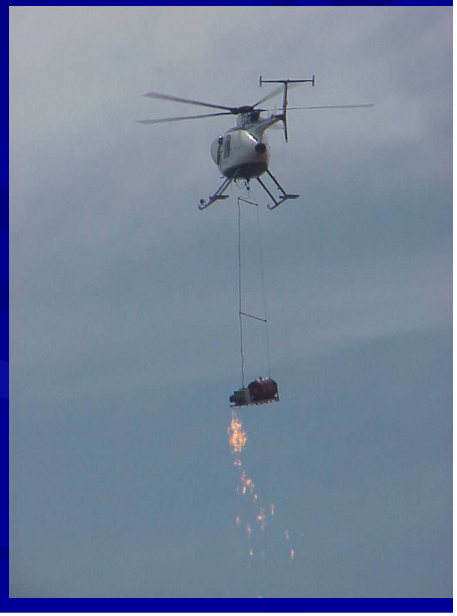
US Forest Service Operational Loads Monitoring Program

Background

- The US Forest Service uses aircraft for a wide variety of missions, including personnel transport, research, forest rehabilitation, law enforcement support, aerial photography, infrared detection, and fire prevention and suppression.
- The primary mission of Forest Service Aviation is to support the ground firefighter through a variety of means including safe delivery of smokejumpers, helitack, air attack, firefighter and cargo transport, surveillance, aerial reconnaissance and fire intelligence gathering, and aerial delivery of fire retardant and water.

Aerial Firefighting Missions



Program Purpose

- This program was implemented by the US Forest Service (Fire and Aviation Management and the Missoula Technology and Development Center) for the purpose of collecting operational loads data in the low level aerial firefighting environment.
- The primary use of the data collected is to define how each aircraft is employed in the aerial firefighting role and develop detailed mission flight profiles that result in a load spectrum for each firefighting mission and allow for the sharing of this data.

