Fleet Metrics: Aircraft Flight Data Collection and Analytics

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Introduction

- TDA, Inc.
- Aircraft structural life may be tracked on a flight-by-flight basis by using measured flight data to model each individual flight
  - Requires extensive recorded parameters for each flight
- It is essential to instrument each aircraft with a high fidelity, high reliability flight data recorder
  - Better fatigue life predictions
  - Realistic loads prediction
Overview

- USN measured flight data
  - SDRS is one system used by USN
- Fatigue Life Assessment
- SDRS collection methods: issues and resolution
- **Fleet Metrics**: Web-Based Flight Data Collection and Analytics
  - Features
  - Applicability
Flight Data Recorders

- How do flight data recorders work (Nz)?
  - Via an accelerometer, Nz (cg vertical acceleration) is measured as a continuous signal
  - It is then pre-filtered, discretized (cut into a certain number of samples/second), then used for analysis
Example: USN P-3 Orion

- **CAG** (Counting Accelerometer Group)
  - Default data recorder
  - Measures Nz (cg vertical acceleration) at 4 “windows”
    - 2g, 2.5g, 3g, 3.5g
  - No other measured parameters
  - No differentiation between maneuver, gust, ground events
  - No tie-in to other aircraft parameters (altitude, airspeed, weight)

- **SDRS** (Structural Data Recording Set)
  - Available on P-3s (and many other USN platforms) starting in mid-late 1990s
  - Provides time history data (primarily) for Nz, speed, altitude
  - Gross weight (via flight engineer input)
  - Trigger-based recording (due to memory limitations)
  - Deadband (+/- 0.25g), rise-fall criteria (+/- 0.25g)
# Critical Measured Parameters for Fatigue Analysis

## Must-haves:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>CAG</th>
<th>SDRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Flight date, time</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>2. Timestamp of each in-flight event</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>3. In-flight events</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>4. Pre-flight, post-flight ground events</td>
<td>✗</td>
<td>✗ post-flt only</td>
</tr>
<tr>
<td>5. Nz</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>6. Aircraft gross weight/fuel, store weight (incl. store drops)</td>
<td>✗</td>
<td>✗ not automatic</td>
</tr>
<tr>
<td>7. Pressure altitude</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>8. Airspeed speed</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>9. Ground speed</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>10. WOW (weight-on-wheels)</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>11. Gear position</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>

## Nice-to-haves:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>CAG</th>
<th>SDRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cabin pressure/pressure cycles</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>2. Roll angle, roll rate (used to separate gust/maneuver)</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>3. Pitch angle, rate (used to measure abrupt maneuvers)</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>4. Flaps deployment events</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>5. Control surface positions</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>6. Vertical speed/sink speed (for landing impact)</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>7. Nx, Ny</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>8. Yaw angle, rate</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>
Life Assessment

Spectra

Fatigue, crack growth
Life Assessment

Essential information

- Weight
- Mach
- Altitude
- Nz

Spectra

Actual Stress History

Pilot flight summaries, etc.

Logbook Data

Flight Recorder Data

Loads/stresses

Predicted Stress History

Fatigue, crack growth
Data is Critical

- Or, “Why is the data *that* important?”
- “…Similarly, the EA-6B fleet is operating on average at a 120 percent design expected life, with an average aircraft age of 24 years… Units of the P-3 and EP-3 fleets have exceeded fatigue life expended limits, and some are now being very closely monitored for continued operation.”

Adm. Greenert, before the Joint Hearing of the House Armed Services Committee, February 13, 2007 Tuesday
Data is Critical

- Proper inspection, maintenance and analysis are required to keep these aircraft flying safely
- Maximum safety and aircraft life dictate maximum data collection
SDRS Collection Process: Need For Improvement

Legacy:

- Fleet personnel
- SDRS Recorder
- Email, FTP
- Data recorded by NAVAIR, transferred to TDA
- Binary-to-ASCII conversion program
- ASCII data transferred from TDA to NAVAIR
- Database loader application

