
Vibroacoustic Launch Analysis using VISPERS: Overview and Demonstration

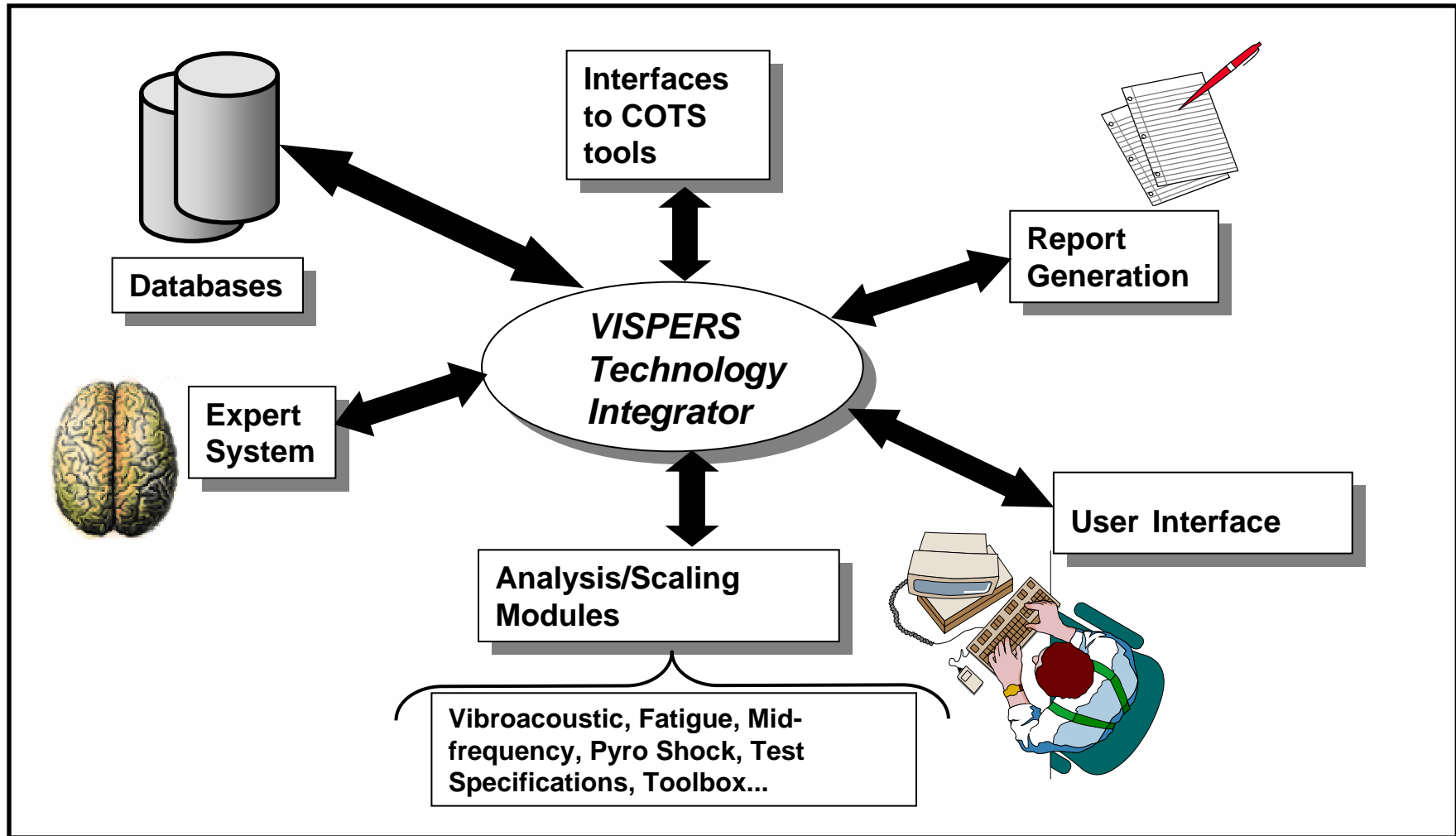
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Jensen, Marie Boeck**

**Presented to the 2005 Thermal and Fluids
Analysis Workshop**

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VISPERS Overview



Motivation for VISPERS

- **Reduce the cost of developing vibroacoustic specifications for space systems and components**
- **Reduce the need for component requalification and vibration isolation**
- **Captures the knowledge and wisdom of experts in vibroacoustics and shock**
- **Captures invaluable spacecraft and launch vehicle test and flight data from heritage programs**

