



**Sikorsky**

A United Technologies Company

# **Technology for Certification and Implementation of HUMS**

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## **Technical Objectives:**

- Reduce the costs of HUMS civil certification through:
  - Developing innovative approaches to certification,
  - Implementing open interface standards, and
  - Enhancing the HUMS Distributed Diagnostic Database.
  - Developing analytical tools to analyze HUMS data.

## **Technical Barriers / Challenges:**

- No HUMS has been certified by the FAA for a credit application
- Data Size, Storage, and Representation.
- Different tools, different databases.
- Application Tools require access to common data or known format.
- Industry requirements.



# HUMS Certification

- Illustrate all aspects of Certification Approach within FAA Advisory Circular Guidelines.
  - Hardware Installation
  - Credit Validation
  - Continued Airworthiness
- Certification in Steps.
- End-to-End process:
  - Aircraft Sensors to Aircraft Multi-function Displays and PCMCIA card.

# HUMS Certification

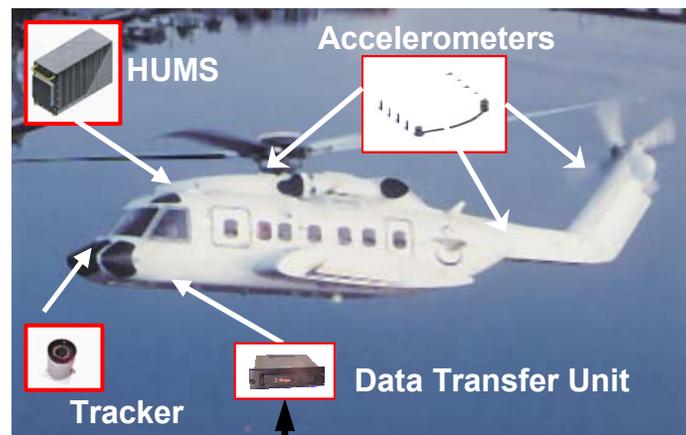
<b>Certification Category</b>	<b>Initial</b>	<b>Maint Credit</b>
<b>Operational Usage</b>	Accurate Record of Usage	Yes
<b>Rotor Track and Balance</b>	Data Collection During Revenue Flight	Yes
<b>Flight Manual Exceedances</b>	Ground Advisory	Yes
<b>Engine Shaft Monitoring</b>	Ground Advisory	Yes
Engine Shaft Balancing	On-board Balance Data	No
Gearbox Diagnostics Data	Advisory Only	No
Parametric Data Collection	Baseline Data	No
Data Trending	Mark Parametric Data for Trending	No
Regime Recognition	Baseline Data Collection	No



**End-to-End: Aircraft Sensors to MFD & PCMCIA card**  
**FHA – SER-920766**  
**Cert. Plan – SER-920272**



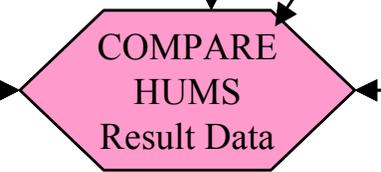
Aircraft MFD



PCMCIA Card

**ADAPS**

Independent Verification Means  
DO178B Software level.

