Condition-Based Maintenance for Highly Engineered Systems

Maintenance Malfunction Information Report

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Introduction

When the Federal Aviation Administration (FAA) was created from the Civil Aeronautics Board, a comprehensive set of Federal Aviation Regulations (FAR's) was developed. From the beginning, these FAR's contained service difficulty reporting requirements. The FAA recognized the importance of reliability tracking and the analysis of this historical data in the agency's overall safety program. By requiring written reports on product reliability, the FAA intended to detect potential incipient failures and negative trends. Early identification of potentially fatal failures could provide overwhelming positive benefit to the aviation industry. For this reason, the Service Difficulty Report (SDR), Mechanical Reliability Reports, Mechanical Interruption Summary Reports, and Continuing Analysis and Surveillance programs are all regulatorally mandated, and are intended to be an integral part of the FAA's overall mission to enhance safety of flight.

As the FAA recognized the importance of reliability reporting for safety, the helicopter industry recognized the necessity of reliability tracking for reasons of safety and economy. Historically, the profitability of helicopter operators has been low. This low profit margin is directly influenced by the inherently high cost of helicopter maintenance. However, maintenance costs are just as critical in the fixed-wing industry. In determining direct and life-cycle costs, all operators need access to complete and accurate reliability data. The acquisition cost of a part or component may not be as important as its reliability cost. Reliability information is a critical element of maintenance costs.

The Service Difficulty Report (SDR) should be the cornerstone of reliability tracking. Through these SDR's, the FAA should be able to provide the historical data necessary to enhance both safety of flight and industry operating costs. However, SDR reporting increases the workload on aircraft operators, thus one reason for the low percentage of operators reporting SDR information.

In the early eighties, the helicopter industry began to focus on the need for sharing of reliability data. Around this same time frame, the world-wide oil industry was undergoing an economic crisis, which drastically impacted the helicopter industry. The need for reliability tracking from an economic perspective became even more critical. Consequentially, the Helicopter Association International (HAI), under the aegis of its Maintenance Technical Committee, initiated efforts to provide a means to collect, analyze and share reliability information otherwise unavailable.

In 1984, the HAI initiated actions leading to the Maintenance Malfunction Information Report (MMIR). By 1986, with the approval of HAI's Board, including financial backing, and with the support of HAI's staff, the Maintenance Technical Committee designed a one-page, four copy, self-carboning MMIR form. This was a "universal" form accepted by manufacturers for warranty claim and by the FAA in lieu of the SDR. Initially, HAI printed and circulated 10,000 copies of this form for field trial use.

That original MMIR form is still in use today; however, the MMIR program has evolved into a comprehensive, automated, management tool. MMIR computer software, developed by HAI, is centered around the completion of the MMIR form; however, by utilizing MMIR software, the maintenance department has permanent records in a database which can be manipulated to provide specific cost and reliability information. Reports can be electronically transmitted to HAI's MMIR database.

The most recent enhancement to the MMIR system is the ability for system users to access the data entry screen, reports, and data submission modules through an Internet browser. All of the functionality of the MMIR CD-ROM software version has been ported over to an HAI-based server, enhanced, and made available at www.mmir.com. No special software is required and the operator can access the system from anywhere on the Internet.

Future enhancements include integrating the MMIR system with advanced Health and Usage Monitoring Systems (HUMS) onboard aircraft. The Usages & Condition Monitoring, Analysis and Reporting system contains an onboard processor that receives input from sensors and accomplishes onboard processing. The data are processed as required and passed to an onboard recording unit that utilizes a data transfer card. After the flight is completed, the card is carried to a ground station and the data are downloaded. Once the data are transferred to the ground station the data are treated to additional processing and used to detect faults and exceedances that require pre-flight attention.

The MMIR program has been accepted by the helicopter industry, and favorably reviewed by the FAA. The HAI is prepared to demonstrate the functional capability of the MMIR system to fulfill the needs of the civil aviation industry for collection, retrieval, and timely dissemination of data on the performance of airframes, components, and repair and replacement parts. The main thrust of this demonstration is to enhance aviation safety and to reduce operating costs.

This demonstration program has the potential to provide the aviation industry with much needed data that would otherwise be unavailable. This will enhance overall progress in aviation safety with minimal risk and minimal expense.

