Contributing to a Healthier Propulsion System for the Joint Strike Fighter (JSF)

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Abstract

The Joint Strike Fighter Science and Technology Advisory Board (JSTAB) is addressing the long term needs of the Joint Strike Fighter (JSF) program by facilitating the transitioning of new and improved sustainable technologies from partner nations, for the design, manufacture and through-life support of the JSF, into the JSF Integrated Product Team. The Defence Science and Technology Organisation (DSTO) Australia is contributing, through the JSTAB program, to the development of advanced vibration analysis algorithms tailored to the JSF lift fan and engine. This presentation will provide an overview of DSTO's advanced vibration analysis program for the JSF, and some of the science and technology being utilised.

Keywords: Joint Strike Fighter, HUMS, Gas turbine engines, Vibration analysis, Machine condition monitoring, Synchronous signal averaging, Envelope analysis, Spectral kurtosis

Introduction

The JSTAB Vibration Prognostics and Health Management (JSTAB-VPHM) program is one of the six JSTAB projects awarded to Australia's Defence Science and Technology Organisation (DSTO).

The JSTAB-VPHM program comprises the tailoring and transitioning of advanced vibration analysis algorithms for condition monitoring of lift fan and engine components for the Short Take Off and Vertical Landing (STOVL) variant of the JSF aircraft.

The two applications presented here are gear and bearing diagnostics for the lift fan, and condition monitoring of a pump in the engine accessory drive gearbox.

This presentation provides an overview of the lift fan bearing diagnostics and the engine accessory drive pump diagnostics, and discusses the following vibration analysis technologies that have been tailored to achieve these goals; synchronous signal averaging, residual signal energy ratio, envelope analysis and spectral kurtosis.

Body of the Paper

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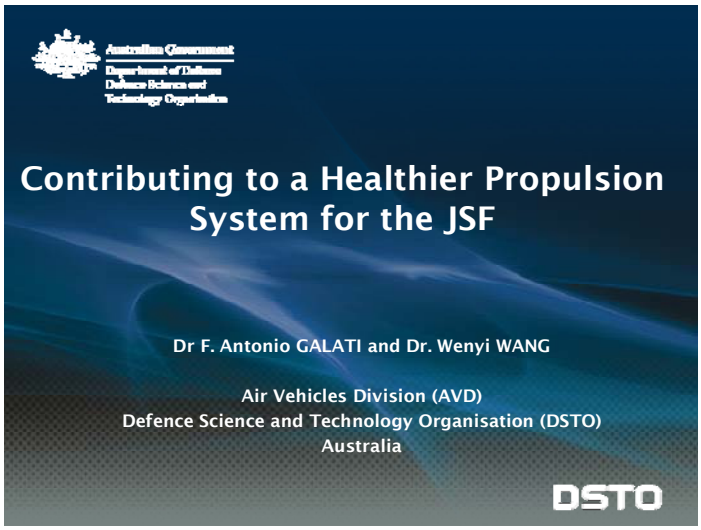

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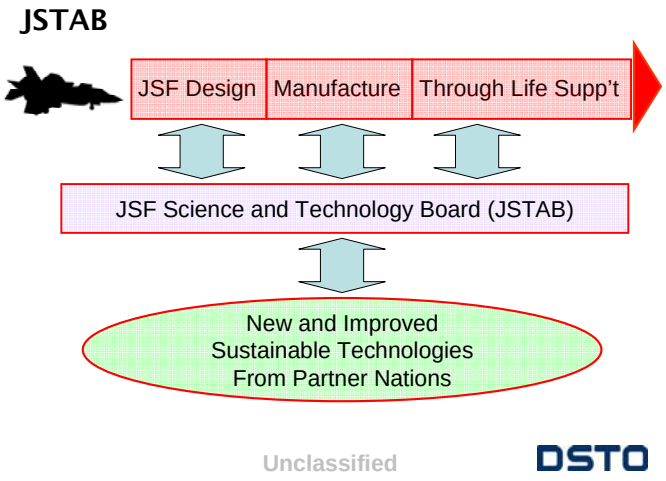

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JSTAB Programs

- 280 proposals and 21 projects awarded
- 7 awarded to AFRL
- 6 awarded to DSTO
  - Advanced Airframe Repair
  - Structural Shape Optimisation
  - Non-destructive Inspection Reliability
  - Aluminium Alloy Coating
  - Corrosion Coating
  - Vibration Prognostics and Health Management Technology (VPHM)