VISPERS Uses

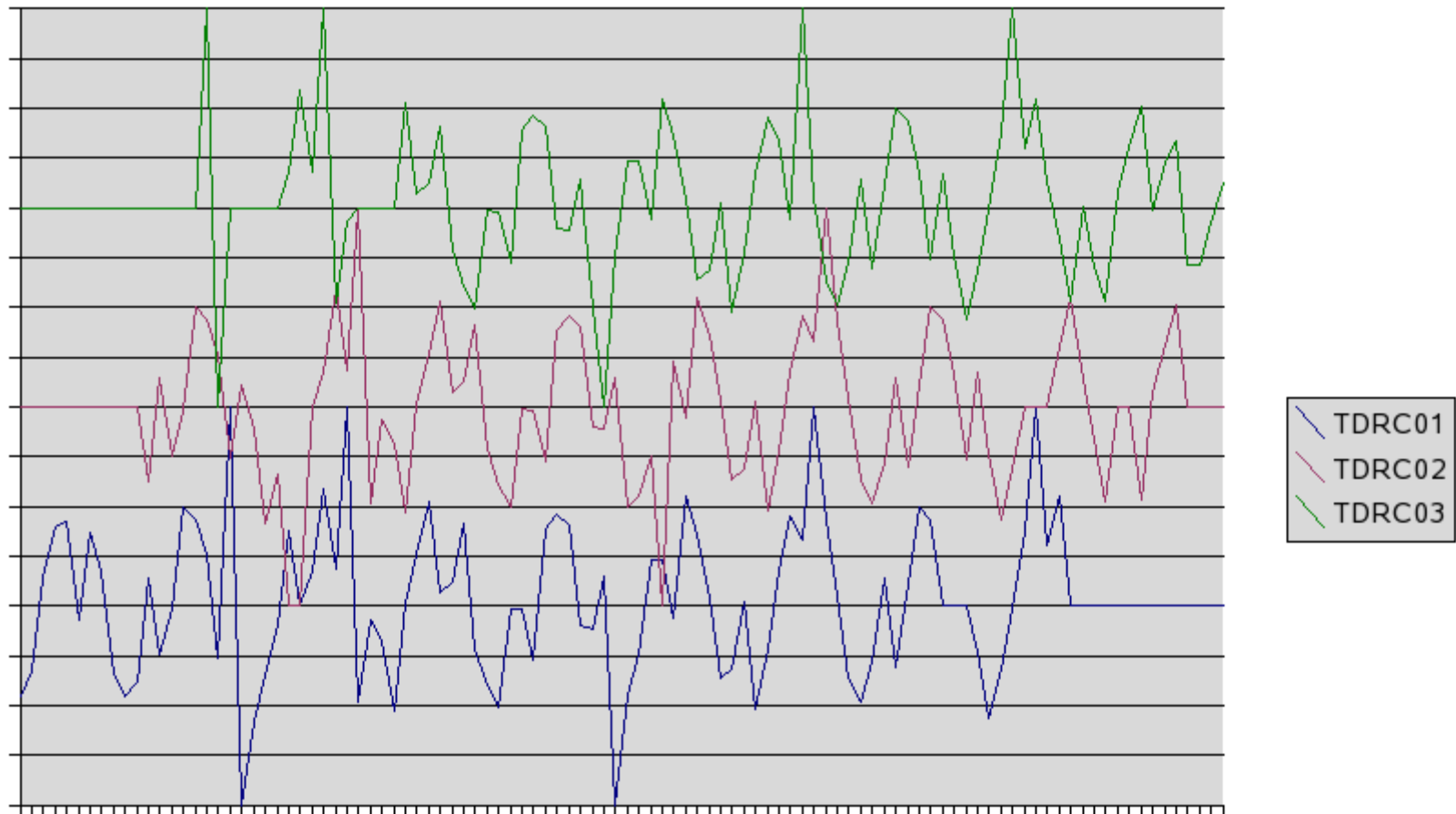
- **Design Stage**
 - External and internal acoustic & vibration predictions
 - Test specification development
- **Flight Verification**
 - Qualification test history and heritage flight data stored in database
- **Post-Flight Data Analysis**
 - Batch tool reduces time required for flight data processing
 - Can easily compare previous flight data from the VISPERS database to new flight data
 - Damage Based Analysis can be used for risk assessment
- **Validation**
 - Archived flight data can be used to test and validate new analytical tools and models

Telemetry Clean-Up VAIL and TACT Lead: Jorge Seidel

Telemetry Requires Clean-Up

- **It's a fact: Telemetry data received from spacecraft will have anomalies.**
 - Data drop-out, Spikes, Saturation, DC-drift, etc.
- **Before the data can be processed, the anomalies must be removed.**
- **VISPERS provides two tools to help the analyst clean-up the waveforms:**
 - TACT: alignment and consolidation of common telemetry streams from multiple sources (TDRC)
 - VAIL: A neural-net based anomaly detection and identification tool.

