is obtained, and this in turn gives rise to narrow confidence bands. In cases where there are few data points, the confidence limits are wider reflecting the uncertainty of the distribution. Having obtained the distribution, it is then necessary to select a CER which is considered to be representative of the fleet operation.

b. The approach adopted is to use whichever of the following gives the higher exchange rate:

(1) 80% probability with 50% confidence.

(2) Arithmetic mean with 95% confidence (the arithmetic mean can be at a range of probabilities dependent on the form of the distribution, but is generally of the order of 50 to 70%).

c. The 80% probability case is usually invoked when there is a large amount of data, so the confidence limits are narrow. If the slope is relatively low then the 80% probability is likely to be higher than the arithmetic mean with 95% confidence. Use of this value takes some account of the known scatter in the data.

d. The arithmetic mean with 95% confidence is usually invoked on smaller samples where the confidence limits are wide. This accounts for the unknowns in the distribution, especially if the slope is high, when use of the 80% probability number could be risky. Having obtained a representative exchange rate, the overall fleet exchange rate is calculated by appropriately combining the exchange rates (eg by SPC weighted by its use in a representative mission mix).

e. This total procedure will provide a representative CER for each critical area of each component for each Mark of engine, to use in lifing critical parts.

65. **Databank Approach.** An alternative approach to Life Declaration is the Databank Approach. This method involves the flight cycle critical area stresses and temperatures being read into a material databank to calculate safe lives directly, rather than performing a specific cyclic test for the critical area. The databank itself will have been compiled in advance from a correlation of laboratory specimen data with previous results of cyclic tests on a variety of component critical features in a given material, with the safe lives for minimum property parts being defined using statistical techniques.

a. A materials databank may be used in place of a specific cyclic test, for the demonstration of critical area safe lives provided that the authenticity of data used can be demonstrated. In this case, it would be the responsibility of the TAA to confirm and accept the appropriateness of the data used.

b. In the production of a material databank, the following requirements would need to be considered:

(1) A statistically significant number of specimens/component tests.

(2) Testing of material possessing the correct specification, microstructure and surface condition.

(3) Adequate testing of the surface condition of the relevant engine component critical area must be included such that it can be shown that all features included in the materials databank exhibit a common cyclic behaviour.

(4) Component testing carried out with representative stress fields and operating conditions (e.g. temperature, surface contact, and residual stress).

(5) All features appropriate to the relevant engine component.

(6) Testing of an adequate total volume of relevant material.

(7) Previous service experience.

d. Where a databank is identified as not being suitable for all critical areas of a component, the feature may need to be alternatively lifed using rig test results from specific cyclic tests.

e. In similarity to Safe Life methodology, the Ar for each critical area would need to be calculated for each declared mission profile. The critical area that had the lowest in-service life would determine the PSCL for the part. As previously discussed, the β factors would be confirmed in accordance with the service usage data.

f. When not possible to fully establish Ar for any feature, Ar would ordinarily be based on a half of the Expected PSCL from the databank.

66. **Damage Tolerance Approach.** The Damage Tolerance Approach is also used in the determination of Critical Part Lives. The aim of this method is to demonstrate, by the appropriate material selection, design, use of reliable inspection methods, control of assembly, overhaul and repair, and with the application of appropriate safety factors, that damage will not propagate to failure within the cyclic life of the component. Such that the failure rate does not exceed extremely remote. In this case, a Margin of Safety to the allowance for material scatter is required in order to achieve acceptable failure rates in service. This approach is not an alternative to the Databank or Traditional Safe Life methods but is intended to be in addition to. Exemption from damage tolerance would only generally be agreeable where previous experience has demonstrated it to be unnecessary or, where the damage tolerance can be demonstrated using a generic materials databank.

a. To achieve damage tolerance requires the growth period from an initial flaw to unstable crack growth to be demonstrated by analysis or test, assuming the initial flaw exists in the critical areas of the component. This is ordinarily achieved either by a component exceeding 2/3 of the dysfunction life in service at its PSCL, or Predicted Safe Cyclic Damage Tolerance Lives (PSCDTL) is less than or equivalent to 1 in 750 with 95% confidence or by assuming conservative damage levels. In this case, it is necessary that the PSCL does not exceed the PSCDTL of the component.

b. This approach would apply to critical parts that are potentially sensitive to failure from surface damage. For the assessment of surface damage tolerance each critical area would be considered separately.

d. In assessing damage tolerance, the PSCDTL would be determined by analysis or test for realistic operating conditions, considering the growth of an initial crack of a specified size (ao) to the critical crack size (ac). The life to grow an initial flaw to the critical size is ordinarily substantiated by relevant specimen or component tests.