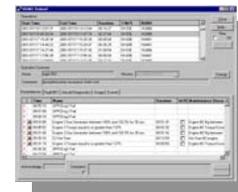


**Airborne**

**Ground station**



Ground COTS Hardware

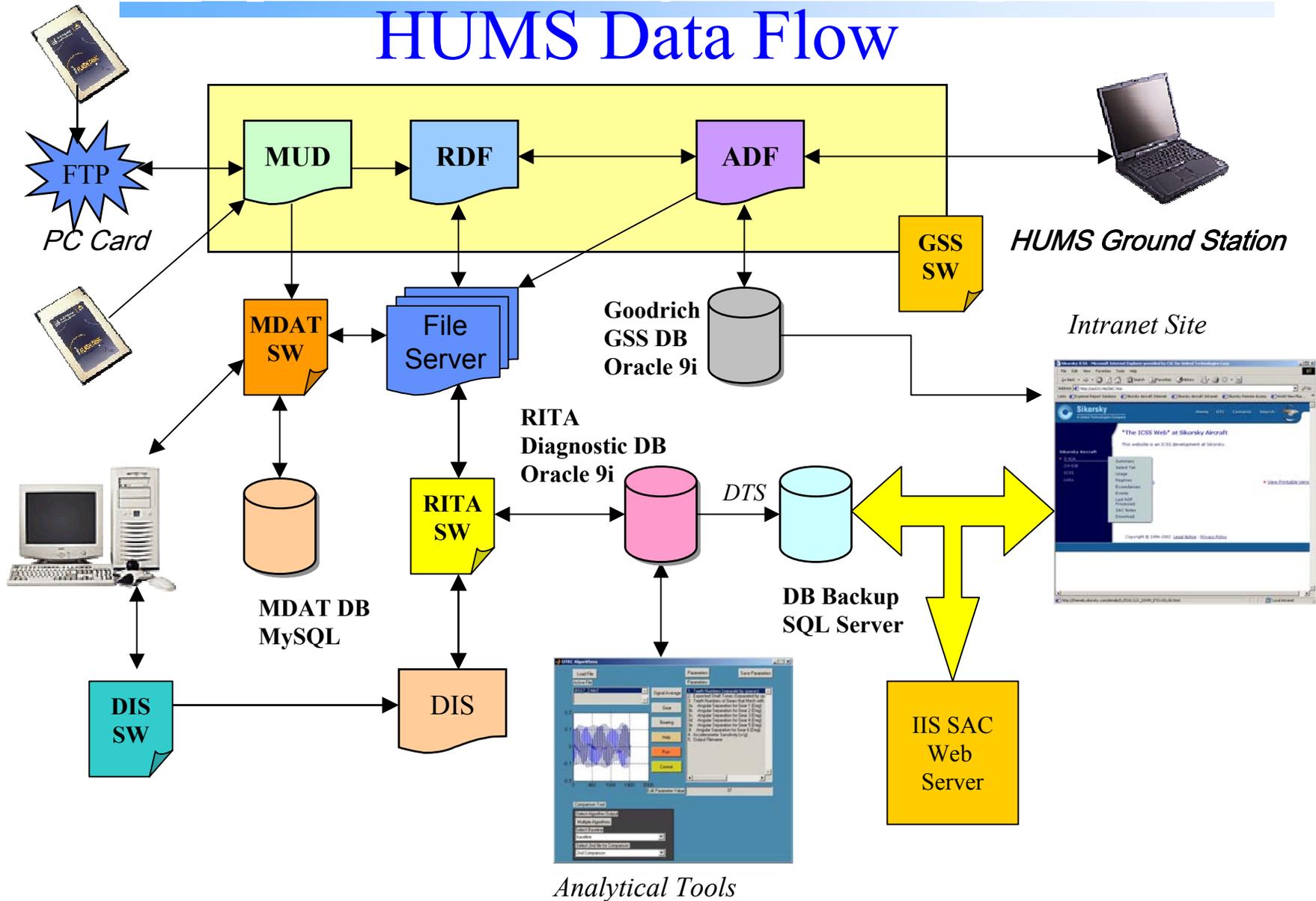


Final HUMS Ground Application DO178B Software Level.





