Monitoring the health of the F-22A airframe during full scale ground testing

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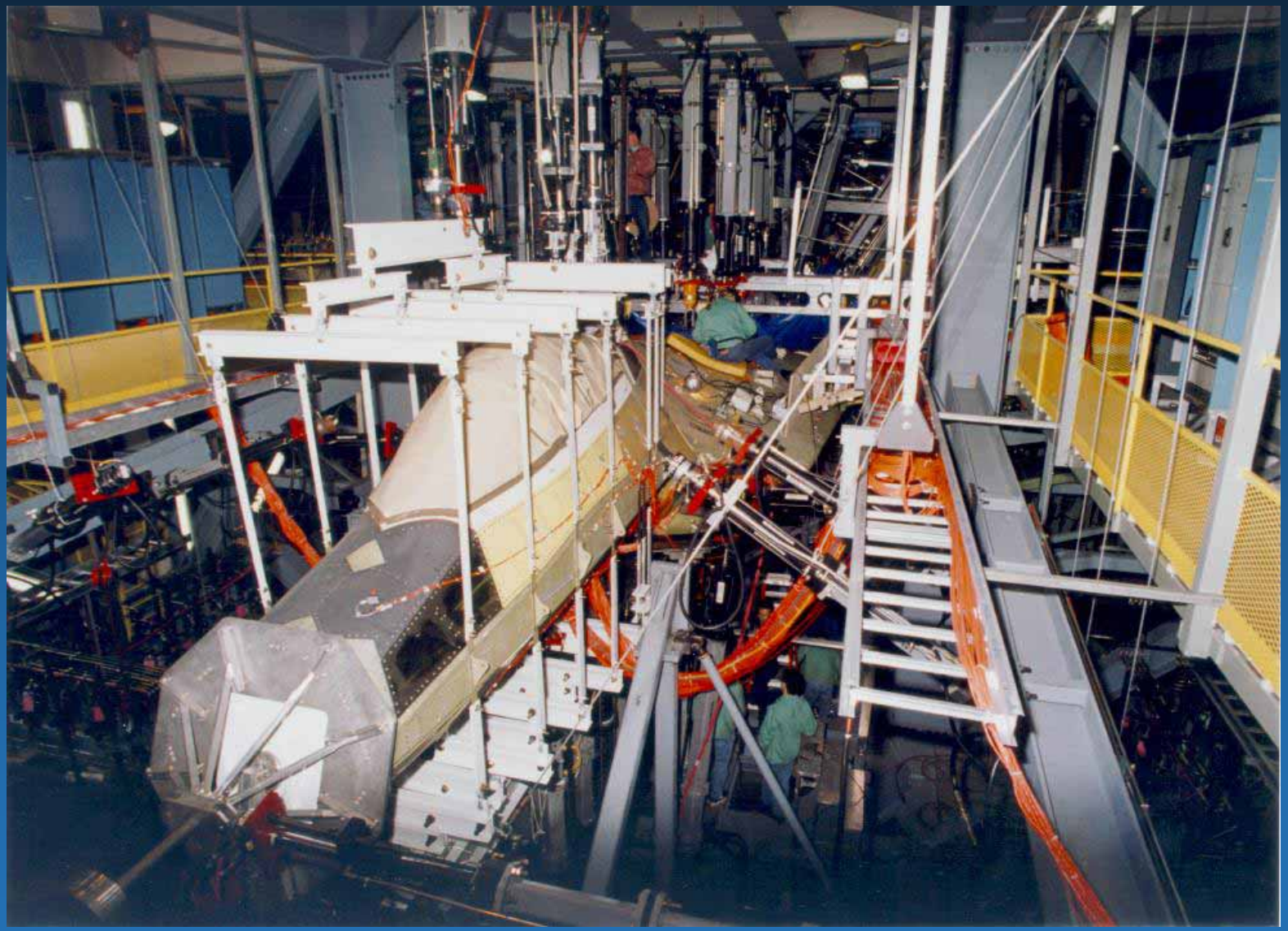
Abstract

F-22A full-scale ground testing necessitated monitoring the health of the airframe. An enormous quantity of load, strain and deflection data was generated in a short period of time and needed to be effectively analyzed. A suite of software tools was developed to satisfy these demands. The software had to allow real-time monitoring or post test review and analysis.

During static testing approximately 4000 channels of loads, strains, deflections and other measurements were monitored for article health. Data monitoring schemes included tabular, graphical and diagram related methods. Various calculations are done during the test to alert the user if deflections or strains are approaching preset flag values. Data was sent over a private internet to program partners allowing offsite monitoring of tests.

During cyclic testing approximately 1500 channels of loads, strains and deflections are continuously monitored. Various mathematical methods are employed to analyze the data, searching for changes in deflection or strain which may signal problems with the structure. Defects were discovered earlier during the test and repaired. This averted more costly repairs or in the worst case catastrophic failure of the airframe.

F-22A Static test article in test fixture



Monitoring parameters

Static test article

~4000 strain gages, 60 deflections, 220 load rams

-55 full aircraft limit load tests
-23 full aircraft ultimate load tests

Fatigue test article

~1400 strain gages, 22 deflections, 220 load rams

-2.68 lifetimes of data at approx 1,000,000 points per lifetime

Topics

On Subject

-Computer aided tools that monitor strains, deflections and loads, monitor changes in values which signal possible problems

-Monitoring often enough to catch problems which may lead to catastrophic failure of airframe.

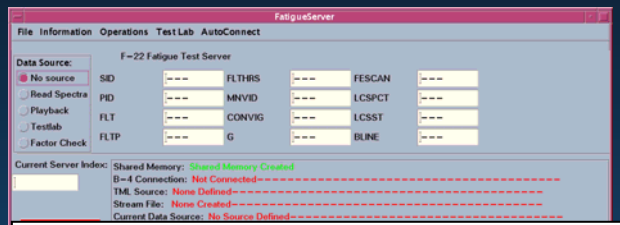
-Maximizing lifetimes for a finite budget. Catastrophic failure tends to ruin your budget.

Off Subject

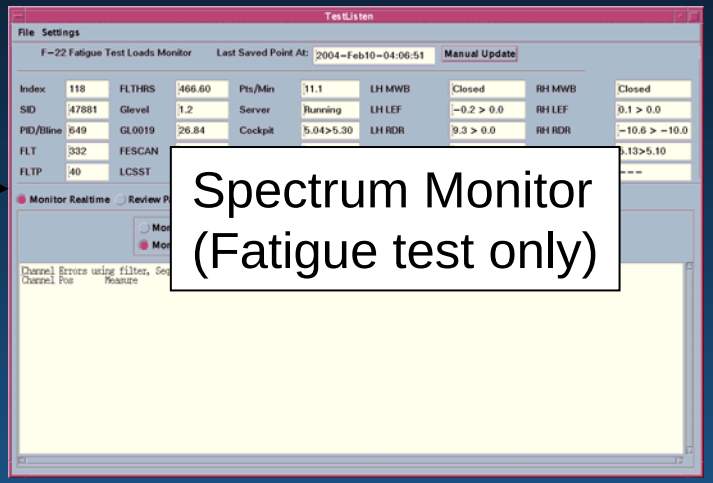
-Using strain/load values as an input to any real time/near-real time durability or damage tolerance analysis

