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April 17th, 2006

From: Vertical Flight Human Factors Program Manager, ATO-P R&D Human Factors
To: Vertical Flight TCRG

Subj: VERTICAL FLIGHT HUMAN FACTORS SECOND QUARTER '06 REPORT

Ref: Vertical flight human factors execution plans (http://www.hf.faa.gov/vffunded.htm)

Projects are listed below

a. Simultaneous Non-interfering Operations - Quantify VFR Navigation Performance.

   Project is complete.

b. Lowering GA Accidents in Low Visibility: UAV See-and-Avoid Requirements - The goal of this project is to assess the feasibility of using the Spatial Standard Observer, or derivatives, to compute N50 values for target image sets. Currently N50 values are obtained empirically, through an expensive and time consuming psychophysical experiment using human observers. Because the SSO attempts to model human image discrimination, it offers the possibility of replacing human observers with computer calculations.

   During this quarter the researcher made the following progress toward plan objectives.

   Article on modeling letter acuity
   The researcher completed a draft of a paper that describes a model of letter acuity, capable of predicting the effects of induced higher order optical aberrations. The model incorporates the Spatial Standard Observer, along with template matching. The researcher also completed over 2000 hours of computer simulations of the model, exploring various matching rules and templates, that will be reported upon in the paper. This model will also serve as the basis for predicting visibility of aircraft and UAVs elsewhere in this project. In particular, the simulations will assist in selection of appropriate matching rules for visibility simulations.

   Development of Psychophysical Apparatus
   Two of the objectives of this project involve psychophysical experiments (visibility and search). During this quarter the researcher continued development of software for the experiments. Work continued on the development of the Showtime library framework. The Showtime's is capable of creating and displaying video in a number of formats utilizing the underlying QuickTime API including HD video. It is also capable of reading raw data files, such as those used for VQEG experiments, without the need for advance preparation of

QuickTime movie files. Current efforts include enhancing Showtime to use OpenGL based display routines to render video in lieu of the default graphics port used by QuickTime. Using OpenGL based display routines will provide greater control, flexibility, and speed. The researcher's current primary focus is in modifying the CLUTs (color look-up tables) used by the graphics card for use in psychophysics experiments. Some work was done to update the display routines to OpenGL but there remains additional work and some troubleshooting. One problem encountered is that some formats are not displaying properly where format choice should be independent of display capability. This issue should be resolved soon.

Aircraft models

The existing online visibility tool relies on simple Mathematica rendering of aircraft and UAV images from 3D models. Likewise the psychophysical experiments will use similar renderings of 3D models. Therefore this task we have been looking for 3D models of relevant UAV craft. The manufacturer has been asked to provide models, but none have yet been received. The researcher has obtained a model of the Global Hawk, and Predator aircrafts. The figure below shows the models rendered against a cloud background.

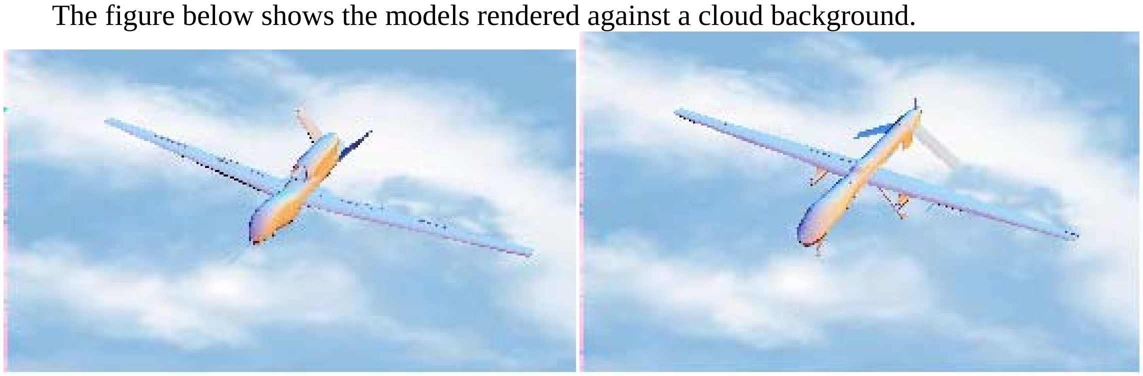


Figure 1. Renderings of 3D models of Global Hawk (left) and Predator (right) UAVs.
We are continuing to work on integration of these models into the psychophysics experiments and the online visibility prototype.