TACT – misaligned, anomalies



TACT

- **Data from multiple files may not be aligned with respect to a common clock**
 - Distance: one mile of range is 6 microseconds offset
 - Clocks: one clock providing the IRIG timestamp may have an offset from another (timestamp applied at TDRC)
 - Clocks: the clock on the spacecraft may drift (timestamp applied at spacecraft).
 - Time-Step: 5000 samples-per-second may not be exactly 5000.0000+ samples-per-second

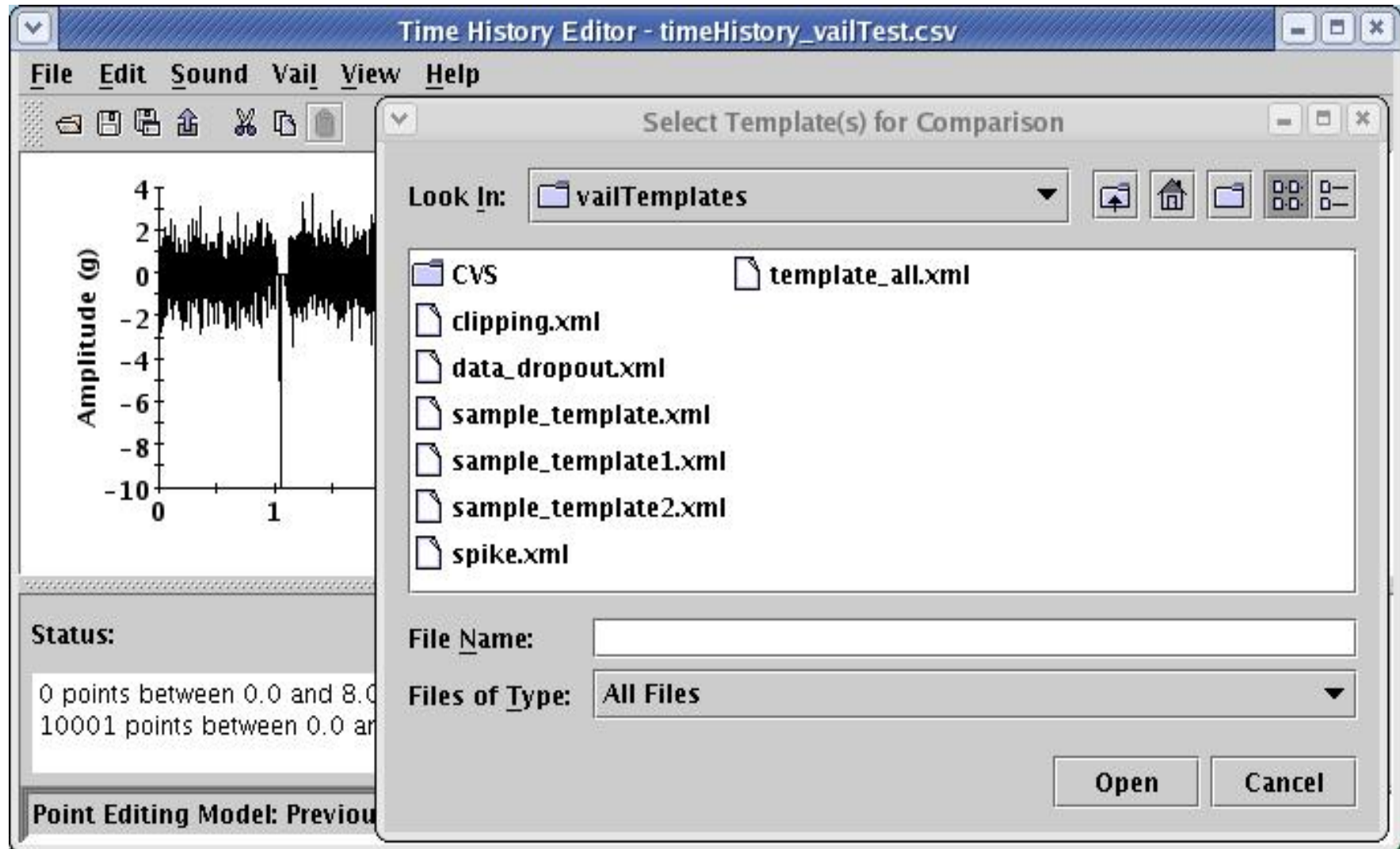
TACT

- **Tact attempts to align two waveforms:**
 - Only look at areas of overlap in data time stamps – time-codes are “close”, within ± 1 second
 - Break the overlap into smaller pieces for processing
 - Method 1: Slide one wave past the other to find the minimum sum-of-absolute-differences
 - Method 2: Using several filtering techniques, find common points and determine the “best match”
 - Method 3: Allow the analyst to specify a point on each waveform, then fine tune with methods 1 and 2