# HUMS Data Flow





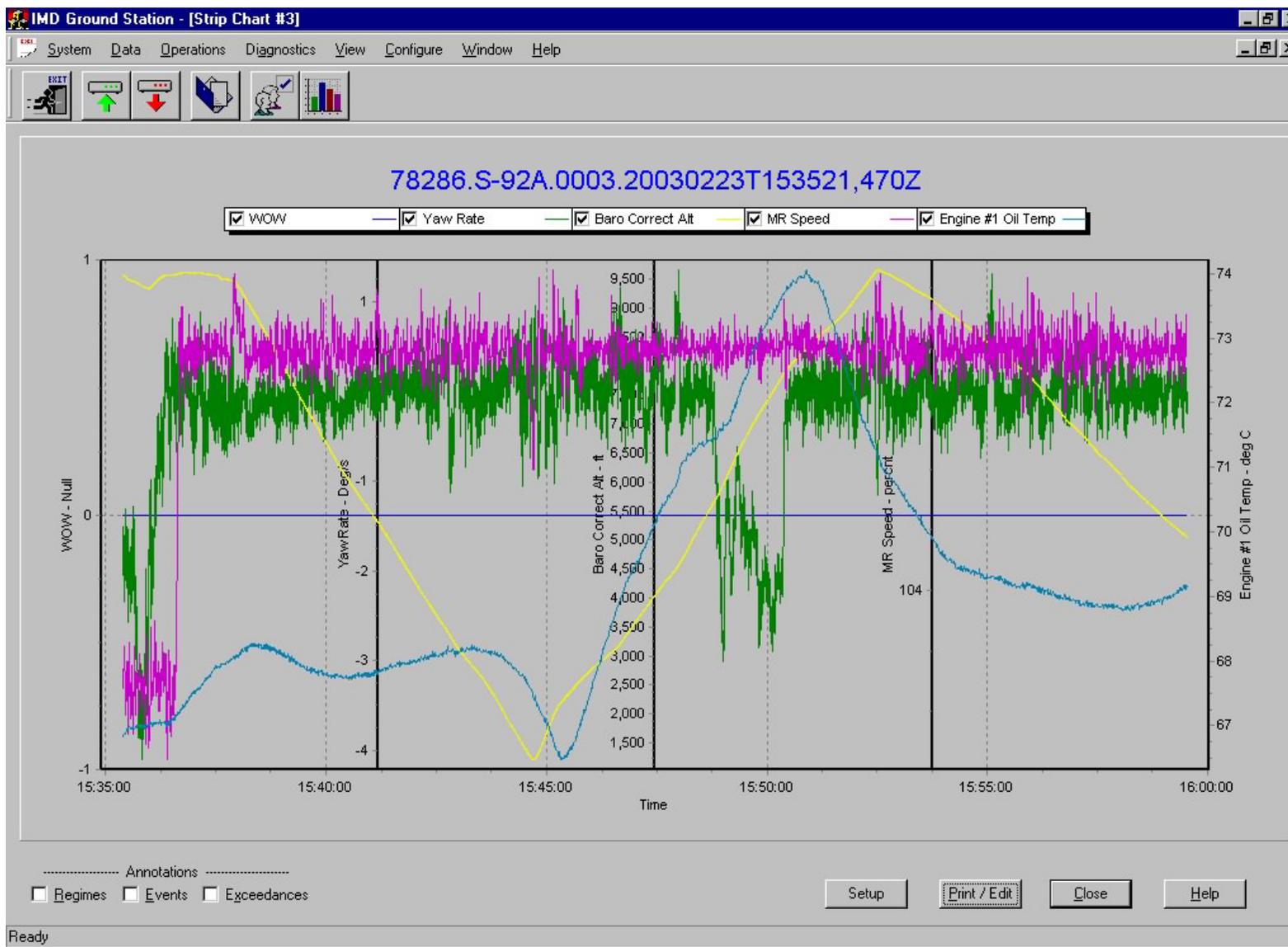
# HUMS Data Issues

## Issue:

- RDF files
  - Number of parameters
  - Private data packets
  - Size of data files
  - Size of parameters
- Variety of Data formats.
- Different Database Schema's
- Different Ground Stations

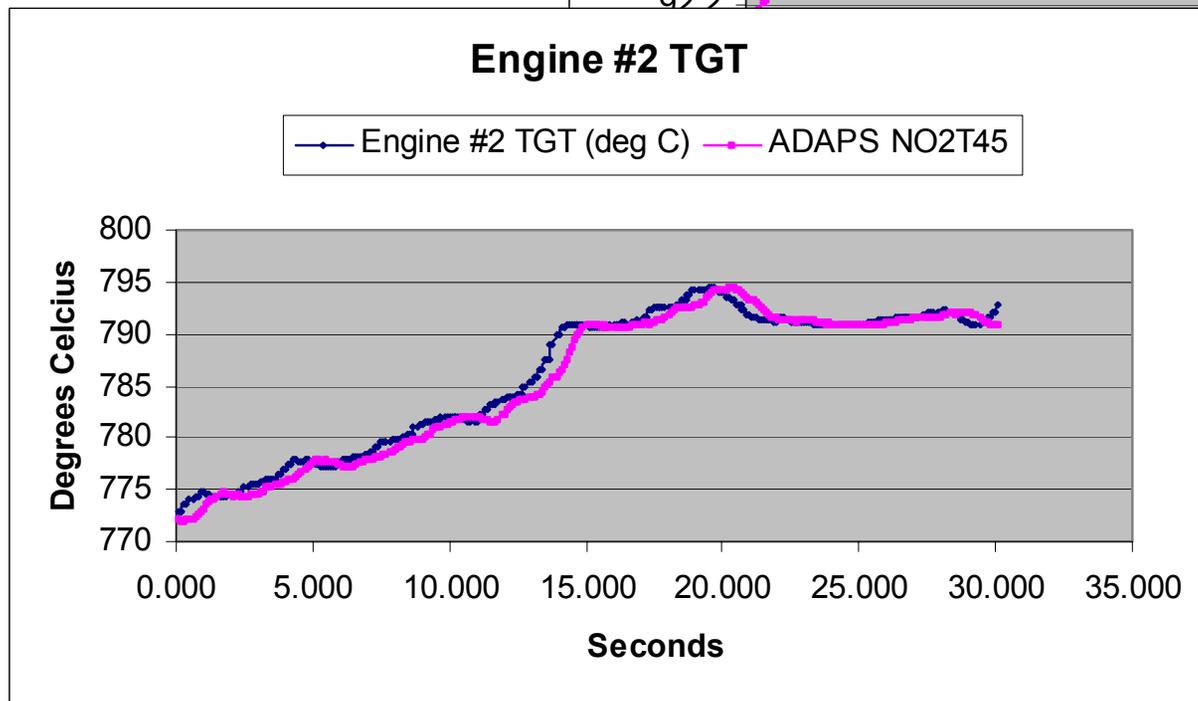
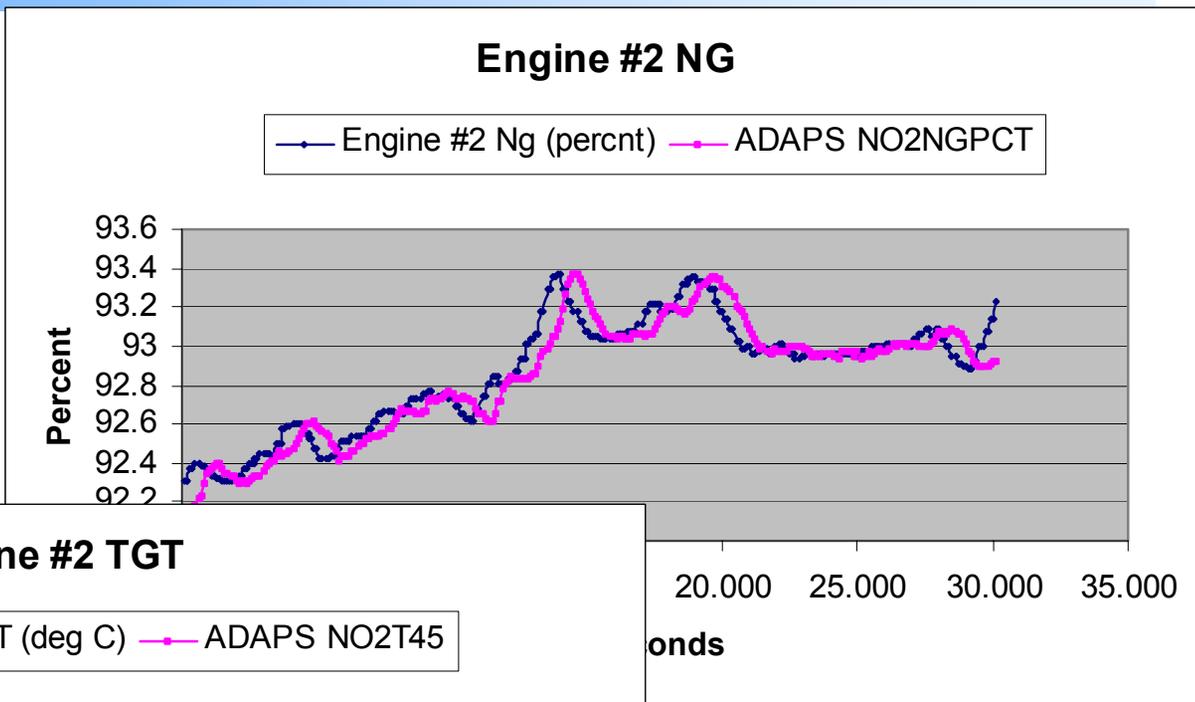
Example: 14.1 MB File

