AIAD : NASA-Langley Research Center

By

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Agenda

- Purpose
- Background
- Problem Statement
- Testing and Analysis
- What did I learn

Purpose

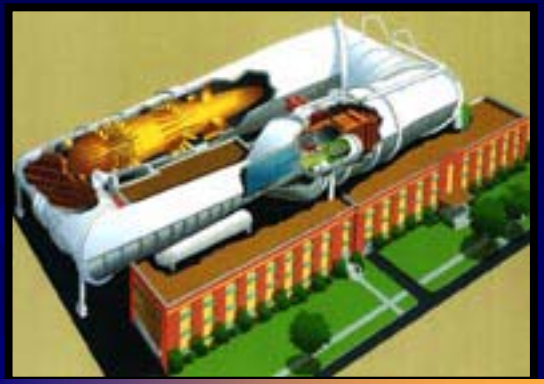
- To gain insight and experience in my Field of Study, Aeronautical Engineering, and to come into contact with the real life application of what I have learned and new concepts that will help me in future classes.
- To work with engineers in the field on a real research project that has possible application to today's soldiers, and in doing so make future and past courses more meaningful to me.
- Project Team Objective- To collect and analyze data taken in the hover cell, to identify key mode crossings at different rotor speeds

Background

Army Research Labs

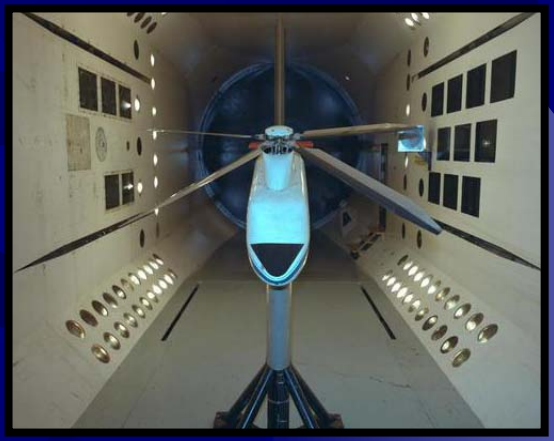
Overview

Background

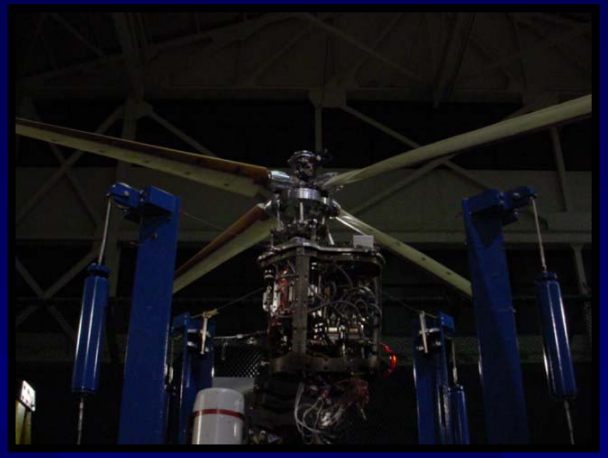


Transonic Dynamics Tunnel

- The Research Center at Langley Air Force Base is ARL and NASA's main aeronautical research facility.
- It's unique facilities put it on the cutting edge of aerospace technology



Background



- WRATS (Wing & Rotor Airelasitc Testing System)
- Research to improve the stability and capability of current tilt rotor systems