VAIL

- **GOAL: Using AI techniques, identify specific anomalous points and suggest corrective actions to the user.**
- **METHOD: Simulates a Neural Net where an anomalous point is recognized and highlighted.**
- **gVail – a grid version of Vail that can be run on clusters (Fellowship) or heterogeneous computing grids (like SETI at Home)**

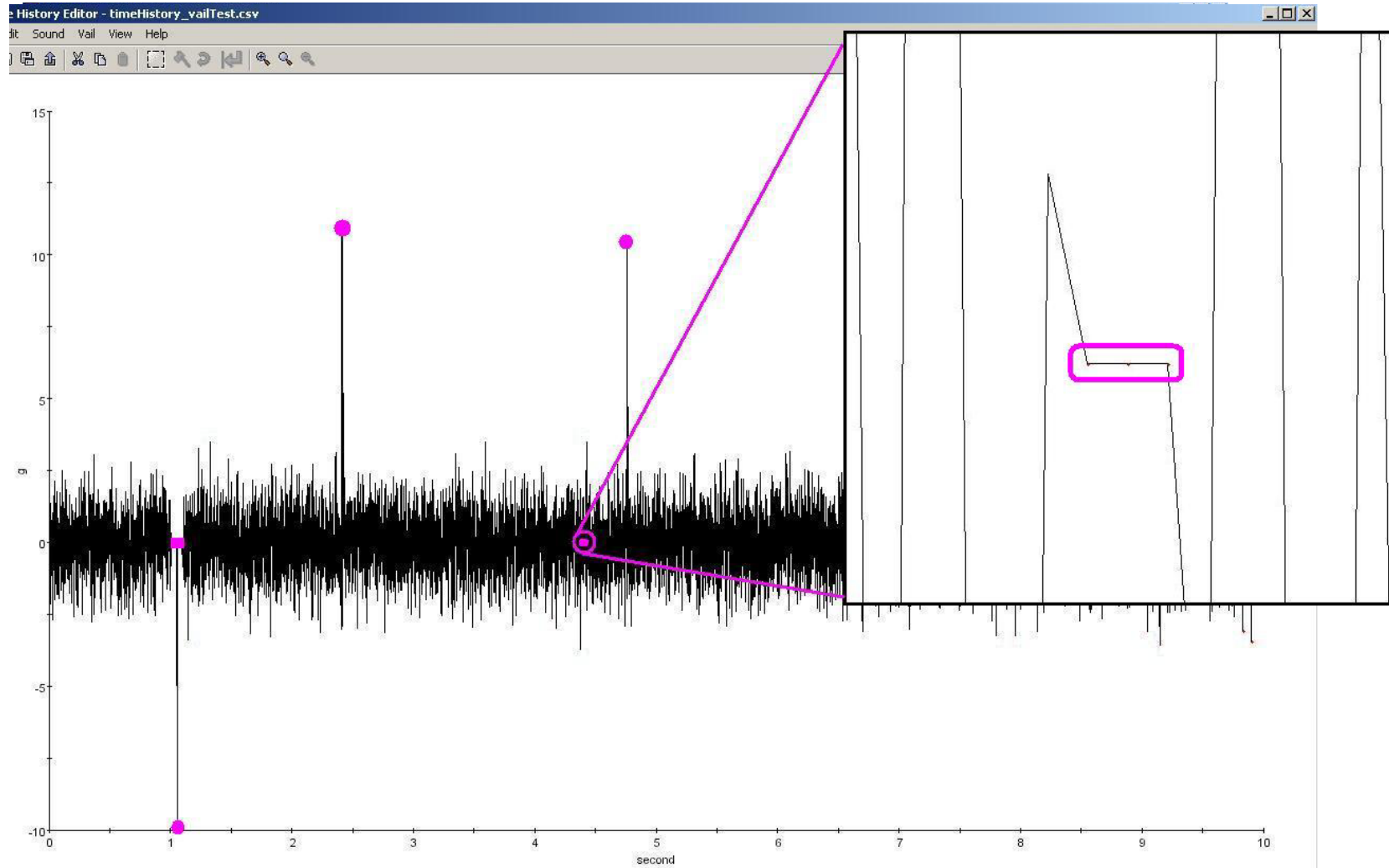
VAIL – Several Templates



VAIL - templates

- **Vail ‘looks’ at each point in the waveform and the neighborhood around that point.**
- **Each template is like a neuron**
 - If the point looks ‘normal’, then go on to the next point. This quick look makes VAIL fast
 - If the point does not look normal, then see if the firing threshold of the neuron is reached
 - If the neuron fires, the point is highlighted, and information is passed to display the ‘type’ of the anomaly and suggested corrective actions.