S-92A	0003	12/19/2003	13:34	15:48		Usage	0.88 hrs	
RTB	AMD	Exceedances	Events	Regimes	Datamap	No of DataSets	No of Parm	Total Samples
3	24	7	132	367	2483	4,807	151	725,857
						9,615	14	134,610
						24,036	14	336,504
						48,074	8	384,592
						4,808	10	48,080
						9,615	10	96,150
						<b>100,955</b>	<b>207</b>	<b>20,897,685</b>



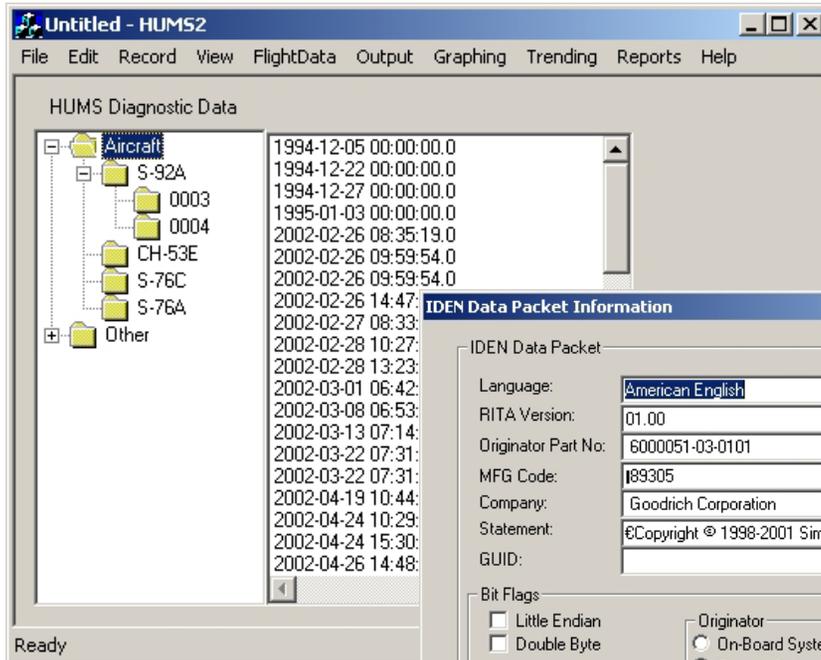


## Comparison of HUMS and ADAPS measured parameter



## Data Processing and Analysis

### Data Reading and Conversion



**Untitled - HUMS2**  
File Edit Record View FlightData Output Graphing Trending Reports Help

HUMS Diagnostic Data

- Aircraft
  - S-92A
    - 0003
    - 0004
    - CH-53E
    - S-76C
    - S-76A
  - Other