Automating the Maintenance Malfunction Information Report (MMIR)

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Introduction

- The Maintenance Malfunction Information Reports are required by the FAA when ever flight essential parts are removed early.
- HAI initiated a program 15 years ago to make it easier for members to meet this obligation.
- The FAA agreed to provide financial support to HAI starting in 1993. This support continues today.
- This paper briefly reviews the history, current capability and future of the HAI MMIR Program.

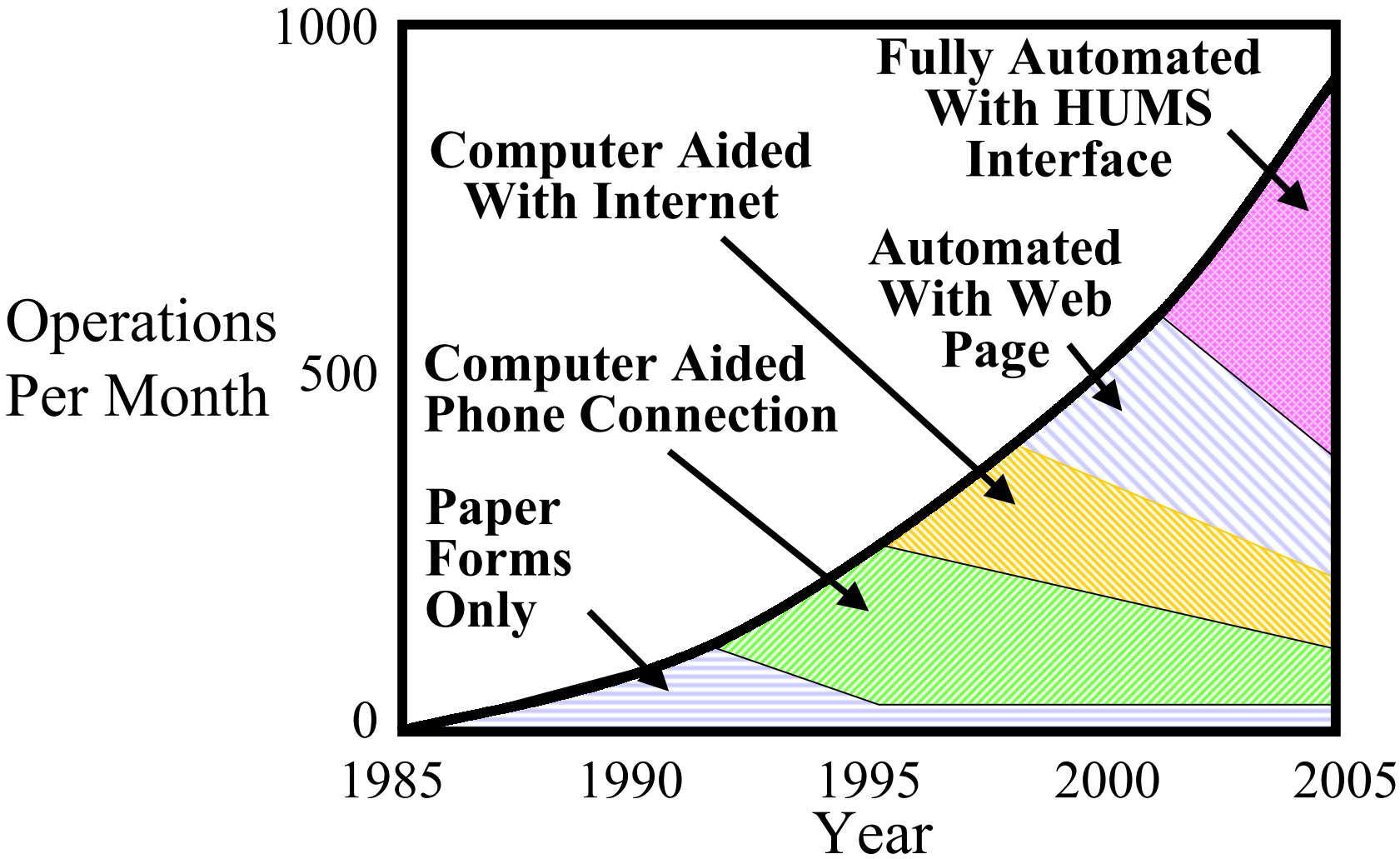
Purpose of HAI Involvement

- Make it easier for the Helicopter Community to Meet Reporting Obligations to the FAA.
- Increase the Effectiveness of MMIR Concept
- Help Operators Deal Effectively With Warrantee Claims.
- Increase OEM Awareness of Fleet Problems.
- Help Individual Operators to Identify a Fleet Wide Problem and Alert the OEM and User Community.
- Enhance Safety and Affordability of Civil Helicopter Operations.
- Protect the Data From Misuse.

