NON-INTRUSIVE FLIGHT TEST INSTRUMENTATION (NIFTI) FOR ASI MANAGEMENT

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Outline

- Introduction
  - a collaboration between AWC, Industry and DST Group
- Capability Overview
  - System description
  - Benefits vs conventional FTI
- Feasibility/Proof of Concept Trials
  - Caribou, YAK52 and PC-9A flight trials
- Capability Development Plan
  - Development of baseline (Gen 1) AWC NIFTI system by
- NIFTI Benefits for ASI Management
- Conclusions
Introduction

- Current development and Certification programs operate small ‘instrumented’ fleets, with conventional flight test instrumentation (FTI), that have significant constrains for managers.

- DST Group and RAAF, Air Warfare Centre (AWC), with Australian industry (Defence Innovations) is developing a FTI capability, i.e. Non-Intrusive Flight Test Instrumentation (NIFTI), that will allow unprecedented flexibility for development and Certification managers.

- NIFTI also offers the ASIP managers a flexible inexpensive tool for quick seamless measurement of operational load and usage information for ASI management of fatigue critical components.
Enabled by an Integrated Project Team between Defence and Industry

Air Warfare Centre
- AWESQN provide:
  - performance requirements
  - engineering analyses and approvals
  - Verification
  - ARDU conduct Flight Trials of NIFTI

DST Group
- Technical coordination
- Scientific inputs, including technical requirements
- Laboratory testing and modelling

Defence Innovations P/L

aadi Defence P/L
- Management and co-ordination
- SMEs on adhesives, aerodynamics, flight trials, materials, and air worthiness
- YAK-52 Flight Trials

Procept P/L
- SME with track record in ultra low power robust electronics hardware, software and wireless communications
- Design and development
NIFTI Concept

NIFTI concept:

- Small, low powered, ‘wireless’ and rapidly configurable (utilising a bespoke wireless communications technology) system
- Pre-qualified and rapidly deployable - short installation, removal and restoration times
- Sensor design is modular allowing ‘plug and play’ capability to easily achieve user defined measurement requirements

Physically, the typical system comprises of

- A single data accumulator (gateway)
- Wireless sensors designed to adhere to any external (or internal) surface, while having negligible influence on aircraft handling qualities, performance or operating limits.
Benefit vs conventional FTI

- Generic
  - removes or reduces the need for dedicated test aircraft
  - reduced design and installation timeframes
  - adds low cost redundancy within the flying program
  - allows test in remote locations / operators preferred locations.....

- Enables ‘quick-look’ assessments
  - to inform large-scale installations / identify areas of concern / quick assessment of structural ‘hot spots’....
Benefit vs conventional FTI

P-3C example from Dec 2015

- Conventional FTI installation took 2 weeks... NIFTI is estimated to require 2 – 3 hours!
- Traditional wired design could not 'reach' some areas of interest due to complications in getting wiring to those locations... not issue with NIFTI
The first conceptual prototype is born. Compact Multi-Parameter Load Evaluation (CMPLE) demonstrated on Caribou.

Proof of concept on PC-9/A: Non-modular wireless gateway; Single node type (3 axis accel.) @ 400Hz sample rate and +/- 16g range; Limited FTE/user interface

Proof of concept on F/A-18A/B and additional functionality feasibility studies

NIFTI Gen 1 (TRL 8): Modular gateway; Multiple sensor node types; Full graphical user interface; Improved RF performance and system robustness
First generation NIFTI (CMPLE developed by DST)

Directorate General of Technical Airworthiness (DGTA) tasked DST to develop a rapid operational loads measurement system in June 2006. More specifically to:

1. produce a strain measuring unit to fit on any structure with minimal impact to airflow, certification, dynamics, wiring, aircraft downtime etc, and
2. demonstrate the unit by measuring the strains on the tail of a Caribou aircraft during a stall.