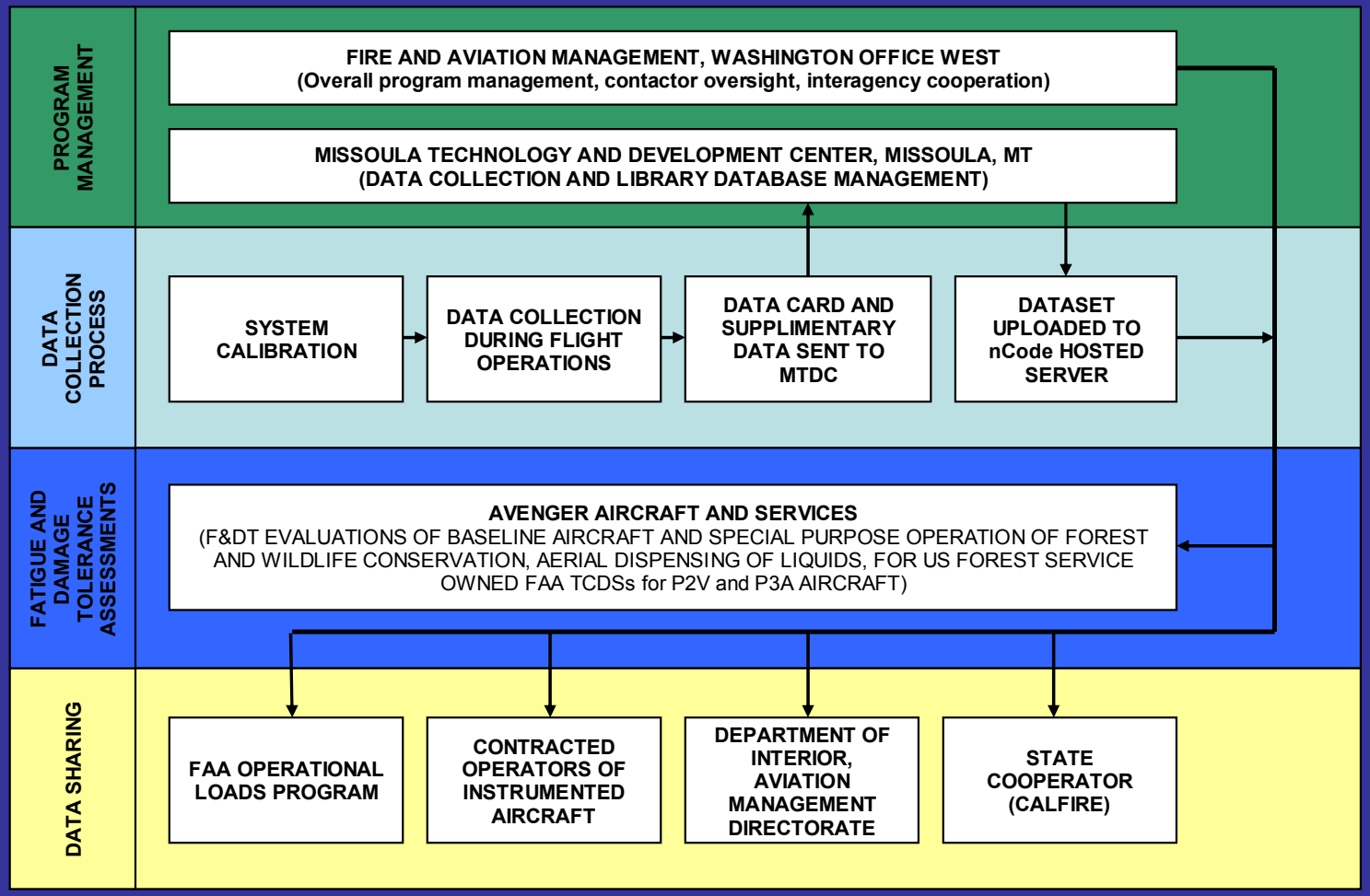
Program Purpose

- The Forest Service and the Federal Aviation Administration are collaborating in a technical exchange program in support of the FAA's Operational Loads Measurement Program.
- Through the FAA, Wichita State University's National Institute for Aviation Research (NIAR) has been tasked to identify maneuver loading and the level of turbulence experienced in the firefighting environment from data collected from airtankers operating in the firefighting environment.
- This effort will result in an FAA published report quantifying this data.

Data is currently or will be collected for the following Missions:

- Fixed Wing Aircraft
  - *Large Airtanker
  - *Aerial Supervision Module (ASM) / Leadplane
  - *Smokejumper
  - *Infrared Aircraft
  - *Air Attack / Reconnaissance / Patrol
- Helicopter
  - Water / Retardant Delivery
  - Firefighter Delivery / Rappel
  - Cargo Delivery
  - Aerial Ignition

US FOREST SERVICE OPERATIONAL LOADS MONITORING PROGRAM STRUCTURE



SEI
Systems & Electronics, Inc.

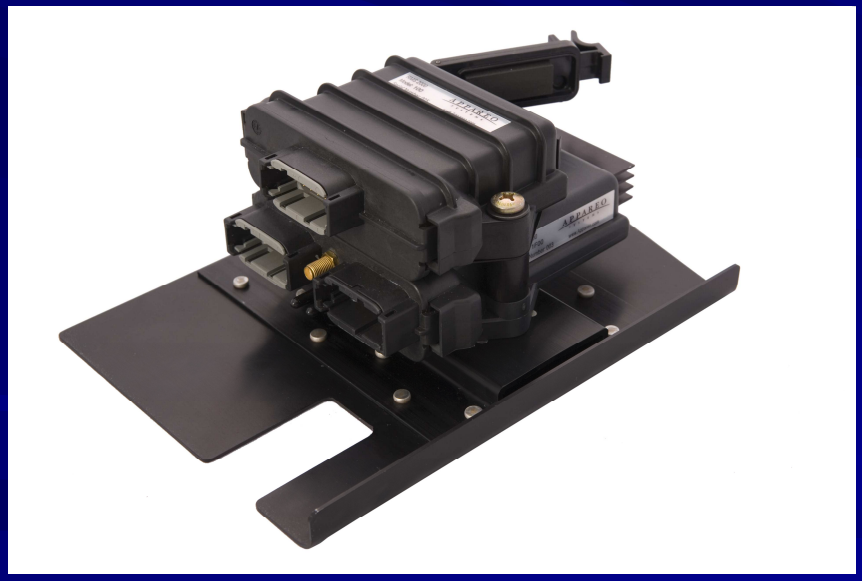
System Hardware

- The SEI Full system was prototyped during the 2003 fire season and has since been refined, adjusting strain sensors to more critical areas and has added additional parameters to aid in flight profile definition. Parameters recorded are:
  - Date/Time GMT
  - Latitude and Longitude Altitude
  - Heading
  - Vertical Acceleration
  - Roll Acceleration
  - Left Aileron position
  - Elevator position
  - Flap position
  - Airspeed
  - Fuel Load
  - Aircraft Avionics power on / power off
  - Aircraft Landing Gear Position
  - Capable of 12 channels of Strain
  - AIRTANKER SPECIFIC PARAMETERS
    - Retardant Load
    - Retardant tank door(s) actuation
    - Jet Tachometer (P2V)
    - Spoiler position (P2V)
    - Over G Indicator (P3)
    - #2 Engine On (Start / Stop Record)