Other activities:

Dr. Watson appointed member of VESA FPDM Committee

Dr. Andrew B. Watson, Senior Scientist for Vision Research and Chief Scientist of the Human Factors Research Division, was appointed to membership in the important VESA (Video Electronics Standards association) FPDM (flat panel display measurement) Committee. This is the primary international standards body for flat panel displays.

Human Vision and Electronic Imaging Conference

Dr. Andrew B. Watson attended the Human Vision and Electronic Imaging Conference in San Jose, CA. Dr Watson serves on the program committee for this conference.

Spatial Standard Observer: Technology Transfer

During the last quarter the researcher delivered presentations and held discussions with a number of companies that are interested in commercial development of the Spatial Standard Observer. Success in this direction will assist this project by providing further development and additional impetus for adoption of the standard observers as a metric for visibility in a wide variety of applications. The companies visited include Photon Dynamics, Westar Display Technologies, Radiant Imaging, KLA Tencor, and Applied Materials.

Spatial Standard Observer International Patent

ARC-14569-1PCT International Patent filed for spatial Standard Observer.

Invited to address Society for Information Display

Dr. Andrew B. Watson was invited to present keynote address on Display Quality at the annual meeting of the Society for Information Display, San Francisco, CA, June, 2006.

Editor for OSA Special Issue on Image Quality

Dr. Andrew B. Watson was invited to serve as guest editor for a special issue on Image Quality in the Journal of the Optical Society of America.

Draft of Article on "Motion picture response time: Simulation, verification, and subjective impact"

This article, to be included as part of an invited presentation at the Society for Information Display in June in San Francisco, CA, describes a new method for quantifying the visual effects of slow response times in liquid crystal displays (LCD). This work will also be presented to the Video Electronics Standards Association (VESA) meeting in April in Boulder CO. A NASA disclosure of invention has been submitted related to this work.

Lecture at Google

Dr. Watson presented a lecture at Google, Inc. entitled "Developing Human Vision Models for Video Compression, Display Design, and Other Visual Technologies." This lecture is part of the ongoing exchange between NASA/ARC and Google to explore areas of mutual research interest.

Human Factors Engineering Society Symposium

Invited to participate in ARC-led symposium proposal on Human Performance Modeling. Submitted abstract on Vision Science and Visual Technology.

This effort is cost shared with NASA Ames. Year two proposal has been accepted and funding will be transferred to NASA Ames.

c. Helicopter Pilot Performance: Visual Flight Rule (VFR) flight into Instrument Meteorological Conditions (IMC) – The researcher formalized arrangements with Helicopter facility to run tests. The researcher arranged a setup billing system and reserved personnel and time in the Flyit Simulator at Silver State Helicopters at McClellen Field in Sacramento, CA. Several rated instructors and an assistant Chief Pilot were made available to help run the experiments.

Researcher completed software development for data collection. A software program has been developed to run simultaneously with the Flyit simulator software. This program collects data from the simulator system including: flight control movements (tail rotor pedals, collective, throttle, cyclic), helicopter attitude and motion and its second order derivatives (pitch, yaw, roll, vertical feet per minute, ground speed, airspeed, accelerations of horizontal, vertical and lateral motion), weather conditions (visibility, cloud cover), radio settings, and some other general parameters and gauge indications. The following is a list of the variables collected by the program:

ground elevation	S32	= (2^16 - Long) * 3.28084 / 256 'Meters
Clock time	U8 "Byte"	= Byte
indicated airspeed	S32	= Long / 128 'Knots
vertical airspeed	S32	= Long * 60 * 3.28084 / 256 'Meters/sec
com freq	U16 "Integer"	= Hex(Integer)
Nav 1 frequency	U16 "Integer"	= Hex(Integer)
Nav 2 freq	U16 "Integer"	= Hex(Integer)
turn coordinator ball minus to left	S8	= Integer from 0-127, or (Integer - 256) from 128-'Plus to right,
turn rate	S16	= Long '-512 2Minute left, +512 2Minute right
lattitude	S64 "Currency"	= Currency * (90 / (10001750 * 2^32)) * 10000
Longitude	S64 "Currency"	= Currency * (360 / 2^64) * 10000