1994-12-05 00:00:00.0  
1994-12-22 00:00:00.0  
1994-12-27 00:00:00.0  
1995-01-03 00:00:00.0  
2002-02-26 08:35:19.0  
2002-02-26 09:59:54.0  
2002-02-26 09:59:54.0  
2002-02-26 14:47:33.0  
2002-02-27 08:33:33.0  
2002-02-28 10:27:33.0  
2002-02-28 13:23:33.0  
2002-03-01 06:42:33.0  
2002-03-08 06:53:33.0  
2002-03-13 07:14:33.0  
2002-03-22 07:31:33.0  
2002-03-22 07:31:33.0  
2002-04-19 10:44:33.0  
2002-04-24 10:29:33.0  
2002-04-24 15:30:33.0  
2002-04-26 14:48:33.0

**IDEN Data Packet Information**

IDEN Data Packet

Language: American English

RITA Version: 01.00

Originator Part No: 6000051-03-0101

MFG Code: 189305

Company: Goodrich Corporation

Statement: ©Copyright © 1998-2001 Simmonds Precision Products, Inc

GUID:

Bit Flags

Little Endian  
 Double Byte

IEEE-32  
 Vendor Specific  
 None

Continuous

Originator

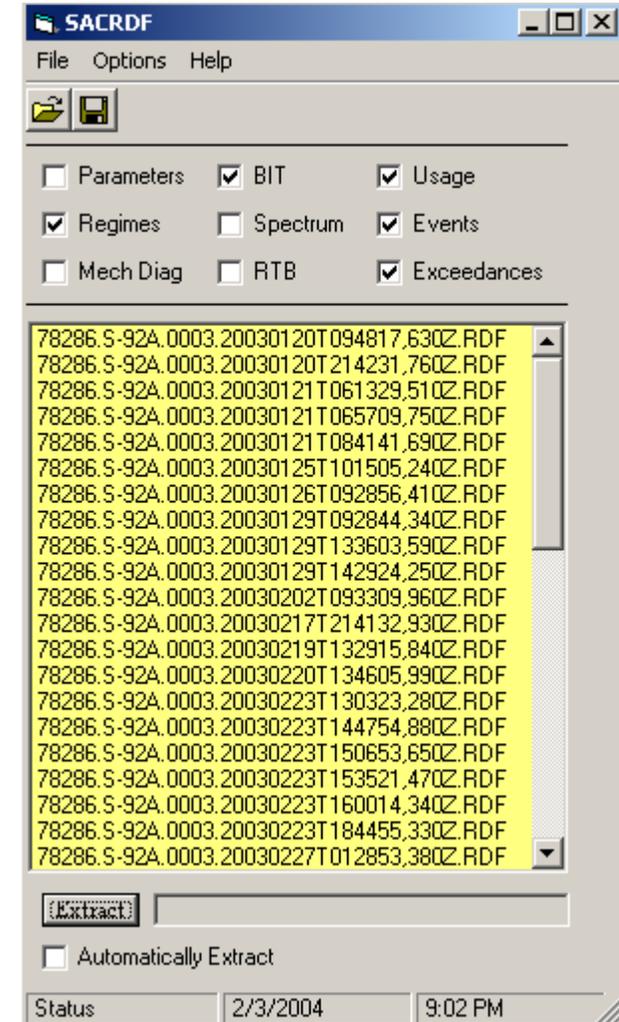
On-Board System  
 Ground System  
 Config Mgr  
 Other System  
 Test System

Purpose

Pre-Operation  
 Operation  
 Configuration  
 Non-Volatile  
 Vendor  
 Test

CRC Value: 5b2ef195

OK Cancel



**SACRDF**  
File Options Help

Parameters  BIT  Usage  
 Regimes  Spectrum  Events  
 Mech Diag  RTB  Exceedances

78286.S-92A.0003.20030120T094817.630Z.RDF  
78286.S-92A.0003.20030120T214231.760Z.RDF  
78286.S-92A.0003.20030121T061329.510Z.RDF  
78286.S-92A.0003.20030121T065709.750Z.RDF  
78286.S-92A.0003.20030121T084141.690Z.RDF  
78286.S-92A.0003.20030125T101505.240Z.RDF  
78286.S-92A.0003.20030126T092856.410Z.RDF  
78286.S-92A.0003.20030129T092844.340Z.RDF  
78286.S-92A.0003.20030129T133603.590Z.RDF  
78286.S-92A.0003.20030129T142924.250Z.RDF  
78286.S-92A.0003.20030202T093309.960Z.RDF  
78286.S-92A.0003.20030217T214132.930Z.RDF  
78286.S-92A.0003.20030219T132915.840Z.RDF  
78286.S-92A.0003.20030220T134605.990Z.RDF  
78286.S-92A.0003.20030223T130323.280Z.RDF  
78286.S-92A.0003.20030223T144754.880Z.RDF  
78286.S-92A.0003.20030223T150653.650Z.RDF  
78286.S-92A.0003.20030223T153521.470Z.RDF  
78286.S-92A.0003.20030223T160014.340Z.RDF  
78286.S-92A.0003.20030223T184455.330Z.RDF  
78286.S-92A.0003.20030227T012853.380Z.RDF

**Extract**

Automatically Extract

Status 2/3/2004 9:02 PM

- SACRDF – Automated
  - MDAT – Goodrich Software
  - HUMS2 – Data Packet Viewer / DIS Converter
- All have database interfaces.