APPAREO SYSTEMS

System Hardware

The Appareo Light Operational Loads Monitoring (OLM) System further supports the mission profile definition and loads spectra development. Parameters recorded are:



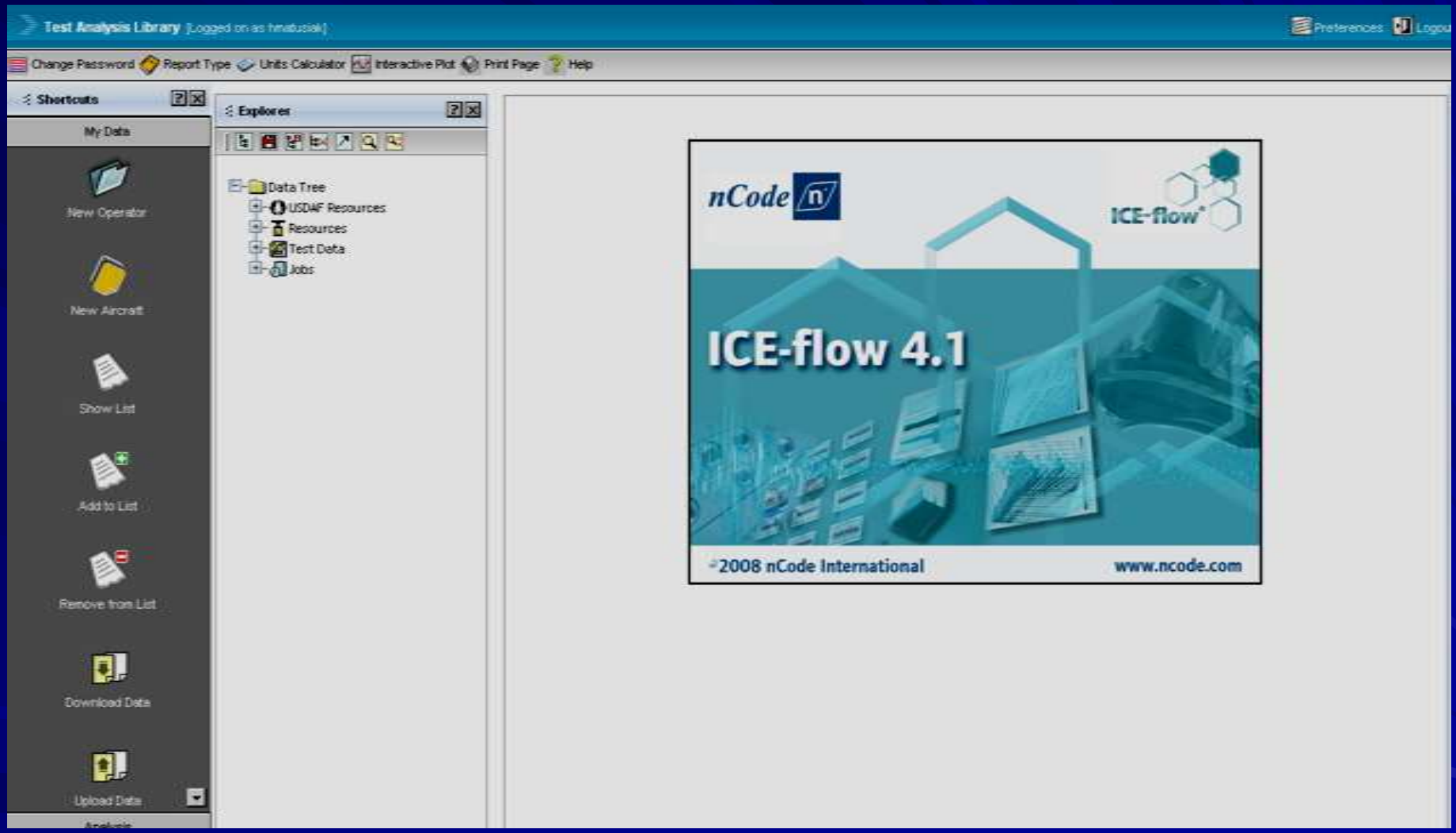
- Date/Time GMT
- Latitude and Longitude Altitude
- Heading
- Vertical Acceleration
- Airspeed
- Fuel Load
- Aircraft Avionics power on / power off
- Aircraft weight on wheels (squat switch)
- AIRTANKER SPECIFIC PARAMETERS
  - Retardant Load
  - Retardant tank door actuation