altitude	S64 "Currency"	= Currency * (3.28084 / 2^32) * 10000 'AGL
pitch	S32	= Long * 360 / 2^32 '-pitch up, +pitch down, degrees
bank	S32	= Long * 360 / 2^32 '-left, +right
heading	U32 "Long"	= Long * 360 / 2^32
crashed	S16	= Integer : 0 = Ok, 1 = Crashed
vertical speed	S16	= (Integer - 2^16) * -3.28084 'Meters per minute
eng 1 torque %	S32	= Long * 100 / 2^14 '%
engine 1 throttle	s16	= Long * 100 / 2^14 '%
engine 1 rotor RPM	S32	= Long * 100 / 2^14 '%
elevator control	S16	= ?
aileron control	s16	= Long '?
rudder control	s16	= Long '?
current visibility	S16	= Long / 100 'Statute miles
lower cloud ceiling	U16 "Integer"	= Integer * 3.28084 'Meters AMSL
cloud base	U16 "Integer"	= Integer * 3.28084 'Meters AMSL
lateral accel	FLT64 "Double"	= Double 'Right/left relative to body axes, in ft/sec/sec
vertical accel	FLT64 "Double"	= Double 'Up/down relative to body axes, in ft/sec/sec
z longit accel	FLT64 "Double"	= Double 'Foward/backward relative to body axes, in ft/sec/sec
z longit veloc (gs)	FLT64 "Double"	= Double 'Forward/backward relative to body axes, in ft/sec
X lateral vel GS	FLT64 "Double"	= Double 'Right/left relative to body axes, in ft/sec
Y verti veloc GS	FLT64 "Double"	= Double 'Up/down relative to body axes, in ft/sec
pitch vel	FLT64 "Double"	= Double 'Relative to body axes, in rads/sec
roll vel	FLT64 "Double"	= Double 'Relative to body axes, in rads/sec
yaw vel	FLT64 "Double"	= Double 'Relative to body axes, in rads/sec
surface type	U32 "Long"	= Long '?
surface condition	U32 "Long"	= Long '?

The full data collection program is available upon request (Visual Basic 6.0 code).

The researcher completed the first phase of data collection and has begun a second phase of data collection. So far, the researcher completed the first phase of data collection consisting of running 17 subjects on five randomly chosen runs from the 17 different conditions. This yields 5 sample runs on each of the 17 conditions and 85 data files. The researcher has also begun the second phase of data collection on 17 additional subjects. In this phase, the intent is to test more low-time commercial pilots since the first data set is biased toward high-time and experienced IFR helicopter pilots. The second phase will yield an additional 85 data files for analysis. So far, a total of 20 subjects has been tested with 15 remaining.

Begun data analysis – The researcher has begun to analyze the data for trends in pilot performance (see details below).