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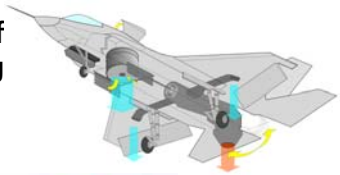
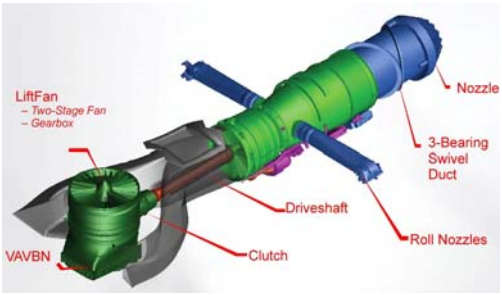
F-35B Short Take Off and Vertical Landing (STOVL) Version





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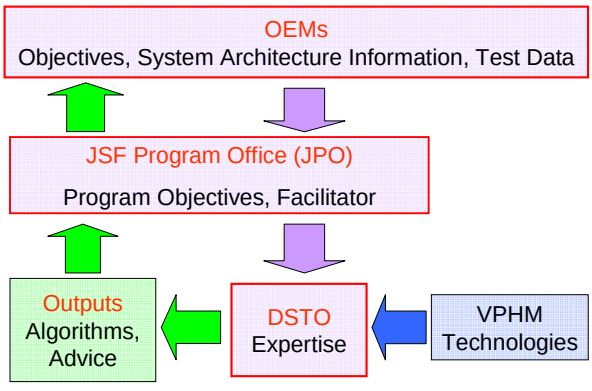
JSTAB-VPHM Program



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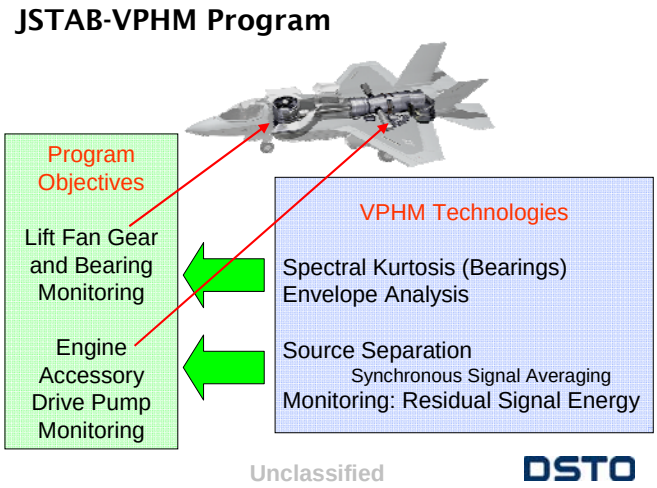

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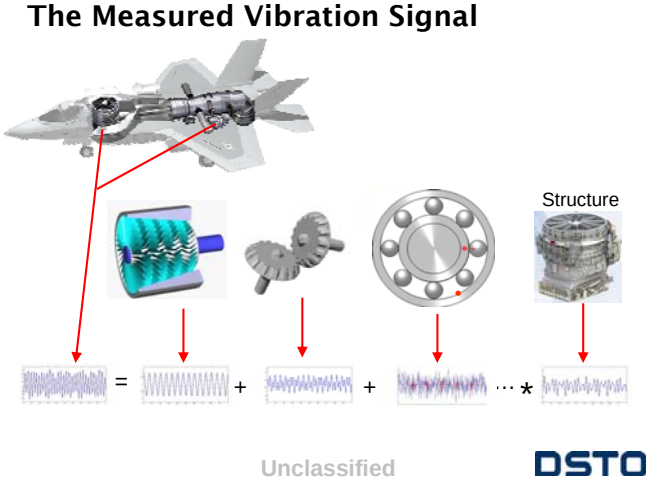

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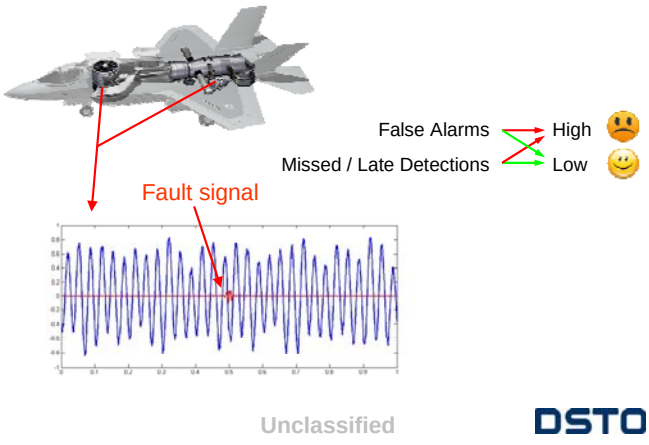