nCode

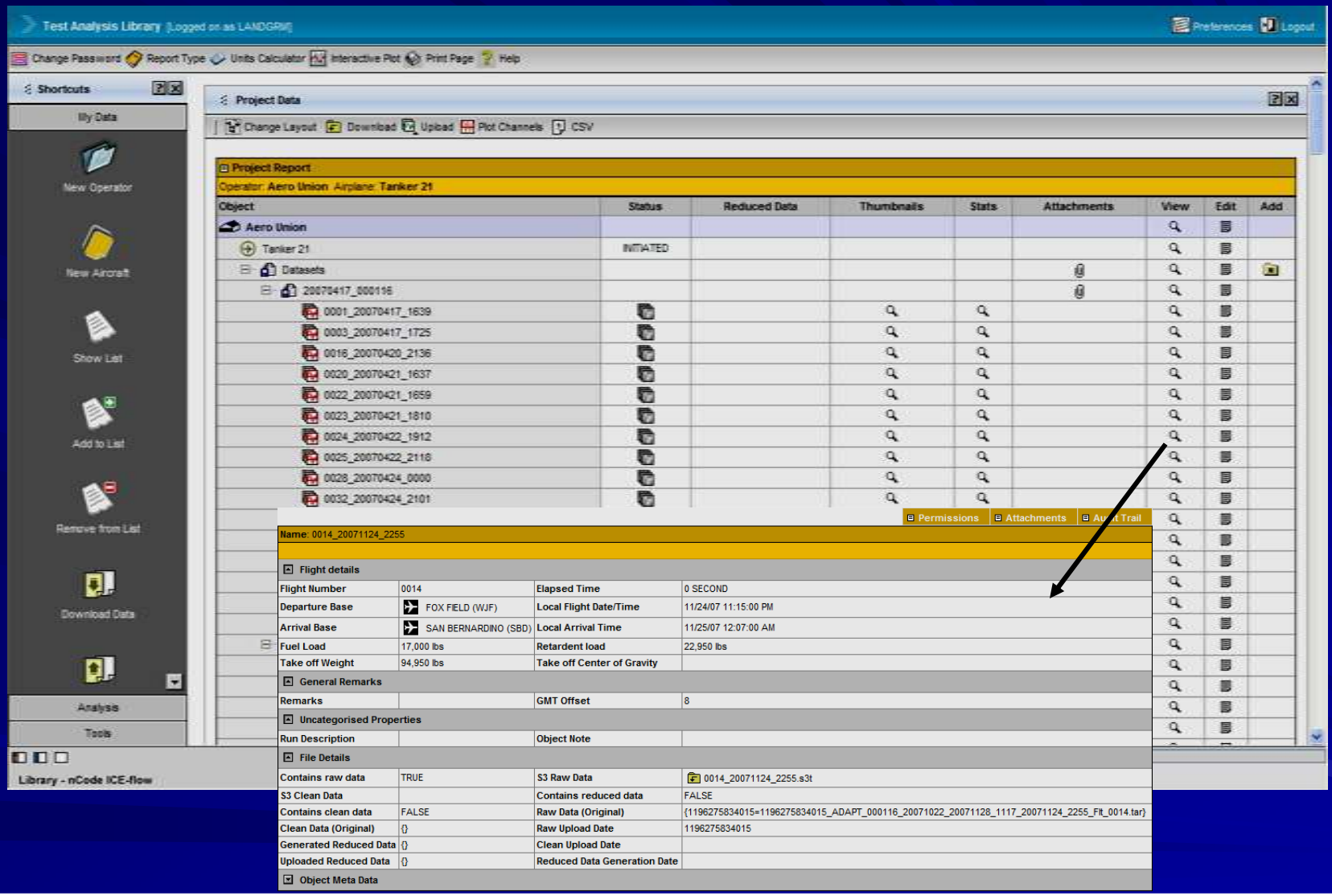
Eliminating the Unexpected

- The OLM Library Database is a commercial off-the-shelf product supplied by nCode International of Southfield, MI. It is based on their ICE-flow Automation Test solutions, a web-based application with multilevel security protocols and access levels. It also tracks the versions of each flight record dataset stored, ensuring traceability to the original dataset.
- An additional nCode analysis tool, GlyphWorks, is used to process the collected data through different analysis "flows." This enables multiple datasets to be processed simultaneously.