Timeframe:
- 0 - 4 wk. (downloaded on average once/month)
- 1 - 12 wk.* (*estimate)
- 1 day (collected by TDA on a daily basis)
- 1 - 4 wk. (processed and transferred monthly)
- 0 - 4 wk.* (*estimate)

Fleet Metrics:

- Fleet personnel
- SDRS Recorder
- Data uploaded

Timeframe:
- 0 - 4 wk. (downloaded to diskette ~ once/month)
- 1 day* (*projected, based on training, easier process, online feedback, etc.)
- 5 - 10 minutes* (*projected application performance, is a function of amount of data)

SDRS Database

Connell, McColl, 11th Joint NASA/FAA/DOD Conference on Aging Aircraft
21-24 April 2008
Legacy Process Issues

- Data collection was a long process
  - Slow getting to where it needed to be
  - Manually-intensive process for conversion
- Data collection levels were unacceptably low
  - Data was "transmitted" on 3.5" floppies via U.S. mail
  - Data sent over e-mail
  - Both of these share another problem…
Legacy Process Issues

- No feedback
  - The data was sent in, did it arrive?
  - If the data recorder is malfunctioning and the data is un-useable, errors not addressed in timely fashion
  - The recorder’s memory filled and some hours were lost
  - SDRS system requires manual input of flight date, gross weight, mission code, etc. (DEK, Data Entry Keypad)
  - DEK not always used properly
    - Gross weight not entered
    - No flight date given
Resolution

- Develop a secure (SSL/https), web-based data upload and processing system for SDRS: Fleet Metrics
  - Improve average fleet SDRS data submittal rates
  - Reduce data transmittal rates (time from recorder download to data “usability”)
  - Reduce the fatigue life expended (FLE) calculation lag time – goal is to minimize lag time between actual fleet usage and FLE calculations
  - Improve fleet visibility of SDRS usage and submittal history

Connell, McColl, 11th Joint NASA/FAA/DOD Conference on Aging Aircraft
21-24 April 2008
Fleet Metrics: How Goals Were Met

- Improve submittal rates
  - Legacy process
    - 2 ways of doing it
      - U.S. mail
      - E-mail
    - Multi-step process with many hands in the middle
  - Fleet Metrics
    - One simplified process accessible from the web
Fleet Metrics: How Goals Were Met

- Reduce transmission time
  - Legacy process ((Much) more than a day)
    - Via floppy
      - The disk gets damaged
      - The disk gets lost
  - E-mail
    - Not secure
    - Only eliminates physical mailing part of process
  - Neither provide delivery notification

- Fleet Metrics
  - Front line to NAVAIR system in minutes
Fleet Metrics: How Goals Were Met

- Reduce FLE calculation lag time
  - Legacy process
    - Data offloaded from a disk or saved from e-mail
    - Desktop application converts binary files into text data files
    - Output sent to NAVAIR
    - QC process and database loading performed manually
    - (Potentially) several weeks or months from end to end
  - Fleet Metrics
    - Data upload, binary conversion, QC, and database loading occur in one stage
Fleet Metrics: How Goals Were Met

- Improve visibility of usage and submittal history
  - Legacy process:
    - U.S. mail or e-mail: No feedback
  - Fleet Metrics:
    - Data usually available in a few minutes

- Other benefits
  - Enhanced security – PKI and SSL leveraged to authenticate and authorize users of the system
  - Can track SDRS entries with other required entries (i.e., logbook)
FLEET METRICS NEW USER APPLICATION

Complete this application to request access to the Fleet Metrics application. Your application will be reviewed. You will be notified of your approval or denial within 4 - 48 hours, depending on the information provided.

All information provided is subject to verification by AIR-4.3.3.4.

Your account username will be your FULL EMAIL ADDRESS. Please make sure that you enter the full address or your account will not be approved. For DOD personnel, you must use your DOD email address (...@navy.mil, etc.).

* Denotes Required

Username (your email address): * Example: first.last@navy.mil (All lowercase, please)
Re-enter username (your email address): * (All lowercase, please)
Requested password: * Note: 10 characters maximum

THIS WILL BE YOUR FLEET METRICS PASSWORD ***

Requested user type: Analysis * 'Analysis' - data upload/analysis (reports, etc.)

