Honeywell Electronics

Enhanced Ground Proximity Warning System (EGPWS):

Flight History Data

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EGPWS Sr. Systems Engineer

Honeywell Aerospace

August 27, 2012

Honeywell

EGPWS Flight History Data

Honeywell

- **EGPWS Flight History Data was designed to:**
  - **Provide detailed data on EGPWS alerts**
    - to improve terrain database
    - to evaluate the performance of EGPWS algorithms in real-world operation
      - maximize CFIT protection
      - minimize nuisance alarms

- **EGPWS Flight History Data can:**
  - **Help provide data to investigate Incidents / Accidents**
    - Where FDRs do not exist on the aircraft or fail to function
      - EGPWS does not add much beyond what FDR provides
    - ***But, it wasn't designed for accident investigation purposes***

EGPWS Flight History Data - Limitations

Honeywell

- **EGPWS Flight History Data:**
  - **Does NOT record Date & Time**
    - EGPWS system time (hours:minutes:seconds) powered
    - Flight Leg (Leg 1 is most recent flight)
  - **Is NOT environmentally protected or crashworthy**
    - The EGPWS can be damaged beyond the ability to provide any data
  - **Does NOT provide a rapid data rate**
    - 1 sample per second
  - **Does NOT record data from all sources**
    - Typically only records source being used
    - This may not be the source being used by the pilot in command

EGPWS Units – Class A TAWS

Honeywell

- **MK V & MK VII**
  - **2 MCU (2.5”W x 8”H x 13”D)**
  - **Found in**
    - All Boeing
    - Most Airbus
    - Large and Medium business jets

- **MK VI & MK VIII & MK XXII**
  - **(3”W x 6”H x 10”D)**
  - **Found in**
    - Medium and Small business jets
    - Turboprops
    - IFR Helicopters

EGPWS Units – Class B TAWS

Honeywell

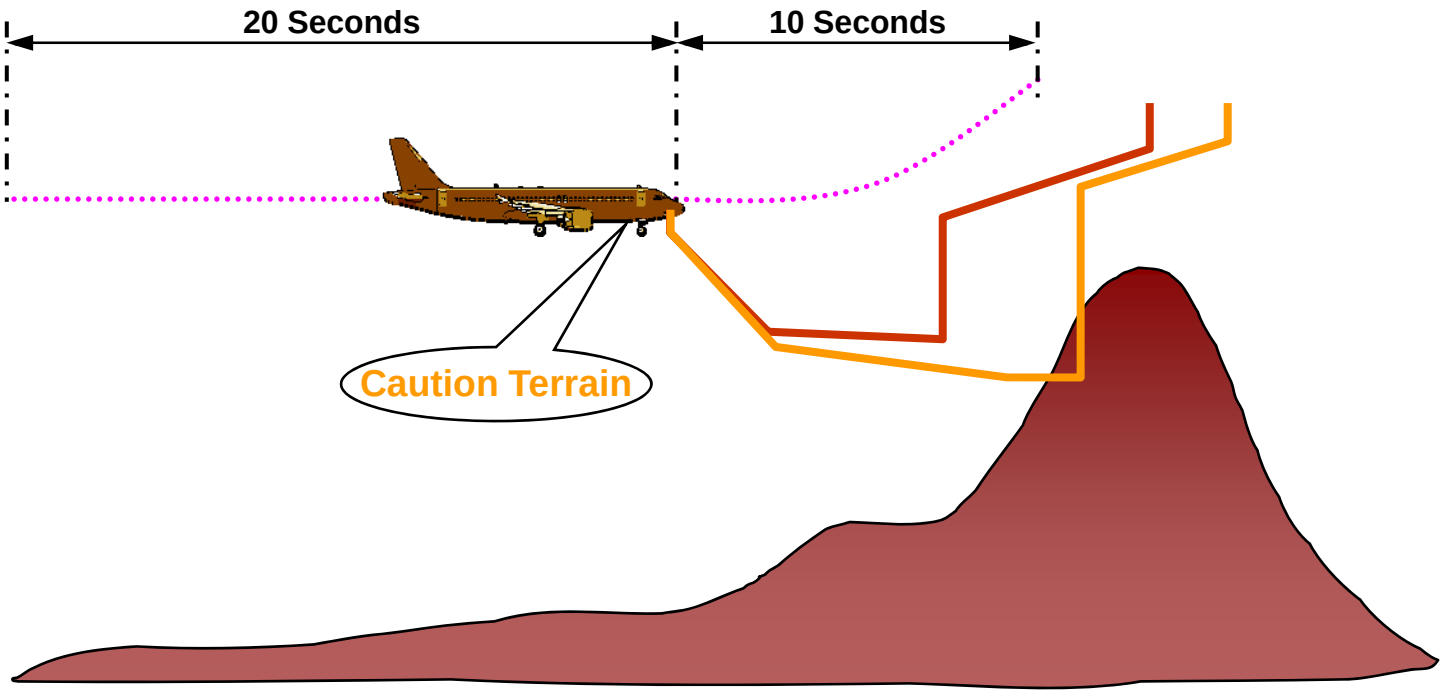
- **KGP560 & KGP860 & MK XXI**
  - **(2”W x 4”H x 6”D)**
  - **Found in**
    - Small business jets
    - Turboprops
    - VFR Helicopters

- **KMH820 & KMH920**
  - **4 MCU (4”W x 7”H x 13”D)**
  - **Earlier units are black**
  - **Found in**
    - Small business jets
    - Turboprops

EGPWS Flight History Data (Warning/Caution)

Honeywell

- **EGPWS records data 20 seconds before and 10 seconds after every EGPWS alert/warning**
  - Used to determine a cause of the alert/warning and pilot reaction



EGPWS Flight History Parameters

Honeywell

- **List of parameters recorded in EGPWS Warning Flight History Data**

Alert Type	Terrain Database Elevation
System Operating Time	GPS Satellites Visible
Corrected Altitude	GPS Satellites Tracked
Latitude	Pitch Angle
Longitude	Roll Angle
Position Source	Glideslope Deviation
Position Uncertainty(HFOM)	Localizer Deviation
Airspeed	Display Range #1
True Airspeed	Display Range #2
Ground Speed	Terrain Display Enabled #1
Minimum Operating Speed	Terrain Display Enabled #2
Barometric Altitude (Uncorrected)	Landing Gear Down
Geometric Altitude	Landing Flaps Selected
Geometric Altitude VFOM	Terrain Awareness & TCF Inhibit
GPS Altitude	Audio Inhibit
GPS VFOM	Body AOA
Radio Altitude	Longitudinal Acceleration
Altitude Rate	Normal Acceleration
Magnetic Track	Inertial Vertical Acceleration
True Track	Filtered Shear/Total Shear
True Heading	Static Air Temperature

Engine Torque Data #1
Engine Torque Data #2
Engine Torque Data #3
Tactical (Low Altitude) Select

Helicopter EGPWS Only

EGPWS Flight History Data

Honeywell

- Does not record what is not input
  - For example, no radio altitude on KGP or KMH Class B units
- Data that is invalid is noted as such
  - For example, glideslope deviation when not ILS tuned
- Data is recorded even when manually inhibited by pilot
- Data can be exported to Excel spreadsheet (.xls file)
  - Excel format facilitates graphing of data
- Data can be superimposed over maps/chart (KML)

Flight History Retrieval Process

Honeywell

- **Flight History information is stored in the EGPWS in a specific area of the non-volatile memory**
- **Data can be downloaded via PCMCIA or CF card**
  - **Card must be programmed with special instruction file**
  - **Process similar to terrain database upload, requires < 5 minutes**
  - **Cards available upon request from Honeywell Engineering**
  - **Data is encrypted**
- **Decoding of encrypted information is done by Honeywell using proprietary tools, tools are not distributed**
- **If unit is damaged:**
  - **Circuit boards can be placed in donor units or fixtures**
  - **Memory chips can be removed and data retrieved via chip reader**
    - Honeywell can accept data directly from chip reader
    - Occasionally memory chips are damaged and unreadable