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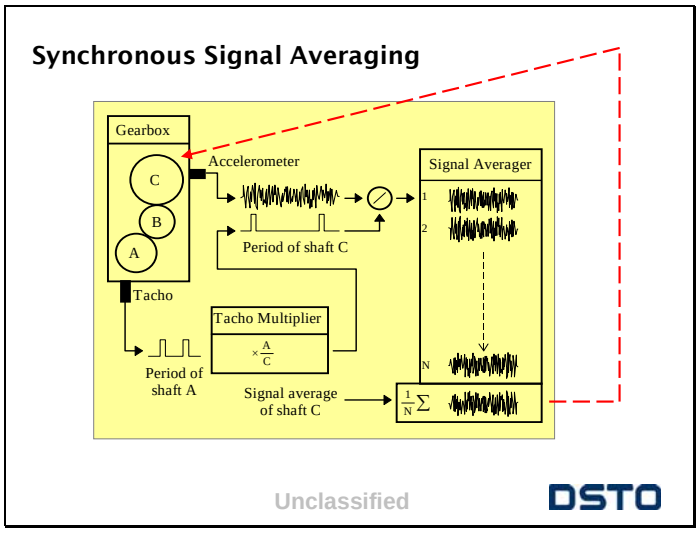

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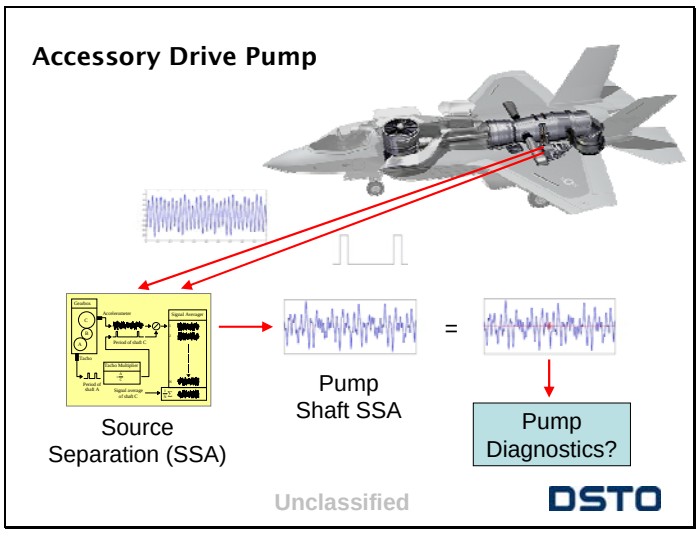

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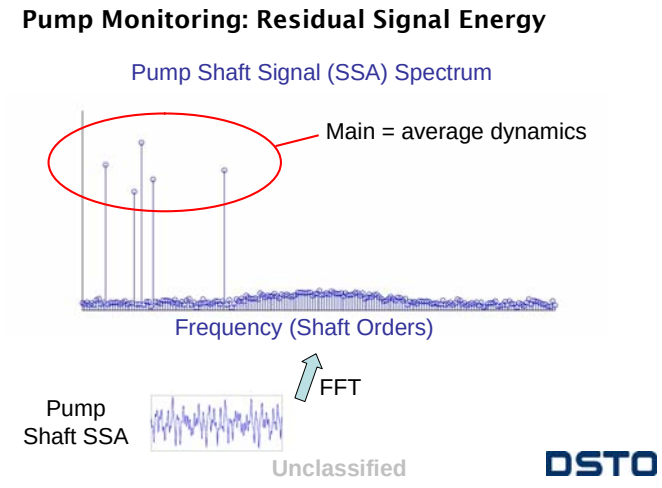

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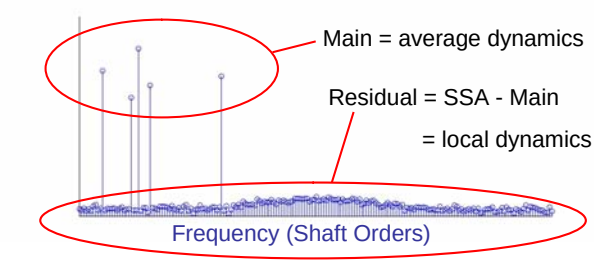
Pump Monitoring: Residual Signal Energy