Problem

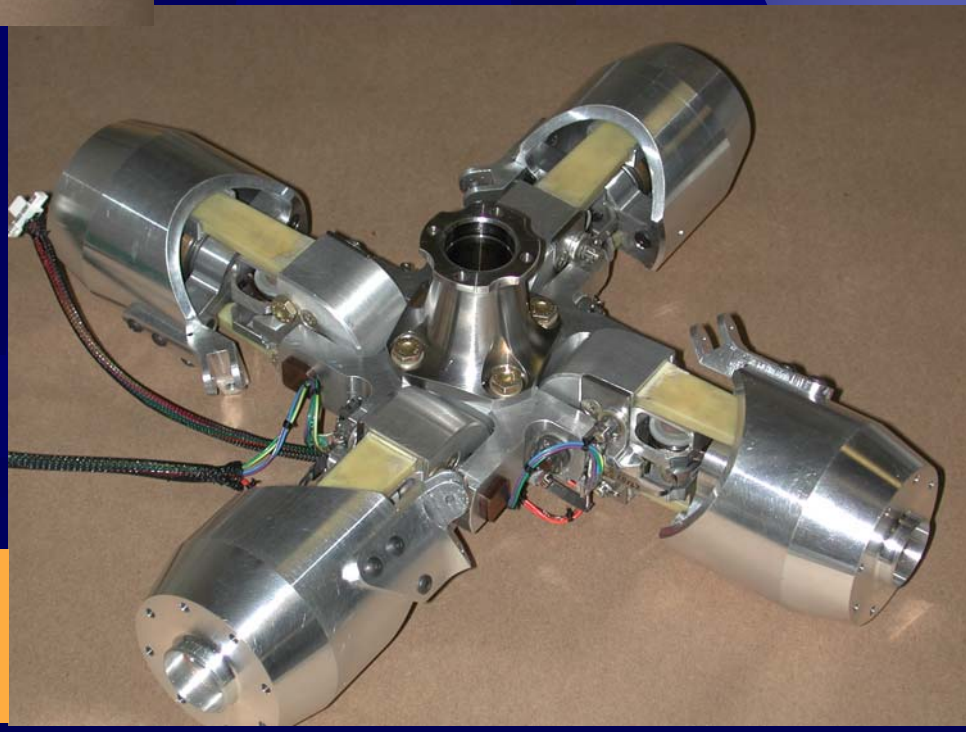
- Today's tilt rotor aircraft use stiff inplane rotor systems because of their stability with regards to ground and whirl flutter conditions.

- However, dynamic blade loads may develop within the stiff rotor system putting the aircraft in danger

Problem

- A Soft inplane system would eliminate the prospect of dynamic loads.
- As a result, the strength requirements would be greatly reduced which would lead to decreased weight and maneuverability

Gimbaled Stiff-In plane



Semi- Articulated Soft-In plane

Problem

- In testing, the Soft inplane system displayed low damping in key modes (Beam Bending and Whirl Flutter)
  - Whirl Flutter : When the aerodynamic modes of the rotors interacts with the modes of the wing
- This lack of damping caused low whirl-flutter stability within its airspeed envelope

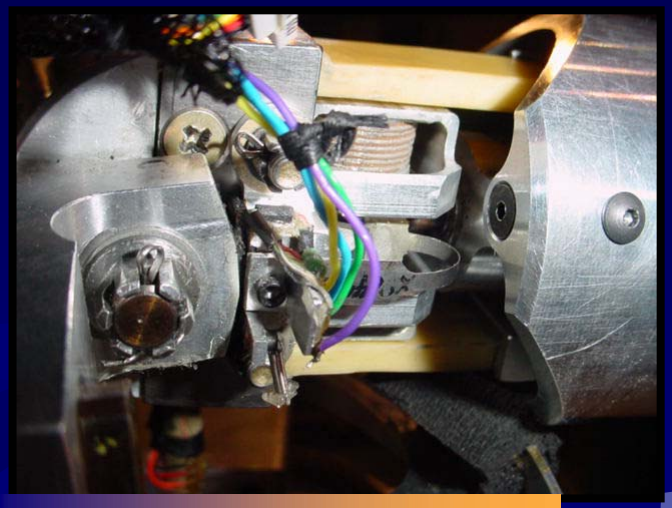
Model mounted in airplane mode inside the tunnel

Testing and Analysis

- Overall Objective- To collect and analyze data taken in the hover cell, to identify key mode crossings at different rotor speeds
- With this information, the WRATS team will attempt to make a new design which will increase damping in these key modes

Testing and Analysis

- Calibrations / Sensors
  - Different sensors
    - Everything from rotor speed to the bending moments and loads in the rotors themselves