Hawker 800 crash at Owatonna MN

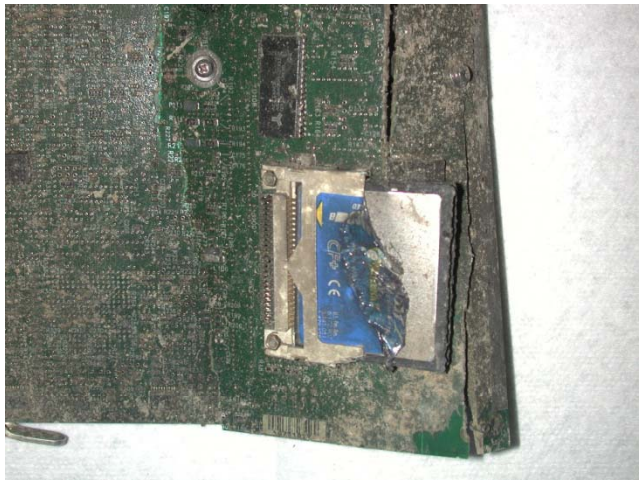
Honeywell

- **NTSB AAR-11/01, 31 July 2008, – 8 Fatal**
  - **CVR, no FDR and none required**
  - **Crashed while attempting late go-around on runway 30**
- **EGPWS issued Bank Angle alert**
  - **Aircraft rolled 90 degrees after becoming airborne off rwy end**
- **Flight History download performed at Honeywell**
  - **Unit functional post-accident**
  - **Memory contained 22 seconds of data**
    - 20 before Bank Angle alert
    - 2 after Bank Angle alert (then loss of power)
- **Data used to confirm:**
  - **Flaps down before landing**
  - **Flaps retracted after landing**
  - **Speed increase on runway**
  - **8 knot tailwind**

Cessna 560 crash at Pueblo, CO

Honeywell

- **NTSB AAR-07/02, 16 February 2005 – 8 fatal**
  - **CVR, no FDR and none required**
  - **Pueblo was a planned fuel stop on cross-country flight**
  - **Crashed 4 mi short of airport in freezing rain**
- **EGPWS issued Bank Angle alert**
  - **EGPWS destroyed in impact, fire**
  - **Circuit cards returned to Honeywell for possible analysis**
- **1 of 2 Flight History data chips broken, data irretrievable**
  - **Manual process used on surviving chip**
  - **30 seconds of partial data set recovered**
    - Altitude, descent rate
    - Pitch, roll
    - Ground speed, ground track angle
  - **Data correlated to radar data**



Honeywell Electronics

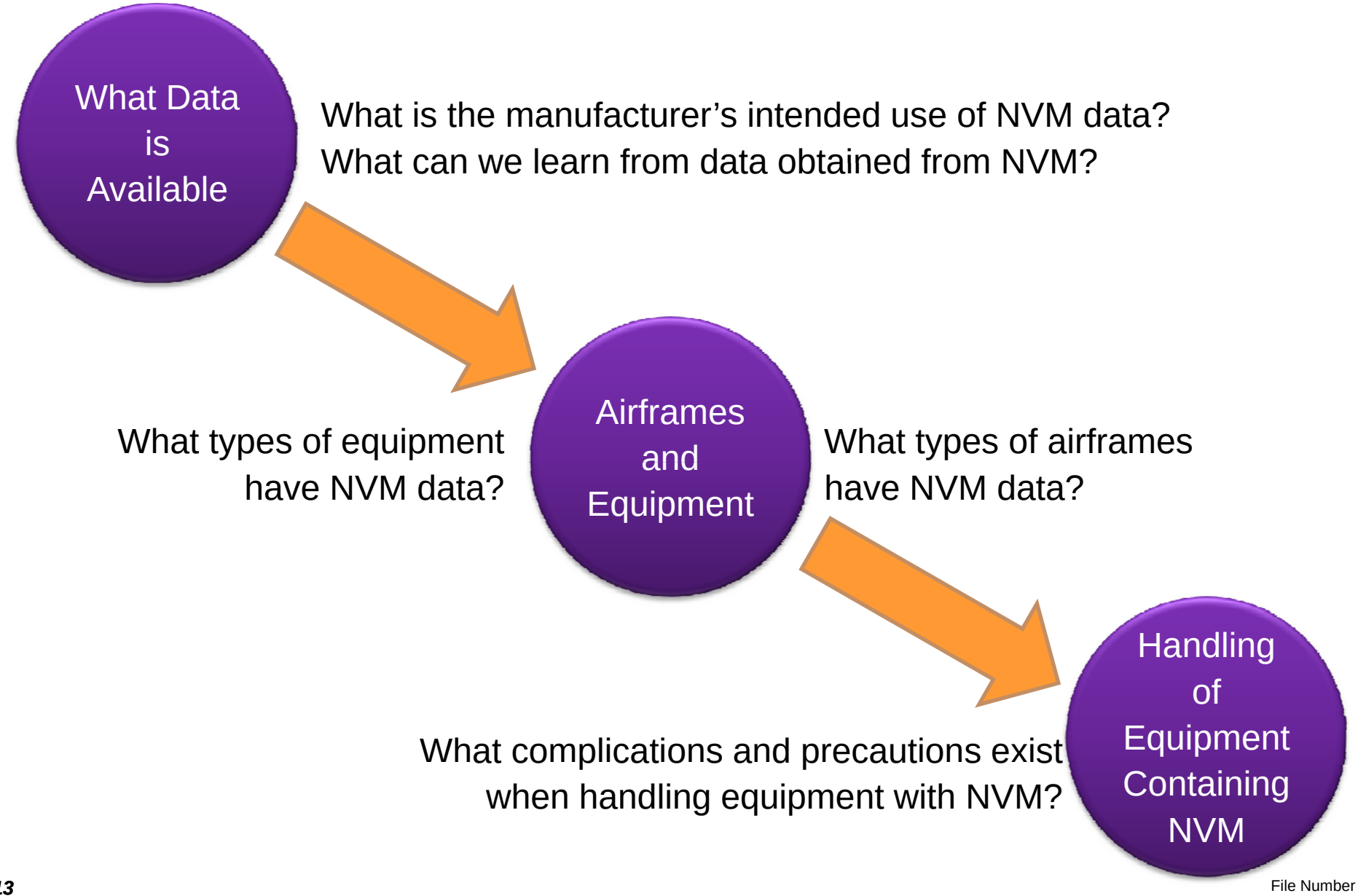
Non-Volatile Memory (NVM):
An Increasing Aide in Investigations

Jay Eller
Air Safety Investigator
Honeywell Aerospace

August 27, 2012

Honeywell

Agenda


What Data is Available
What is the manufacturer's intended use of NVM data?
What can we learn from data obtained from NVM?
Airframes and Equipment
What types of equipment have NVM data?
What types of airframes have NVM data?
Handling of Equipment Containing NVM
What complications and precautions exist when handling equipment with NVM?

Intended Uses of NVM in Electronics

Honeywell
PRODUCT INTEGRITY

- **Maintenance/Tracking**
  - Logging of failures which require maintenance at next interval.
  - Logging of exceedances or failures which may require immediate attention.
  - Tracking of fleet such as EMS and Fire Fighting.
- **Trend analysis**
  - Engine performance over a period of time.
  - Aircraft performance over a period of time.
  - Could be specific to an altitude, temperature, or other operational condition.
- **Trouble Shooting**
  - Capturing detailed data when a particular event has occurred.
  - Event could be pilot initiated (press of a button) or a predetermined scenario.

