



SIKORSKY'S HEALTH MANAGEMENT JOURNEY: PAST, PRESENT AND FUTURE

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SAC HEALTH MANAGEMENT EVOLUTION



S-6™



S-76C++™



S-92A®



CH-148



S-76D™



CH-53E



UH-60A,L,M



SAFETY

*MAINTENANCE &
TROUBLE SHOOTING*

MH-60S/R



*CONDITION BASED
MAINTENANCE*

SAC HEALTH MANAGEMENT VISION



Eliminate Unscheduled Maintenance

Optimize Scheduled Maintenance

Focus Troubleshooting & Reduce False Removals

Maximize Detection Time Before Failure

Enhance Safety



S-92[®] HEALTH MANAGEMENT SYSTEM



Customer

Sikorsky



S-92[®] Operators

HUMS
Collected
Data



MFD
Ground Based
Application

"Check HUMS"

Helicopter Flight Data Mgt.

HUMS/Maintenance
Data & Field Events

Data Transfer
Multiple time a day

Proactive Support

Web Portal

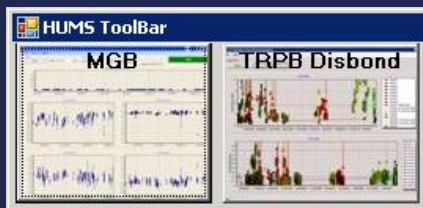
KDT

CI Box Plot

SPLAT

Matlab

New HUMS Tools



Retirement
Time
Adjustment



S-92[®] Hub

VALUE TO THE OPERATOR

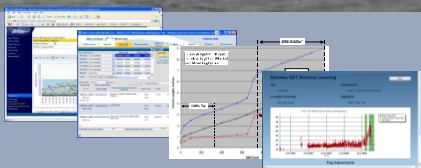
New HUMS tools, maintenance credits, etc.

S-92[®] TEN YEARS OF MATURATION



S-92[®] FMOC

Now 250+ aircraft

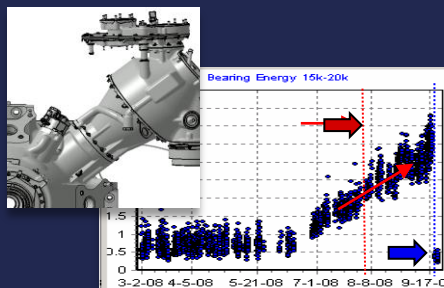


10GB+ data daily



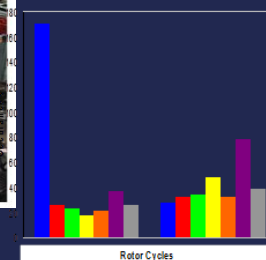
Downtime Avoidance

High-sensitivity vibe analysis enabled early detection of degrading health and proactive response.



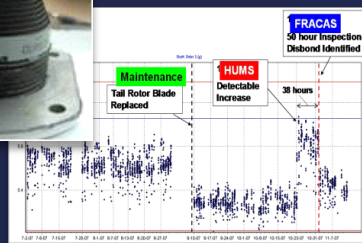
Extended Time-on-Wing

Leveraged S-92[®] Main Rotor Hub life adjustment to gain additional retirement time adjustment credits from the FAA



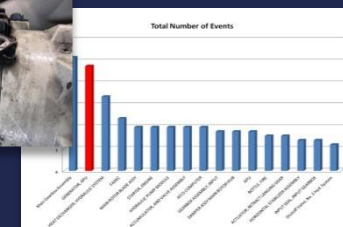
New Detection Capability

Research isolated vibe-signature of previously undetectable Pivot Bearing issue and enabled software enhancement



Level-of-Repair Optimization

Identified opportunity to significantly reduce removals of APU Generator - a top AOG driver