Lead Lag Strain Gage

Rotor load sensor

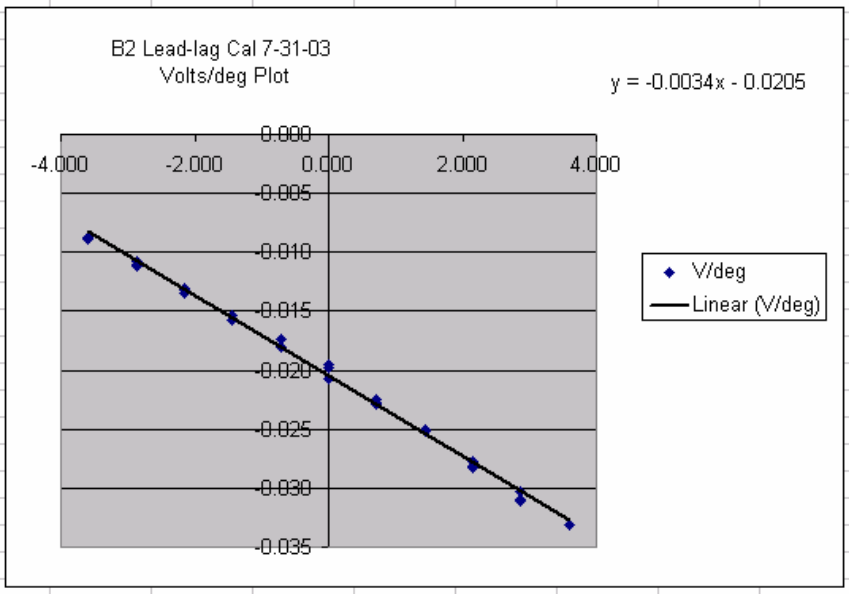
Flapping Pot Gage

Lead-lag cal on rover stand

WRATS Gage Calibration Data — Coll=0

Raw Voltage Data

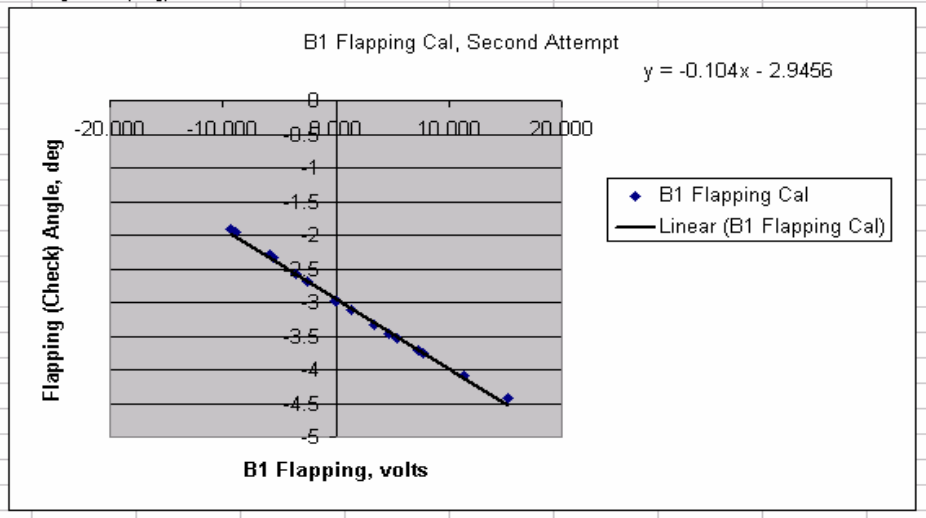
Tab Point	Comment	pos, in	pos, deg	B2 Lead Lag
9178	B2 Lead-la	0.0	0.000	-0.020
9179	B2 Lead-la	0.0	0.000	-0.020
9180	B2 Lead-la	0.5	0.718	-0.022
9181	B2 Lead-la	0.5	0.718	-0.022
9182	B2 Lead-la	1.0	1.436	-0.025
9183	B2 Lead-la	1.0	1.436	-0.025
9184	B2 Lead-la	1.5	2.154	-0.028
9185	B2 Lead-la	1.5	2.154	-0.028
9186	B2 Lead-la	2.0	2.873	-0.030
9187	B2 Lead-la	2.0	2.873	-0.030
9188	B2 Lead-la	2.5	3.592	-0.033
9189	B2 Lead-la	2.5	3.592	-0.033
9190	B2 Lead-la	2.0	2.873	-0.031
9191	B2 Lead-la	2.0	2.873	-0.031
9192	B2 Lead-la	1.5	2.154	-0.028
9193	B2 Lead-la	1.5	2.154	-0.028
9194	B2 Lead-la	1.0	1.436	-0.025
9195	B2 Lead-la	0.5	0.718	-0.023
9196	B2 Lead-la	0.5	0.718	-0.023
9197	B2 Lead-la	0.0	0.000	-0.021