VAIL – Finds hidden anomalies



Time History Analysis

Lead: Jessica Jensen

Use of Damage Potential Analysis

- **Launch Vehicle**

- Traditional maximax algorithm used to evaluate flight data
 - A brief period of strong oscillation can dominate the spectrum and re-qualification may seem necessary
- Damage Potential Analysis takes into account not only the maximum response but also the duration of peak levels (fatigue)
 - Still yields a conservative spectrum
 - May help avoid unnecessary re-qualification of hardware

- **Spacecraft**

- Spacecraft/components tend to be over-tested when qualified on a shaker table for vibration or shock due to the rigidity of the table
- Damage Potential Analysis can provide insight as to whether relief in the specification can be allowed

Damage Potential Analysis Theory

Flight maximum
amplitude response

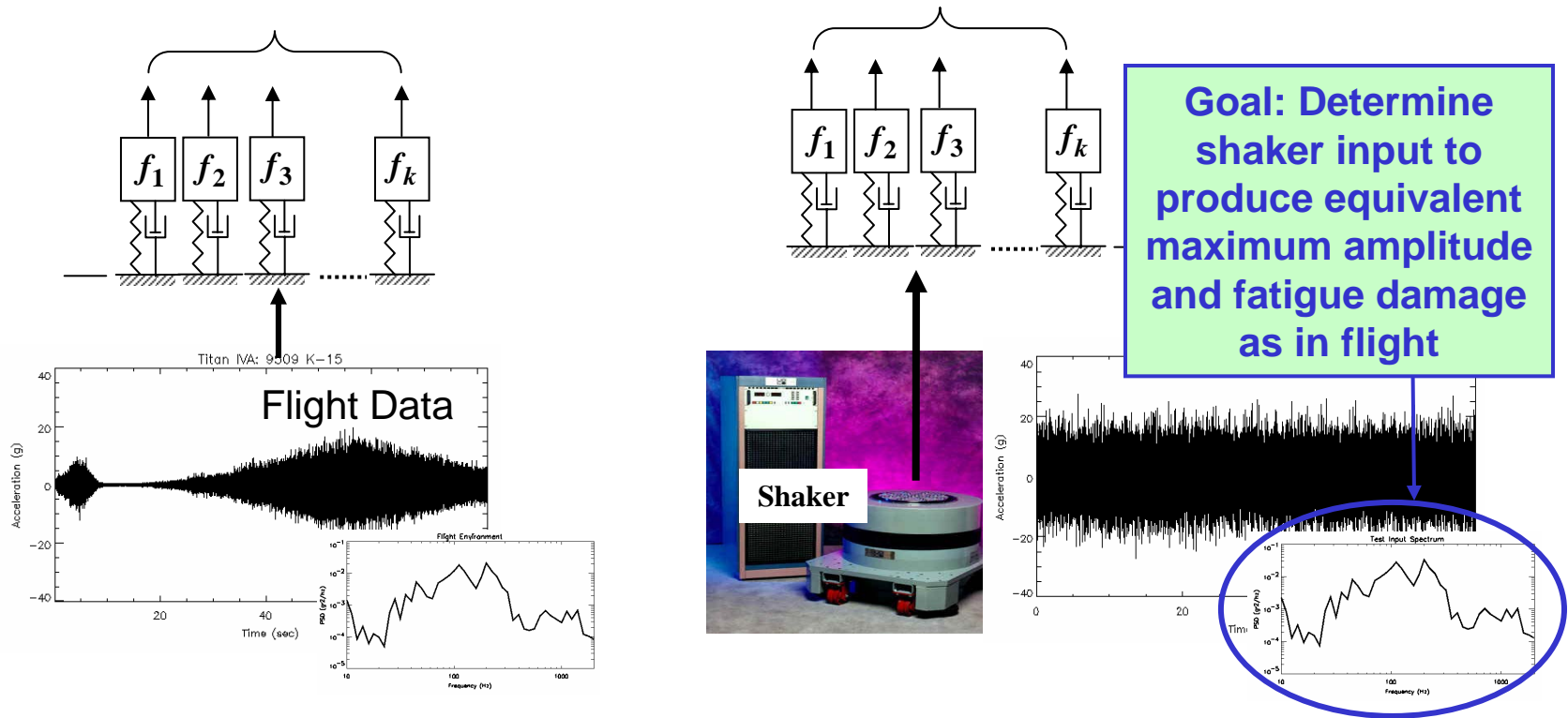
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Test maximum
amplitude response