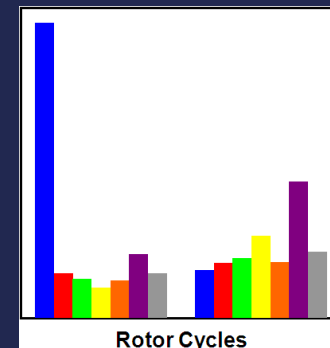
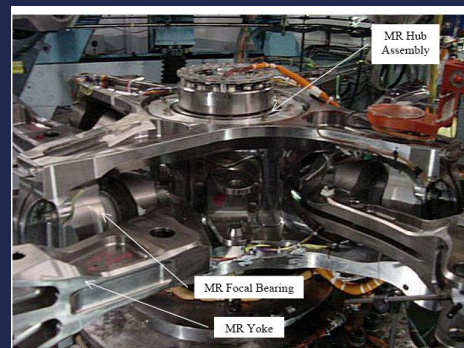
EXTENDING TIME-ON-WING



LLP Retirement Extension (Serial #)

FAA approved S-92[®] main rotor (MR) hub life

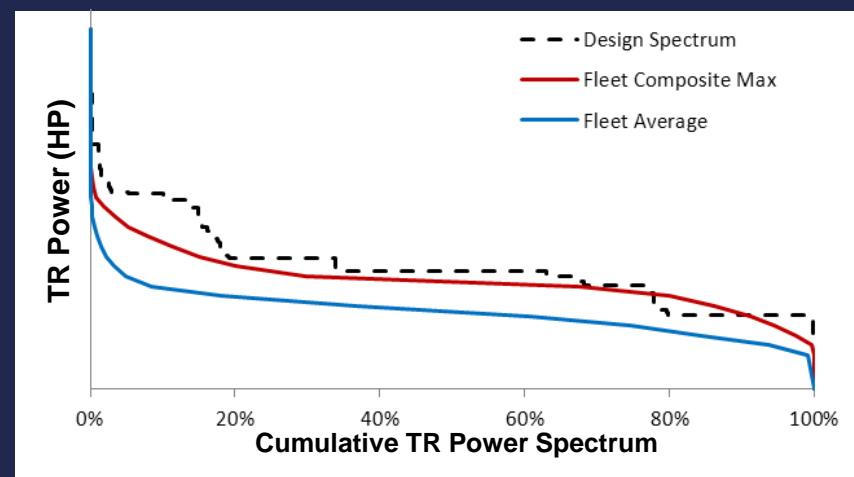
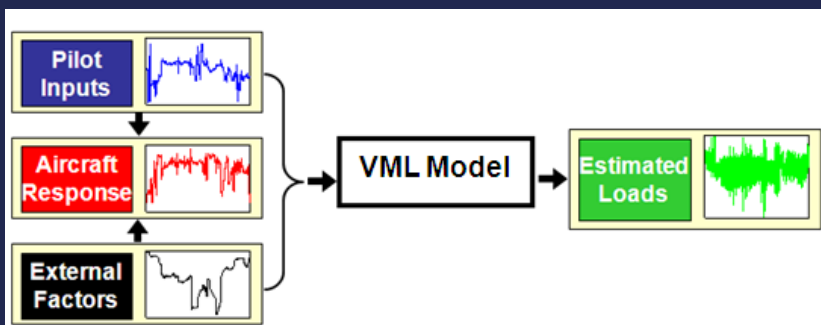
Average benefit of 50% one-time CRT extension



Fleet Spectrum Update (Part #)