				-11.8118	-0.0174	1.358572

Avg Zero (deg)

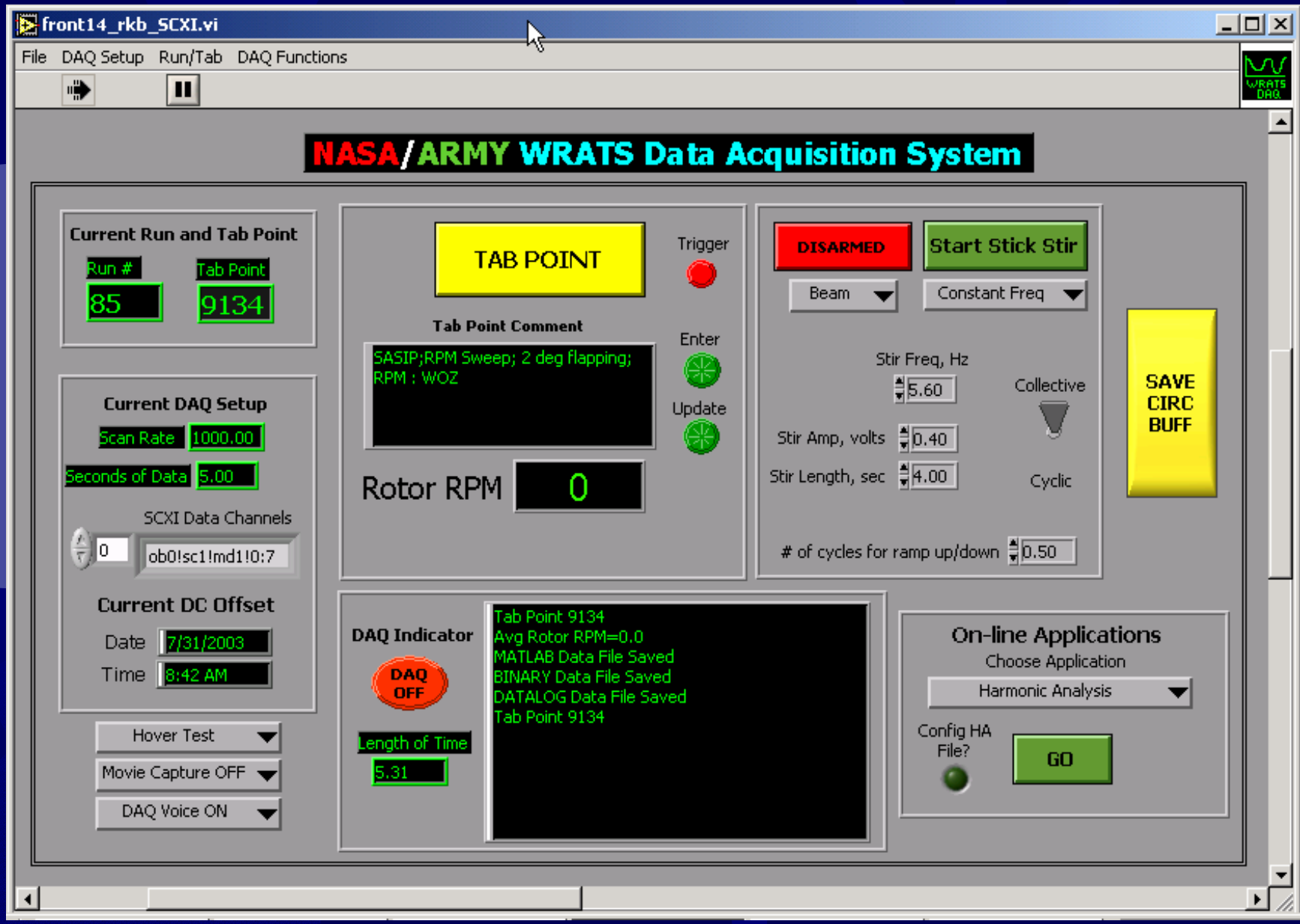
Tab Point	Comment	Zero?	B1 Flappin	Qflex Volts	Qflex Angl	Flap Angle
8852	Blade 1 Fl	yes	-2.97324	-0.184308	2.383	-0.044
8853	Blade 1 Fl	yes	-2.97756	-0.187728	2.423	-0.004
8854	Blade 1 Fl	yes	-2.98071	-0.190474	2.455	0.029
8855	Blade 1 Fl	yes	-2.97821	-0.18813	2.428	0.001
8856	Blade 1 Fl	yes	-2.97916	-0.189502	2.444	0.017
8857	Blade 1 Fl	no	-1.95425	0.567623	-6.499	-8.926
8858	Blade 1 Fl	no	-2.33131	0.284925	-3.160	-5.586
8859	Blade 1 Fl	no	-2.57947	0.112587	-1.124	-3.551
8860	Blade 1 Fl	no	-3.11976	-0.301359	3.765	1.339
8861	Blade 1 Fl	no	-3.33277	-0.472017	5.781	3.354
8862	Blade 1 Fl	no	-3.53363	-0.645987	7.836	5.409
8863	Blade 1 Fl	no	-3.70781	-0.804245	9.705	7.279
8864	Blade 1 Fl	no	-4.42254	-1.480684	17.695	15.269
8865	Blade 1 Fl	no	-4.08635	-1.151489	13.807	11.380
8866	Blade 1 Fl	no	-3.75865	-0.844505	10.181	7.754
8867	Blade 1 Fl	no	-3.4666	-0.582812	7.090	4.663
8868	Blade 1 Fl	no	-3.12204	-0.300896	3.760	1.333
8869	Blade 1 Fl	no	-2.69879	0.021828	-0.052	-2.479