e. The initial flaw sizes (ao) assumed would be based on an understanding of the flaw distributions due to manufacture or surface damage and considering process control and non-destructive Inspection (NDI) techniques. For initial flaw sizes based on NDI techniques the flaw size applied would be based on the flaw that can be detected with demonstrated probability and confidence.

f. For those components assumed to contain an initial defect population whose upper bounds are considerably lower than the NDI limit, the initial defect size could be determined based on the product of the process and the process controls.

g. It is likely that a probabilistic approach may be adopted which would include the initial flaw size distribution and the crack growth rate distribution when determining a PSCDTL to 1/750 and 95% confidence. In this case all the analysis would need to be justified to the TAA by the DO.

h. This assessment may further incorporate a crack initiation life within the analysis, where sufficient validation testing has been conducted to demonstrate the initiation behaviour and scatter. The DO would further need to demonstrate that the effects of the assembly techniques will not introduce defects larger than those assumed at new manufacture.

i. Residual stresses are always taken into account when determining the PSCDTL, as are the effects of vibratory stress on the onset of unstable crack growth. The consequences of surface treatments on the ability to inspect the component would need to be considered when determining the PSCDTL. Any beneficial effects of induced residual compressive stresses introduced by the manufacturing process, such as shot peening etc, may also be taken into account. However, the justification behind the procedures used would need to be understood accordingly. The effect of the Service environment on residual stresses would need to be considered in this case.

j. The residual strength of each critical part with the maximum damage present would need to be enough to sustain the highest stress occurring during its operation without catastrophic failure. As such, consideration would need to be given to normal overspeed due to control system tolerances and engine deterioration.

67. **Approved Nomenclature for use in lifing statements.** When dealing with lifing documentation you will note that the nomenclature ordinarily used conforms to standard engineering terms. Table 2 lists a nomenclature of the common abbreviations found in Engine Lifing Statements.

Head symbols	
N	Life in cycles
F	Factored cyclic life (that is, the estimated 1/750 quantile to 95% confidence)
A	Value of ‘F’ for life limiting area of component
S	Fraction of A released for service
H	S converted into hours
n	Sample size
sf	Estimated scatter, that is, for the ratio of the $+3\sigma$ and -3σ lives on the respective population distribution
y(n)	Scatter factor (for disc test sample size ‘n’) to get from the geometric mean life to the life at which not more than 1/750 components have a exceeded the specified failure criterion (eg a crack) to 95% confidence. For example (1)=4.003
β	Exchange rate
Subscripts	
t	Test
r	Reference
gm	Geometric mean of sample (that is, expected log-mean life of the population) in units of reference cycles
+3σ	Expected plus 3 sigma point on population distribution
-3σ	Expected minus 3 sigma point on population distribution
av	Average (exchange rate)
f	Factored (safe exchange rate), that the greater of the 80% probability and 95% confidence values
Superscripts	
0	‘No visible cracks’
i	From virgin to life-to-first-crack
a	From virgin to crack size ‘a’
d	From virgin to dysfunction
s	From virgin to the service life
si	From the service life to life-to-first-crack
sa	From the service life to a crack size ‘a’
sd	From service life to dysfunction
ia	From life-to-first-crack to a crack size ‘a’
p	From life-to-first-crack to dysfunction
c	Composite value (of exchange rate), used so that cycles recorded in engine parts tracking spreadsheets are in true cycles. This eliminates the need for a symbol for the damage tolerance life, since the life declared is then 2/3 dysfunction
Braced superscripts	
i	State of art inspection
(i)	Ltfc based on striation count over sufficiently large crack growth interval to incur significant error.
{i}	Ltfc based on fracture mechanics back calculation over sufficiently large crack growth interval to incur significant error.
Examples of how these semantic rules would be applied.	
N_r^i	Cyclic life-to-first crack converted to equivalent reference cycles
N_t^{si}	Rig test life-to-first-crack of an ex-service disc (that is, excluding the cycles consumed in service)
β_{av}^i	Average exchange rate for ltfc regime
β_f^i	Factored (i.e. safe) exchange rate for ltfc regime

S_r	Service release life in reference cycles
S_{efh}	Service release life in engine flying hours
$\frac{2}{3}F_r^d$	2/3 dysfunction safe life in reference cycles

Table 2: Lifing Symbology

Suggested Reading List

68. If you require additional guidance in relation to a propulsion related query below is a list of additional regulations and publications that may provide you with the answer. If you are still unsure please contact the relevant desk officer within MAA-Cert-MPS branch.

a. Def Stan 00-970: Design and Airworthiness Requirements for Service Aircraft, Pt 11, Engines.

b. JAP(D) 100C-22: Procedures for Developing Preventive Maintenance:

(1) Chap 6 - Failure Mode, Effects & Critical Analysis.