Virtual Monitoring of Loads (VML) used to calculate TR torque from 500kFH

Load statistics used to revise usage spectrum → 3.25X retirement time



“BIG DATA” ANALYTICS APPLICATIONS



Hadoop® Cluster

- The new paradigm – cloud computing
- HADOOP by Cloudera



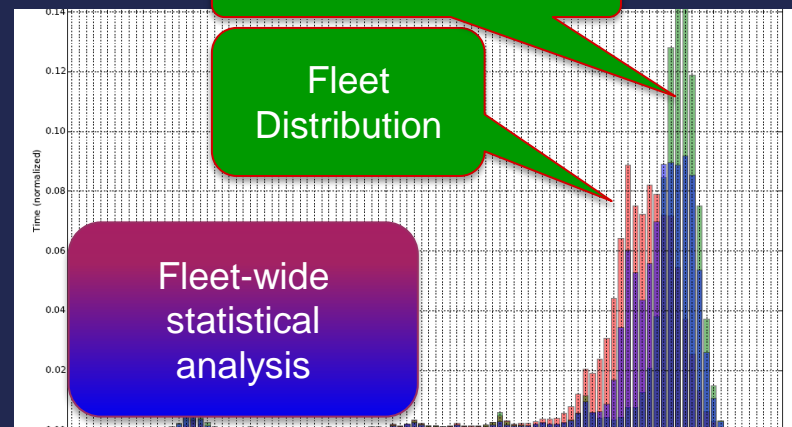
Analysis across the entire fleet (16+ Tb) in a few minutes.

- HADOOP = An open source implementation of MapReduce, a powerful for deep analysis of very large data sets.

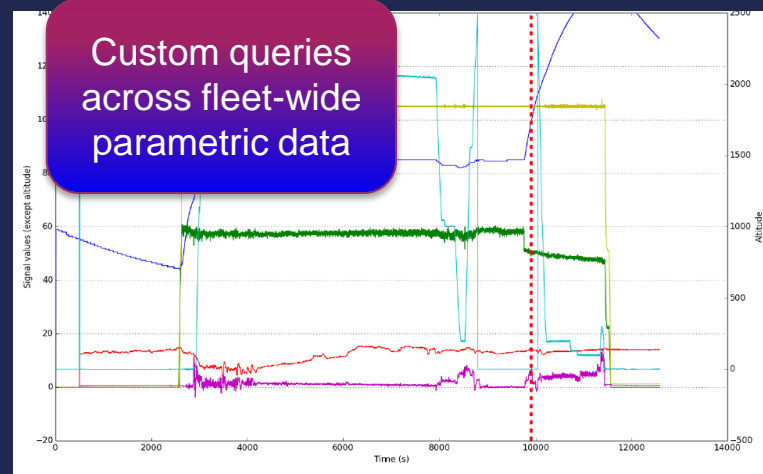
Tail Distribution

Fleet Distribution

Fleet-wide statistical analysis



Custom queries across fleet-wide parametric data



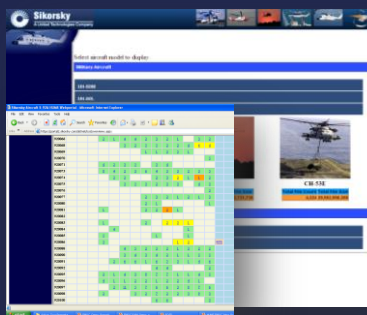
EXPANDING ANALYTICS



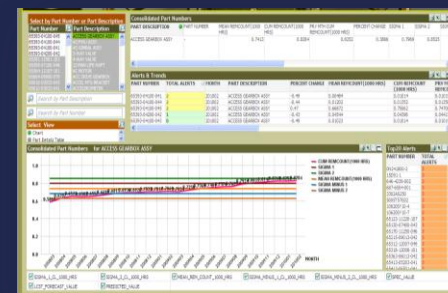
Optimizing support through awareness and insight



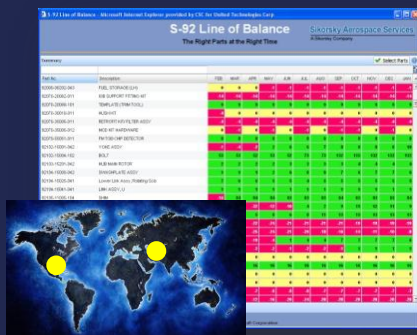
Fleet Demographics



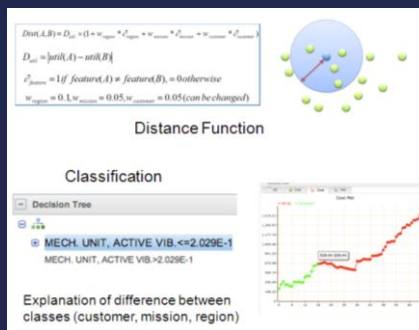
Health Monitoring and Drill-Down



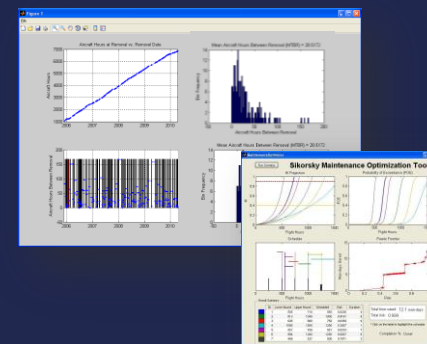
Cost/Maintenance Trending and Investigation