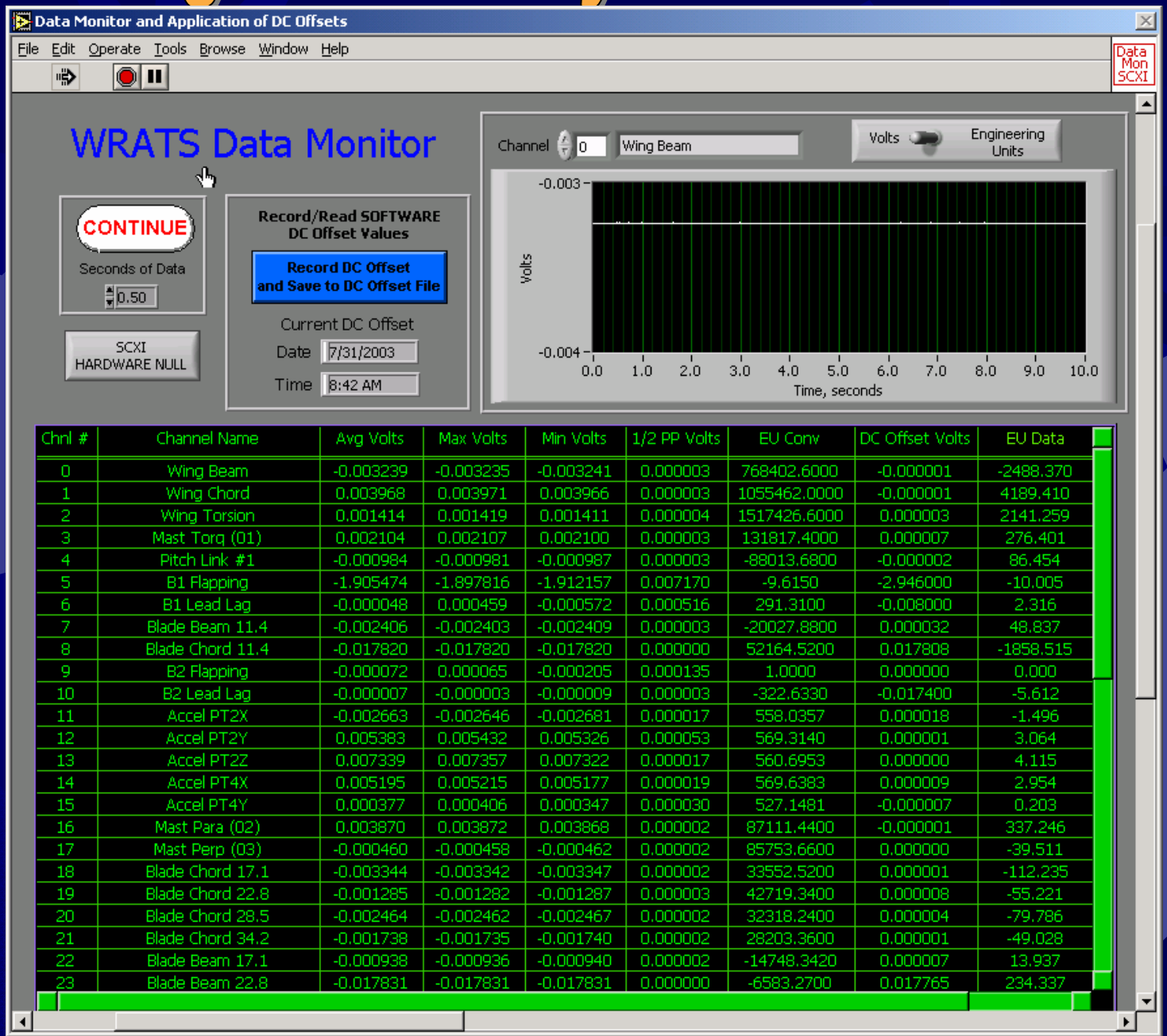
Testing and Analysis

- Data Collection
  - Slip Rings relay signal through beam and into a patch panel.
    - Main system on computer
    - Backups

Testing and Analysis



Testing and Analysis



Chnl #	Channel Name	Avg Volts	Max Volts	Min Volts	1/2 PP Volts	EU Conv	DC Offset Volts	EU Data
0	Wing Beam	-0.003239	-0.003235	-0.003241	0.000003	768402.6000	-0.000001	-2488.370
1	Wing Chord	0.003968	0.003971	0.003966	0.000003	1055462.0000	-0.000001	4189.410
2	Wing Torsion	0.001414	0.001419	0.001411	0.000004	1517426.6000	0.000003	2141.259
3	Mast Torq (01)	0.002104	0.002107	0.002100	0.000003	131817.4000	0.000007	276.401
4	Pitch Link #1	-0.000984	-0.000981	-0.000987	0.000003	-88013.6800	-0.000002	86.454
5	B1 Flapping	-1.905474	-1.897816	-1.912157	0.007170	-9.6150	-2.946000	-10.005
6	B1 Lead Lag	-0.000048	0.000459	-0.000572	0.000516	291.3100	-0.008000	2.316
7	Blade Beam 11.4	-0.002406	-0.002403	-0.002409	0.000003	-20027.8800	0.000032	48.837
8	Blade Chord 11.4	-0.017820	-0.017820	-0.017820	0.000000	52164.5200	0.017808	-1858.515
9	B2 Flapping	-0.000072	0.000065	-0.000205	0.000135	1.0000	0.000000	0.000