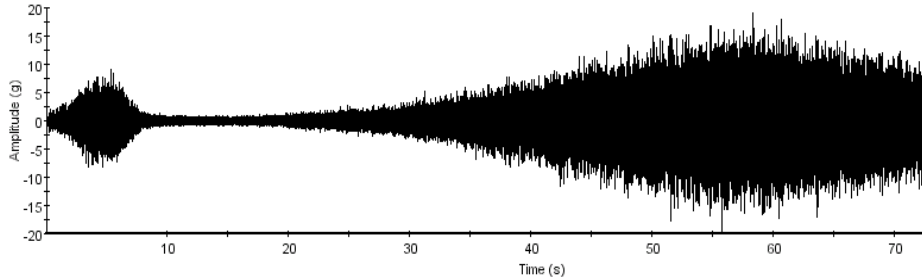
Flight fatigue damage

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Test fatigue damage

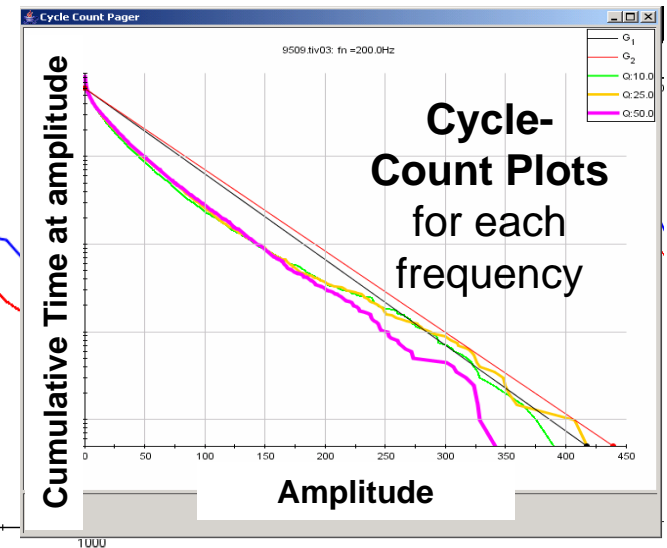
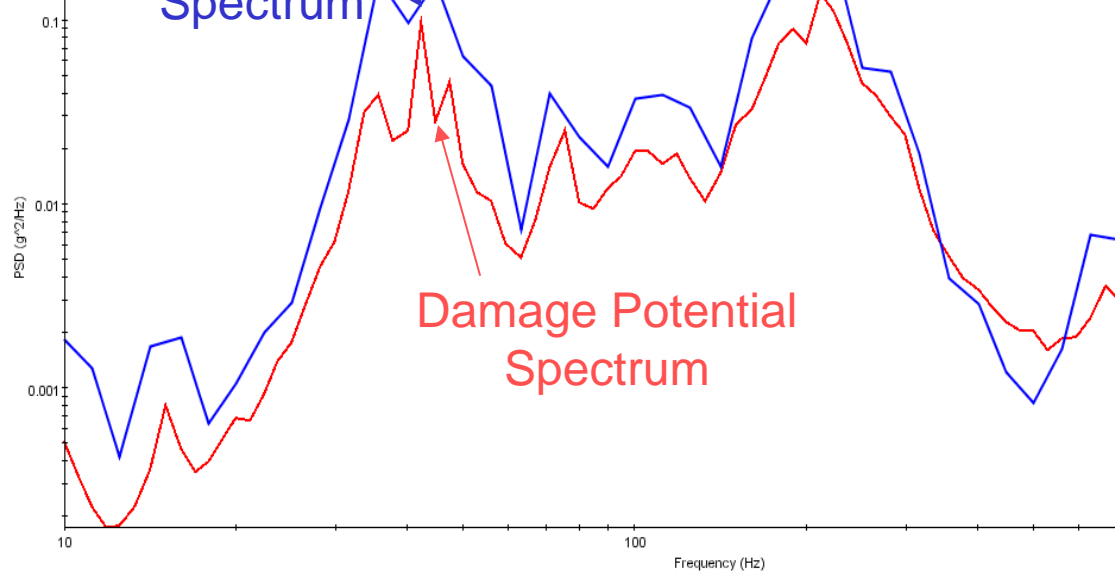