# Aircraft Summary Page



**Summary:** Overall Fleet View.

A Green folder indicates if there was a file recently processed

A Red folder indicates an alert generated.

**Sikorsky Aircraft**

HUMS Data

ICSS

Links

## Aircraft Overview

CH-53E

163086

S-92A

#1

0003

[Events](#)

[Exceedances](#)

[Overview](#)

[Regimes](#)

0004

HALREVC

HALREVCE16

HALREVCE2

HALREVCE3



# Aircraft Summary Page (Cont)



### Sikorsky Aircraft

[HUMS Data](#)

[ICSS](#)

[Links](#)

### Aircraft Summary Overview

<b>S-92A</b>	<b>0003 - Last File</b>
Last Processing Date:	8/22/2003 12:34:34 PM
File Processed:	78286.S-92A.0003_~.20030822T123434.560Z.RDF
Operation Time:	8/22/2003 12:34:35 PM Duration: 134.449 Mins
Regimes:	<ol style="list-style-type: none"> <li>40:Forward Flight to 0.8 Vne - 1.994 hrs</li> <li>39:Forward Flight to 0.5 Vne - 0.094 hrs</li> <li>01:MPU Power, No Rotors Turning - 0.087 hrs</li> </ol>
Exceedances:	<ol style="list-style-type: none"> <li>RTB120OvrLim - 26</li> <li>Rtr Brk Nr&gt;70% - 6</li> <li>Gnd Taxi&gt;65Kts - 2</li> </ol>

<b>S-92A</b>	<b>0003 - Overall</b>
Regimes:	<ol style="list-style-type: none"> <li>Undetermined - 228.887 hrs</li> <li>077:Forward Flight to 1.0 Vne, - 107.377 hrs</li> <li>002:Ground Run - 47.597 hrs</li> </ol>
Events:	<ol style="list-style-type: none"> <li>MD END - 3733</li> <li>RTBAcqAbort - 2348</li> <li>MD ABORT - 1622</li> </ol>
Exceedances:	<ol style="list-style-type: none"> <li>MGBOilP&lt;45OR&gt;65 - 2101</li> <li>E1OilP&lt;20psid - 506</li> <li>E2OilP&lt;20psid - 479</li> </ol>

This page shows the statistics for the aircraft and the last flight processed.

- No of RDF processed
- No of flight hours
- Date range for data
- Top 3 Regimes
- Top 3 Events
- Top 3 Exceedances



# Aircraft Exceedances



### Sikorsky Aircraft

- [HUMS Data](#)
- [ICSS](#)
- [Links](#)

## Aircraft Exceedance Overview

<b>S-92A</b>	<b>0003</b>
Last Processing Date:	8/22/2003 12:34:34 PM
File Processed:	78286.S-92A.0003_~.20030822T123434.560Z.RDF

Exceedance Name	Count
<a href="#">MGBOilP&lt;45OR&gt;65</a>	2101
<a href="#">E1OilP&lt;20psid</a>	506
<a href="#">E2OilP&lt;20psid</a>	479
<a href="#">RTBGndOvrLim</a>	
<a href="#">TRGndOvrLim</a>	
<a href="#">RTB120OvrLim</a>	
<a href="#">RTB140OvrLim</a>	
<a href="#">E1OilP&lt;30psid</a>	
<a href="#">E2OilP&lt;30psid</a>	
<a href="#">RTBVhOvrLim</a>	
<a href="#">RTBHvrOvrLim</a>	
<a href="#">RTB80OvrLim</a>	
<a href="#">Eng2Q&gt;111%</a>	
<a href="#">Eng1Q&gt;111%</a>	
<a href="#">E1OilP&gt;150psid</a>	
<a href="#">MGBOilP&lt;45OR&gt;70</a>	



### Sikorsky Aircraft

- [HUMS Data](#)
- [ICSS](#)
- [Links](#)

## Exceedance Specific Listing

<b>S-92A</b>	<b>0003</b>
Exceedance Name:	E1OilP<20psid

File Name	Operation Time	Count
78286.S-92A.0003.20030514T052725,780Z.RDF	5/14/2003 5:27:25 AM	11
78286.S-92A.0003.20030509T130958,500Z.RDF	5/9/2003 1:09:58 PM	10
78286.S-92A.0003.20030528T091104,670Z.RDF	5/28/2003 9:11:04 AM	8
78286.S-92A.0003.20030527T125555,986Z.RDF	5/27/2003 12:11:25 PM	7
78286.S-92A.0003.20030121T124238,310Z.RDF	1/21/2003 12:41:47 PM	7
78286.S-92A.0003.20030620T085826,190Z.RDF	6/20/2003 8:58:26 AM	7
78286.S-92A.0003.20030701T092439,280Z.RDF	7/1/2003 9:24:39 AM	6
78286.S-92A.0003.20030122T123245,520Z.RDF	1/22/2003 12:32:45 PM	6
78286.S-92A.0003.20030123T163941,420Z.RDF	1/23/2003 4:39:41 PM	6

**Exceedances:** Exceedance summary page displays all exceedances.

There is another drill-down page to select a particular RDF file.