Mile Stones

- 1985 - Carbon Paper & Manual Entry to Data Base
- FAA Grant 1993, Paperless MMIR
- 1994 - Desk Top Software to Eliminate Paper and Minimize Error & Automate Entry to Data Base
- FAA Grant 1998
- 1999 - Internet Connection
- 1999 - MMIR Entry on Web Page
- 2000 - First Automated Interface With HUMS Ground Station

Utilization Increases With Automation



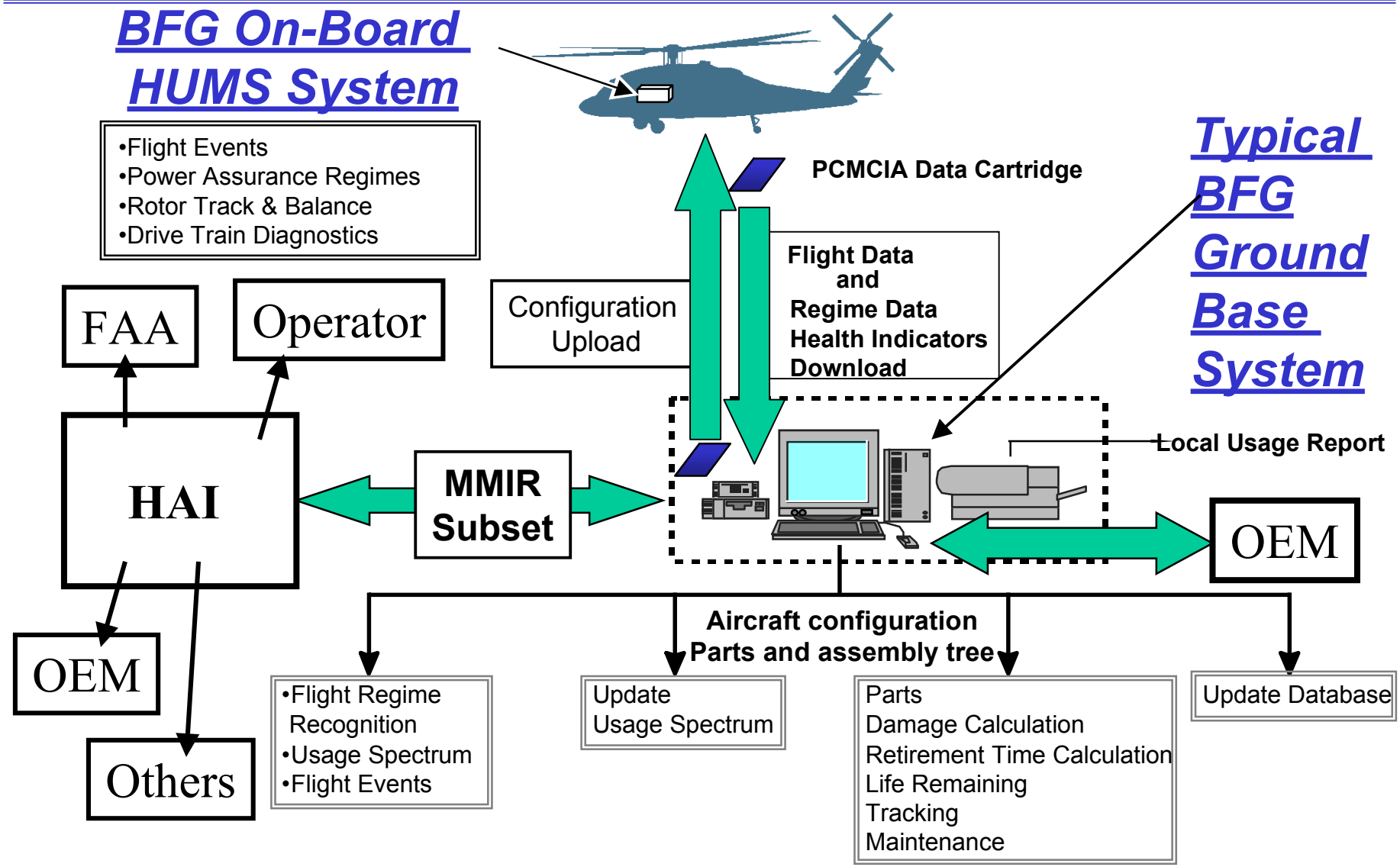
Current Activity

- Interface the MMIR Software With BFG UNIX Ground Station to:
  - Demonstrate a Concept Leading to a Generic Interface
  - Fill Out the Current MMIR Data Fields Automatically
  - Draft an Open Software Interface Specification.
- Establish Objectives and Tasking for “MMIR 2004”.
- Initial Activities In Support of “MMIR 2004”:
  - Identify and Understand Advanced Usage Concepts
  - Consider Need to:
    - Report Health Indicators
    - Study Automated Analytical Fleet Analysis Concepts

MMIR 2000

- MMIR Software Is Installed in HUMS Ground Station.
- A Flat File Is Produced By Ground Station When Parts Are Removed.
- The Software Interface Enables MMIR Software to Read the Flat File.
- MMIR Software Fills Out the Fields of the MMIR Report and Holds For Review.
- After Review by a Local Maintenance Supervisor, the Report Is Forwarded to HAI Electronically.
- HAI Distributes Information As Authorized by Operator.

MMIR 2000 Information Flow



Need For MMIR 2004

- HUMS Development Continues And Must Be Accommodated:
  - Advanced Mechanical Usage Metrics
  - Advanced Mechanical Health Metrics
  - Mechanical Health Histories
- Data Base Capability Is Increasing Rapidly and Is Becoming More Affordable.
- Internet Bandwidth Will Continue to Increase
- There Will Be a Need to Accommodate the Information Products of Both:
  - Comprehensive HUMS and
  - Less Capable Monitoring Equipment

MMIR 2004 Tasking

- Increase Automation:
  - HAI MMIR Data Base Mining and Analysis