All Could be Beneficial in Accident Investigation

Various Levels of Data Available

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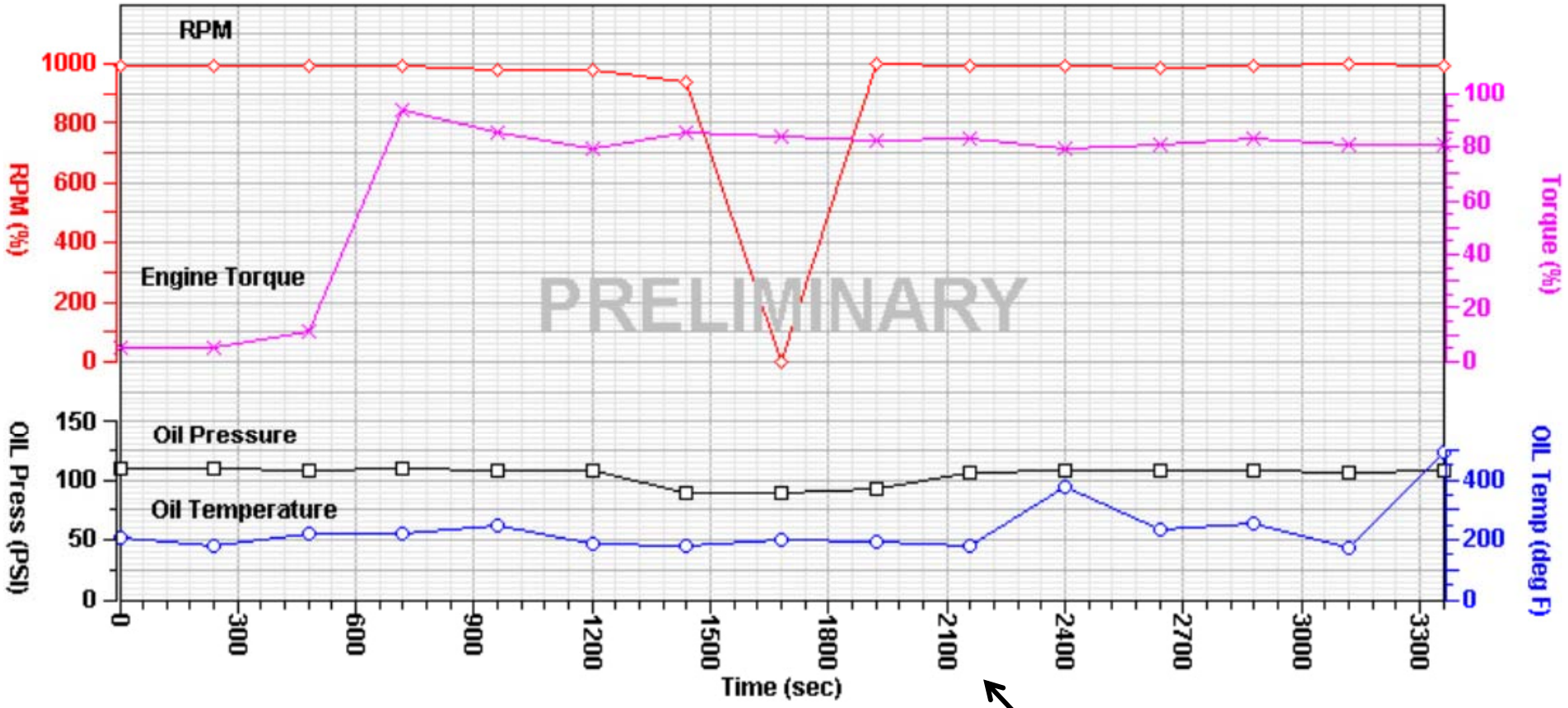
PRODUCT INTEGRITY

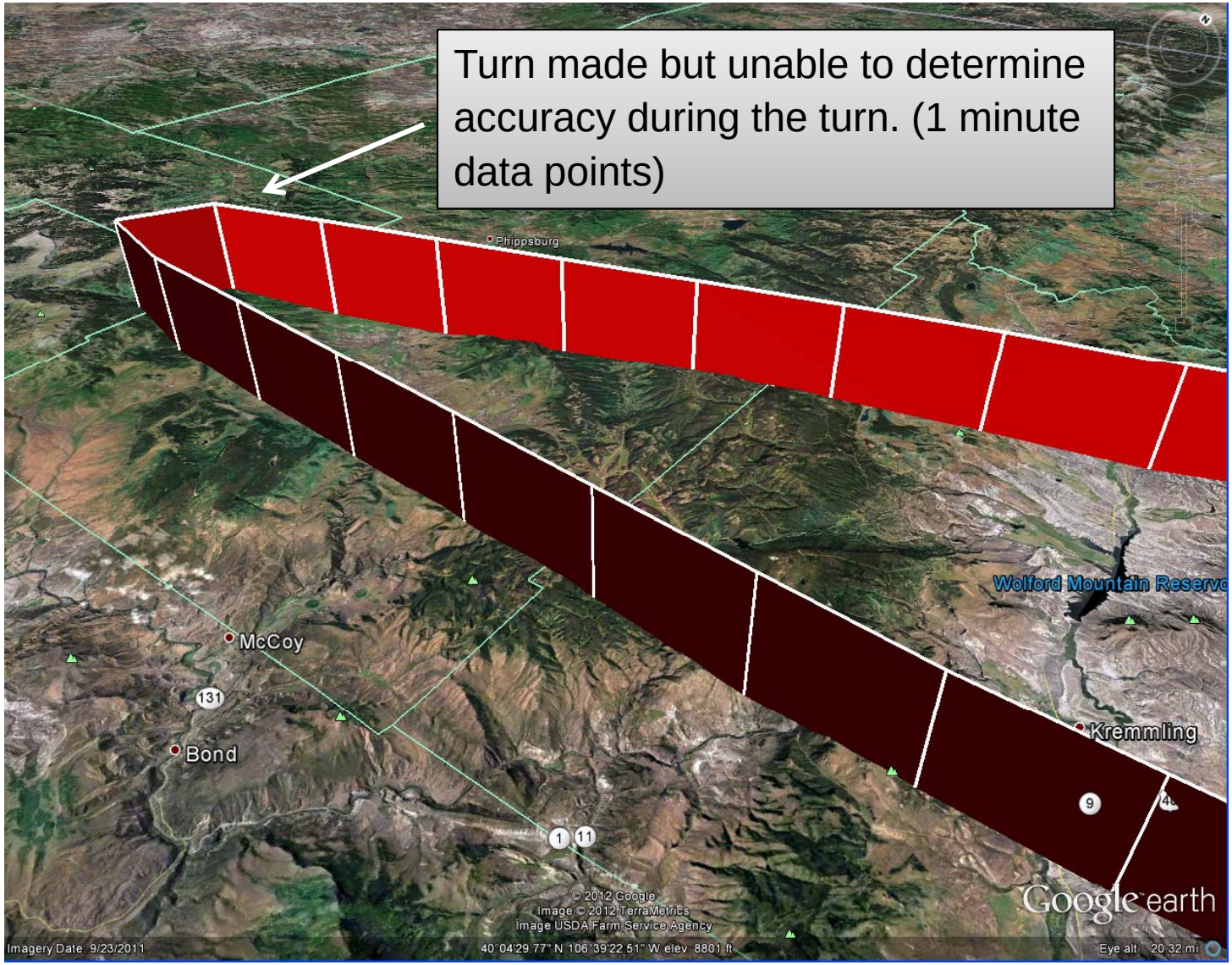
- **Low Fidelity Data:**
  - Slow sample rates (greater than 1 sample per minute)
  - Minimal data precision (ie: Latitude, Longitude, altitude, etc)
  - Would show long term trending with little inability to show immediate behaviors/signatures.
- **Medium Fidelity Data:**
  - Medium sample rates from 1/sec to 1/minute
  - Moderate data precision.
  - Would show medium range trending with minimal ability to show immediate behaviors/signatures
- **High Fidelity Data:**
  - High frequency rate of data capture (1Hz or faster)
  - High data precision.
  - Good indication of immediate behaviors and performance just prior to the accident.