-Specific airframe related anomalies found during testing

Data Flow



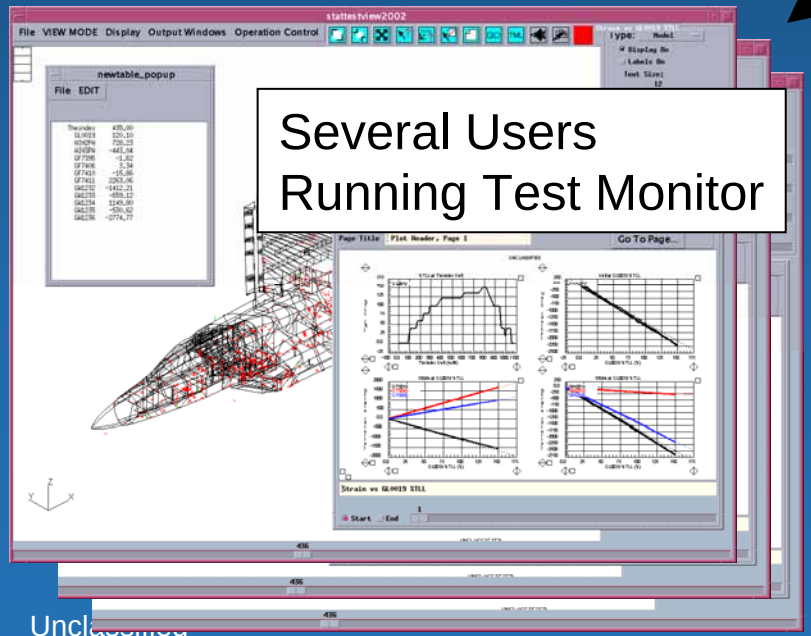
Main Server
-Connects to data acquisition
server at test site



Spectrum Monitor
(Fatigue test only)

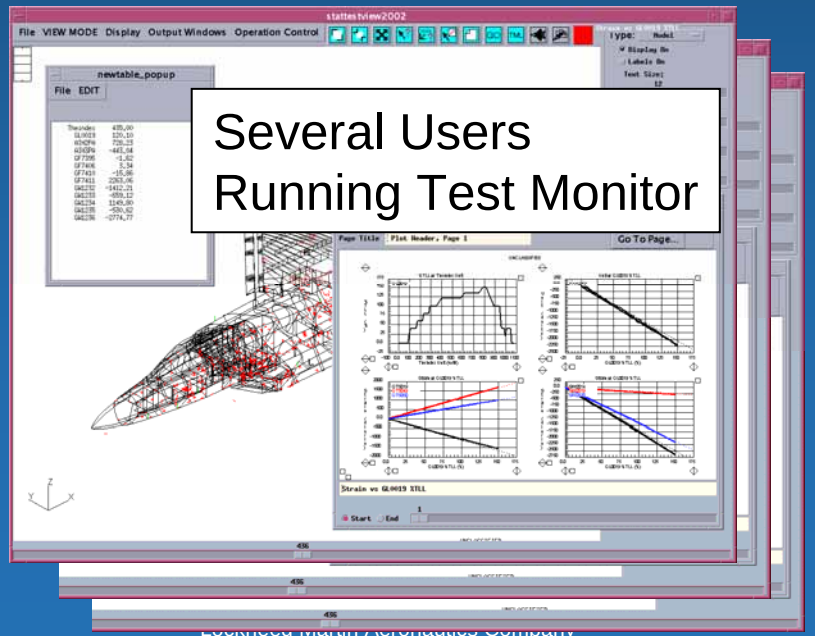
Private
Internet

Geographic Site Marietta Ga



Several Users
Running Test Monitor

Other Geographic Site(Static Test)