## RTB Intranet Module

Intranet Site that has the Sikorsky Aircraft RTB Adjustment Module converted to COM. Web page is designed from a Visual Basic in DHTML layout.

Page created in support of Goodrich's RITA HUMS effort.

Address http://ac631146/sacrtbdemo.htm

Links Expense Report Solutions Sikorsky Aircraft Internet Sikorsky Aircraft Intranet Sikorsky Remote Access



**S-92A RTB Demo**

	Vertical		Roll		Overhead Lateral		Track (mm)			
	ips	degrees	ips	degrees	ips	degrees	Yel	Blu	Red	Blk
Ground	0.42	134	0.42	23	0.37	173	0	-0.1	0	0
Hover	0.2	118	0.29	33	0.62	212	0.9	-0.5	0.3	-0.7
80 kts	0.3	109	0.21	16	0.44	191	1	-0.2	0	-0.7
120 kts	0.35	88	0.22	26	0.52	198	0.7	0	0	-0.8
140 kts	0.27	83	0.09	36	0.33	200	0.4	0.3	0	-0.6
Vh	0.25	73	0.06	25	0.28	199	0.4	0.3	-0.1	-0.5

Controls  PCR  IBTabs  OBTabs  Weights

**Results**

	Yel	Blu	Red	Blk		V Ips	V Deg	R Ips	R Deg	O Ips	O D
PCR	0	4	-5	2	Gnd	0.52	140	0.1	30	0.05	101
IBTab	-28	31	-38	38	Hover	0.14	97	0.1	12	0.18	188
OBTAB	-8	-20	43	-19	80kts	0.09	153	0.03	77	0.02	52
Weights	6.06	0.57			120kts	0.03	90	0.02	18	0.04	116
					140kts	0.06	41	0.08	161	0.13	327
					Vh	0.07	353	0.12	181	0.24	355

Done  Local intranet

# HUMS Status Summary

- Twenty-one (21) flights for main rotor vibration tuning development. The HUMS RTB algorithm has been configured using this data.
- Engine driveshaft 1/rev balance ground run testing was done to obtain a complete set of adjustment coefficients for both engines.
- Evaluated Goodrich S-92 HUMS RTB algorithm, (Coefficient weightings, main rotor 2/rev and 3/rev thresholds).
- HUMS Ground stations were updated to Goodrich Block 11 software release. Individual ground station functions were evaluated against intended requirements.
- S-92A A/C 0003 and A/C 0004 flight tests were performed to support check out of HUMS Block 1.4 MPU software release.
- HUMS flight data from A/C 0003 and A/C 0004 was reviewed on the Ground station to test exceedance detection, regime detection, usage, etc.
- Generated 133 Trend Templates and 113 Exceedance templates on HUMS ground station to support data analysis against HUMS flight data.



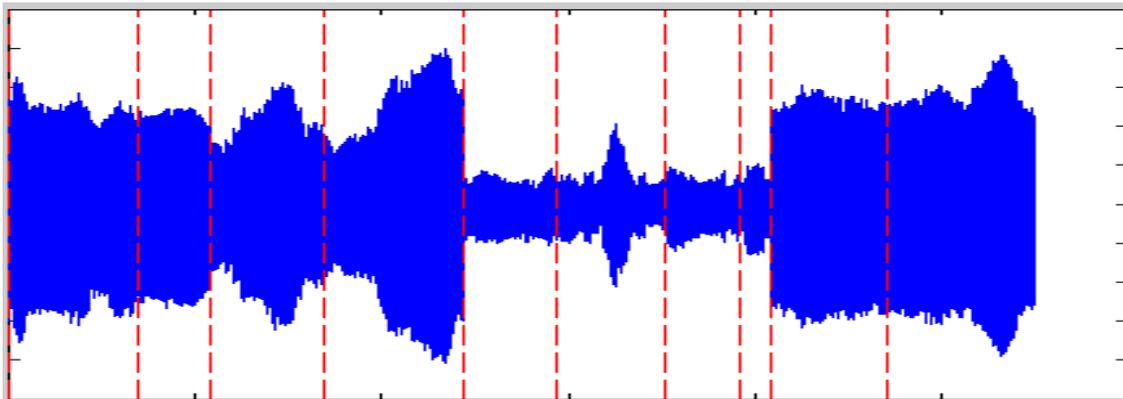
## Current Status

- Certification Plan Presented to FAA.
  - SER-920272 HUMS Certification Plan.
  - SER-920766 Functional Hazard Analysis.
  - SER-920829 HUMS Qualification Test Plan.
- Analyzing S-92a AC 0003 & 0004 HUMS Flight Data.
- Diagnostic Database populated with S-92 HUMS data.
- Diagnostic Tools.
- Intranet Site Created.