Example of Low Fidelity Data

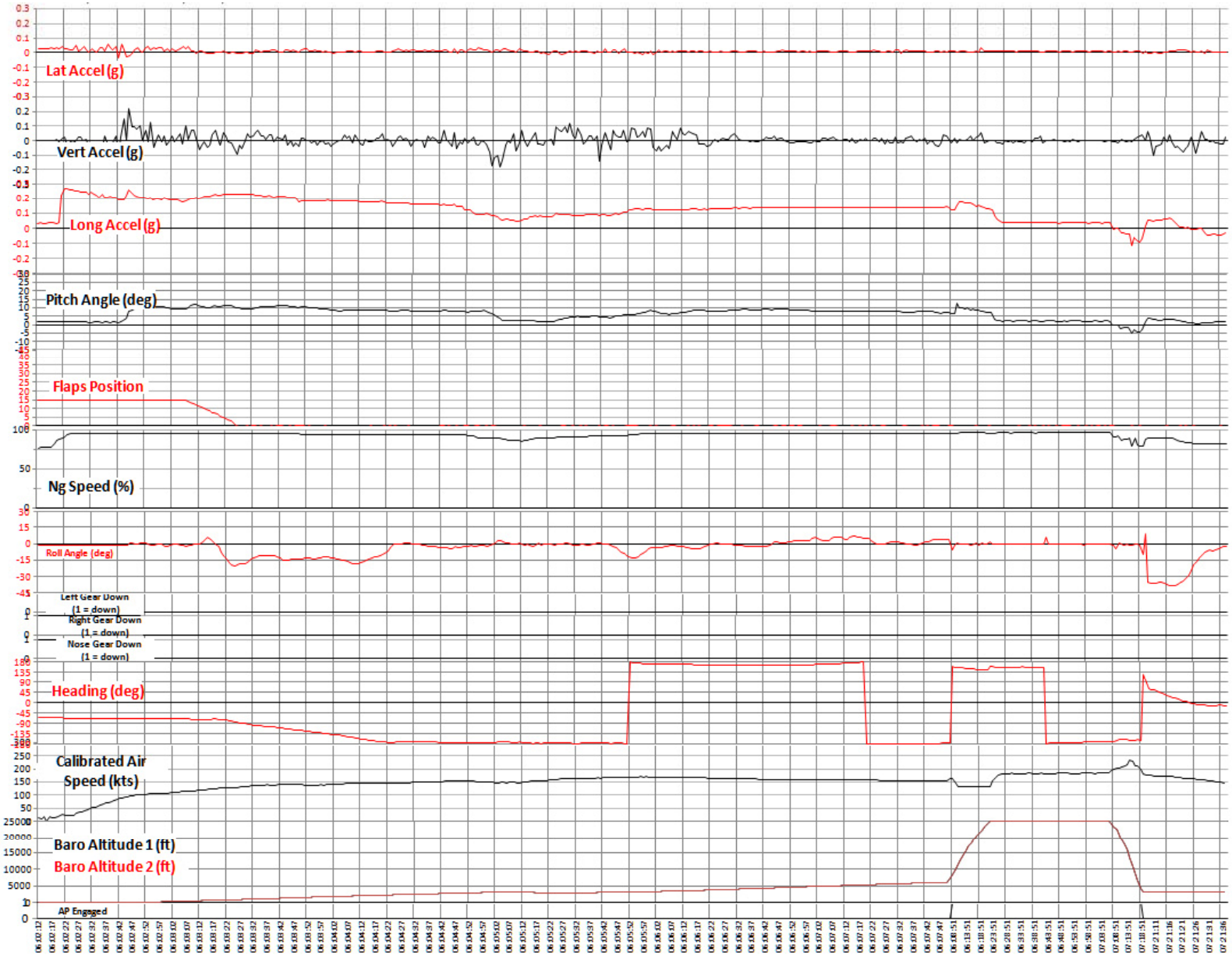


Data points are on 4 minute increments.

Example of Medium Fidelity Data

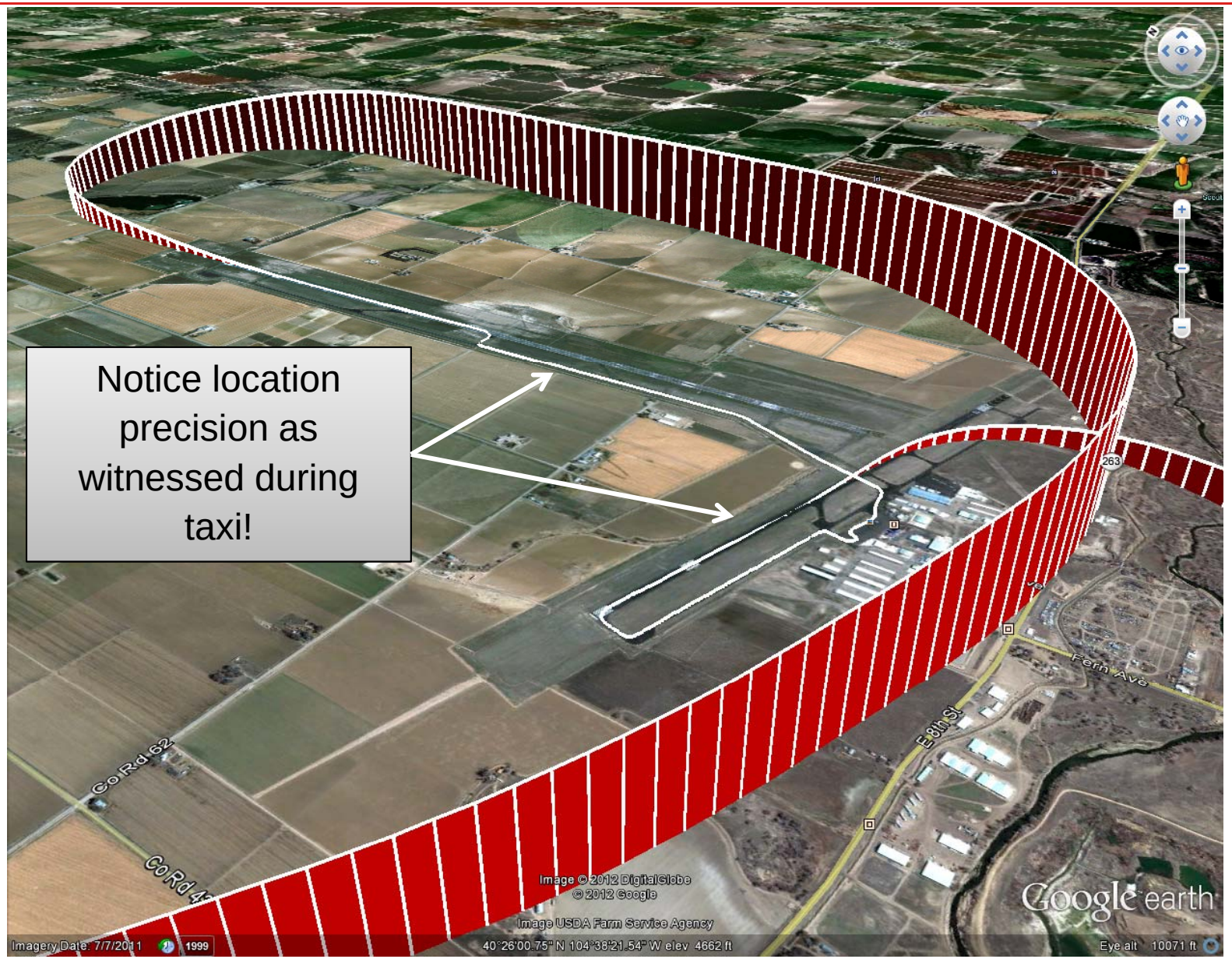


Example of High Fidelity Data (1Hz Rate)