  - Undertake a Campaign to Encourage Maintenance Management Software Users to Require the Suppliers to Automatically Output Data to the MMIR Module for Export to HAI.
- Meet With HAI Operators to Define Recommended Information Display Standards For HUMS Products.
- Work With OEM, Suppliers and Academia to Understand and Recommend Advance Usage Metrics

The Challenges:

- The MMIR Information Fields And Software Enhancements Must Anticipate, Accommodate and Exploit New Usage Metrics and Mechanical Health Monitoring Information Products.
  - Health Indicator Histories Associated With Engine and Power Train Maintenance Actions.
  - Tracking of Advanced Usage Metrics Where Condition Detection Is Not Available.
- The Results Will Greatly Enhance the Capability of the MMIR Process.

Normalized Through-Put Power:
Answering the Challenge

- "Normalized Through-Put Power" refers to the power that has been passed trough a mechanical assembly over a period of time.
- After each flight,the time history of torque is used to develop a torque usage spectrum (Time Spent at Torque Regimes).
- The spectrum is then treated to the following process:
  - The time spent in each power range (regime) is normalized by multiplying each increment of time by the usage rate correction factor applicable to that power range.
  - The products are summed to produce a single value of "Normalized Through-Put Power".
  - Normalized Power is tracked over the life of the aircraft as a function of flight time.
- The MMIR report will include the value of Normalized Through-Put Power consumed by the assembly when removed for maintenance.

Rotor Brake Usage Spectrum

Rotor Speed When Brake First Applied (%)	<10	10-19	20-29	>29
Above 95	2	8	6	4
95 to 85	6	30	20	12
84 to 74	5	25	15	11
Below 74	8	30	**60**	27

Elapsed Time Between Brake Application and Decelerating through 20 % Nr (Sec.)