Supply Chain Optimization



Text mining and Statistical Analysis



Maintenance Optimization

PHM SYSTEM INTEGRATION LAB (SIL)



Architectural Elements Developed in Parallel to Subsystem Technology Maturation

Integrated Vehicle Health Management Unit (IVHMU)

On-Board Processing and Storage of Aircraft State Parameters
Traditional HUMS Functionality



Prognostic and Health Management Unit (PHMU) Card

Integrated Diagnostic and Reasoning Algorithms
Embedded Application Software



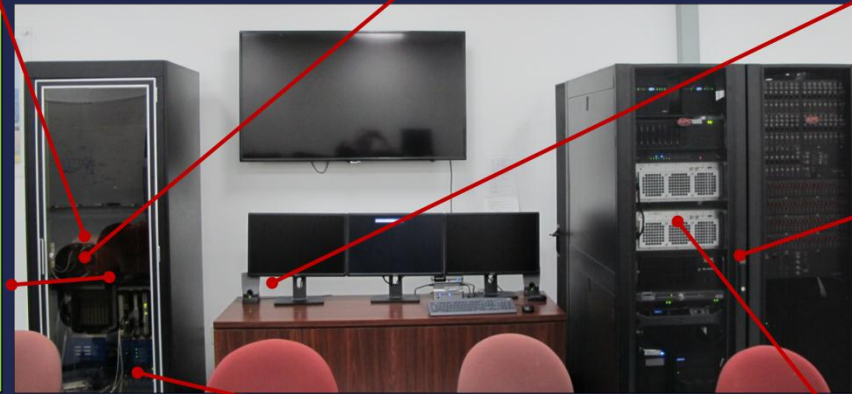
Aircraft Notebook

At-aircraft download, health displays, and troubleshooting
Data transfer between Operators Server & Aircraft



Network Acquisition and Interface Unit (NAIU)

I/O handling for PHM Network
Data Management for Real-Time SW
Data Storage and Download to GBS



FMOC Server

Fleet-based diagnostic & prognostic algorithms
Knowledge Discovery Toolkit (KDT)
Optimized maintenance planning



PHM SIL Hydraulics

Integrated VMS hardware and sensors for technology V&V



PHM Network

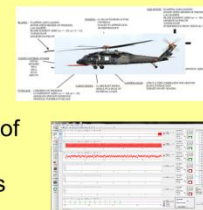
Various sources of input data for on-board processing



PHM SIL Playback

Purpose

Playback Previously-Recorded Data and Simulate Flight for V&V of New Diagnostic and Prognostic Technologies