(2) Chap 7 - The Metrics and Characteristics of Failure Contents.

(3) Chap 12 - Condition Monitoring and Condition Based Maintenance.

c. RA5723: Ageing Aircraft Audit.

d. RA5724: Life Extension Programme.

e. RA5725: Out of Service Date Extension.

f. RA5600 Series: Propulsion System Design Requirements and Assurance.

g. RA1500: Certification of UK Military Registered Air Systems

h. Nimrod Review Report.

i. Certification Specifications for Engines: CS-E.

Propulsion Courses

69. The following courses may be of interest to desk officers involved with PI.

a. Propulsion Integrity Course (PIC). 2½ day course at Shrivenham.

b. Military aerospace and airworthiness suite**:**

(1) Airworthiness of Military Aircraft Course (AMAC) - MAA 03.

(2) Gas Turbine Appreciation - MAA 10.

(3) Jet Engine Controls - MAA 09.

(4) Mechanical Integrity of Gas Turbines - MAA 14.

Annexes

A. Propulsion Integrity Strategy Document.

B. PSIMP Example Layout.

Annex A - Propulsion Integrity Strategy Document

1. This section provides suggested headings, content and format for a Propulsion Integrity Strategy Document (PISD) using the ESVRE format. It is not a comprehensive list and other formats may be acceptable. Not all headings will be appropriate to all Platforms, dependent on usage and position in life cycle, and PTs should tailor their PISD to accurately reflect those activities which are pertinent to their Platform.

Introduction Section

2. The following content may be included in the introduction section:

a. Title – include names of Engine and APU (if applicable) in the title.

b. Contents page.

c. Abbreviations list.

d. Distribution List – as required. It is suggested that all stakeholders receive a soft copy. The MAA have no requirement for a hard copy, but the DO and others may have a requirement.

e. Record of amendment – include issue number, review requirements and reason for change. This will create an audit trail.

f. References – as required. Consider Hyperlinks to aid the reader.

g. Key Stakeholders - Identify all Key Stakeholders and their Propulsion Integrity (PI) responsibilities.

h. The Aim and Scope of the PISD:

(1) The PISD informs stakeholders how the PT will manage the PI activities underpinning airworthiness.

(2) PI management activities are not fixed and may be subject to change throughout the life of the programme. Therefore, the PISD should be considered to be a living document and subject to regular review.

(3) The document will form part of the platforms TLMP and associated Safety Case. Aim to use the document as a record of the evidence and rationale behind all PI decisions taken throughout the life of the aircraft.

(4) If the Propeller is to be covered within the PSIWG and not in the Structure IWG (SIWG), detail it here. Ensure a corresponding statement is made in the Structures Integrity Strategy Document (SISD).

i. List of annexes:

(1) PSIMP (see Annex B for an example layout).

(2) A sample PSIWG Agenda.

(3) ToR for PSIWG.

(4) Schematic of PI Meetings - detailing what other meetings discuss PI, who the key stakeholders are and how they interact.

Engine Introduction

3. Provide a brief description of the Engine and APU (if applicable).

a. Include all variants in service.

b. Provide details of the ISD and planned OSD.

c. If there has been a recent mark change or PI related modification to the engine, provide a brief history.

d. Ensure that the support arrangements are detailed, including references to MAOS/DAOS contracts and the expiry dates.

e. List who the CAM is/are.

4. List all areas of Non-Compliance with RA5722 and the MRP.

a. Include details of proposed outcome, e.g. compliance with RA5722, AAMC or Waiver.

b. Provide an action plan with a timeline for resolution and the submission of correspondence to the MAA.

5. List all extant MAA authorised AAMC and Waivers, including expiry dates.

Establishing

6. **PISD.** Detail when the document will be reviewed and issued to the stakeholders for comment. It is suggested that this is done in line with the PSIWGs. Good practice is to send out the documents with the PSIWG calling notice to allow sufficient time for the stakeholders to review and comment.

7. **Management of the PSIMP.** State the objective and summarize the content of the PSIMP. Detail how it is managed and when it is reviewed. Again, it is suggested that this is done in line with the PSIWGs. Consider if activities that are normal daily business require to be included in the PSIMP.

8. **PSIWG and Agenda.** List the stakeholders required, the frequency and the purpose of the PSIWG. Provide a sample agenda (place in Annex). If an example agenda is detailed in the PISD, ensure this is the one that is used at PSIWGs.

9. **Certification.** Detail how and to what standard the Engine/APU (if applicable) was certified. Ensure the TAA acknowledges any non-compliance with Def Stan 00-970, such as battle damage and armament gas ingestion.