Pump Shaft Signal (SSA) Spectrum



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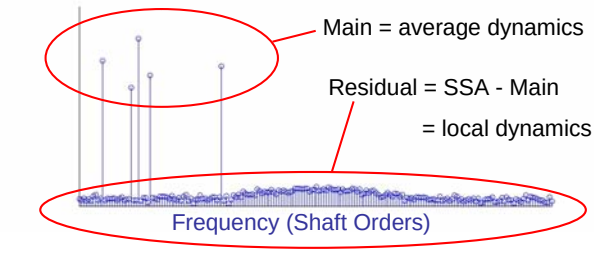

$$\text{Pump Condition Index} \sim= \frac{\text{RMS Energy (Residual Signal)}}{\text{RMS Energy (Pump Shaft Signal)}}$$

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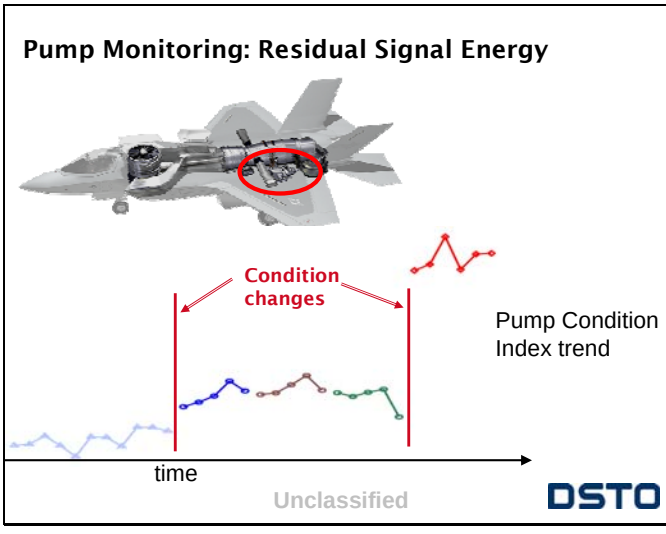
Pump Monitoring: Residual Signal Energy



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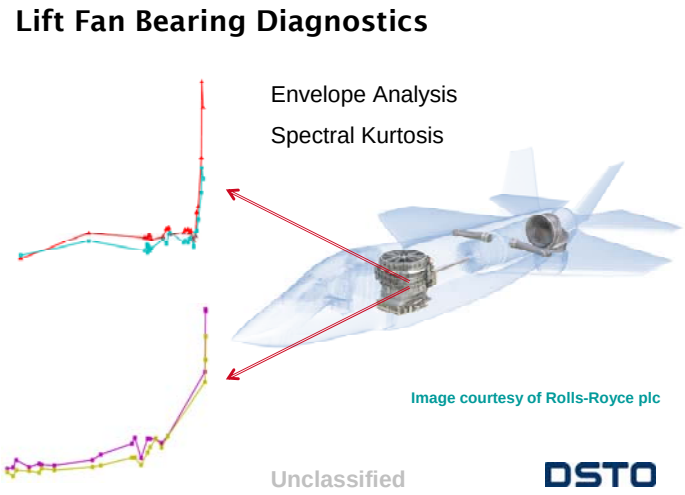

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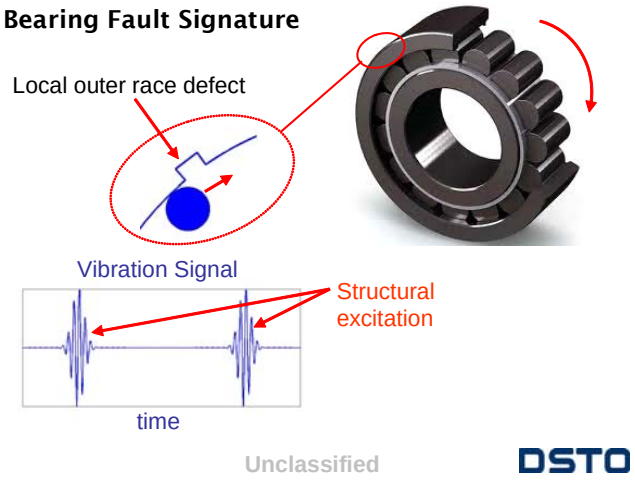