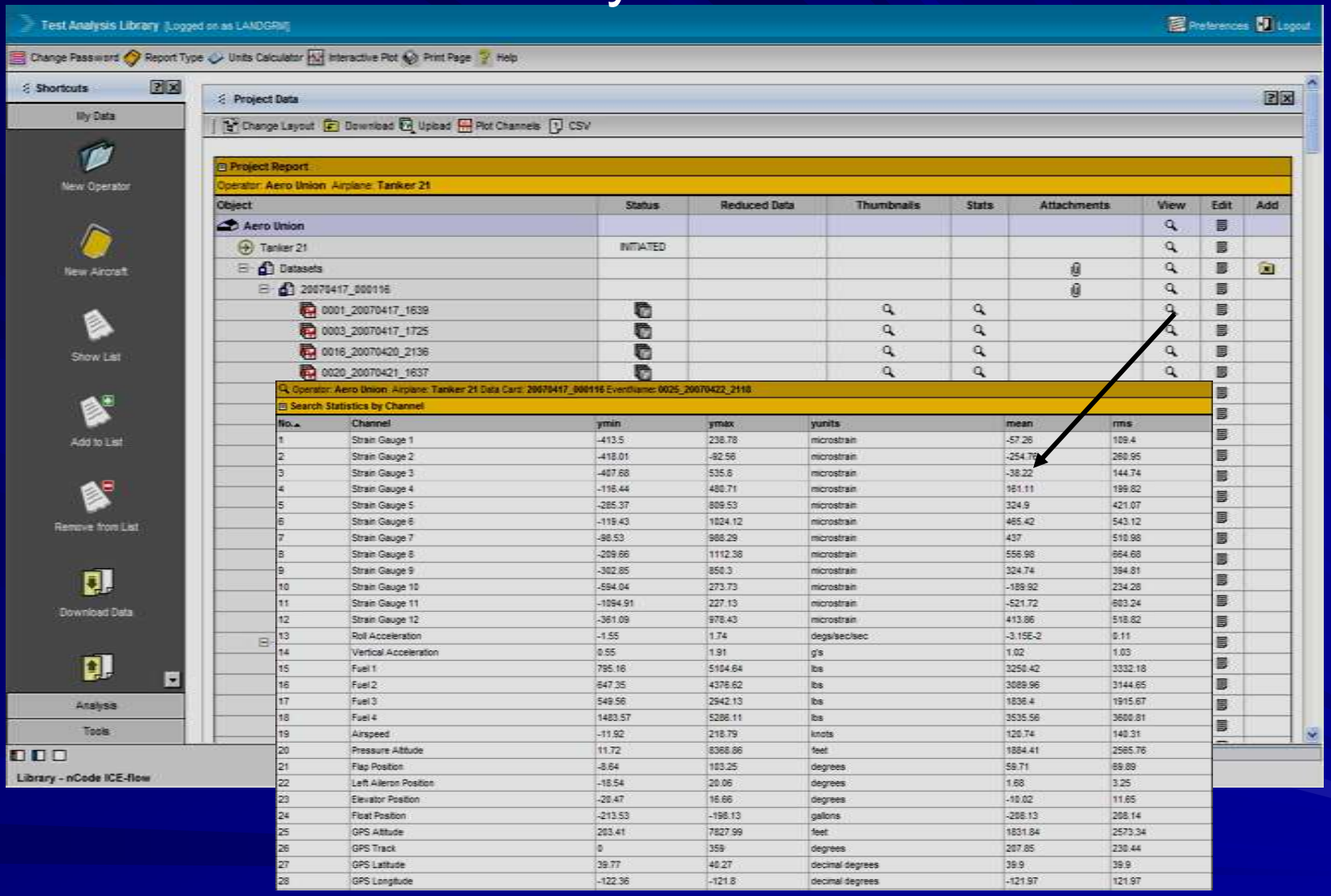
Home Screen after logging in



Individual Flight Datasets with Stored Metadata

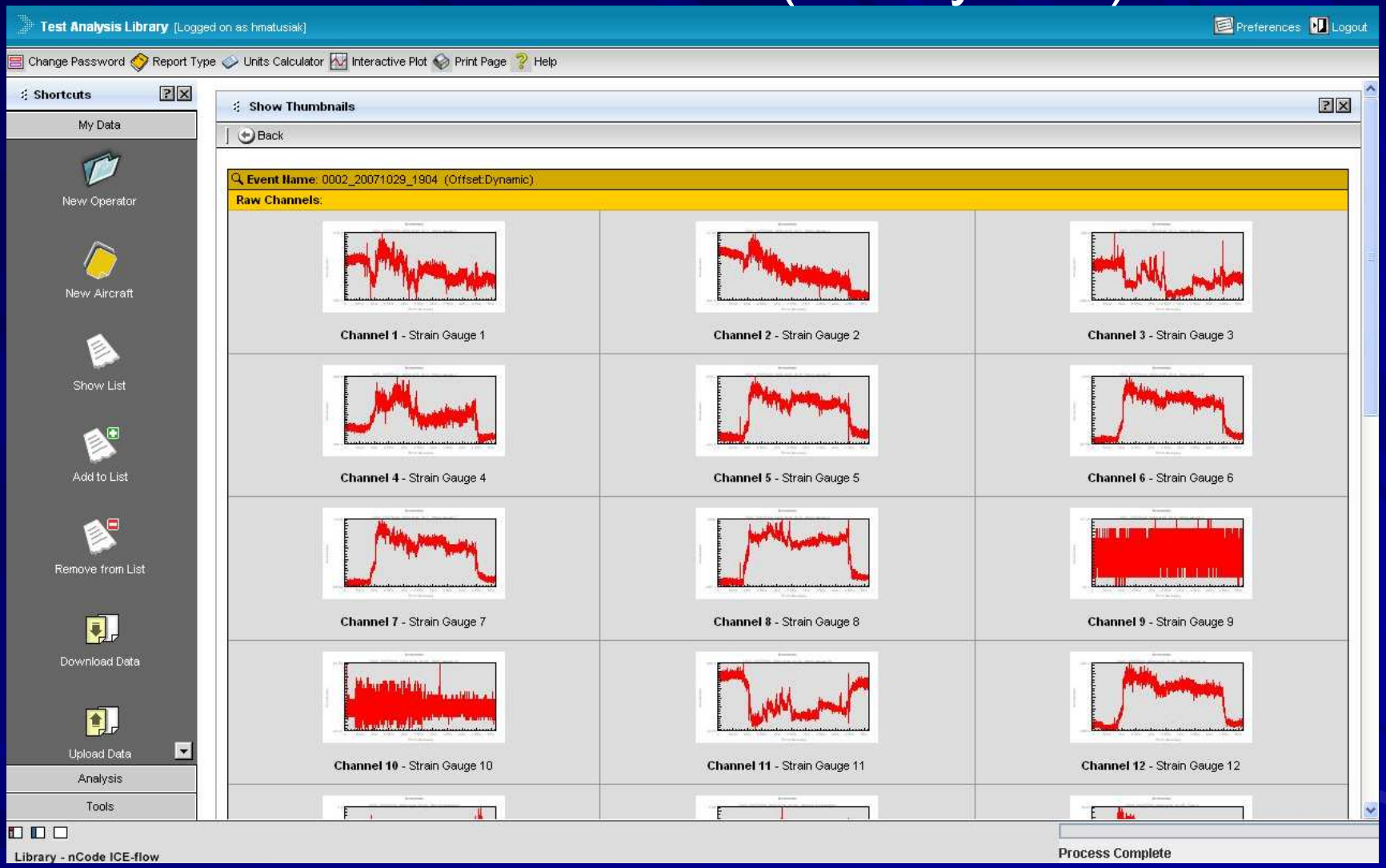


Searchable Statistics by Channel

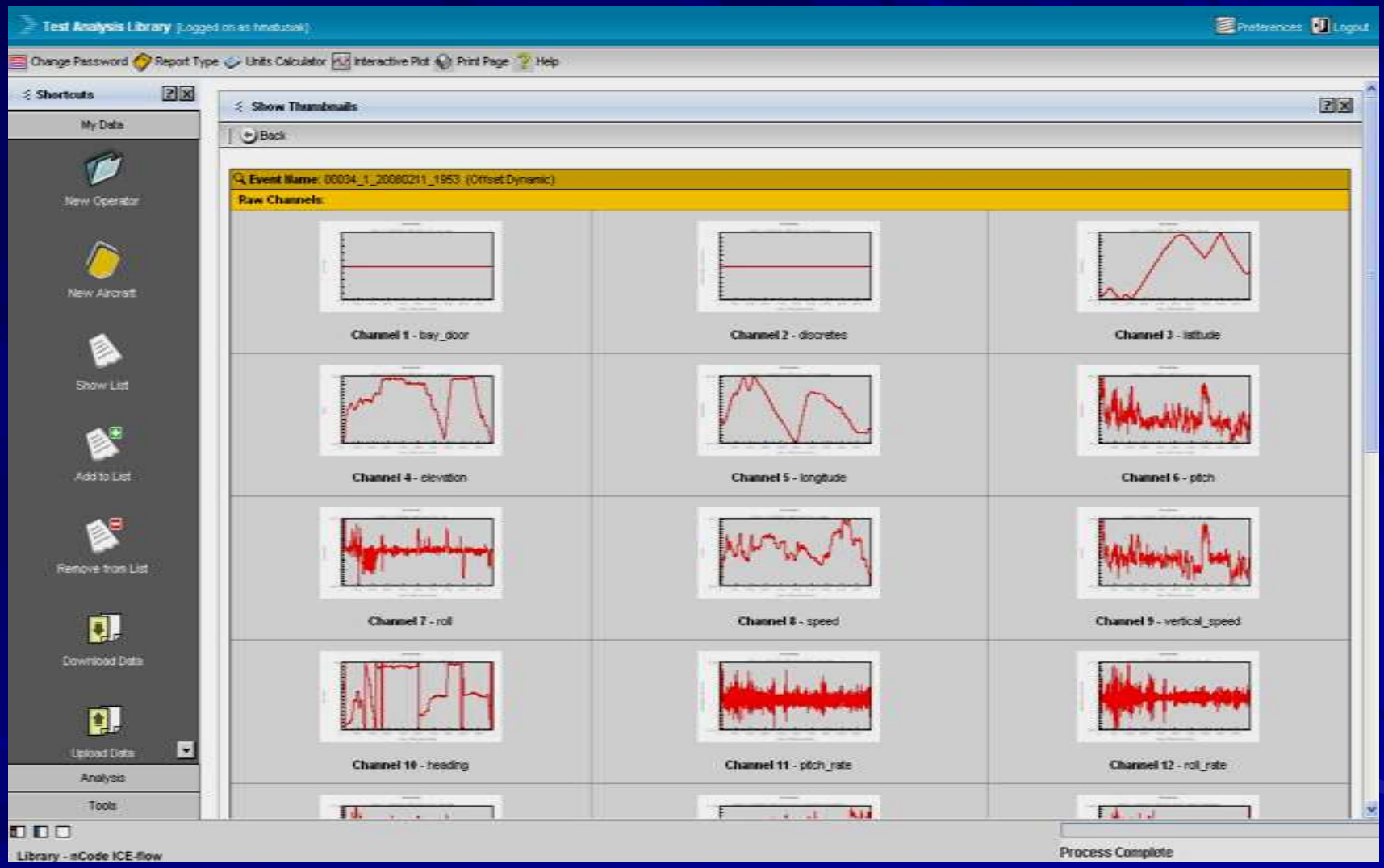


No.	Channel	ymin	ymax	yunits	mean	rms
1	Strain Gauge 1	-413.5	238.78	microstrain	-57.26	109.4
2	Strain Gauge 2	-418.01	-92.56	microstrain	-254.79	260.95
3	Strain Gauge 3	-467.68	535.6	microstrain	-38.22	144.74
4	Strain Gauge 4	-116.44	480.71	microstrain	161.11	199.82
5	Strain Gauge 5	-285.37	809.53	microstrain	324.9	421.07
6	Strain Gauge 6	-119.43	1024.12	microstrain	465.42	543.12
7	Strain Gauge 7	-98.53	968.29	microstrain	437	510.98
8	Strain Gauge 8	-209.66	1112.38	microstrain	556.98	664.68
9	Strain Gauge 9	-302.85	850.3	microstrain	324.74	394.81
10	Strain Gauge 10	-594.04	273.73	microstrain	-189.92	234.28
11	Strain Gauge 11	-1094.91	227.13	microstrain	-521.72	603.24
12	Strain Gauge 12	-361.09	978.43	microstrain	413.86	518.82
13	Roll Acceleration	-1.55	1.74	degs/sec/sec	-3.15E-2	0.11
14	Vertical Acceleration	0.55	1.91	g's	1.02	1.03
15	Fuel 1	795.16	5104.64	lbs	3250.42	3332.18
16	Fuel 2	647.35	4376.62	lbs	3089.96	3144.65
17	Fuel 3	549.56	2942.13	lbs	1836.4	1915.67