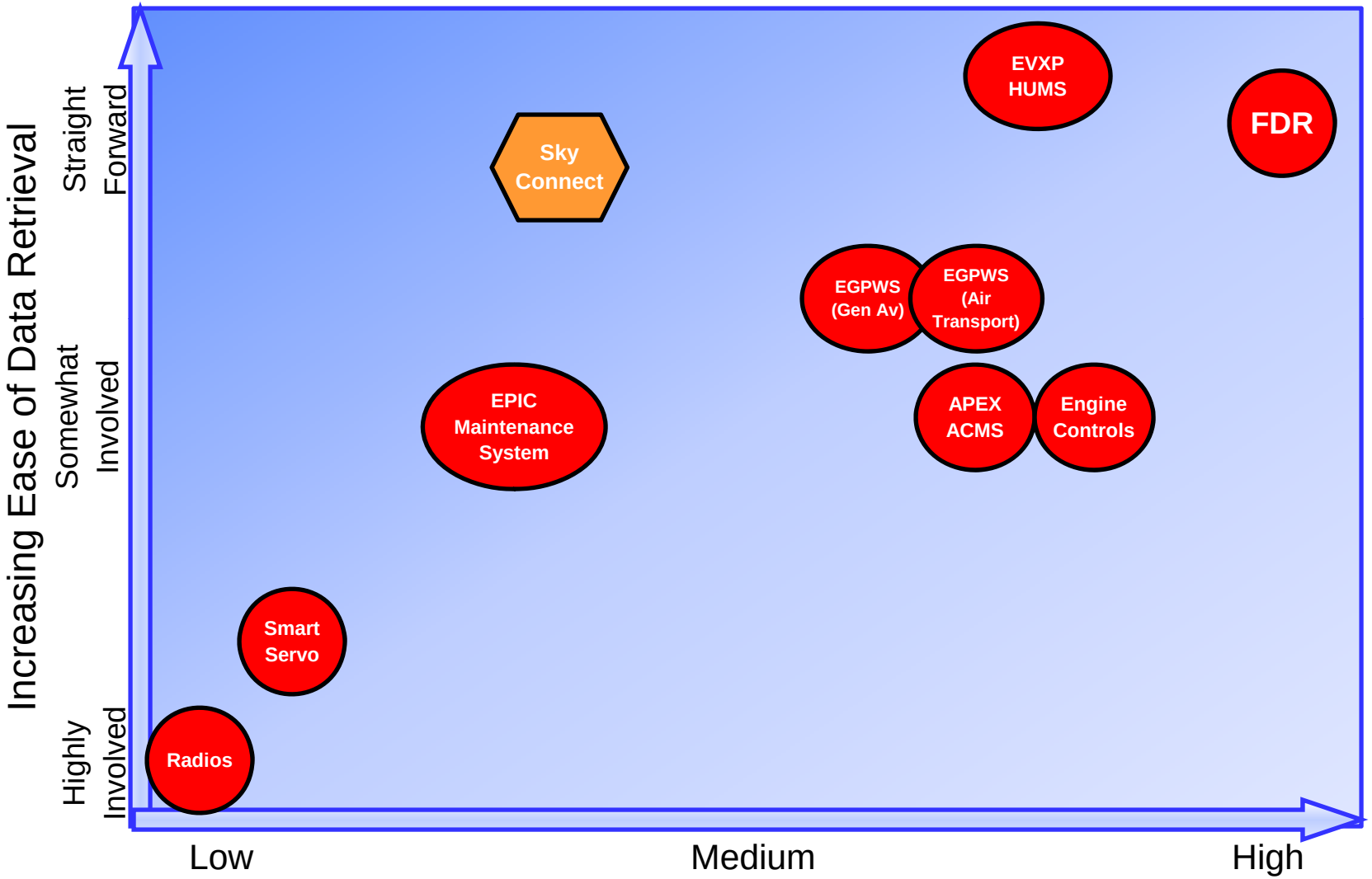


File Number

Example of High Fidelity Data (1Hz Rate)



Types of Equipment and Data Fidelity



ACMS = Aircraft Condition Monitoring System
HUMS = Health and Usage Monitoring System

Aircraft With Primus APEX

High, Medium, and Low Fidelity Data

Pilatus PC-12 NG

Viking Air

Twin Otter 400

Aircraft With HUMS

Sikorsky S76C++

High, Medium, and Low Fidelity Data

HUMS = Health and Usage Monitoring System

Agusta A109E

Aircraft with Primus EPIC (Medium and Low Fidelity)

Honeywell
PRODUCT INTEGRITY

File Number

Examples of Aircraft With Sky Connect

EMS Helo Fleet

Charter Fleet

Medium and Low Fidelity Data

Fire and Rescue

Agriculture Fleet

Note: Aircraft models shown may not represent actual models containing Sky Connect

Preservation & Recovery of Non-Volatile Memory (NVM) Evidence

General Precautions

- Assume that the electronic component is subject to electrostatic discharge (ESD) damage.
  - Do not attempt to handle any electronic components using leather gloves.
- Before cutting wires to components, insure component does not have holdup RAM requiring power to maintain.
- If the component is dry, keep it dry.
  - Ship it “as is” to the component supplier or investigation lab.
  - Do not attempt to scrub, brush, or otherwise mechanically remove dirt and debris from electronic components.
- If the component is wet, keep it wet.
  - If the electronic component is wet with mud or other material, treat it the same as a water-soaked board from a water crash site. Flush it with water and ship it in water.
- Do not use any chemicals, such as bleach, to clean the component.
  - This is critical for components with biohazard contamination.
- Attempt to identify the types of electronics that the investigation team will focus on prior to going on-scene.
  - Establish a priority listing for non-volatile memory

Be prepared to handle electronic devices prior to arriving at the accident site.

If an accident has occurred in fresh or salt water…

- **Recovered electronic components should be placed in a container filled with 2 MOhm de-ionized water.**
  - **Bottled drinking water is acceptable, provided the water has been produced using a reverse osmosis (RO) process, as opposed to bottled spring water.**
  - **Do not use tap water, distilled water or medical grade 10 MOhm water.**
- **If de-ionized or RO water is not available at the accident site, clean and ship the component in the water it was found in – salt or fresh.**
  - **Never try to transfer a component to another medium (such as air).**
  - **Never remove components from water and allow to "air dry", or attempt to use uncontrolled heating devices to dry the components.**

Use de-ionized or RO water, NOT tap or distilled water

General Packing and Shipping Guidelines

- **Use hard plastic shipping containers when possible – avoid Styrofoam.**
- **Wrap electronic components with a layer of electrostatic safe material, such as “pink poly” (named for its color) or other ESD approved product.**
- **Use packing materials that will not react with the contents or deteriorate while packed. ESD-safe bubble wrap, or empty plastic containers inserted between the shipped items and the sides of the container, is appropriate.**
  - **Do not use Styrofoam “peanuts” or other similar packing materials.**
- **Ship wet accident site components in a manner that preserves the integrity of the water-filled packing container.**

Use a hard plastic container and ESD safe packing materials.

In Closing…

- **Monitoring Systems and NVM Data – What it is… and is not.**
  - **It is a tool for investigators to use**
  - **It is not a flight data recorder**

- **Plus's and Minus's**

Large volume of available data	→	**Not crashworthy**
High G-load tolerant plastic NVM	→	**Not fire tolerant**
Fire tolerant ceramic NVM	→	**Not G-load tolerant**
Easy to read data format (Excel)	→	**Only downloadable by OEM**

- **Limited Availability**
  - **Aircraft equipped with Apex or EPIC.**
  - **Helicopters equipped with HUMS functionality.**
  - **Installations with Sky Connect.**
  - **Installation can vary from S/N to S/N on same platform depending on options installed.**

Honeywell Digital Engine Controls Incident Recorder

Applicability to Accident Investigation

Jim Allen
Manager of Accident Investigation
Honeywell Aerospace

August 27, 2012

Honeywell

Agenda

Honeywell

- Introduction
- Applications
- Use of Engine Control Data in Accident Investigation
- Post Accident Precautions
- Honeywell Support in Investigations
- Questions

Turbofan Engine Digital Control System

Honeywell

- **Honeywell Turbofan Engines utilize Digital Control with Engine Condition Trend Monitoring (ECTM)**
  - **Two generations of controls**
    - Generation One, Digital Electronic Engine Controls (DEEC)
      - TFE731-2/3/4/5 (New Production and Retrofit of older units)
      - TFE731-20/40/50/60 (All from Production)
    - Generation Two, Full Authority Digital Electronic Control (FADEC)
      - HTF7000 series
- **ECTM data is divided into three broad catagories.**
  - **Engine Statistics**
  - **Engine Maintenance/Troubleshooting**
  - **Operational Information**
- **In addition, both generations have Incident Recorders incorporated.**

Examples of Data available via ECTM

Honeywell

- **Engine Statistics**
  - Engine & Computer Information – Model, Part, and Serial Number
  - Performance Trending
  - Life Cycle Data – Engine Times, Cycle Counting, Landings, etc.

- **Engine Troubleshooting & Maintenance**
  - Engine & Computer Data – Engine Exceedances, Computer Faults
  - Event Data – Auto capture of in-flight events

- **Operational Information**
  - Engine Speed & Thrust Reverser Cycles
  - Interturbine Temperature Trends and Cycles
  - Power Lever Angle (PLA) Usage Profile
  - Flight Chronology

TFE731 DEEC – Generation One (Gen 1)

Honeywell

TFE731-2/3/4/5 N1 DEEC
(Retrofit)
- Fuselage mounted -

TFE731-20/40/50/60 DEEC
(Production)
- Engine mounted*-

TFE731-50 DEEC in Hawker 900XP is fuselage mounted

Gen 1 Incident Recorder Design Parameters

Honeywell

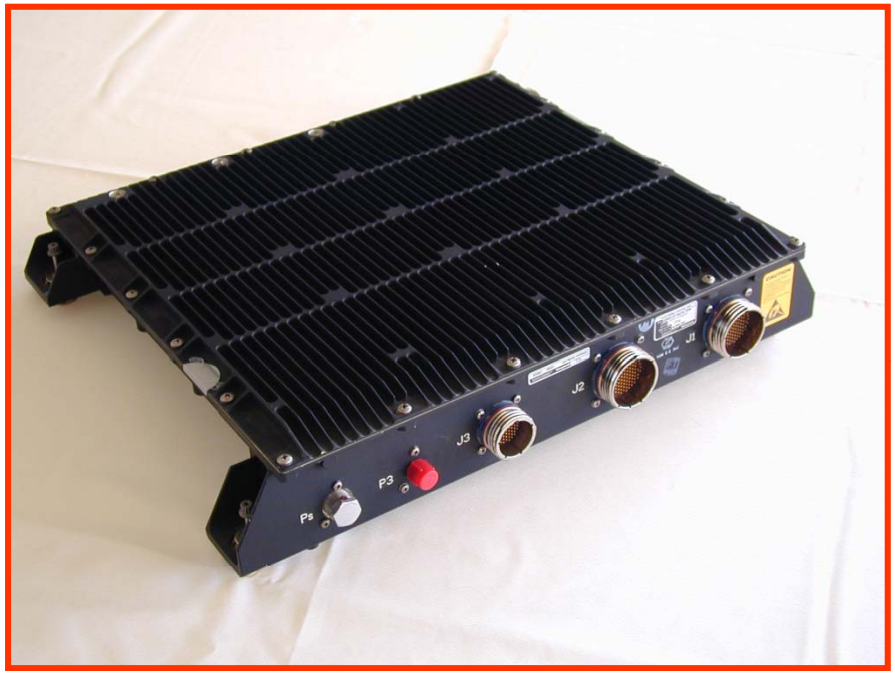
- **Design Features**
  - Records nine engine and aircraft parameters.
  - Records basic engine and aircraft information for approximately the last 1 1/2 hours of engine operation.
  - Begins recording when the start initiates.
  - Stops recording after engine shutdown or 5 minutes after Weight on Wheels (WOW) is true (On ground).