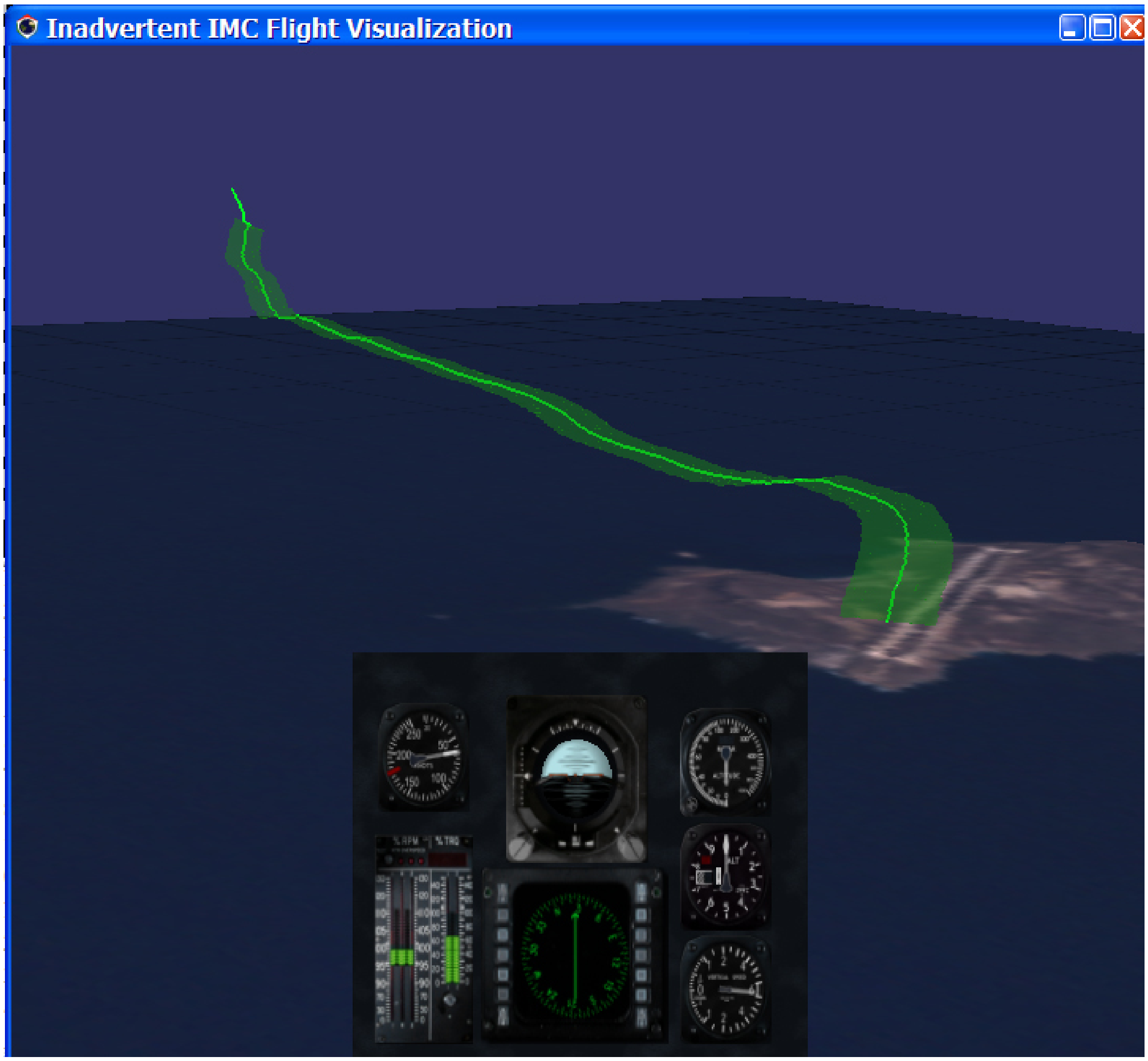
In FY06Q2, the researcher has continued to collect data from subjects recruited from across the country. A total of 20 subjects out of a goal of 35 have been completed. Currently the simulator is being utilized by Silver Sate to cover a ground school commitment and should be returned for our use by the end of March, 2006 when the researcher will resume testing of subjects.

The researcher has also begun data analysis on the subjects we have already tested. Below is a short section of a data file covering approximately 30 seconds of the 15 minute test flight. This section shows the liftoff and start of forward flight and illustrates the parameters collected.