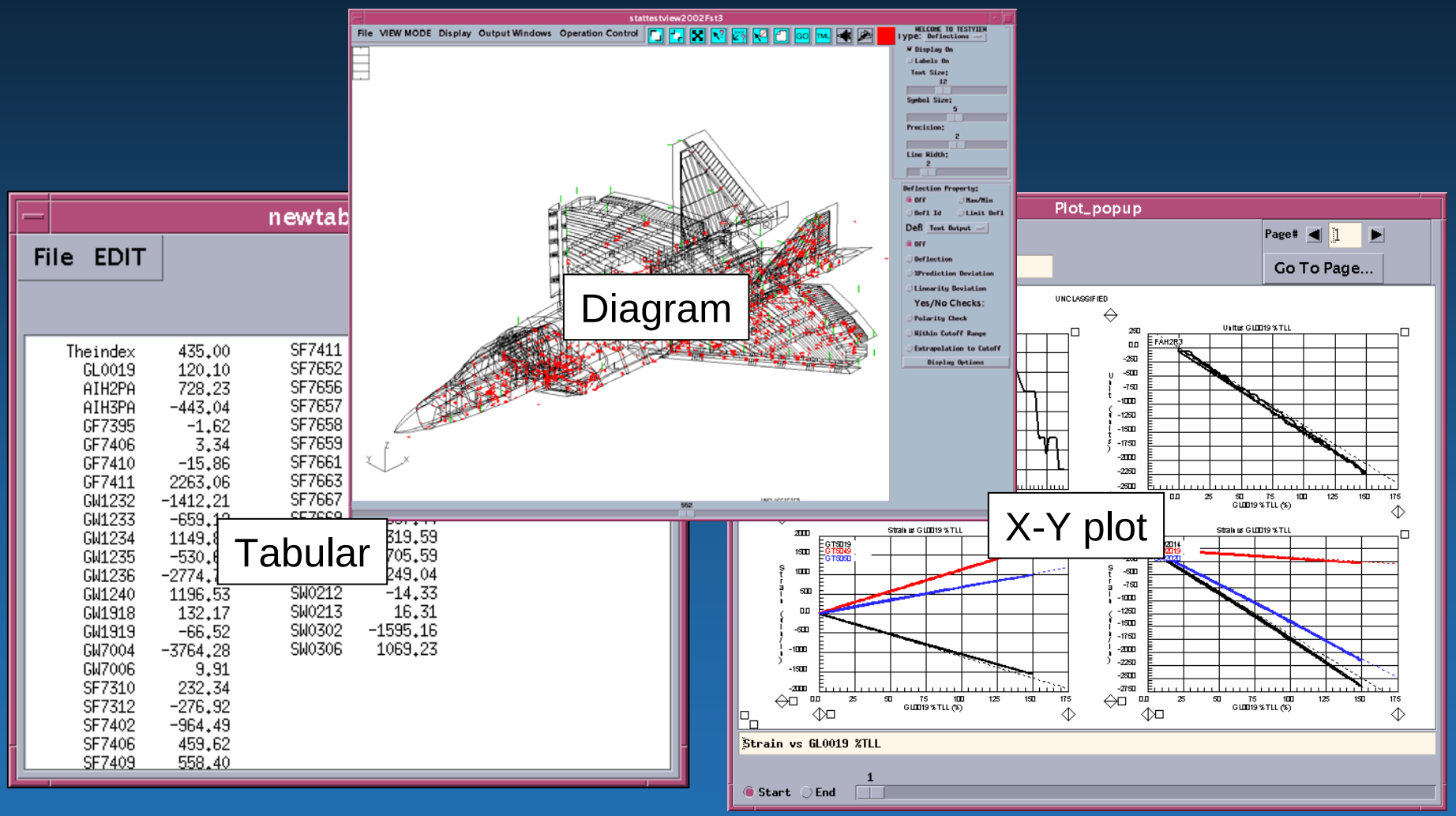


Several Users
Running Test Monitor

Monitoring Static Tests

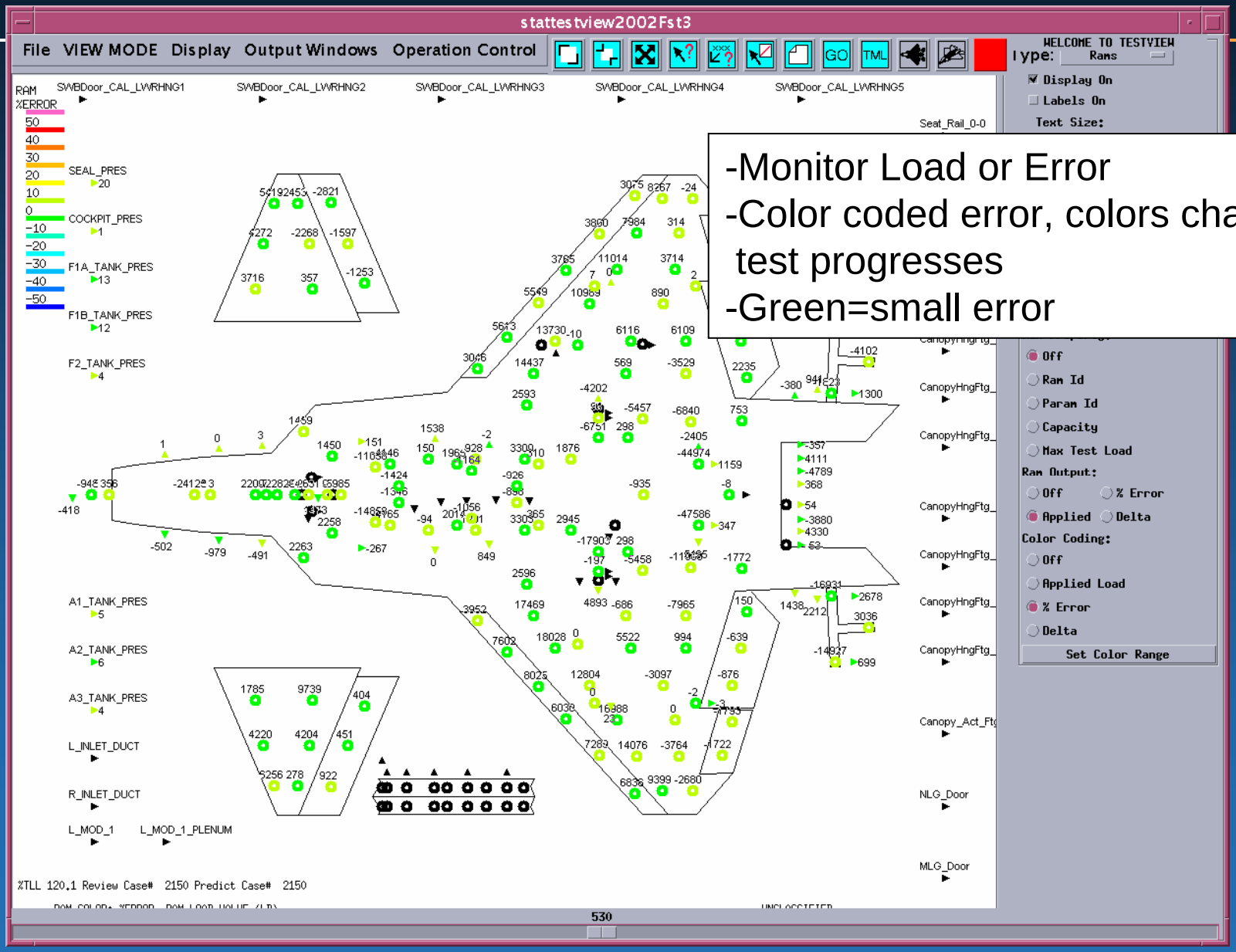
-More real-time monitoring on test data
-Comparisons to FEM predictions important
-Broad overview of data important

Monitor data by diagram, by table or by X-Y chart



-Same program used during real-time testing and post test data analysis

Diagram Test Monitor For Load Rams during Static Test



-Monitor Load or Error
-Color coded error, colors change as test progresses
-Green=small error

Diagram Monitor for Strain gages and deflections

Strain gages and deflections:
-Display values
-Display predictions (Static Test)
-Color code by prediction deviation (Static Test)
-Color code for polarity check
-Color code within preset cutoff limits