- **Data is collected in "Buckets" to indicate parameter range**
  - i.e. The N1 speed was between 75 and 80% maximum speed.
  - This allowed data to fit into available memory.
  - Medium to High Fidelity data.

- **Data Resolution**
  - Data is collected at increasing intervals from the end of the data stream starting at one second intervals.
  - This allowed for the most recent data to have the highest fidelity while maximizing the data stream available for download.

HTF7000 Family – Generation Two (Gen 2)

Honeywell



HTF7000 FADEC
(Engine mounted, 2 units per engine)

Gen 2 Incident Recorder Design Parameters

Honeywell

- **Design Features**
  - Records 36 engine and aircraft parameters.
  - Records enhanced engine and aircraft information for the last 60 minutes of operation.
  - Begins recording when the start initiates.
  - Stops recording after engine shutdown or 5 minutes after WOW is true (On ground).

- **Data is collected as discrete values.**
  - I.E., N1 speed was 75.7% of maximum speed; Altitude was 21,316 feet.
  - Aircraft Latitude and Longitude are stored parameters.

- **Data Resolution**
  - Data is collected at increasing intervals from the end of the data stream starting at 100 millisecond intervals.

TFE731 Applications – Gen 1 Civil DEEC (Retrofit)

Honeywell

Cessna Citation III/VI/VII

North American
Rockwell Sabreliner 65

Raytheon Hawker HS1-731;
125-400-731/600-731/700/800/800XP

Dassault Falcon 10/100

Dassault Falcon 20-5/200

Dassault Falcon 50 / 50-4

Dassault Falcon 900

Gulfstream G100
(Astra 1125)

IAI Westwind 1124
/1124A

Lockheed Jetstar / Jetstar
II

Learjet M35 / M35A / M36

Learjet M31

Learjet M55

TFE731 Applications – Gen 1 Military DEEC (Retrofit & Production)

Honeywell

CASA 101AA / BB / CC “Aviojet”

Tzu Chiang”

FMA IA 63 “Pampa”

Hongdu (Nanchang) Aviation Industry Corporation
K8 “Karakorum”
(Production)

TFE731 Applications – Gen 1 Civil DEEC (Production)

Honeywell

Dassault Falcon 50EX

Dassault Falcon 900EX / 900DX

Hawker 900XP

Gulfstream 100
(Astra SPX)

Gulfstream G150

Learjet M40

Learjet M45

HTF7000 Family Turbofan Applications – Gen 2 Civil FADEC (Production)

Honeywell

Bombardier Challenger CL 300

Gulfstream 280

Embraer Legacy 450 and 500

Use of Incident Recorder Data in Accident Investigation

Honeywell

- These are NOT Flight Data Recorders but,
  - The data can be very helpful in backing up FDR and CVR data.
  - Can be especially helpful if FDR data is not recoverable, wasn't working, or the aircraft wasn't equipped with one.
- Units are not hardened and designed for impact and fire protection like an FDR or CVR.
- Units are installed on some aircraft not required to have an FDR.
- Does not record Date & Time.
  - Data is presented based on time from the end of the data (i.e. impact or loss of power to the DEEC or FADEC)