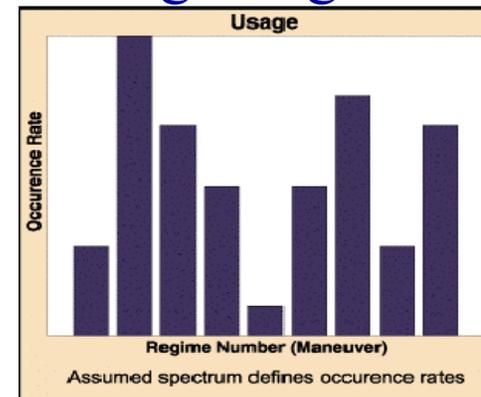


# Development of Component Usage Spectra

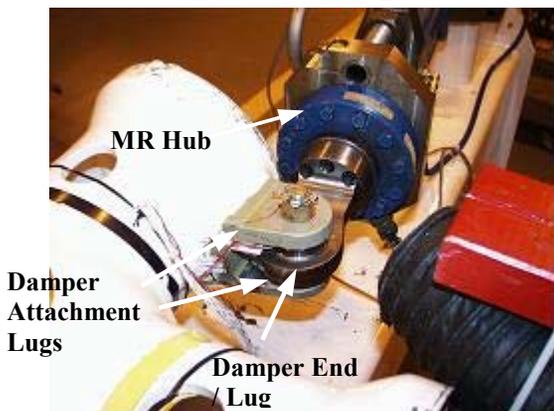
## Flight History



## Usage Regimes



## Component Spectra

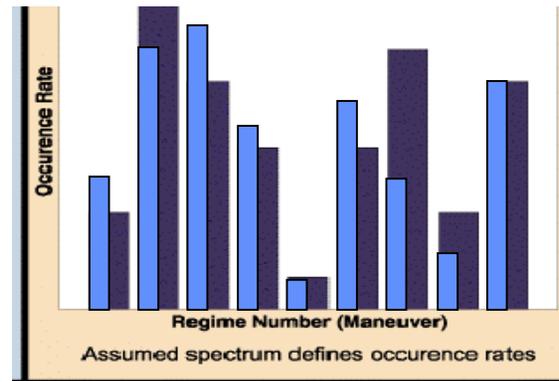
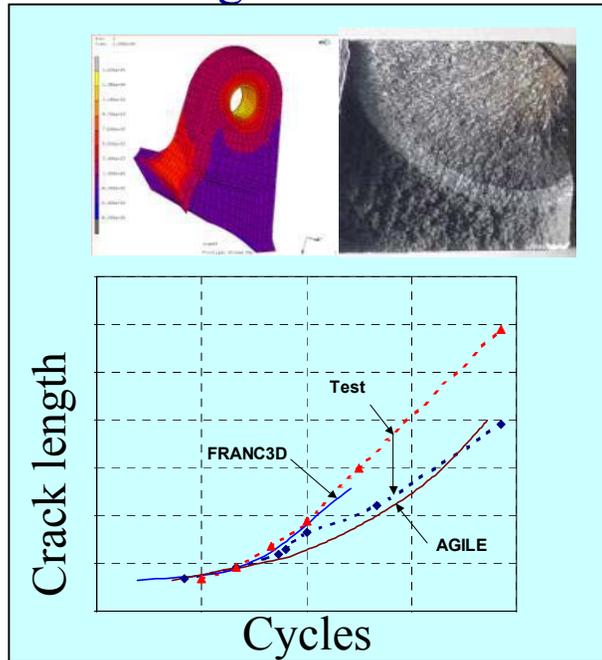


- Use Component Spectra to assess life and maintenance impact
- Prediction of component loads and derived parameters
- Issues
  - Consideration of data gaps
  - Usage substitution
  - Procedures for Forecasting

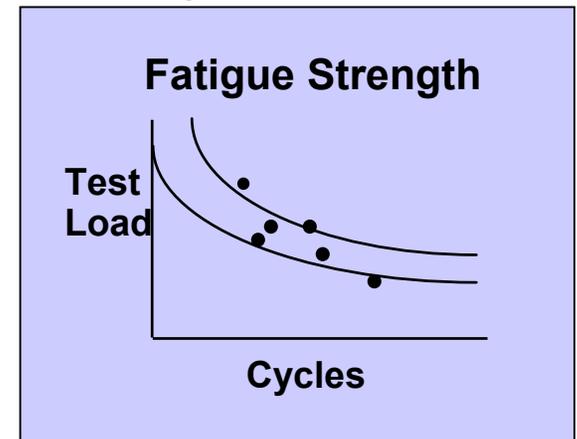
# HUMS based Fatigue Assessment

## Usage Spectra and Loads

### Damage Tolerance



### Fatigue Evaluation



Improved Safety from HUMS based Fatigue and Damage Tolerance Assessment