PHM SIL Static Room

Purpose

Integrate Structural and Electrical HW and sensors for technology V&V



SIL PLAYBACK SYSTEM



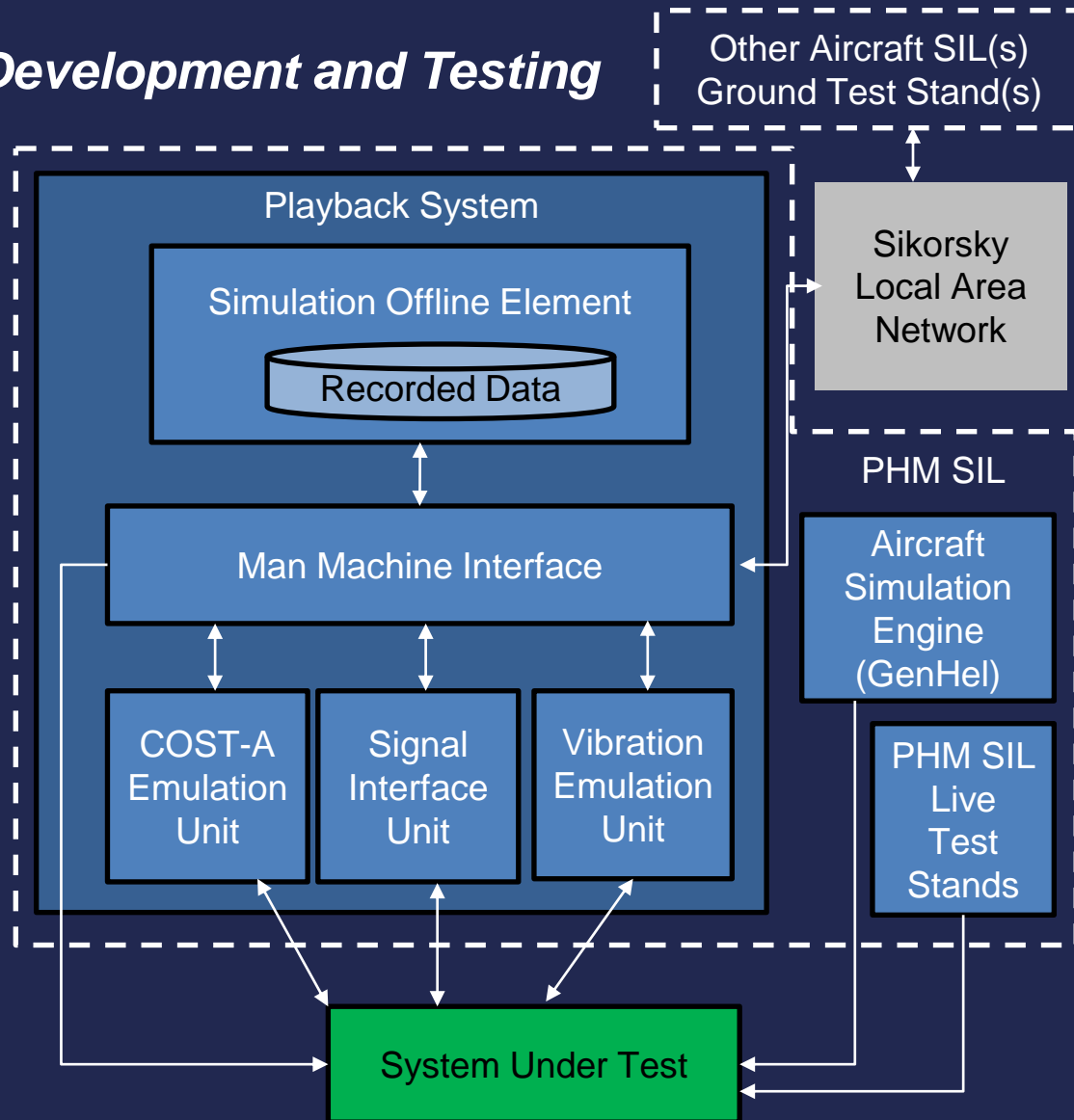
Enabling capability for PHM Development and Testing