Requested aircraft platforms: P3/EP-3E * At least 1 platform is required

Last name: *
First name: *
Middle initial: 
Phone number: * Example: 1112223333 (no spaces, hyphens, or parentheses)

Extension: 
Applicant status: Military *
Squadron/Company: (None) *

Contact information (required if applicant is a contractor):
POC name: 
POC email: 
POC phone number: Ex: 1112223333 (no spaces, hyphens, or parentheses)

Submit form  Cancel
Please upload your SDRS data below.

1. Select file(s) to be uploaded:
Enter file to be uploaded (full path name); max file size is 1 MB; for larger sets of data, please break into smaller zip files.

Note: only SDRS data files (*.Download) are required. Please do not directly upload ASCII (text) SDRS files; the binary data files are required.

2. Select a squadron:

The squadron name is a validation check intended to ensure that Fleet metrics correspond to the aircraft in the SDRS data file. It is displayed on any warning message that needs to be displayed on the following page.

3. Upload files:

Upload File  Reset Form

How to upload multiple files:

To upload multiple SDRS data files, please add them to a zipped file using a zip utility. Simply add all required files (no subdirectories, please) and upload this zip file. For help with this step, please contact Technical Support. Note: do not mix aircraft platforms within the same zip file (i.e., no P-3 and EA-6B files in the same zip file).

Common problems (and how to solve them)

1. yyyy_iyy files: Occasionally files will get corrupted, resulting in filenames like P_3yyyyy_yyy2005123_121112 Download. Per PMA-209, files that contain [yyyyy] for BUHO have a corrupt flight header. The data may still be usable. What causes this to occur is that the RC glitches during shutdown and the processor cannot properly update the header during power down. It is usually random but if it happens often on a particular aircraft then the RC should be replaced.
   - Short-term fix: rename file, replacing yyyy with BUHO prior to upload.
   - Long-term fix: contact PMA-209.
   - NOTE: Do not include these files within a zip file you intend to upload.

Click here for more frequently asked questions.

Supported aircraft platforms:
P-3/H-3A, EA-6B

Supported file formats:
- Binary SDRS data files
- Zip files containing one or more binary SDRS data files

Note: please do not directly upload ASCII (text) SDRS data files; the binary data files are required.

File naming conventions:

Files within the uploaded zip files (or binary files directly uploaded) must conform to one of the following two naming conventions:

- Long format: example:
PMA_20050308_210700.Download

- 0.3 format: example: 3Feb9516.000 (4 char BUHO representation + YY + Julian Data + file sequence; 168th day of 1995)

Note: the actual name of the zip file itself is not important; only the file(s) within.
<table>
<thead>
<tr>
<th>Aircraft</th>
<th>FUND</th>
<th>Mission Date</th>
<th>Download Date</th>
<th>Entered Date</th>
<th>FLH</th>
<th>Sub-Fit</th>
<th>FLH Hrs</th>
<th># Landings</th>
<th>Logged Mission Data (P-3/EP-3E only)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>04/03/08 (94)</td>
<td>04/03/08 (94)</td>
<td>04/03/08 (94)</td>
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<td>1</td>
<td>3.50</td>
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<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>04/02/08 (93)</td>
<td>04/02/08 (93)</td>
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<td></td>
<td></td>
<td>04/02/08 (93)</td>
<td>04/02/08 (93)</td>
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<td>75</td>
<td>1</td>
<td>1.50</td>
<td>1</td>
<td>Delete</td>
</tr>
</tbody>
</table>

**SAMPLE DATA**

Click here to add logged mission data for a missing SORS mission.

Click to view flight time histories.

Click to “split” measured data into multiple flights (to better match logbooks).

View (or add) flight engineer mission info (flight time, gross weights, cargo, mission code).

View data recorder errors.
Wrap Up

- Fatigue life assessment
- Maximizing flight data collection is critical for accurate aircraft structural fatigue life assessment
- Data collection process needs to be timely, accurate and provide feedback
- Fleet Metrics successfully addresses these requirements
Questions?