10. **Qualification.** Discuss the 'as flown' usage and configuration. Capture any FMECA or Fault Tree Analysis that has been carried out, and how this is used to inform the SOI and SOIU.

11. **Critical Components and Component Lives.** Describe how critical components have been identified. Detail where this is listed and how this will be maintained throughout the life of the Propulsion System.

12. **Component Lives and Exchange Rates.** What lifing methodology was used (finite life, condition based etc) and how is the lifing recorded (cycles, fg hrs, starts etc)?

13. **Hazard and Risk management.** Discuss engine related hazards, document that they are sentenced and highlight any outstanding issues.

Sustaining

14. **Configuration Control.** Explain how Configuration Control is managed and how it is maintained by the TAA.

15. **Collection of Usage and Failure data.** Explain what Engine Parameter data is required by the DO (speeds, temperatures and operating hours etc), when and how it is presented to the DO and what analysis and feedback is provided. Provide a link to the document detailing that the engine DO is content with the data provided.

16. **Health monitoring.** Detail what method of health monitoring is employed e.g. SOAP, vibration analysis etc, and what is done with the results.

17. **SPS and Maintenance Schedule review.** What is the strategy for reviewing the SPS and Maintenance Schedule? Capture timings and actions in the PSIMP.

18. **Obsolescence Management.** Provide details of the Obsolescence Management Plan. Detail its location and hyperlink for visibility.

19. **AAA requirement.** Detail when the next review is to be carried out, and who will be carrying out the AAA. List any outstanding actions with an action plan. Ensure that dates and actions are transferred to the PSIMP. Highlight any omissions – e.g. AAPA. Also consider hyperlinking the AAA report.

20. **Acceptance and Endorsement of PI risk strategies.** As agreed at the last PSIWG and hyperlink the minutes.

Validating

21. **SPS and Maintenance schedule review.** Discuss any expected changes to the operational requirements and the validity of the Maintenance Schedule and component lives within the design assumptions.

22. **Review of Engine Lifing assumptions.** Detail how actual usage data gathered from the 'as flown' configuration will be validated to refine the DO assumptions, how this data is delivered to the DO for ratification and how often. Detail the process and periodicities for both the formal Engine Technical Life Review by the DO and the DO review of the SOIU.

23. **Sampling Requirements.** Explain the sampling requirements, as dictated by the DO, and consequently, where the Sampling regime is documented. Explain what components will

be sampled and when, the sampling requirements on lifex components and component subject to tear down etc.

Recovering

24. **Occurrence reporting.** Explain how D-ASORs and F760s etc are managed. Detail the process for raising significant issues to the PSIWG and, if required, higher. Describe how the PT conduct trend analysis and how the impact of issues is assessed and managed.

Exploiting

25. **In-service experience or other platforms or operators.** How is information from other users/sources collected, reviewed and exploited? Explain what PI information is currently used from operators of the same and similar engines/platforms. Information can also be obtained from other MoD operators that have previously operated in the same environment, such as Maritime operations or operating in a dusty environment.

26. **Historical Documents.** Links to historical decisions affecting PI should be placed within the PISD to ensure corporate knowledge is not lost.

The following is for consideration whilst writing the PISD

27. The following lessons identified and areas of best practice are of note:

a. Refer to post titles not named individuals. This will reduce the work required to review the PISD when personnel change post.

b. Minimise the use of pictures unless they are required to support the narrative, this reduces the size of the document and produces a succinct strategy.

c. It is recommended not to refer to dates of the PSIWG and other PI meetings in the PISD. By placing these in the PSIMP, you will reduce the items in the PISD that require review.

Annex B - PSIMP Example Layout

This annex provides a suggested format for a Propulsion System Integrity Management Plan (PSIMP). Other formats may be acceptable.

PROPULSION SYSTEMS INTEGRITY MANAGEMENT PLAN LAYOUT EXAMPLE

SPECIFICS				
Platform				
Engine Type				
OEM				
In Service Date				
Out of Service Date				
AAA				

	Action / Requirement	PoC	Ref Document (hyperlink)	Last Carried out	Freq	When due	2014	2015	2016	2017
Airworthiness Management										
Establishing	PSIWG	Joan Doe	Strat Doc Annex B	Dec 13	6 Monthly	Jun-14				
Sustain	Review Config Management Plan	Rolls Royce/EA	RR/2007/123	Aug 13	2 Yearly					
Validate	Review Support Policy Statement	Joe Bloggs	SPS	Jun 2010	5 Yearly	Jun-15				
Recovery										
Exploiting										

To copy this layout to a new Excel worksheet - Double click on the table, copy, then paste into a new Excel workbook.