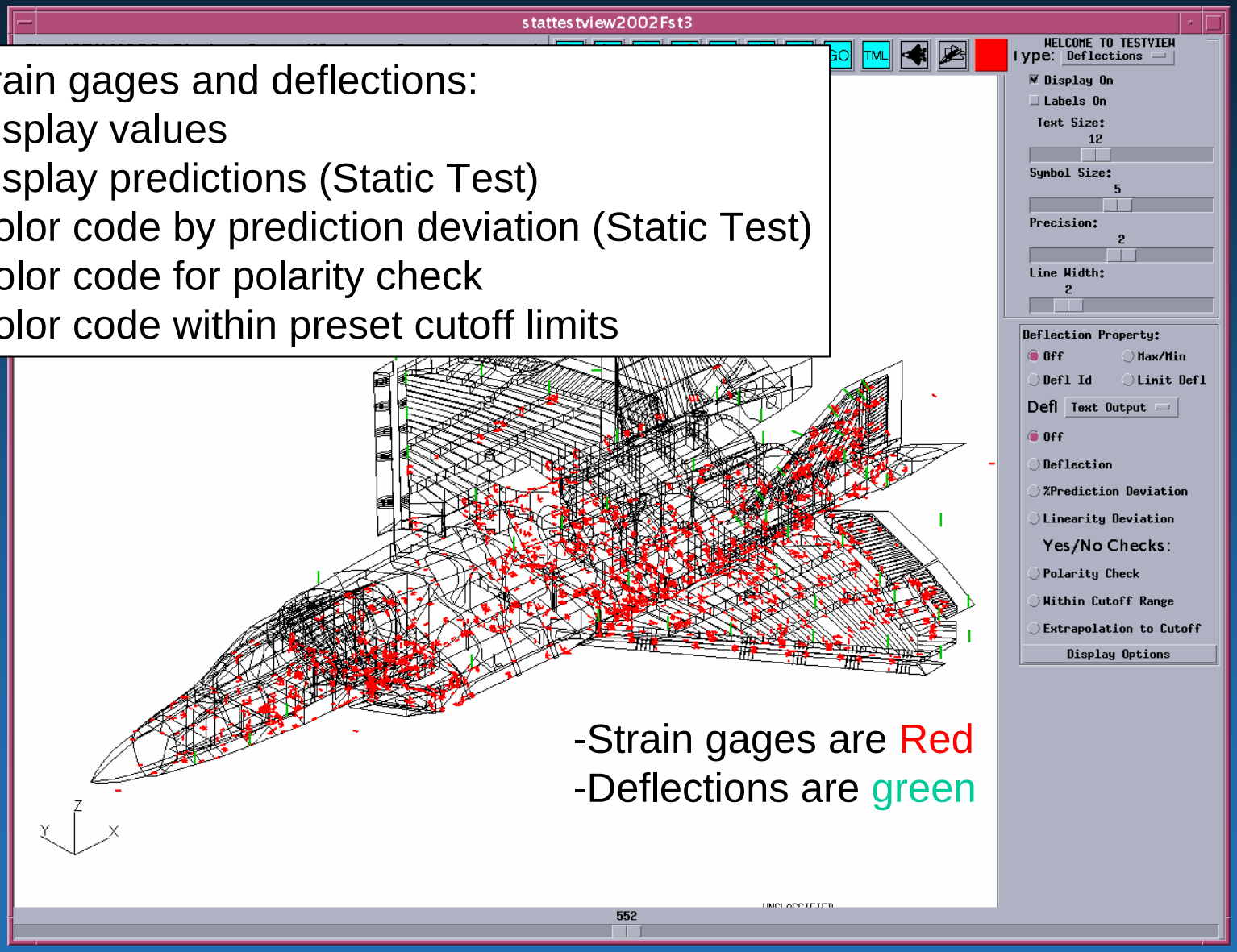
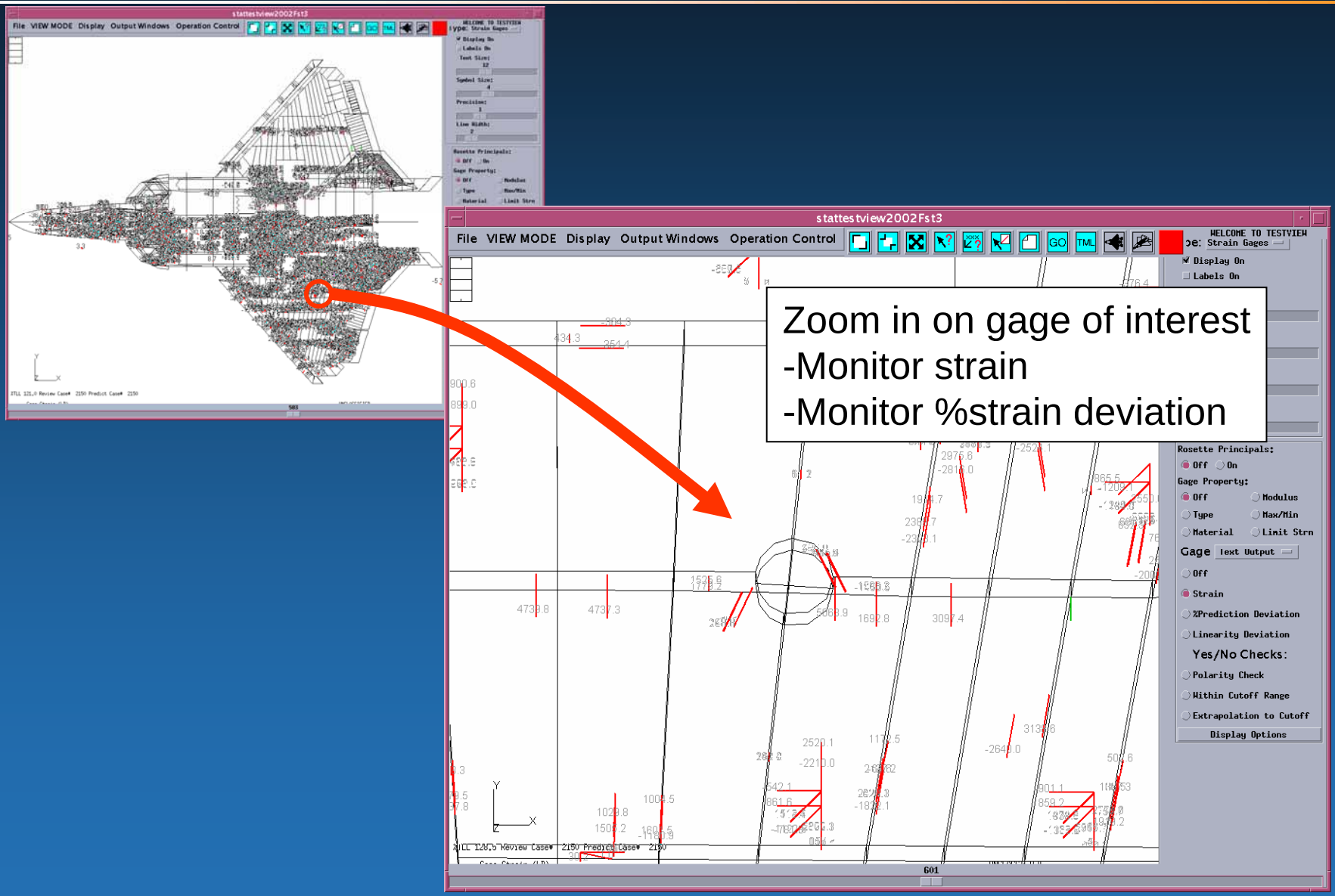
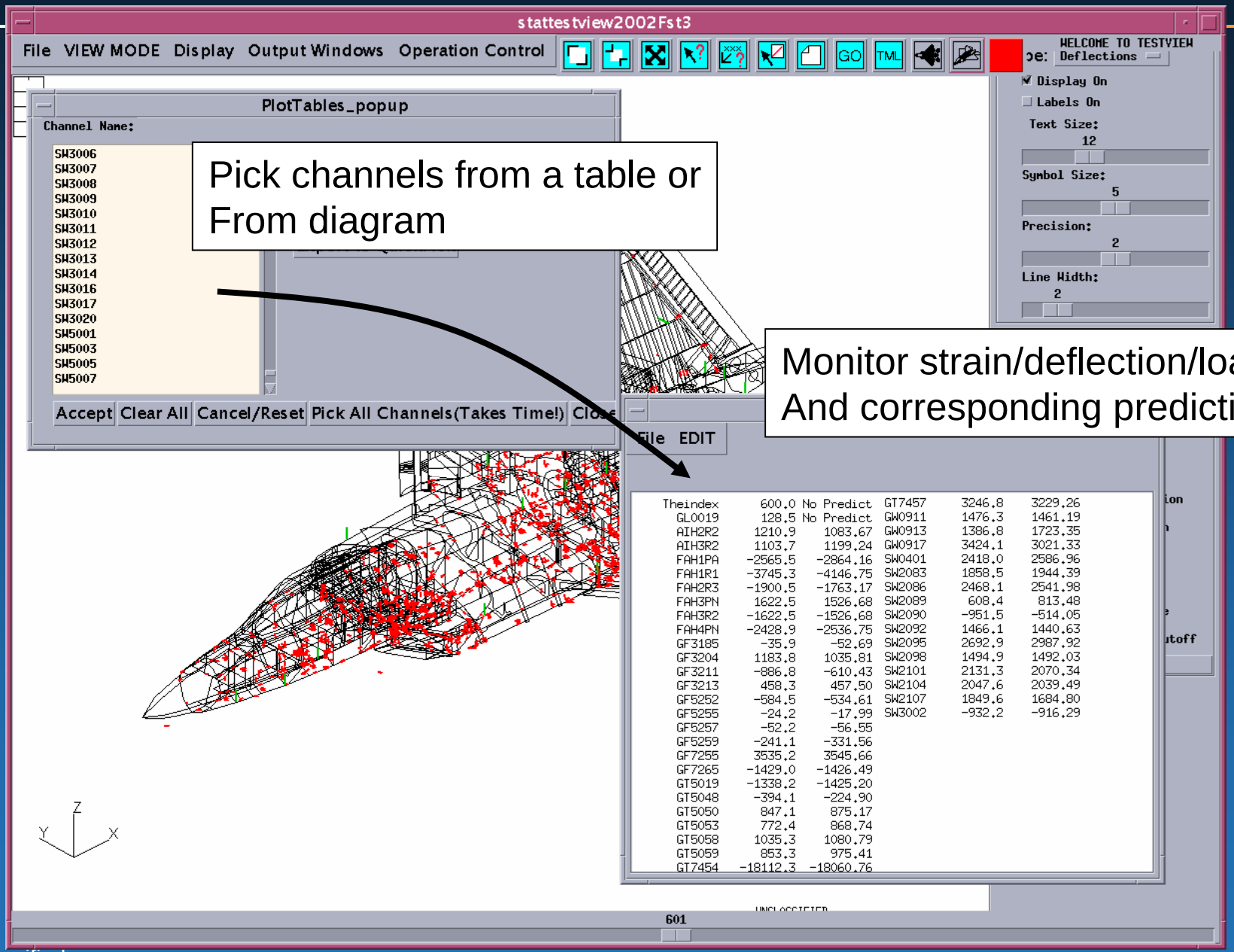