Primary Functionality

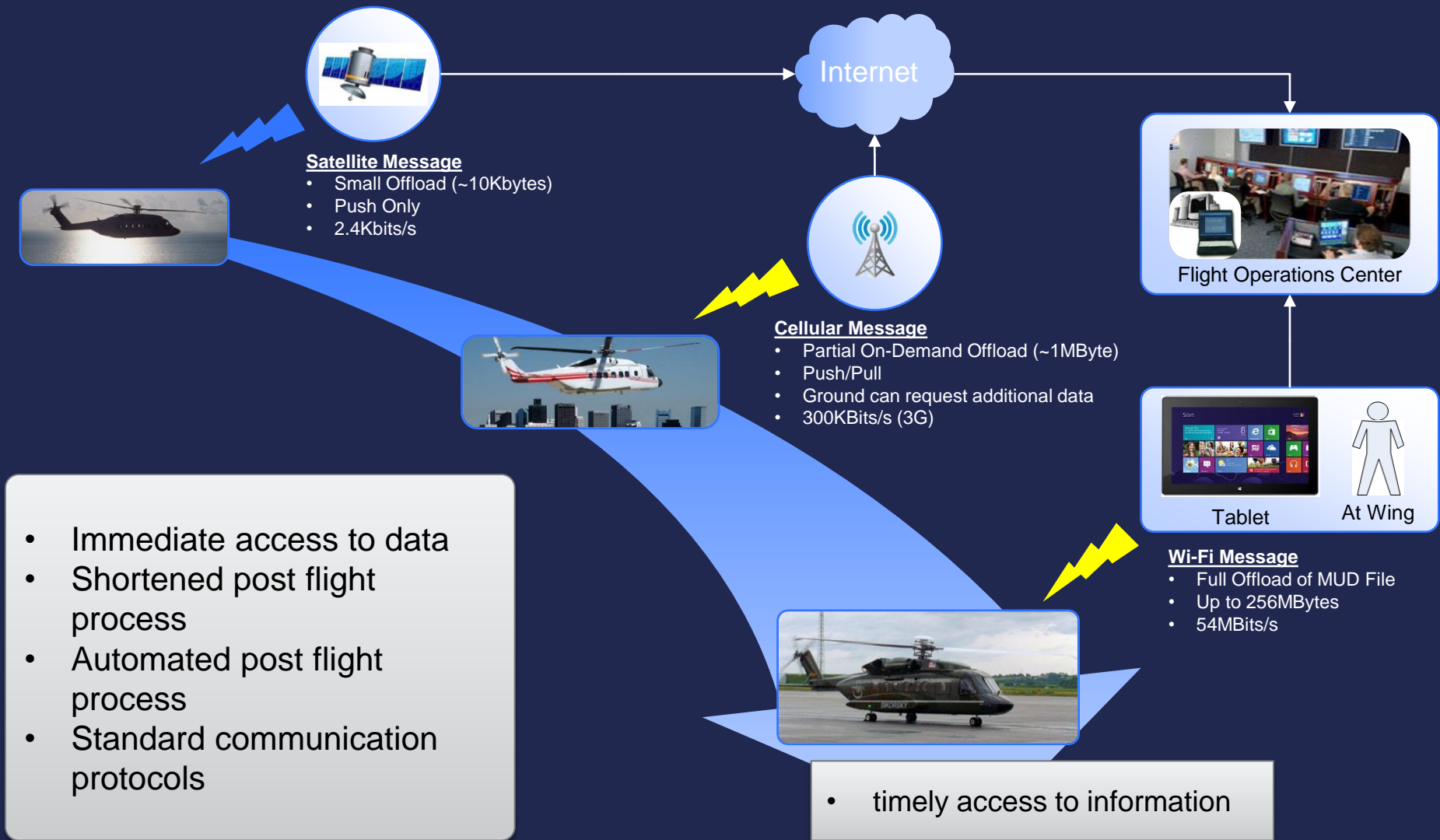
- Seamlessly merge integrated flight data, seeded fault data, simulated data
- Playback data to fully simulate avionics system

Challenges

- Specifying and developing intuitive user interface
- Converting often massive, heterogeneous data files to common format
- Defining and implementing playback interfaces



REAL-TIME DATA DOWNLOAD



- Immediate access to data
- Shortened post flight process
- Automated post flight process
- Standard communication protocols

- timely access to information

MOBILE MX TOOLKIT WORKFLOW



MOBILE MAINTENANCE TOOLSET

Andy Ruestow Mechanical Engineer

North Sea Bristow Fleet

Fleet View

920050 38.3 days ago	920062 7.2 days ago	920065 7.2 days ago	920067 7.1 days ago	920068 7 days ago	920068 11.8 days ago	920157 7.2 days ago	920158 7.3 days ago
920166 7 days ago	920167 11.9 days ago	920169 7 days ago	920171 8.2 days ago	920174 13.1 days ago	920175 7.2 days ago	920176 7 days ago	920196 7.9 days ago
920197 28.3 days ago							

Each tile represents an Aircraft

Yellow = Alert found
Green = No Alerts
Time since last data



MOBILE MAINTENANCE TOOLSET

Andy Ruestow Mechanical Engineer

Aircraft

Aircraft Details
Tail Number 920174
Flight Date 01/29/2014 13:09:57

RTB Alert Found!