10	B2 Lead Lag	-0.000007	-0.000003	-0.000009	0.000003	-322.6330	-0.017400	-5.612
11	Accel PT2X	-0.002663	-0.002646	-0.002681	0.000017	558.0357	0.000018	-1.496
12	Accel PT2Y	0.005383	0.005432	0.005326	0.000053	569.3140	0.000001	3.064
13	Accel PT2Z	0.007339	0.007357	0.007322	0.000017	560.6953	0.000000	4.115
14	Accel PT4X	0.005195	0.005215	0.005177	0.000019	569.6383	0.000009	2.954
15	Accel PT4Y	0.000377	0.000406	0.000347	0.000030	527.1481	-0.000007	0.203
16	Mast Para (02)	0.003870	0.003872	0.003868	0.000002	87111.4400	-0.000001	337.246
17	Mast Perp (03)	-0.000460	-0.000458	-0.000462	0.000002	85753.6600	0.000000	-39.511
18	Blade Chord 17.1	-0.003344	-0.003342	-0.003347	0.000002	33552.5200	0.000001	-112.235
19	Blade Chord 22.8	-0.001285	-0.001282	-0.001287	0.000003	42719.3400	0.000008	-55.221
20	Blade Chord 28.5	-0.002464	-0.002462	-0.002467	0.000002	32318.2400	0.000004	-79.786
21	Blade Chord 34.2	-0.001738	-0.001735	-0.001740	0.000002	28203.3600	0.000001	-49.028
22	Blade Beam 17.1	-0.000938	-0.000936	-0.000940	0.000002	-14748.3420	0.000007	13.937
23	Blade Beam 22.8	-0.017831	-0.017831	-0.017831	0.000000	-6583.2700	0.017765	234.337