Detailed Requirements:

- Rapidly deployable aircraft loads measurement system consisting of
  - light weight, portable, self-contained, platform independent sensing module to measure operational strain/temp or acceleration/temp
  - support equipment which allows (1) quick installation, commission and removal to minimise operational impact (a/c downtime) and (2) quick and easy to calibrate, synchronise and interrogate
- No wiring means no excessive certification requirements

DST developed CMPLE (Compact Multi Parameter Loads Evaluation System) for successful flight trials on Caribou in July 2008.
First generation NIFTI – *CMPLE* demonstration on Caribou tailplane loads flight trial

**Capabilities**
- Record unidirectional strain on a surface and temperature, or acceleration and temperature (user selectable) for up to 3 hours
- Record at up to 1024Hz
- Maximum strain level of 2,000 microstrain with bandwidth of 30 Hz
- Operating temperature -20°C to +60°C
- Connection to PC controller by wires
NIFTI Development – Phase I: PC9 Proof of Concept

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DST Prototype (CMPLE) 2008

Phase I: PC9-A 2015

Feasibility Studies 2017-19

Core System Development

AWC Gen 1 (TRL 8) 2019

Phase III: JPO
PHASE I

The NIFTI system Phase I provided:

- **Pilot Control**: simple user interface to start and stop recording, initiate emergency shutdown

- **Gateway**: non-modular system capable of communicating with 10 wireless nodes

- **Nodes**: accelerometer sensor node, 3CH (3-axis), @400Hz, +/- 16G

- **Charger**: allows in situ charging of the nodes
Phase 1 – NIFTI PC-9 Proof-of-concept
NIFTI flight trialed on YAK-52 (Pre PC-9 flight trial)

Gateway strapped in cockpit
Phase 1 – NIFTI PC-9 Proof-of-concept

NIFTI successfully flight trialed on AWC PC-9 between 19-26 Oct 2015

AWC PC-9/A Proof-Of-Concept flight trial outcomes:
• Full installation/removal < 1hr
• Continuous RF comms between gateway and NIFTI sensors during flight
NIFTI Development – Phase Ib and II

The first conceptual prototype is born: Compact Multi-Parameter Load Evaluation (CMPLE) demonstrated on Caribou

Proof of concept on PC-9/A: Non-modular wireless gateway; Single node type (3 axis accel.) @ 400Hz sample rate and +/- 16g range; Limited FTE/user interface

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Phase Ib: F/A-18 A/B Feasibility Studies 2017-19

Phase II: AWC Gen 1 (TRL 8) Core System Development 2019
AWC Capability Development Plan

- **Start Oct 2016**
  - ‘Gen 1’ Capability
  - Various ‘End State’ Scoping Studies for future system enhancements
  - User Interface
  - Stores Separation
  - Reports 3 - 8
  - AIM 120 POD

- **6 months from start**
  - Milestone event

- **36 months from start (2019)**
  - TRL 8 Baseline System
  - Commitment of funding / purchase order
  - Product delivery / capability enhancement delivery
Potential first ‘fast jet’ application

- Proposed demonstration of prototype Gen1 AWC NIFTI system on Classic Hornet in 2018/19
  - Demonstrate functionality and fast application NIFTI sensor nodes on 6 proposed locations
  - Install Gateway in Supersonic Camera Pod (w & w/o External Fuel Tanks)

- Observe system performance during 2-3 flights at the following flight conditions
  1. high vibration (MPH to 7.5g and 30 degrees AoA / take-off and landing / >10 min flight at 0.95IMN / 1000 ft AMSL)
  2. low temperature < -45°C
  3. high speed ~ 635KIAS and 1.3 IMN
### Proposed NIFTI sensor node locations