- Exceedances
- Mechanical Diagnostics
- Rotor Track and Balance
- Engine Power Assurance Check
- High Speed Shaft Coupling

Tail Summary



MOBILE MAINTENANCE TOOLSET

Andy Ruestow Mechanical Engineer

Aircraft

Aircraft Details
Tail Number 920158
Flight Date 01/09/2014 14:25:05

Processing Complete

- ✓ SD Card
- ✓ Flight Manual Exceedances
- ✓ Mechanical Diagnostics
- ✓ Rotor Track and Balance
- ✓ EPAC Exceedances
- ✓ High Speed Shaft Coupling

Wireless Transfer
✓ 920158 - 01/09/2014 14:25:05

Wireless Transmission

MOBILE MAINTENANCE TOOLSET

Andy Ruestow Mechanical Engineer

Rotor Track and Balance

Aircraft Details
Tail Number 920158

Drilldown

80 kts

Operation Time 01/29/2014 13:29:49
Harmonic 1
Value 0.28 IPS
Threshold 0.25 IPS
Accelerometer Overhead Lateral

Alert Details

SAC GROUND BASED APPLICATION



Sikorsky SGBA Key Functions

Operation Usage

Mechanical Diagnostics

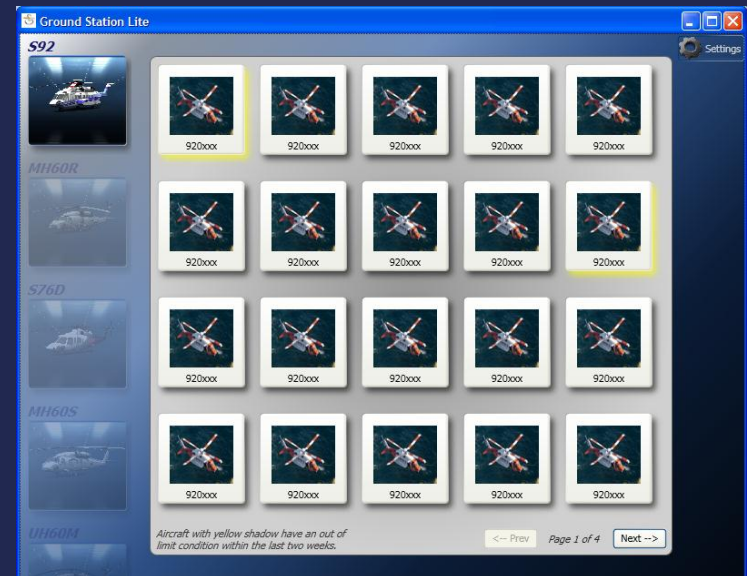
RTB

Flight Manual Exceedances

Alert Trending

Parametric

HUMS Toolbar



Flights
SWZ: S92xxx
All Flights
Start Date: 03/01/2013
End Date: 02/22/2013
Search

RTB Acquisitions
Pressing the Below Buttons will affect/Uncheck the corresponding acquisitions in the below grid.

Include	Exclude	Auto Ground	Auto Hover
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

1P Acquired Values

	Overhead Vertical		Derived Roll		Overhead Lateral		Pilot Lateral	
	In	Deg	In	Deg	In	Deg	In	Deg
* Ground	0.30	226	0.12	84	0.06	52	0.09	300
Hover	0.02	158	0.03	26	0.09	31	0.02	46
80 kts	0.05	104	0.07	60	0.18	64	0.06	68
120 kts	0.09	47	0.07	40	0.23	67	0.20	76
140 kts	0.16	32	0.08	34	0.24	44	0.08	57
WV130 kts	0.26	20	0.10	27	0.28	32	0.05	52