Testing and Analysis

Harmonic_Analysis2.vi

Harmonic Analysis

Tab Point 9134

Rotor RPM 0.0

# of Avgs 10

# of Harmonics 6

Analyzing

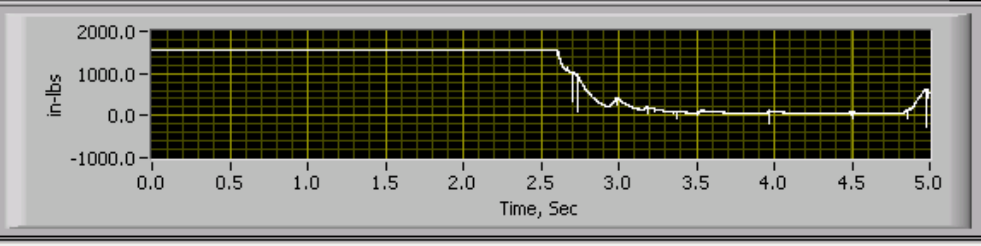
CONTINUE

Chnl	Chnl List	Mean & 1/2PP	1P	2P	3P	4P	5P	6P	
			0.00	0.00	0.00	0.00	0.00	0.00	Phase
		0.041	0.000	0.000	0.000	0.000	0.000	0.000	Cosine Amp
			0.000	0.000	0.000	0.000	0.000	0.000	Sine Amp
42	Qflex5 Flapping	-0.005	0.000	0.000	0.000	0.000	0.000	0.000	Mag
			0.00	0.00	0.00	0.00	0.00	0.00	Phase
		0.018	0.000	0.000	0.000	0.000	0.000	0.000	Cosine Amp
			0.000	0.000	0.000	0.000	0.000	0.000	Sine Amp
43	Blade 4	-0.006	0.000	0.000	0.000	0.000	0.000	0.000	Mag
			0.00	0.00	0.00	0.00	0.00	0.00	Phase
		0.014	0.000	0.000	0.000	0.000	0.000	0.000	Cosine Amp
			0.000	0.000	0.000	0.000	0.000	0.000	Sine Amp
44	Collective	10.273	0.000	0.000	0.000	0.000	0.000	0.000	Mag
			0.00	0.00	0.00	0.00	0.00	0.00	Phase
		0.032	0.000	0.000	0.000	0.000	0.000	0.000	Cosine Amp
			0.000	0.000	0.000	0.000	0.000	0.000	Sine Amp
45	ongitudinal Cyclic (+Fwc	1.553	0.000	0.000	0.000	0.000	0.000	0.000	Mag