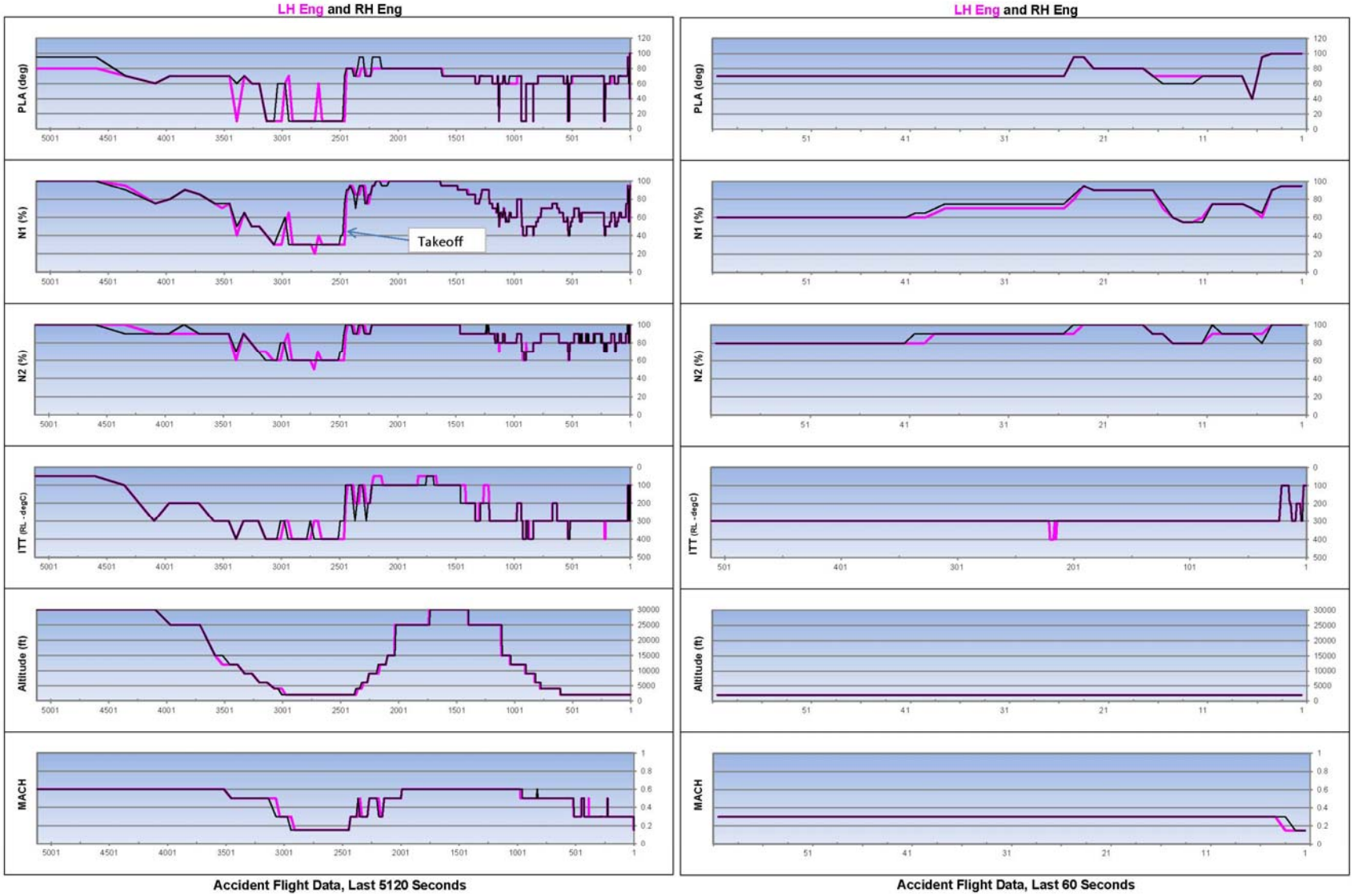
Generation 1 DEEC Plotted Data

Honeywell

Sec	N1		N2		ITT		WOW		Mach		PLA		Altitude		T/R		Comp Mode	
	74675	74266	74675	74266	74675	74266	74675	74266	74675	74266	74675	74266	74675	74266	74675	74266	74675	74266
1	90%-95%	90%-95%	90%-101.5%	90%-101.5%	(mx-200)-(mx-100)	(mx-200)-(mx-100)	ground	ground	< .15	< .15	> tko	> tko	< 2000	< 2000	deployed	deployed	AM abs(n1error)<100	n1error < -100
2	90%-95%	90%-95%	90%-101.5%	90%-101.5%	(mx-200)-(mx-100)	(mx-200)-(mx-100)	ground	ground	< .15	< .15	> tko	> tko	< 2000	< 2000	deployed	deployed	AM abs(n1error)<100	AM abs(n1error)<100
3	90%-95%	90%-95%	90%-101.5%	90%-101.5%	(mx-200)-(mx-100)	(mx-200)-(mx-100)	ground	ground	< .15	.15 - .3	> tko	> tko	< 2000	< 2000	deployed	deployed	AM abs(n1error)<100	AM abs(n1error)<100
4	85%-90%	85%-90%	90%-101.5%	90%-101.5%	(mx-300)-(mx-200)	400-(mx-300)	air	air	.15 - .3	.15 - .3	> tko	> tko	< 2000	< 2000	stowed	stowed	n1error > 100	n1error > 100
5	55%-60%	60%-65%	80%-90%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	mx clm-tko	mx clm-tko	< 2000	< 2000	stowed	stowed	n1error > 100	n1error > 100
6	65%-70%	65%-70%	80%-90%	80%-90%	(mx-300)-(mx-200)	(mx-300)-(mx-200)	air	air	.15 - .3	.15 - .3	idle-40	idle-40	< 2000	< 2000	stowed	stowed	n1error < -100	n1error < -100
7	70%-75%	70%-75%	80%-90%	80%-90%	(mx-300)-(mx-200)	(mx-300)-(mx-200)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
8	70%-75%	70%-75%	80%-90%	80%-90%	(mx-300)-(mx-200)	(mx-300)-(mx-200)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
9	70%-75%	70%-75%	80%-90%	80%-90%	(mx-300)-(mx-200)	(mx-300)-(mx-200)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	n1error < -100
10	70%-75%	70%-75%	80%-90%	90%-101.5%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	n1error < -100	AM abs(n1error)<100
11	55%-60%	50%-55%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	n1error > 100	n1error > 100
12	50%-55%	50%-55%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	40-60	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
13	50%-55%	50%-55%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	40-60	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
14	55%-60%	55%-60%	70%-80%	70%-80%	(mx-300)-(mx-200)	(mx-300)-(mx-200)	air	air	.15 - .3	.15 - .3	60-mx cru	40-60	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	n1error < -100
15	65%-70%	70%-75%	80%-90%	80%-90%	(mx-300)-(mx-200)	(mx-300)-(mx-200)	air	air	.15 - .3	.15 - .3	60-mx cru	40-60	< 2000	< 2000	stowed	stowed	n1error < -100	n1error < -100
16	85%-90%	85%-90%	80%-90%	80%-90%	(mx-200)-(mx-100)	(mx-200)-(mx-100)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	n1error < -100	n1error < -100
17	85%-90%	85%-90%	90%-101.5%	90%-101.5%	(mx-200)-(mx-100)	(mx-200)-(mx-100)	air	air	.15 - .3	.15 - .3	mx cru-mx clm	mx cru-mx clm	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
18	85%-90%	85%-90%	90%-101.5%	90%-101.5%	(mx-200)-(mx-100)	(mx-200)-(mx-100)	air	air	.15 - .3	.15 - .3	mx cru-mx clm	mx cru-mx clm	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
19	85%-90%	85%-90%	90%-101.5%	90%-101.5%	(mx-200)-(mx-100)	(mx-200)-(mx-100)	air	air	.15 - .3	.15 - .3	mx cru-mx clm	mx cru-mx clm	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
20	85%-90%	85%-90%	90%-101.5%	90%-101.5%	(mx-200)-(mx-100)	(mx-200)-(mx-100)	air	air	.15 - .3	.15 - .3	mx cru-mx clm	mx cru-mx clm	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
21	85%-90%	85%-90%	90%-101.5%	90%-101.5%	(mx-200)-(mx-100)	(mx-200)-(mx-100)	air	air	.15 - .3	.15 - .3	mx cru-mx clm	mx cru-mx clm	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
22	85%-90%	85%-90%	90%-101.5%	90%-101.5%	(mx-200)-(mx-100)	(mx-200)-(mx-100)	air	air	.15 - .3	.15 - .3	mx cru-mx clm	mx cru-mx clm	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	n1error > 100
23	90%-95%	90%-95%	90%-101.5%	90%-101.5%	(mx-300)-(mx-200)	(mx-300)-(mx-200)	air	air	.15 - .3	.15 - .3	mx clm-tko	mx clm-tko	< 2000	< 2000	stowed	stowed	n1error < -100	AM abs(n1error)<100
24	75%-80%	80%-85%	80%-90%	90%-101.5%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	mx clm-tko	mx clm-tko	< 2000	< 2000	stowed	stowed	n1error > 100	n1error > 100
25	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
26	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
27	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
28	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
29	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
30	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
31	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
32	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
33	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
34	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
35	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
36	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
37	65%-70%	70%-75%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	n1error < -100	n1error < -100
38	60%-65%	65%-70%	80%-90%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	n1error > 100	n1error > 100
39	55%-60%	60%-65%	70%-80%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	n1error < -100
40	55%-60%	60%-65%	70%-80%	80%-90%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	n1error < -100
41	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	n1error > 100	n1error > 100
42	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
43	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
44	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
45	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
46	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
47	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
48	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
49	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
50	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
51	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
52	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
53	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
54	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
55	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
56	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
57	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
58	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
59	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100
60	55%-60%	55%-60%	70%-80%	70%-80%	400-(mx-300)	400-(mx-300)	air	air	.15 - .3	.15 - .3	60-mx cru	60-mx cru	< 2000	< 2000	stowed	stowed	AM abs(n1error)<100	AM abs(n1error)<100