Base Line

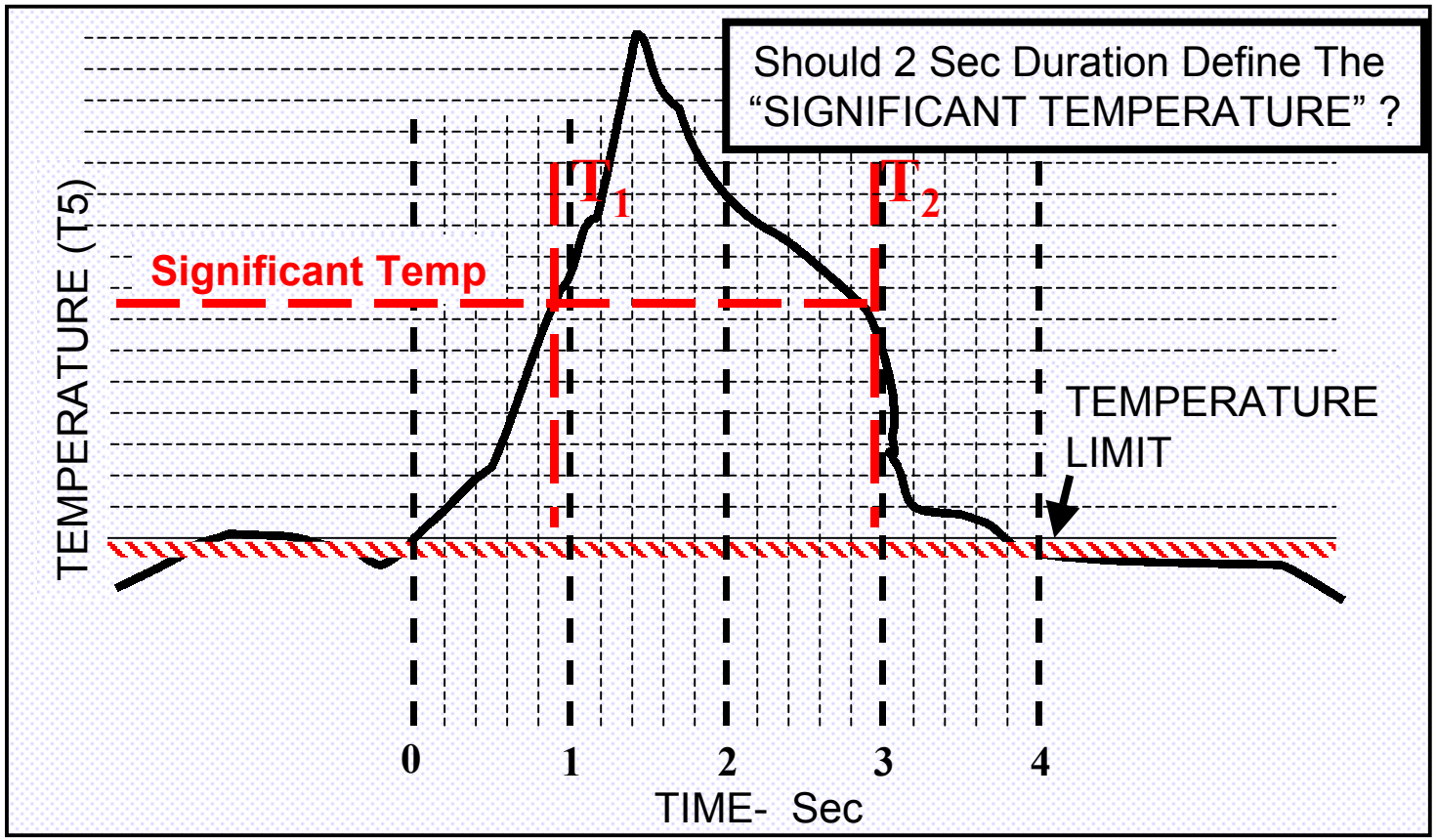
The Challenge

(1) Develop a process that allows the usage report to reflect the variations in brake application rate as shown to the left as a flat file.

(2) Develop a process that normalizes this spectrum in a way that allows the usage report to reported as a single numeric value.

For Example: **Assume the 169 actual applications reported above equate to 626 normalized applications when adjusted for variations in damage rate.**

Exceedance Reporting Challenge:



Quantify an exceedance time history with one or two terms that can be summed over time.

Mechanical Health Indicators

- **Operator Challenge:** Operator Software Calculates & Stores Health Indicators After Each Flight for Each Component of Assembly of the Power Train.
- When an Assembly Is Removed or Repaired on Aircraft, a Health History of the Assembly or Component Shall Be Appended to the MMIR (Flat File).
- **HAI Challenge:** The Health VS Usage characteristic observed during the transition from normal to the point of removal will be held in the HAI Data Base as a generic event for the insight of maintainers operation the same model helicopter.

Invitation

Visit …

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