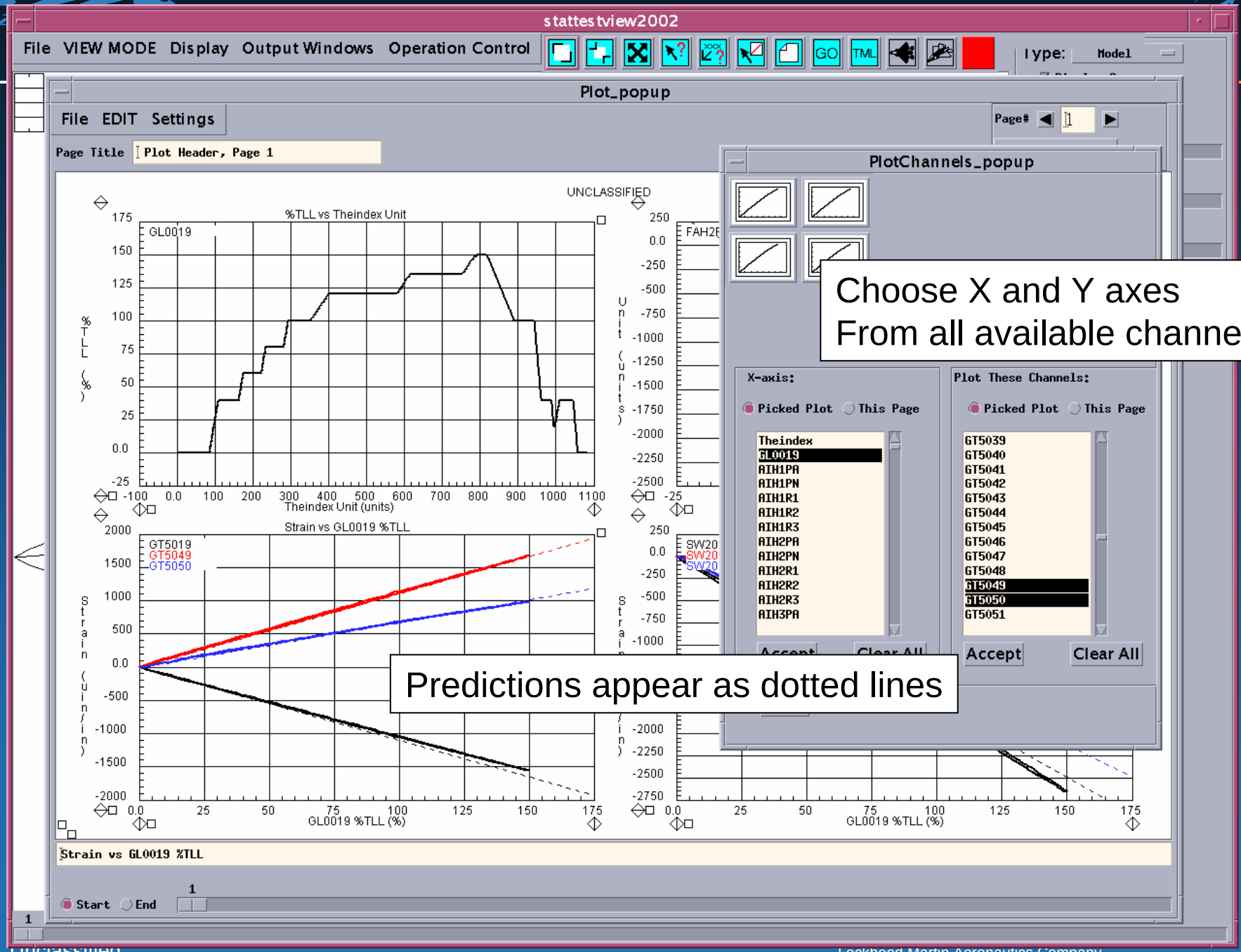
Diagram Test Monitor for Strain gage value monitoring



Tabular Test Monitor for monitoring channels in tabular format



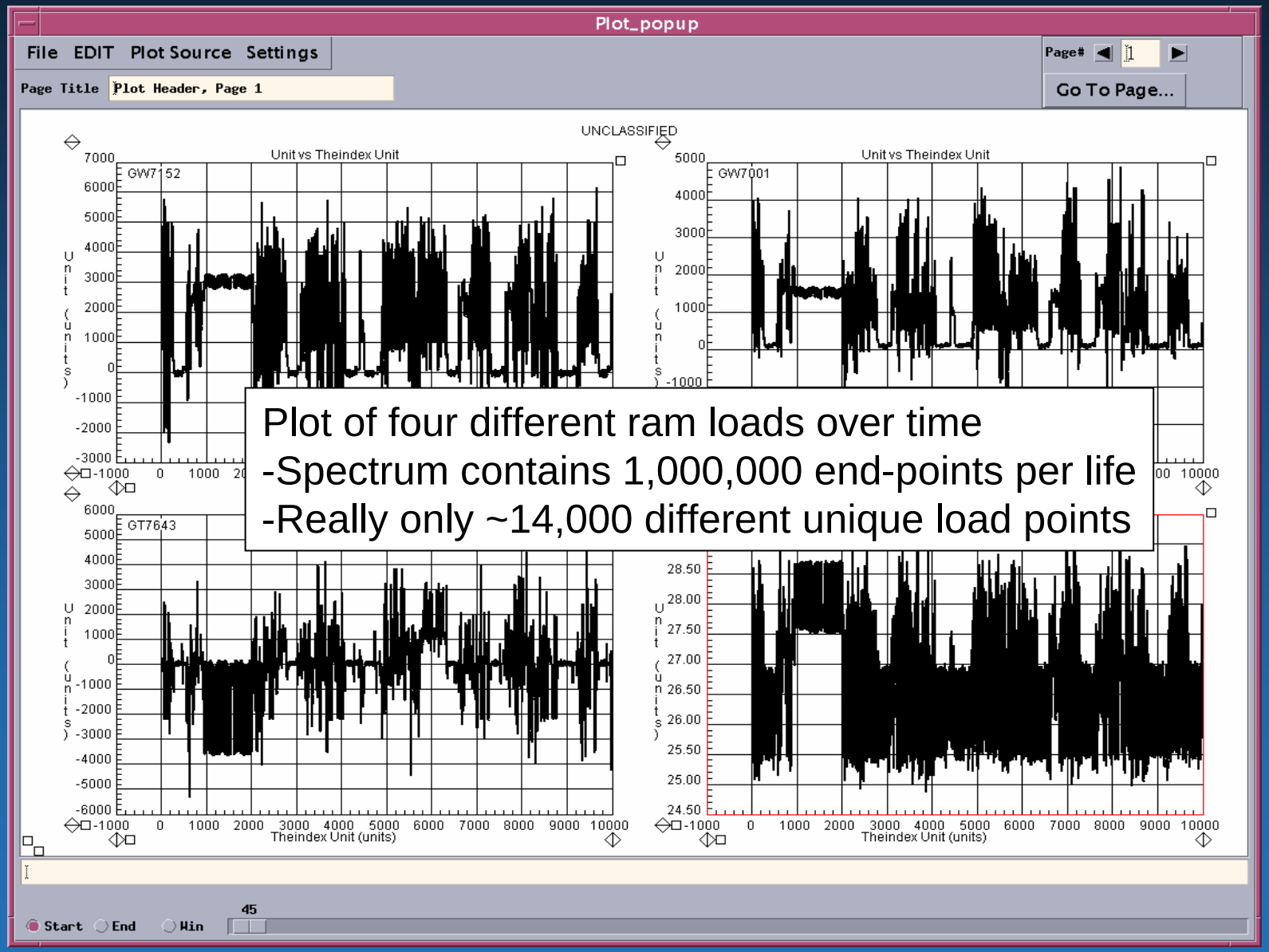
Test Monitor for X-Y plotting capability during static test