Tick	Clock 24-Hour	Elevator %	Aileron %	Rudder %	Gnd Elev meters	Ind Airspee knots	Vert Airspe meters/sec	Lattitude degrees	Longitude degrees	Altitude meters AG	Pitch degrees	Bank degrees	Heading degrees	Vert Speec meters/mir	X Lat Acc ft/sec^2	Y Vert Acc ft/sec^2	Z Long Acc ft/sec^2	X Lat Vel ft/sec	Y Vert Vel ft/sec	Pitch Vel radians/sec
324	12:32:53	11	5	-26	181	0	0	33.0179	-118.602	186	0.26	-0.11	65.99	0	0.43	2.65	1.42	0	0	0
325	12:32:54	13	4	-13	181	0	26	33.0179	-118.602	186	-0.06	-0.26	65.03	36	0.17	4.15	-0.34	0.15	2.35	-0.025
326	12:32:55	0	-2	-9	181	0	167	33.0179	-118.602	189	-1.33	-0.7	63.55	180	-0.04	1.64	-0.41	0.3	4.64	-0.013
327	12:32:55	0	0	-15	181	0	270	33.0179	-118.602	193	-1.76	-0.7	62.44	272	0.28	-1.2	-0.87	0.61	4.8	-0.001
328	12:32:56	-2	-2	-18	181	0	254	33.0179	-118.602	197	-1.69	-0.49	60.43	242	0.17	-2.22	-0.88	0.81	3.25	0.004
329	12:32:57	-2	2	-8	181	0	166	33.0179	-118.602	199	-1.49	-0.32	57.9	150	0.08	-1.71	-0.92	0.96	1.62	0.004
330	12:32:58	-3	0	-6	181	0	77	33.0179	-118.602	200	-1.29	-0.42	56.95	59	0.19	-1.24	-0.49	1.08	0.36	0.005
331	12:32:59	-5	-3	0	181	0	10	33.0179	-118.602	201	-0.96	-0.31	56.95	3	0.17	0.67	-0.29	1.2	0.17	0.009
332	12:33:00	-11	-2	-4	181	0	14	33.0179	-118.602	201	-0.34	0	57.94	13	0.09	0.46	0.26	1.3	0.61	0.021
333	12:33:01	-9	-2	0	181	0	56	33.0179	-118.6021	202	0.73	0.26	58.77	62	-0.1	1.24	0.6	1.28	1.97	0.02
334	12:33:01	-8	0	-3	181	0	123	33.0179	-118.6021	204	1.73	0.52	59.97	127	-0.14	0.52	1.16	1.13	2.67	0.018
335	12:33:02	-12	3	-9	181	0	159	33.0179	-118.6021	206	2.64	0.45	60.5	160	-0.26	0.38	1.88	0.98	3.03	0.021
336	12:33:03	-11	3	-9	181	0	179	33.0179	-118.6021	209	3.76	0.06	59.92	180	-0.03	0.46	2.07	0.87	3.34	0.024
337	12:33:04	-9	3	-9	181	0	199	33.0179	-118.6021	212	4.87	-0.4	59.11	200	0.25	0.88	2.8	0.98	3.95	0.019
338	12:33:05	-9	2	-9	181	0	221	33.0179	-118.602	215	5.78	-0.78	58.26	223	0.5	1.25	3.33	1.3	4.86	0.018
339	12:33:06	-10	0	-9	181	0	262	33.0179	-118.602	219	6.69	-1.06	57.4	269	0.65	6.21	3.87	1.77	6.61	0.019
340	12:33:07	-8	-1	-9	181	0	343	33.0179	-118.602	224	7.63	-1.15	56.62	351	0.65	6.41	4.27	2.36	8.84	0.016
341	12:33:07	-12	-2	-8	181	0	435	33.0179	-118.602	230	8.37	-1.13	55.87	442	0.73	-0.19	5.19	2.94	11.26	0.018
342	12:33:08	-18	0	-5	181	1	535	33.0179	-118.6019	238	9.52	-1.12	55.23	547	0.56	1.23	5.39	3.52	14.37	0.033
343	12:33:09	-14	2	-2	181	4	648	33.018	-118.6019	247	11.01	-1.29	55.27	659	-0.11	6.54	6.27	3.8	18.02	0.026
344	12:33:10	-18	2	-2	181	7	781	33.018	-118.6018	258	12.32	-1.43	56.11	803	-0.25	5.85	7.31	3.68	22.88	0.028
345	12:33:11	-20	2	-2	181	12	935	33.018	-118.6017	272	13.86	-1.49	57.08	948	-0.32	4.73	7.98	3.42	27.39	0.034
346	12:33:12	-12	2	-6	181	16	1011	33.0181	-118.6016	287	15.31	-1.64	57.68	1007	0.43	1.21	8.88	3.38	29.71	0.013
347	12:33:12	-8	6	-4	181	21	944	33.0181	-118.6014	300	15.63	-2.29	57.13	921	1.15	-0.77	9.24	4.32	29.27	-0.009
348	12:33:13	-11	6	0	181	26	808	33.0182	-118.6013	311	14.93	-3.49	56.67	787	0.5	-1.1	9.49	5.15	28.35	-0.02
349	12:33:14	-15	2	0	181	31	682	33.0183	-118.6011	321	14.24	-4.36	57.57	659	-0.83	-0.26	9.11	4.89	27.89	-0.01
350	12:33:15	-15	-1	0	181	36	575	33.0184	-118.6009	329	13.89	-4.22	59.26	561	-0.94	-0.34	8.83	4.13	27.7	-0.013
351	12:33:16	-14	-8	0	181	41	494	33.0184	-118.6007	336	13.27	-3.36	60.86	482	-0.59	-0.84	8.55	3.4	27.18	-0.021
352	12:33:17	-6	-8	0	181	46	439	33.0185	-118.6005	342	12.05	-1.66	62.04	433	-0.55	-1.97	7.51	2.91	26.15	-0.042
353	12:33:17	-11	-7	0	181	50	437	33.0186	-118.6003	348	9.95	-0.24	62.62	439	-0.35	-1.74	6.82	2.5	24.14	-0.043
354	12:33:18	-16	1	0	181	54	496	33.0187	-118.6	355	8.24	-0.12	62.74	505	0.21	0.51	5.52	2.19	24.04	-0.023
355	12:33:19	-14	-4	0	181	57	592	33.0188	-118.5998	364	7.01	-0.4	62.41	603	0.99	-0.64	4.61	2.7	23.94	-0.03
356	12:33:20	-12	-8	-3	181	59	699	33.0189	-118.5995	374	5.42	0.61	61.77	711	1.05	-1.49	3.44	3.68	22.98	-0.038
357	12:33:21	-27	-4	-4	181	61	819	33.0191	-118.5992	387	4.07	1.85	60.67	830	0.9	1.72	2.53	4.65	23.11	-0.005
358	12:33:22	-20	-2	-5	181	62	935	33.0192	-118.5989	401	3.67	2.56	59.31	944	1.08	-0.32	1.83	5.44	23.76	-0.02