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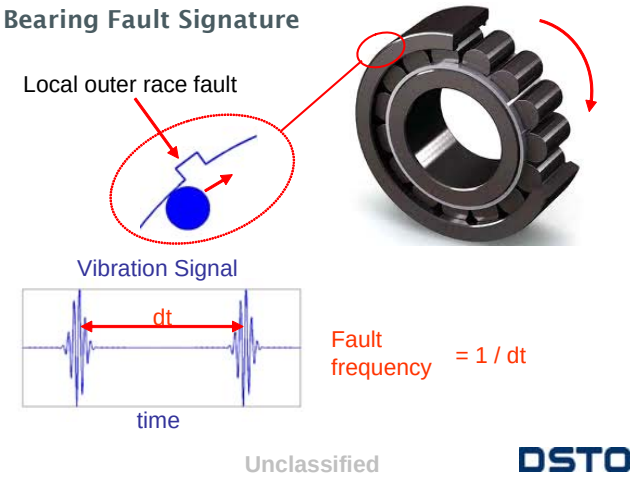

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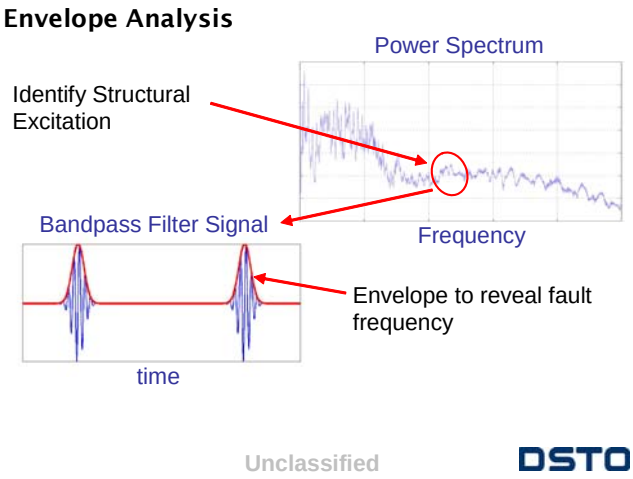

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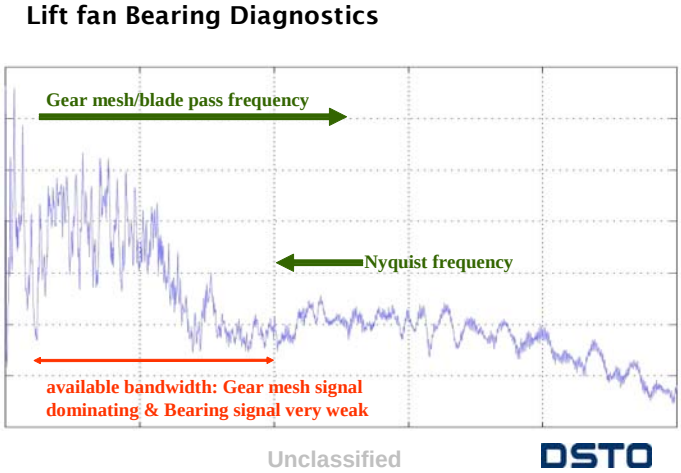

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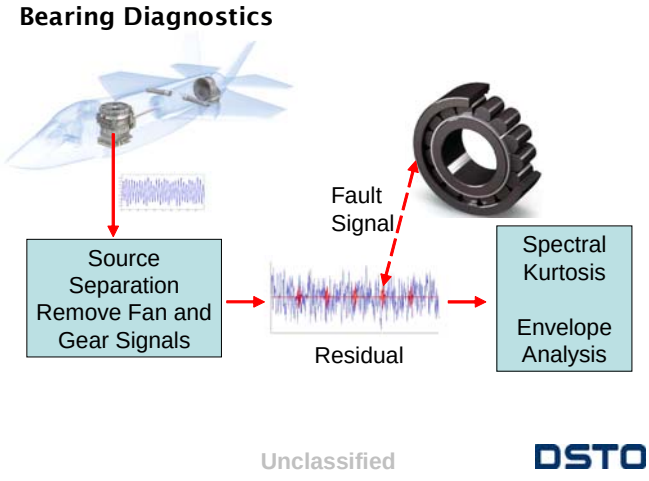