Unique problems with durability testing

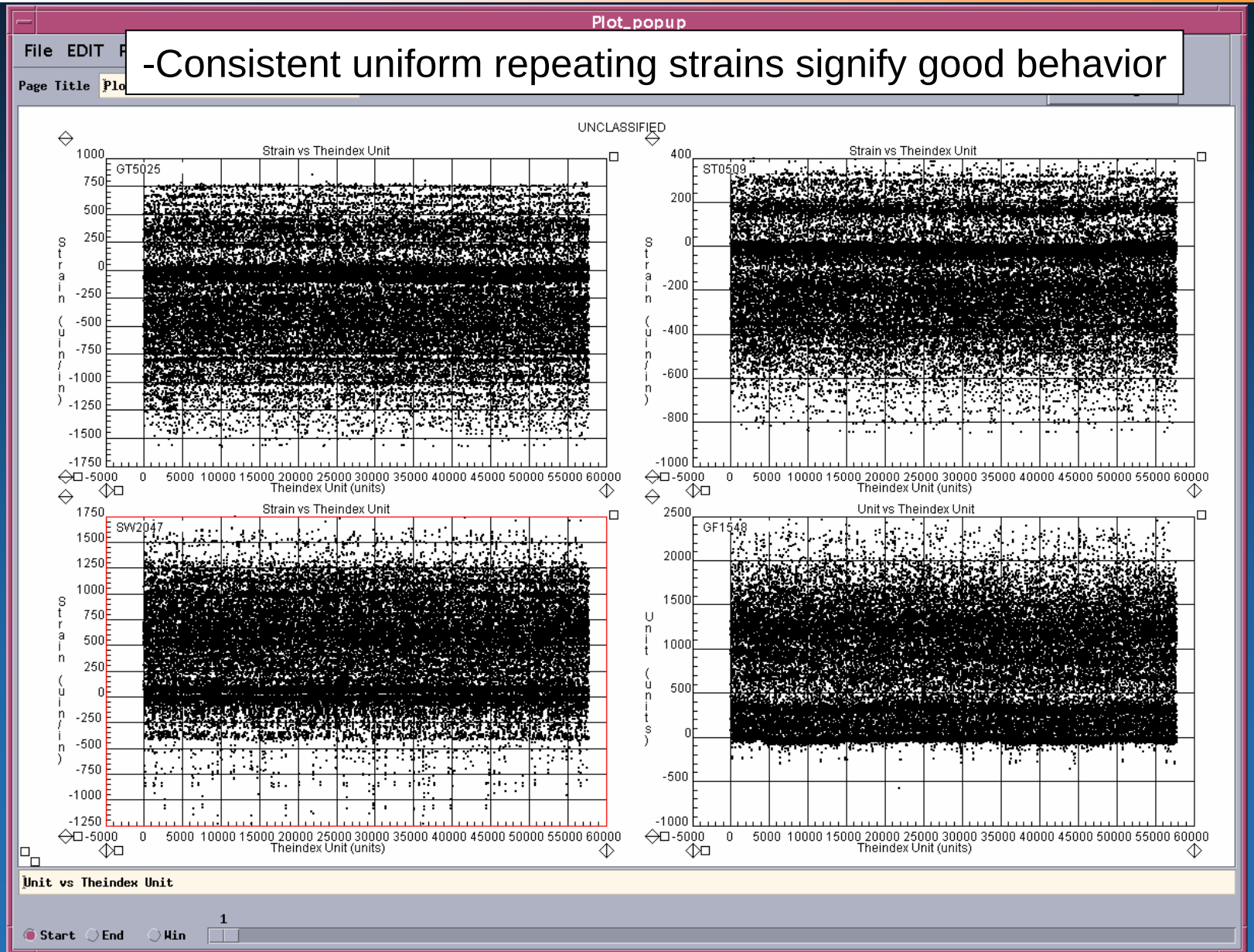
-Testing 24/7
-Little manual monitoring of strain/deflection data
-Emphasis on automated monitoring schemes
-Data trends become important