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>One node on the underside of the wing adjacent to a pylon. (1 node total)</td>
</tr>
<tr>
<td>2</td>
<td>One node on the outer surface of the pylon. (1 node total)</td>
</tr>
<tr>
<td>3</td>
<td>One node on each vertical tail - upper, trailing edge outboard surfaces. (2 nodes total)</td>
</tr>
<tr>
<td>4</td>
<td>One node on the flat upper surface of each launcher rail on the wingtips. (2 nodes total)</td>
</tr>
<tr>
<td>5</td>
<td>One node on the keel surface, adjacent to the arrestor hook attachment point. (1 node total)</td>
</tr>
<tr>
<td>6</td>
<td>One node on the flat surface of each hip weapons station (stations 4 &amp; 6). (2 nodes total)</td>
</tr>
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**AWC NIFTI Baseline/Gen1 System – Sensor Nodes**

Minimum sensor channel resolution: 16 bits
Oversample rate: 4096Hz
Endurance: 4hrs flight recording + 4hrs standby @ -45°C & +60°C

Internal storage where transmission is not possible or authorised:
4 hours of decimated data (1024Hz) for 3 sensor channels
Charge time: 0-100% ≤ 3hrs
Environmentally sealed: IP67 rated
Self-health check: On command

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**Accelerometer Sensor Nodes**

- Internal sensors
  - 3-axis accelerometer
  - Temperature

**Strain Gauge Nodes**

- Collects strain from externally mounted strain gauges
  - 3 differential voltage inputs; and
  - 3 voltage senses
System Description

Typical Aircraft-Store Compatibility (ASC) Activities

- Aircraft Flutter
- Store Separation
- Aircraft Loads
- EMC/EMI
- Aircraft Stability and Control

On-board avionics

- Inertial Motion Unit
- Air Data
- Power Systems
- Wind Angles
- Propulsion System
- Control Surface Posn
- TSPI......

Typical sensor data recorded by COTS FTI on “orange wired” aircraft

- Accelerometers
- Strain Gauges
- Camera
- IMU
- Pressure
- Proximity
...

NIFTI

Data logging on-board

Telemetry to ground station

PMD

Telemetry to ground station
NIFTI within SBI “hot spot” program

<table>
<thead>
<tr>
<th>Operational</th>
<th>Engineering Support</th>
<th>Maintenance (depot/field)</th>
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<tbody>
<tr>
<td>Fatigue assessment of critical component (“hot spot”)</td>
<td>NO</td>
<td>Repair/Replace component</td>
</tr>
<tr>
<td>DT approach feasible</td>
<td>YES</td>
<td></td>
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**Damage Tolerance Analysis**
- Develop “hot spot” SBI program considering, component inspectability, NDI method (i.e. damage detectability, POD and etc.) determine inspection threshold, interval, area and procedure, etc...

**NIFTI**
- Operational loads and usage monitoring
- Establish transfer function via strain survey, and/or FEA
- Determine:
  - rate of effort (ROE),
  - operational spectrum,
  - mission severity,
  - effective K at “hot spot”

NIFTI allows quick operational strain/acceleration measurements at/near structural ‘hot spot’ to facilitate/validate SBI program.
NIFTI Benefits for ASI Management

- NIFTI also offers the ASIP managers a flexible inexpensive tool for quick seamless (one-off) measurement of operational load and usage information for fatigue critical components.

- NIFTI strain or acceleration sensor modules can potentially be installed as
  - stand-alone inexpensive monitoring and recording modules or,
  - by also incorporating the gateway, a wirelessly networked (time synchronised) array of sensing modules with recording at the sensor modules and/or within the gateway
Conclusions

• Outlined the capability and benefits to flight test community

• Demonstrated the feasibility of a NIFTI system on an operational aircraft

• Outlined the NIFTI capability development plan
  • Development of baseline (Gen 1) AWC NIFTI system by 2018/19

• Outlined benefits of NIFTI to ASIP managers as a flexible inexpensive tool for quick seamless measurement of operational load and usage information for ASI management of fatigue critical components.
## Contacts

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<tr>
<th>Future Program &amp; Contractual</th>
<th>Scientific</th>
<th>Engineering/Customer Engagement</th>
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