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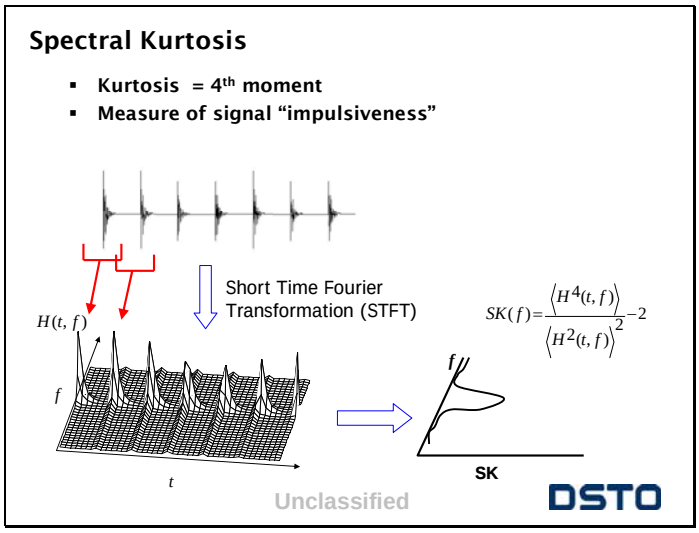

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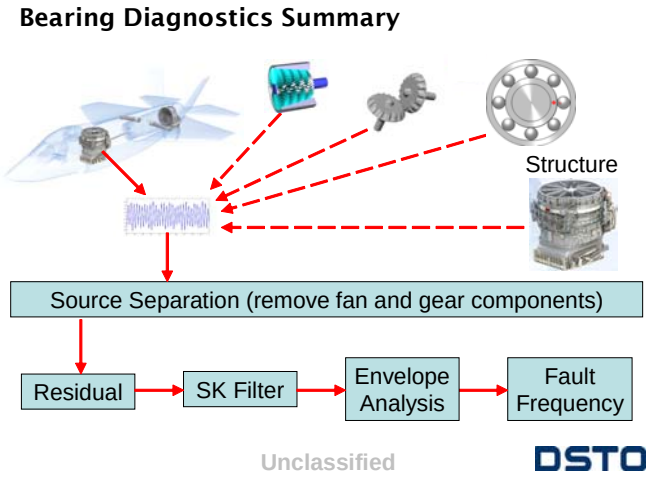

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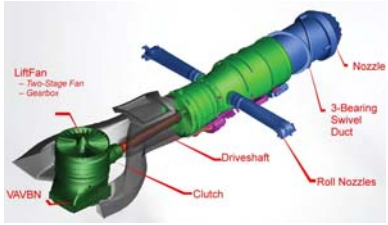

Highlights

- 1st JSTAB project to achieve technology transition
- Lift Fan VPHM Technology insertion
  - DSTO gear & bearing algorithms -> to OEMs (via JPO)
  - OEMs to incorporate into upgraded FADECs
- LF VPHM technology migrating to main engine
  - Pump failure detection method developed
  - Algorithms delivered to OEM (via JPO)
  - OEM to use in test stand

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Questions?

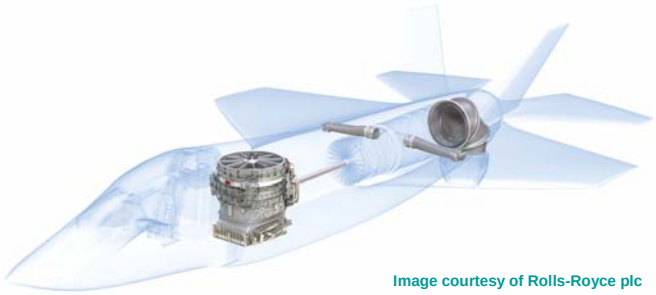

Image courtesy of Rolls-Royce plc

Acknowledgements:

Dr B. David Forrester

UNSW CoE in Helicopter Structures and Diagnostics

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Conclusions

DSTO have successfully identified and tailored advanced vibration analysis algorithms for condition monitoring of JSF lift fan gears and bearings, and a pump in the engine accessory drive gearbox as part of the JSTAB-VPHM program.

Algorithms for lift fan gear and bearing monitoring have been passed to the lift fan manufacturer for incorporation into the lift fan digital electronic control system in a future upgrade. Algorithms for condition monitoring of the engine accessory drive gearbox pump have been passed to the engine manufacturer for integration into their test facilities.

Acknowledgements

The authors would like to acknowledge Dr B. David Forrester (DSTO) for leading the initial JSTAB-VPHM program and for his technical contributions to the final program.

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