Making sense of durability data



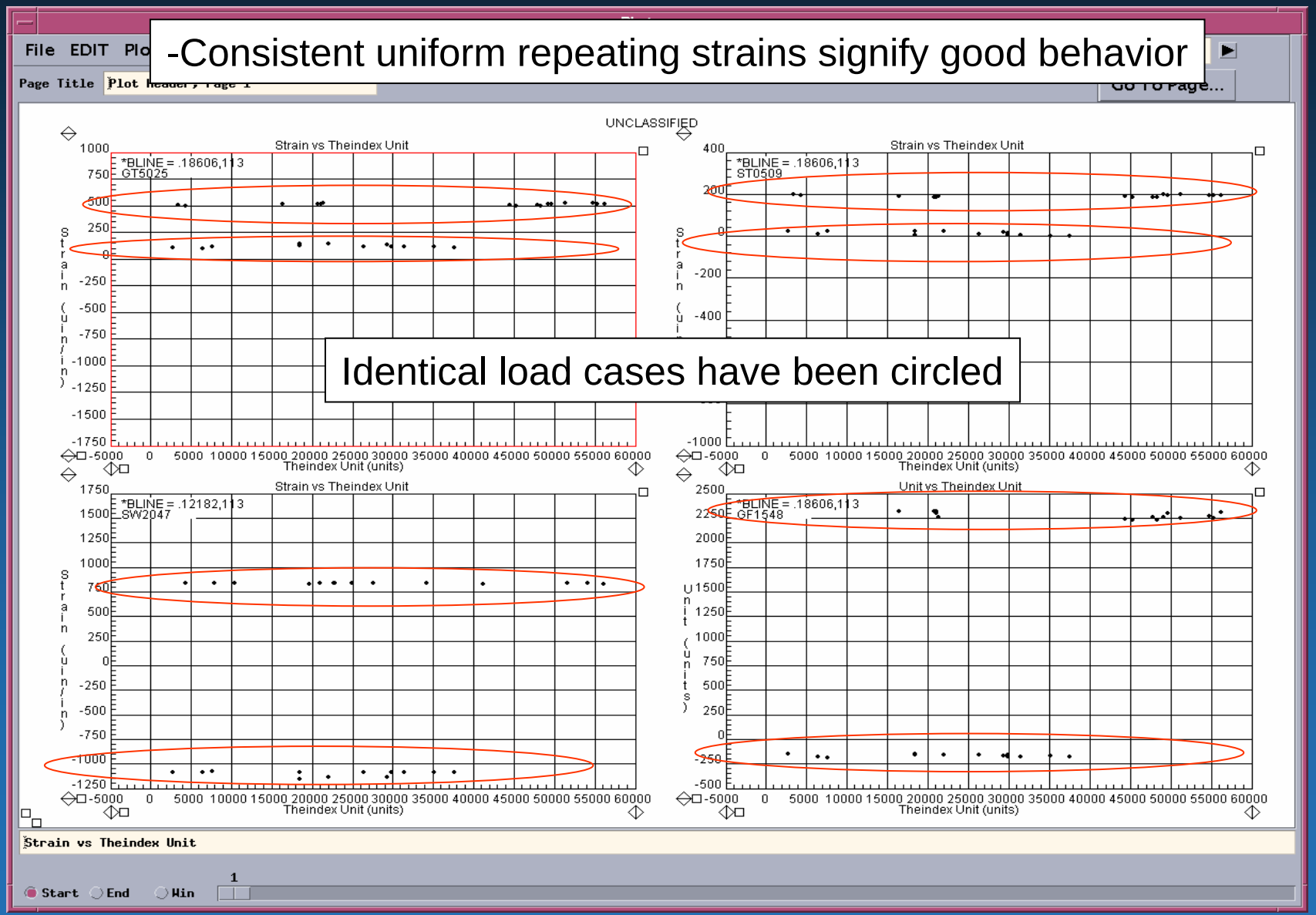
A 1/10 life slice of durability data

-Consistent uniform repeating strains signify good behavior

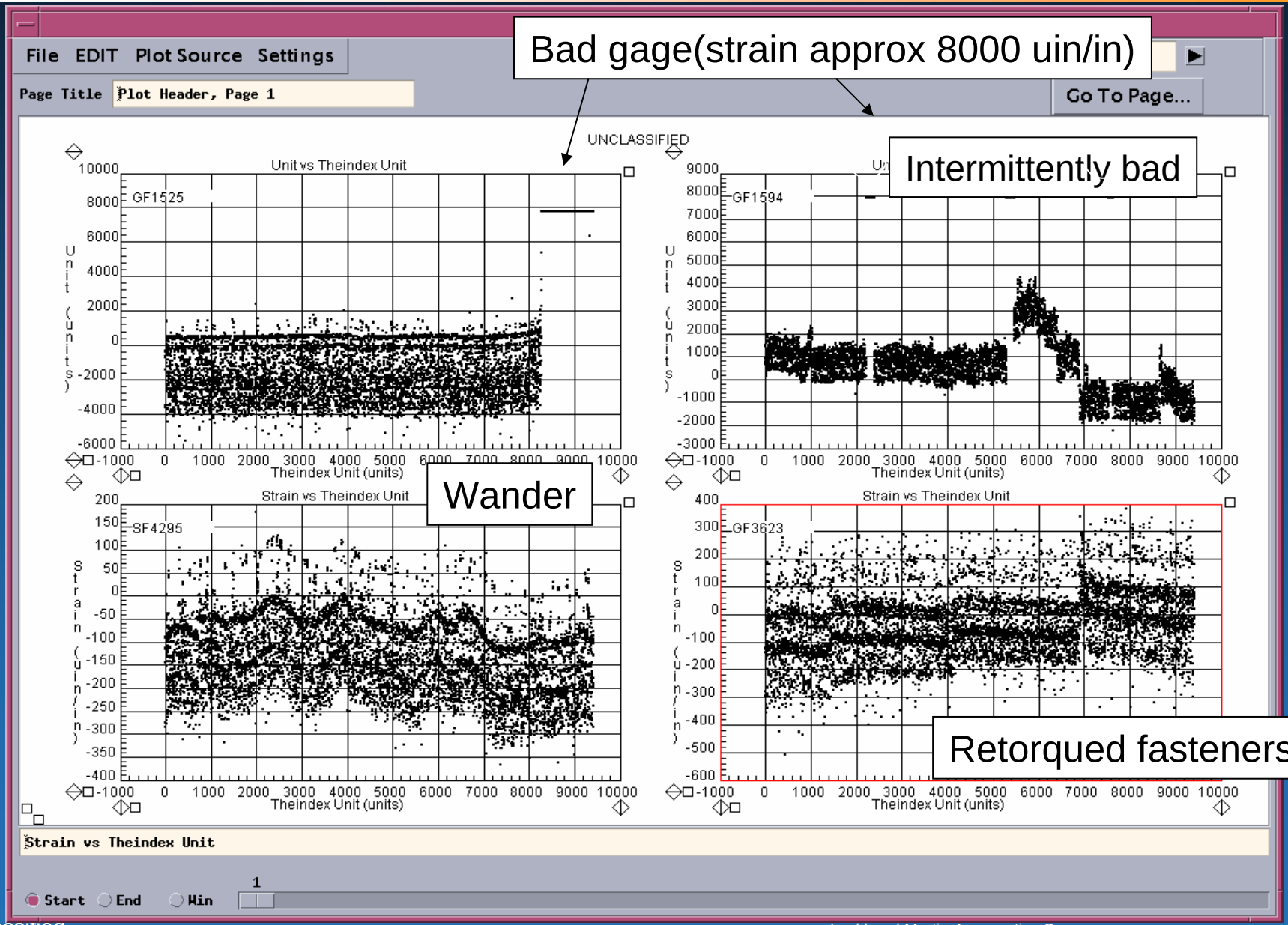


Filtered load cases in a 1/10 life slice

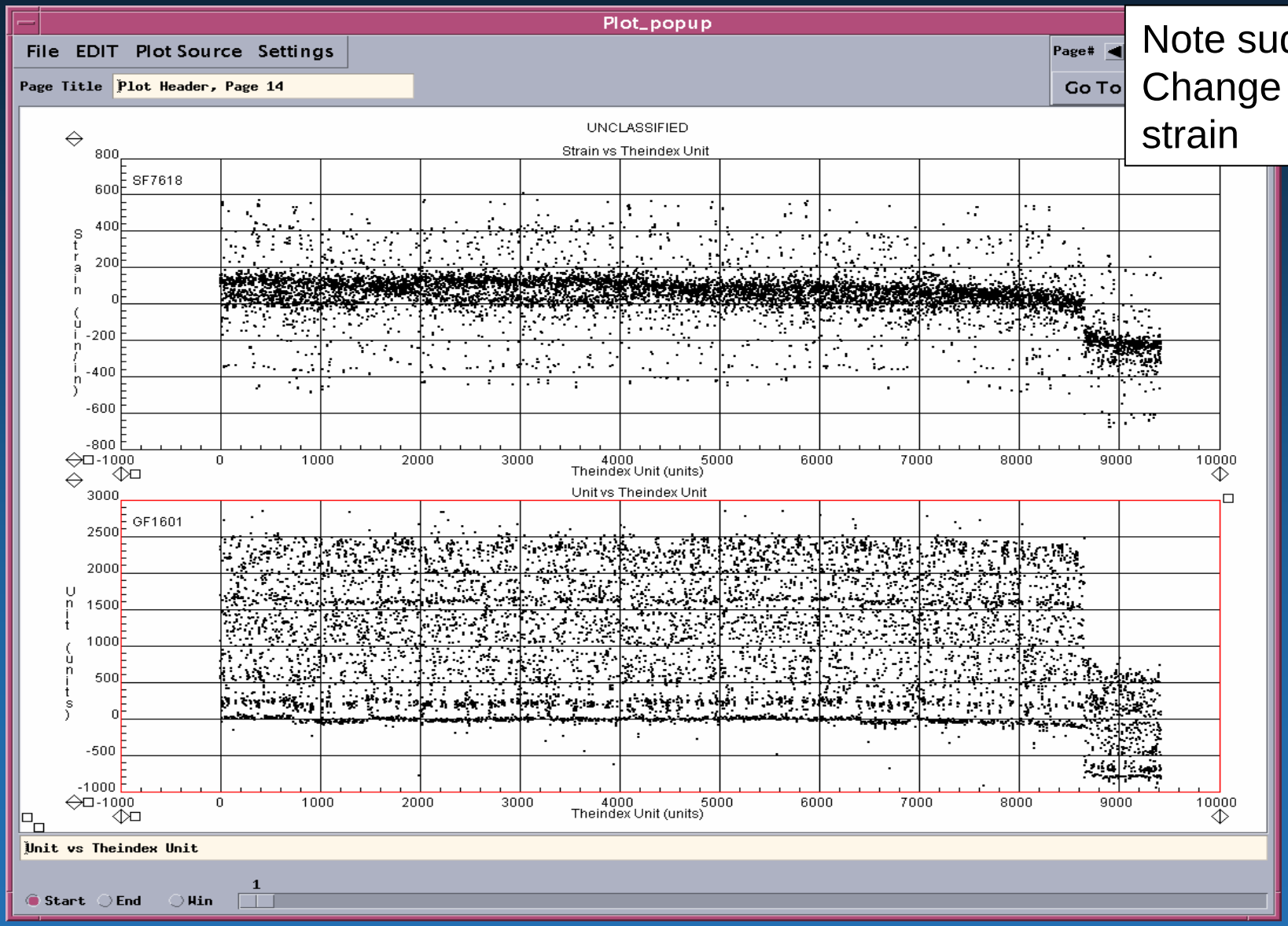
-Consistent uniform repeating strains signify good behavior