Roll Vel	Yaw Vel	Eng1 Torq	Eng1 Rotor	Eng1 Throt	Turn Coord	Turn Rate	Com Freq	Nav1 Freq	Nav2 Freq	Surface Ty	Surface Co	Current Vis	Lower Clou	Lower Clou	Crashed
radians/se	radians/se	%	%	%	-128 to +12	-512 to + 512						miles at gr	meters	meters	
0	-0.008	72.16	99.99	68.1		-35	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.01	-0.04	84.98	99.99	77.55		-148	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.002	-0.023	84.97	99.99	79.91		-258	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.001	-0.034	80.31	99.99	76.37		-232	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.004	-0.058	76.85	99.99	73.62		-355	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.004	-0.028	76.34	99.99	73.62		-495	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.001	-0.003	76.83	99.99	73.62		-274	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.006	0.016	82.32	99.99	77.94		-81	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.005	0.014	82.32	99.99	77.94		115	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.004	0.023	88.17	99.99	82.28		155	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.002	0.016	88.17	99.99	82.28		213	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.008	-0.009	88.16	99.99	82.28		141	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.008	-0.017	88.15	99.99	82.28		-39	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.008	-0.018	88.14	99.99	82.28		-121	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.006	-0.019	88.14	99.99	82.28		-153	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0	-0.016	88.14	99.99	82.28		-166	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.001	-0.016	88.12	99.99	82.28		-158	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.004	-0.014	88.1	99.98	82.28		-158	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0	-0.004	88.07	99.98	82.28		-133	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.007	0.015	88.04	99.98	82.28		-22	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.006	0.02	88.04	99.99	82.28		110	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.007	0.017	87.99	99.97	82.28		170	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.007	-0.004	83.09	99.95	79.13		138	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.023	-0.014	78.05	99.98	74.79		-37	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.025	0.009	78.03	99.98	74.79		-79	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.009	0.031	78.03	99.99	74.79		92	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.003	0.033	78	99.99	74.79		256	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.028	0.025	77.99	99.99	74.79		298	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.029	0.014	77.97	99.99	74.79		242	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.018	0.005	77.95	99.99	74.79		152	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
-0.008	-0.005	77.95	99.99	74.79		53	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.016	-0.011	77.93	99.99	74.79		-31	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.03	-0.018	77.9	99.99	74.79		-95	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.015	-0.025	77.87	99.99	74.79		-175	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No
0.002	-0.032	77.83	99.99	74.79		-239	127.3	111.4	111.4	Concrete	Normal	20	5000	2500	No

Because of the overwhelming amount of data and the difficulties with getting a global idea of the trends we have also started analyzing the data by reconstructing the flight profiles. This is being done with software being developed by Dr. Joseph Sullivan at the Post graduate Naval School in Monterey. This software will have the capability to replay the flight and will allow us to view the aircraft attitude and position from several perspectives. A screen shot from the preliminary version of this program is illustrated below.



All available information indicates the project is on track.

William K. Krebs, Ph.D.