18	Fuel 4	1483.57	5286.11	lbs	3535.56	3600.81
19	Airspeed	-11.92	218.79	knots	120.74	140.31
20	Pressure Altitude	11.72	8368.86	feet	1884.41	2585.76
21	Flap Position	-8.64	103.25	degrees	59.71	69.89
22	Left Aileron Position	-18.54	20.06	degrees	1.68	3.25
23	Elevator Position	-20.47	16.66	degrees	-10.02	11.65
24	Float Position	-213.53	-198.13	gallons	-208.13	208.14
25	GPS Altitude	283.41	7827.99	feet	1831.84	2573.34
26	GPS Track	0	359	degrees	207.85	230.44
27	GPS Latitude	39.77	40.27	decimal degrees	39.9	39.9
28	GPS Longitude	-122.36	-121.8	decimal degrees	-121.97	121.97

Data Generated Thumbnails (SEI System)



Data Generated Thumbnails (Appareo System)



Timeline

- 2003 - 3 aircraft instrumented
- 2004 - An additional P2V is instrumented
- 2005
  - P2V systems are reconfigured to support Fatigue and Damage Tolerance evaluation being performed by Avenger Aircraft and Services
  - Contract awarded for Full OLM system and installation to Systems and Electronics Inc
  - Contract awarded for OLM Library Database to nCode International
- 2006
  - 2 additional P2V aircraft instrumented

Timeline

- 2007
  - APPAREO Systems awarded contract for “Light” OLM system and installation
  - 7 additional Light systems installed