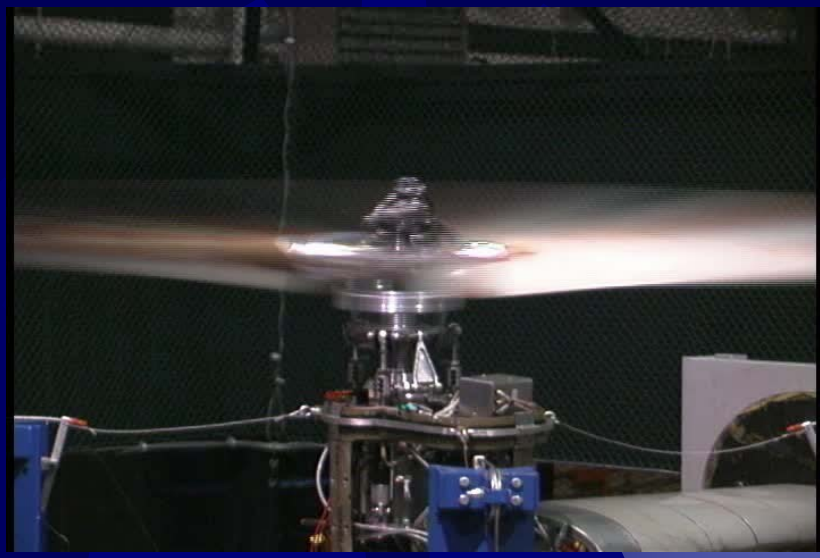
Channel # 1

Wing Chord

Data vs Time

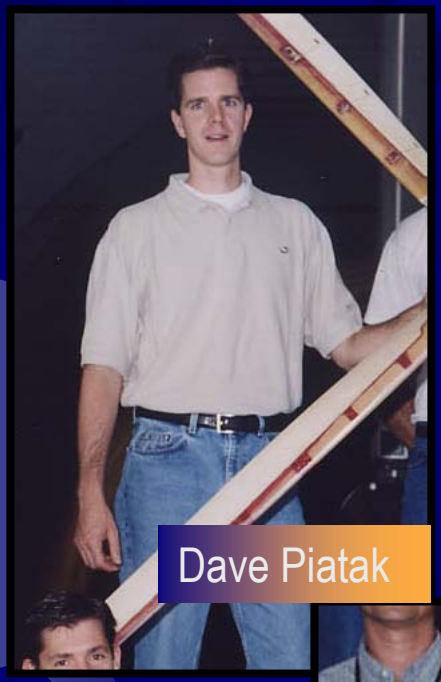


What did I learn?



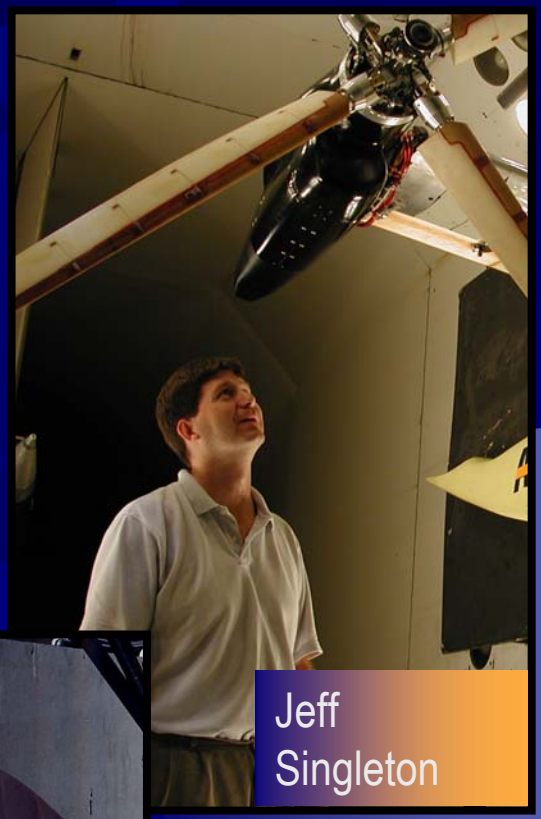
- Modes and Resonance
- Principles of Aerospace Engineering
  - Engines and Flight controls
  - Aerodynamic forces
- Experimental design and testing
  - Data Collection and interpretation
  - Real World Application of Knowledge

Special Thanks To:



Dave Piatak

Mike Ramsey



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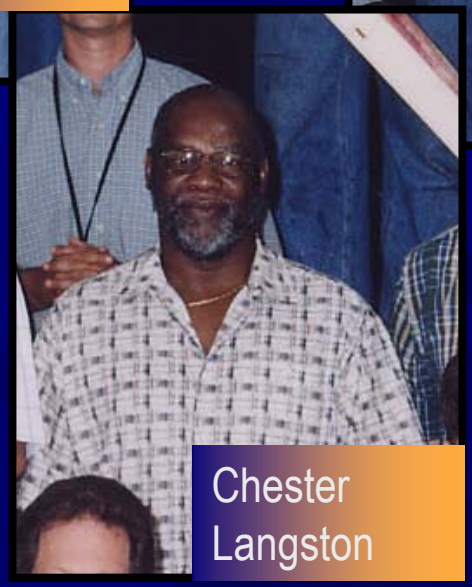

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Dr. Mark Nixon