2P Acquired Values

	Derived Vertical		Derived Roll		Overhead Lateral		Pilot Lateral	
	In	Deg	In	Deg	In	Deg	In	Deg
* Ground	0.02	102	0.01	20	0.01	240	0.01	183
Hover	0.02	228	0.00	0	0.01	331	0.02	337
80 kts	0.05	52	0.01	168	0.04	39	0.00	21
120 kts	0.04	74	0.01	130	0.07	100	0.07	88
140 kts	0.03	288	0.00	132	0.10	100	0.10	208
WV130 kts	0.02	337	0.03	143	0.07	205	0.09	203

3P Acquired Values

	Overhead Vertical		Derived Roll		Overhead Lateral		Pilot Lateral	
	In	Deg	In	Deg	In	Deg	In	Deg
* Ground	0.01	223	0.01	271	0.01	312	0.02	329
Hover	0.02	18	0.01	108	0.01	91	0.01	275
80 kts	0.05	49	0.01	391	0.01	129	0.02	41
120 kts	0.07	44	0.02	167	0.02	145	0.01	358
140 kts	0.07	28	0.02	90	0.02	81	0.05	244
WV130 kts	0.07	7	0.01	71	0.02	17	0.03	264

Track Acquired Values

	Track		Lag	
	In	Deg	In	Deg
* Ground	6	0	1	4
Hover	-5	2	-3	6
80 kts	-4	6	3	-5
120 kts	-11	9	8	-5
140 kts	-17	14	11	-9
WV130 kts	-13	12	-12	-8

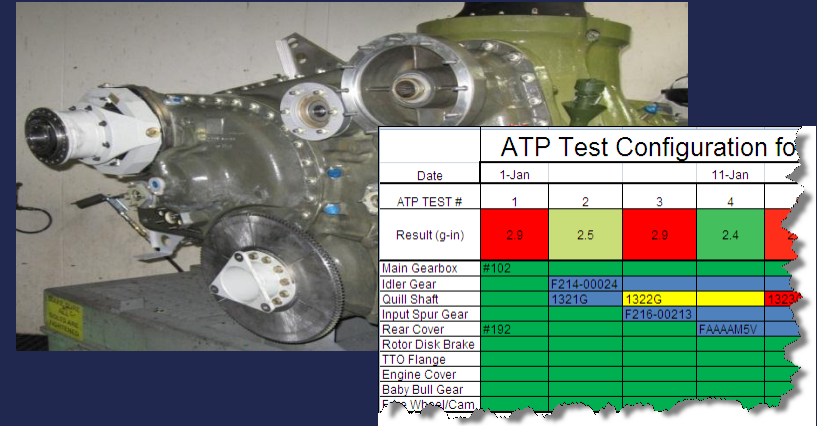
INCREASING THE VALUE OF HUMS



Transition to CBM+



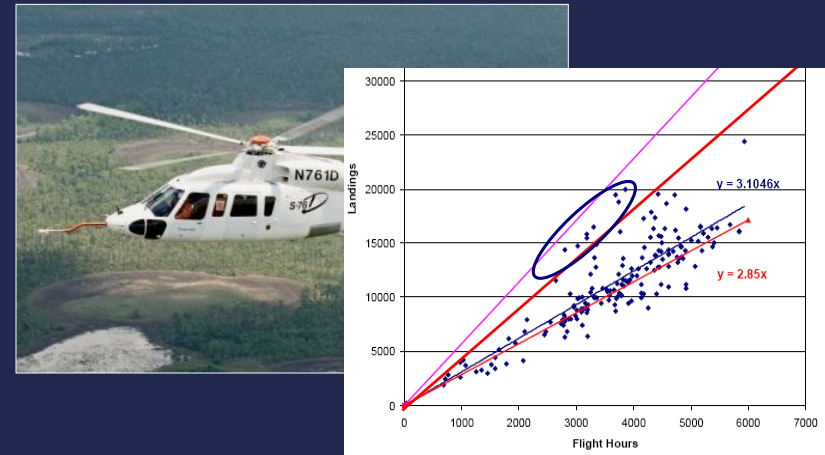
Incorporate into Aircraft Delivery



Expand Safety Attributes



Change the Design Paradigm



Questions?



Sikorsky

A United Technologies Company

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