    - 2 Additional P3 (Airtanker Profile)
    - 1 CALFIRE S2T (Airtanker Profile)
    - 1 Forest Service DC3TP4 (Smokejumper Profile)
    - 1 Forest Service Twin Otter (Smokejumper Profile)
    - 1 Forest Service King Air 90 (ASM Profile)
    - 1 Forest Service King Air 200 (IR Profile)

Timeline

- 2007
  - From lessons learned all systems are standardized
  - Parameters collected have been modified to limit the manually collected supplementary pilot data. These parameters are:
    - Time and date in Greenwich Mean Time (GMT)
    - Lat and Long (from GPS)
    - Heading (from GPS)
    - Altitude (from GPS)
    - Fuel Load (electronically recorded if possible)
    - Retardant Level (electronically recorded if possible)

Current Status

- 2008
  - 19 additional Light systems installed (7 in progress)
    - 6 P3 (Airtanker Profile)
    - 8 P2V (Airtanker Profile)
    - 1 Thrush 413 (Single Engine Airtanker)
    - 1 Bell 212 (*Helitack Mission Mix)
    - 1 DC3TP4 (Smokejumper Profile)
    - 1 Twin Otter (Smokejumper Profile)
    - 1 Aero Commander 500 (Air Attack Profile)
  - All large airtankers contracted to the Forest Service instrumented with OLM systems

Challenges / Achievements

- **Challenges:**
  - Data quality issues stemming from the integration of a digital data collection system on older aircraft.
  - No lull in fire activity
  - The system installations cost additional aircraft down time
- **Achievements:**
  - Over 2500 missions of flight data collected and matched with pilot supplementary data.
  - Collected data was used to complete Fatigue and Damage Tolerance assessment of P2V and P3A aircraft for the special purpose operation of Forest and Wildlife Conservation (Aerial Dispensing of Liquids) firefighting mission.

Conclusions

- The US Forest Service Operational Loads Monitoring Program and resultant byproducts have brought a new awareness of the impact firefighting has on aircraft performing these special missions.
- Data being collected is relevant to current usage and will have a positive effect as it is applied to establish proper inspections and corresponding intervals for firefighting aircraft. (Increased safety)
- The collection of operational loads data and its subsequent reduction and application in analysis is the key to the appropriate use of aircraft pressed into an additional or alternate usage that is beyond what the OEM originally intended.


Questions?