Same time slice, bad durability behavior

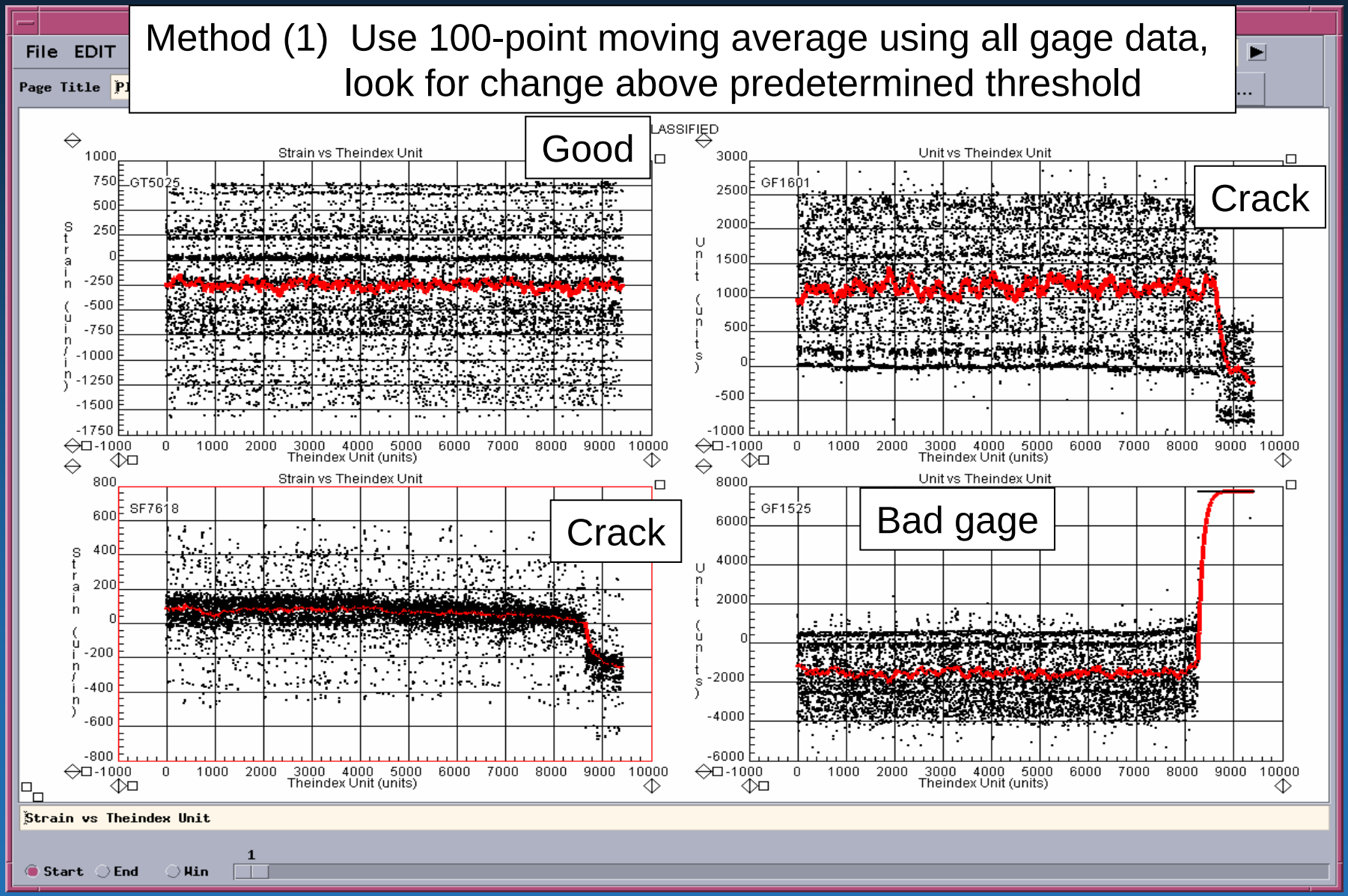


Structural Damage

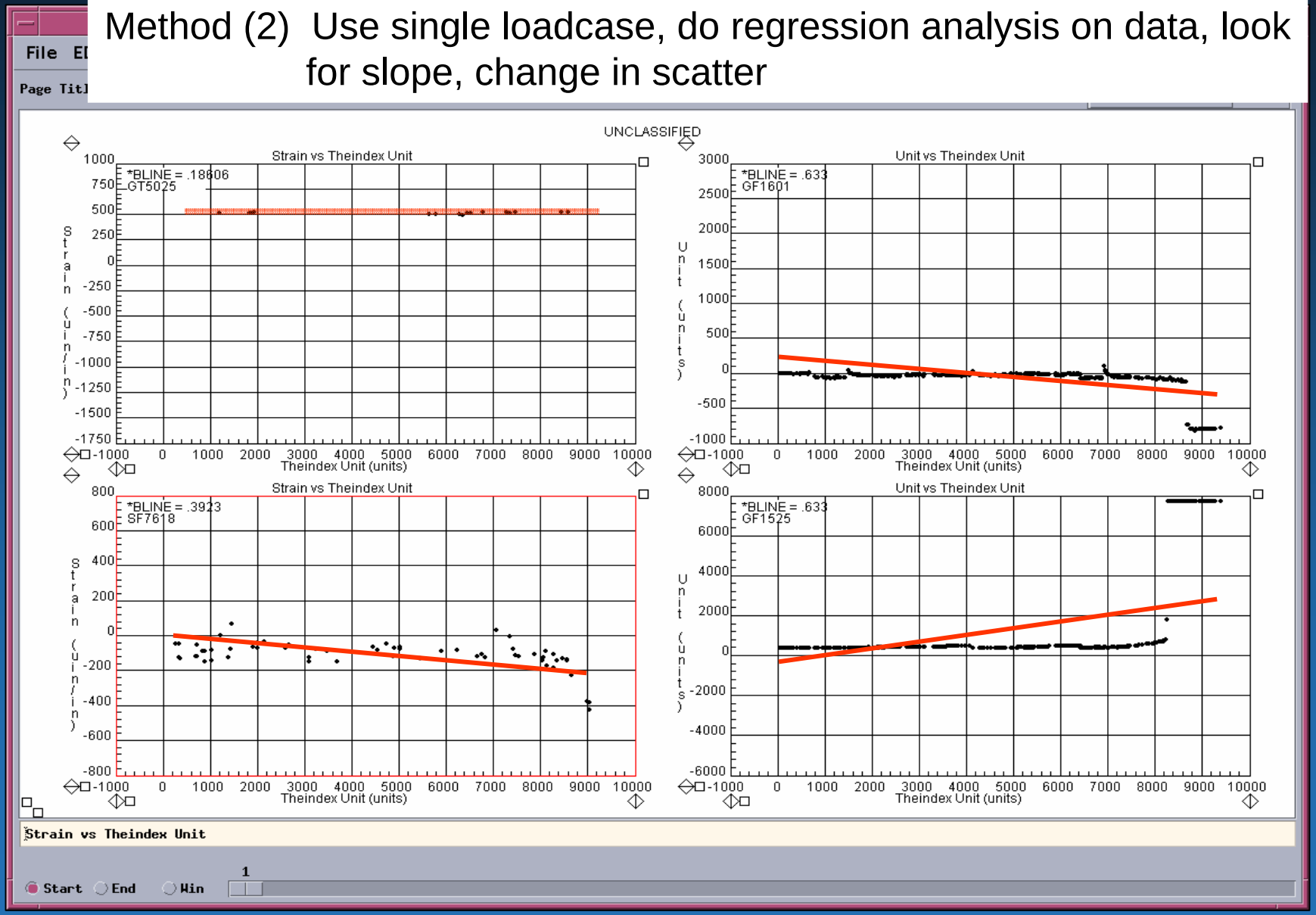


Note sudden Change in strain

Method (1) Use 100-point moving average using all gage data, look for change above predetermined threshold



Method (2) Use single loadcase, do regression analysis on data, look for slope, change in scatter



Summary

-F-22 employed a sophisticated array of automated means to monitor strain gages and deflections during full-scale static and durability testing.

-Real-time comparisons to predictions and preset error limits allowed closer observation of critical data channels.

-Fatigue test monitoring employed a variety of methods to examine strain and deflection data. A variety of real-time and near real-time methods were employed to flag problems with the instrumentation/airframe