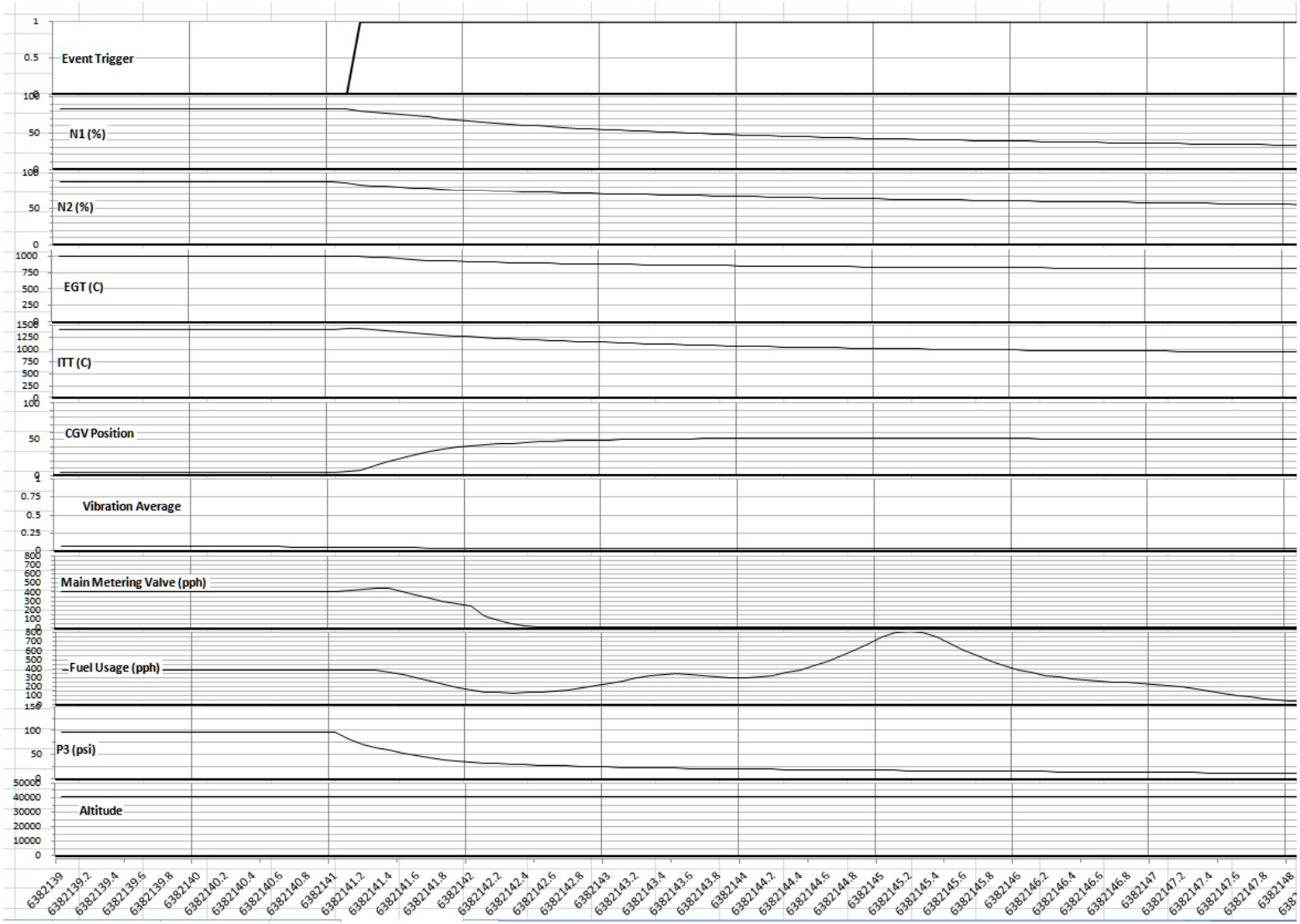
Generation 1 DEEC Plotted Data

Honeywell



Generation 2 FADEC Plotted Data

Honeywell



Post Accident Precautions

Honeywell

- **If the DEEC or FADEC appears intact:**
  - **Do not attempt to power up the units.**
  - **Do not attempt to download the data with process used by operator and field service personnel.**
    - This process automatically erases the data from the units as part of the download.
- **If units are damaged, collect parts potentially from the units and return.**
  - **Especially loose integrated circuit chips.**
- **Follow General Precautions previously discussed.**
    - Electrostatic precautions
      - No leather gloves when handling.
    - If wet, keep wet, if dry, keep dry.
    - No chemicals for cleaning.
    - Use appropriate shipping procedures.

Do Not Attempt to power up the DEEC or FADEC after an accident has occurred

Post Accident Precautions (continued)

Honeywell

- Use care when cutting wires and removing harness
- If possible, don't allow any electronic debris to freeze.
- Do not flex or straighten a bent, broken or damaged circuit card.
- Avoid exposure to magnetic fields such as large motors, large magnets or shipboard radar.

Attempt to identify the types of electronics that the investigation will focus on prior to going to the accident site.

Honeywell Support for Downloading and Analysis

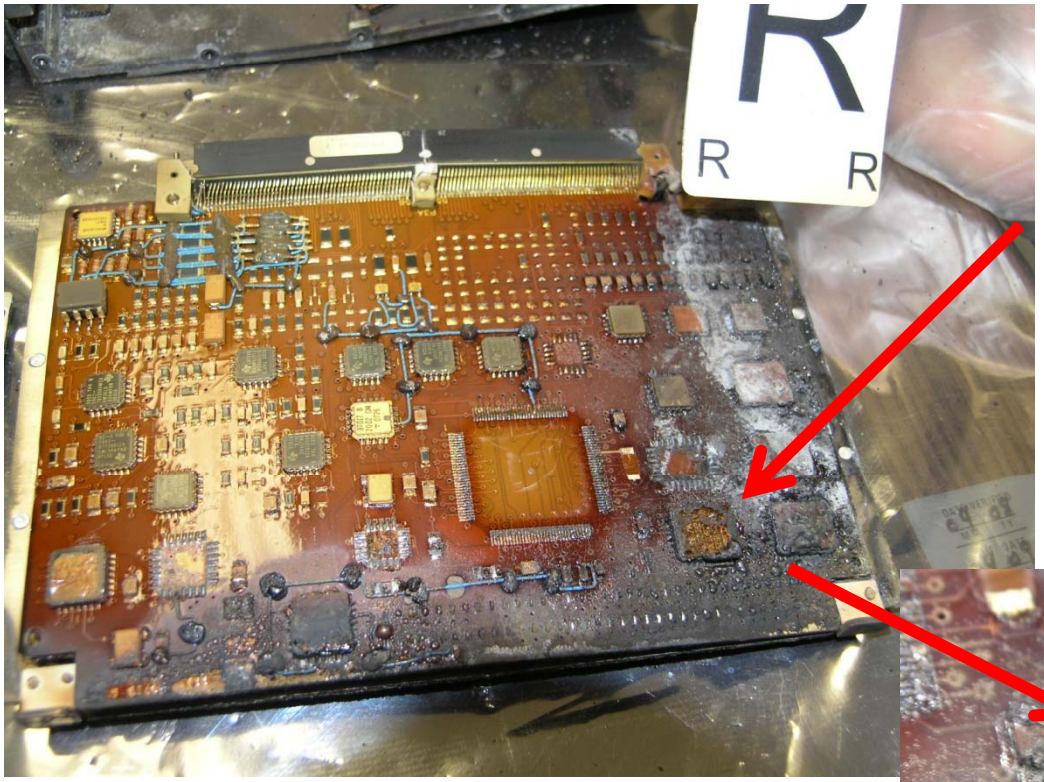
Honeywell

- **Honeywell is best equipped to handle and download the data from our engine DEEC's and FADEC's after an accident or incident.**
  - **Have appropriate equipment and trained personnel to properly analyze and prepare units for downloading.**
  - **Access to Engineering expertise to deal with challenges due to damage from impact and fire, etc.**
  - **Experienced in dealing with chip level recovery and use of slave units for downloading.**
  - **Experienced in analysis of the downloaded data with tools prepared for quick analysis**
- **Units shipped separately or with accident/incident engines will be bonded, unopened until appropriate party members are in attendance.**

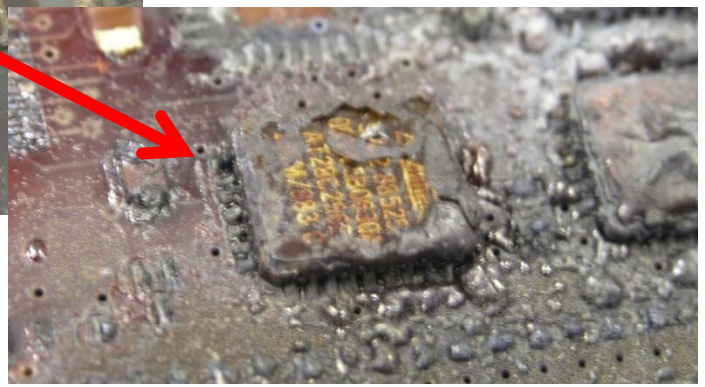
Example of Challenging Download

Honeywell

- **Engine mounted TFE731 DEEC was severely heat and impact damaged during the accident sequence.**



- **Incident Recorder chip was cleaned, removed, and copied.**
- **The chip copy was then installed in a slave unit and successfully downloaded.**



Accident Contact Information

Honeywell

- **For assistance with any Honeywell Aerospace products involved in an Accident or Incident, Contact:**

Jim Allen

Manager of Accident Investigation

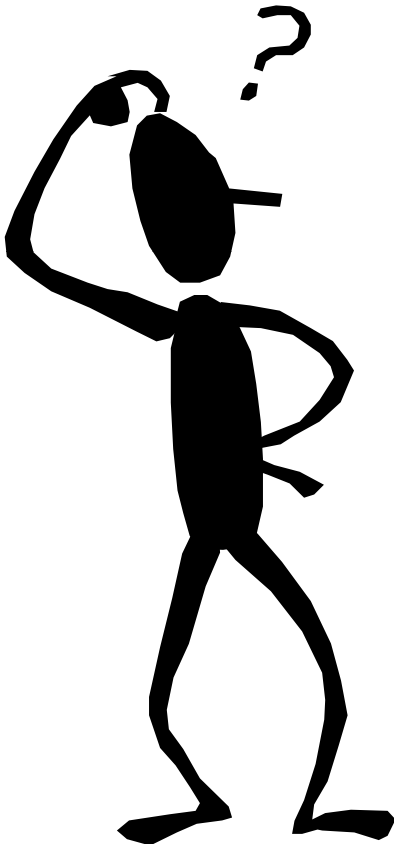
Honeywell Product Integrity

1944 E Sky Harbor Circle

Phoenix, Arizona 85234

Phone 602-365-5672

24 hour Accident Hot Line, 1-602-365-2423



Questions?