Damage Potential Exclusively in VISPERS



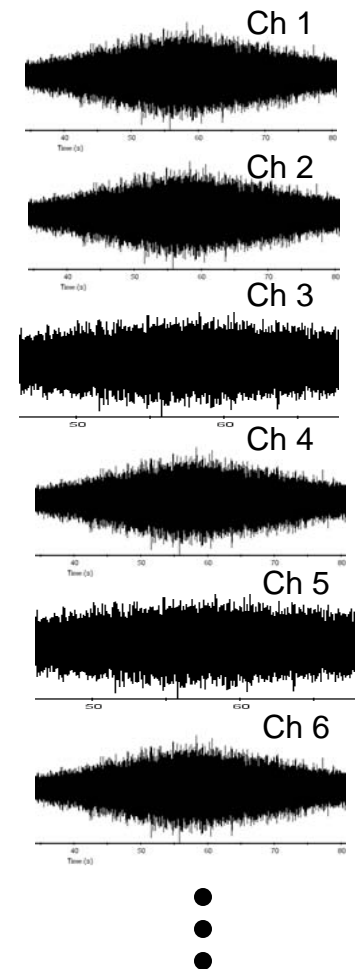
- Easy to use graphical interface
- Cycle count plots help the user understand the dynamics of the system and some of the assumptions behind the Damage Potential Algorithm

Traditional Maximax Spectrum



Traditional Processing Now in Batch Format

- **Allows input of flight parameters so that all vibration, shock and acoustic data from a flight can be processed simultaneously**
- **Significantly cuts down turnaround time for post-flight data analysis**
- **Can prepare and save model before flight**
- **Generates a report showing all the time histories and their corresponding vibration, shock, and acoustic environments**



Batch Data Analysis Tool – User Interface

The screenshot shows the VISPERS Batch Data Analysis software interface. The main window is titled "VISPERS Batch Data Analysis" and has a menu bar with "File", "Edit", "Maximax", "SRS", and "View". Below the menu bar are several icons. The interface is divided into several sections:

- Flight Data:** Contains fields for "Name:" (Titan IV Flight K05) and "Date:" (01/30/2004). Below this is a "Description:" field (Testing BDAT) and a "Comments:" section with a text area.
- Flight Events Timeline:** A table with columns: Start Time, Stop Time, Description, Acoustic, Vibration, Shock, Symbol, and Color. It lists three events: Liftoff (Acoustic checked, Vibration checked, Shock unchecked), TSMG (Acoustic checked, Vibration checked, Shock unchecked), and Engine shut down (Acoustic unchecked, Vibration unchecked, Shock checked).
- Time Histories:** A table with columns: Time History File Name (Double-click to change), Type, Start Time, Stop Time, Points, and a color-coded bar. It lists four files: tiv05_mic660 (Acoustic), tiv05_9557 (Vibration), tiv05_9662 (Vibration), and tiv05_9668 (Vibration).

Callout boxes with blue borders and arrows point to specific features:

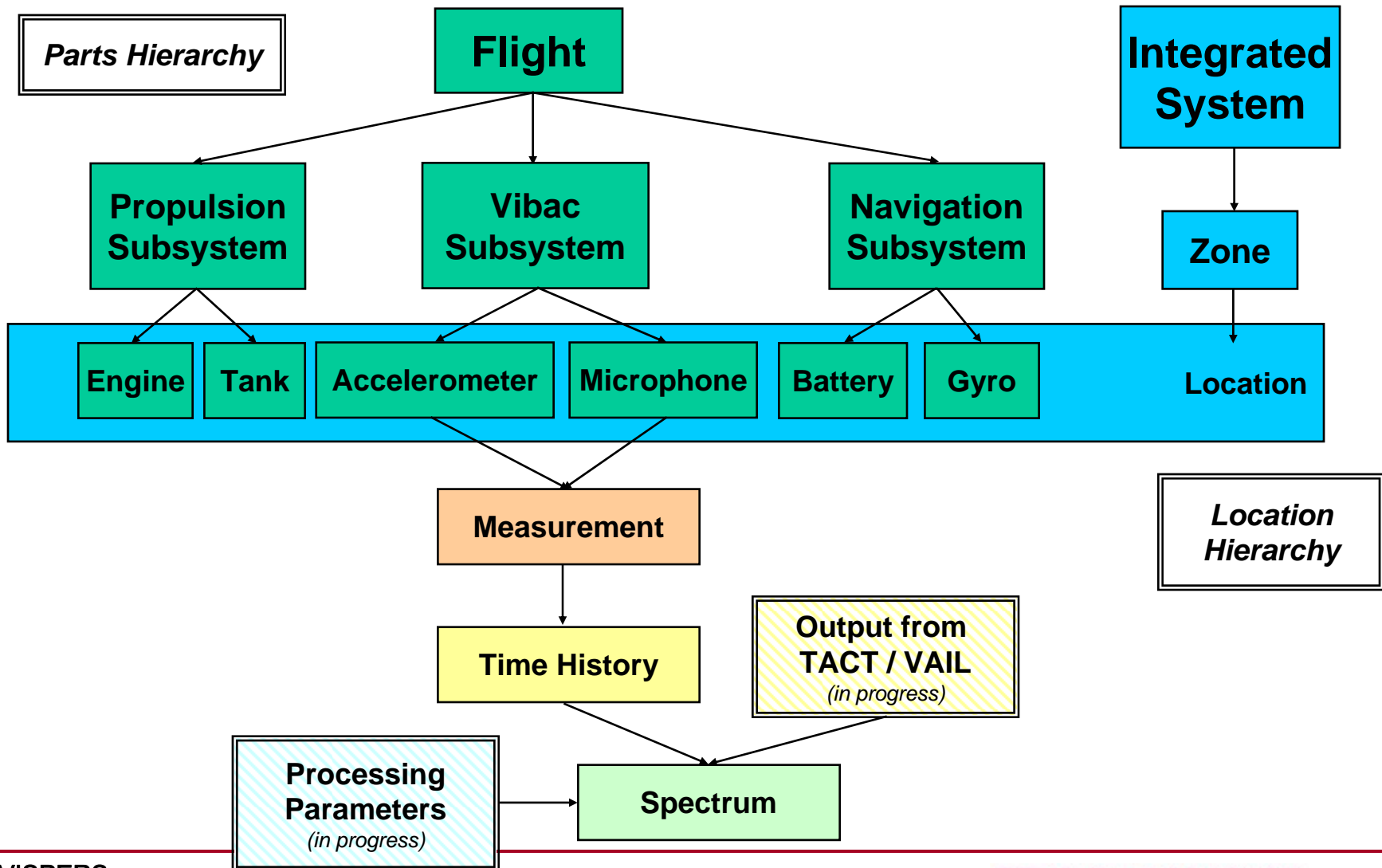
- "Set Maximax and SRS Settings for all files" points to the "SRS" menu item.
- "Flight Events Timeline" points to the Flight Events table.
- "Flight Description" points to the Description field.
- "Specify Vibration, Shock, and Acoustic Time Intervals" points to the checkboxes in the Flight Events table.
- "Time history files" points to the Time Histories table.

Enter Parameters → Click Process → Report (.pdf) is Generated

Database

Lead: Marie Boeck

Database Structure



Example Input Screens

The image displays two screenshots of the VISPERS DB Front application interface. The left screenshot shows the 'Transducer' input screen, and the right screenshot shows the 'Time History' input screen.

Transducer Input Screen:

- Category: flight
- Transducer Type: accelerometer
- Transducer Model: 306M68
- Serial Number: 1542
- Output Designator #1: -X
- Output Designator #2: +Y
- Output Designator #3: +Z
- Family: LV IFS
- Flight: Titan IVA
- Location: Titan IVA K-7
- 9511-12-13
- Comments: Titan IVA K-7 9511-12-13 +Z, -X, +Y
- Buttons: Add, Update, Delete, Rename

Time History Input Screen:

- Measurement Type: acoustic
- Measurement Category: flight
- Family: LV IFS
- Flight: Titan IVA
- Measurement Name: Titan IVA K-2
- 9381
- Time History Name: 9381_JD_20_55
- Ground Station: Cape Canaveral
- Measurement Unit: [dropdown]
- Browse Files
- Selected File: /A-02\FMA1_020K_JD_20_55_9381.iis
- Start Time: 20.0 End Time: 50.0
- Time Unit: s Samples/s: [input]
- Comments: [text area]
- Buttons: Add, Update, Delete, Rename

PID = 1229

Add Time History

Current Efforts

- **Expert System**

- Integrate grid-enabled version of VAIL, developed by team of Harvey Mudd College undergraduates
- Create templates for additional anomalies, develop tool for generating templates
- Continue to develop TACT algorithms

- **Database**

- Schema refinement
- Complete database front end tool

- **Continuing Research**

- External liftoff acoustic prediction algorithms

Summary

- **The VISPERS team has made significant progress in implementing a tool set to**
 - Efficiently process multiple time history data streams using both traditional and improved analysis techniques
 - Automatically identify common anomalies in vibration and acoustic time histories
 - Capture vibration, acoustic, and vehicle configuration data for future analysis and comparisons
- **Although VISPERS is already quite capable, much remains to be done.**

Backup

TACT – time correction

- **The analyst can select how to correct the time-stamps when the waves are not aligned**
 1. Base all times on the “best” T0, and the time step that is specified by the sample rate.
 2. Specify the time for any point, and Tact computes the times for all other points based on the time step.
 3. Specify the time of any two points and the time step will be adjusted based on those points.
 4. Specify the time step and all times will be adjusted based on that time step and the “first” time stamp.