Assessing Hot Fire Data with WinPlot

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Introduction

Engine data assessment has two primary components which drive WinPlot's development:

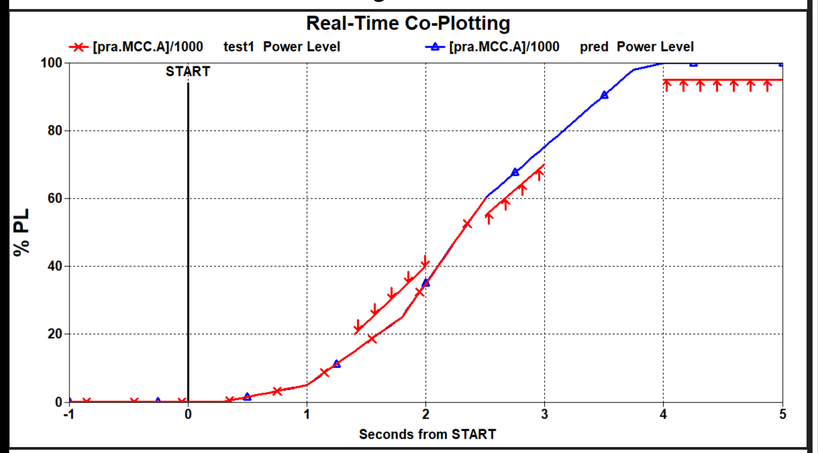
1. Accessing pertinent data
   - Requires the ability to find historical data and efficiently utilize it in comparisons and analysis
   - Facilitates automation for effective analysis
2. Interpreting data
   - To form and validate a physics-based technical understanding
   - For both exploratory and explanatory analysis

Visualization

Data Plotting

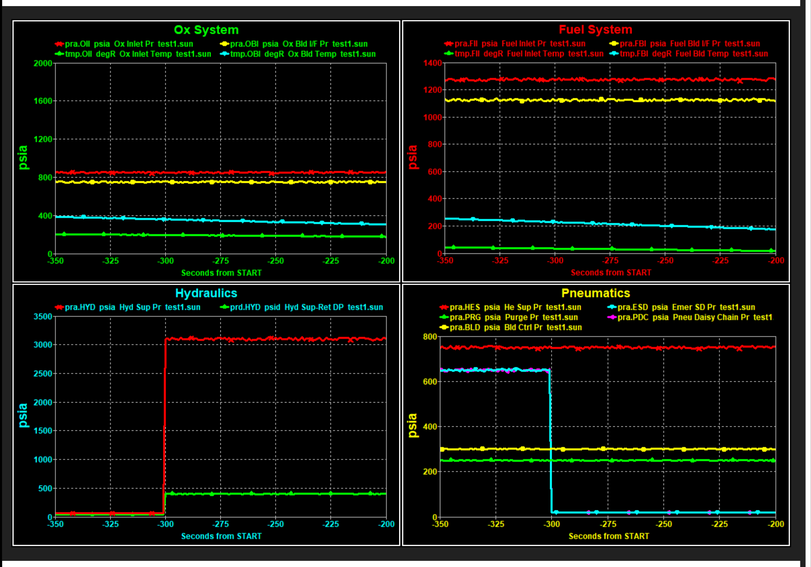
Seamlessly plot data from multiple sources, including historical, real-time, and predictions.

Dynamically add and remove markers such as redlines, events, text, boxes, and images.



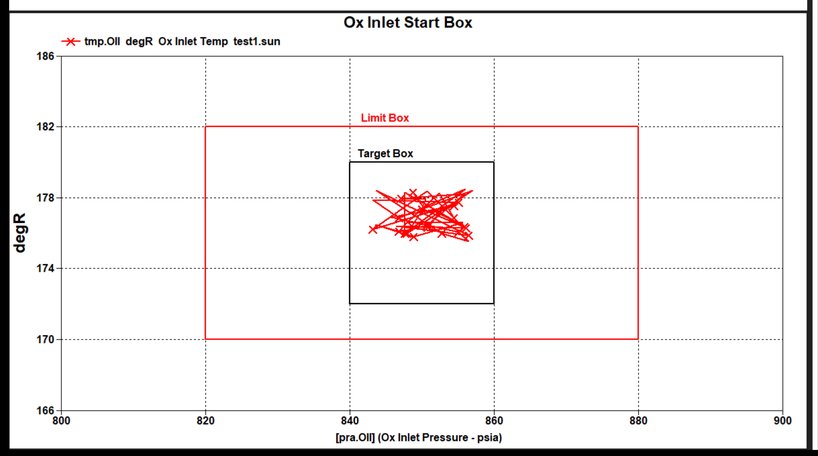
Aesthetic Customization

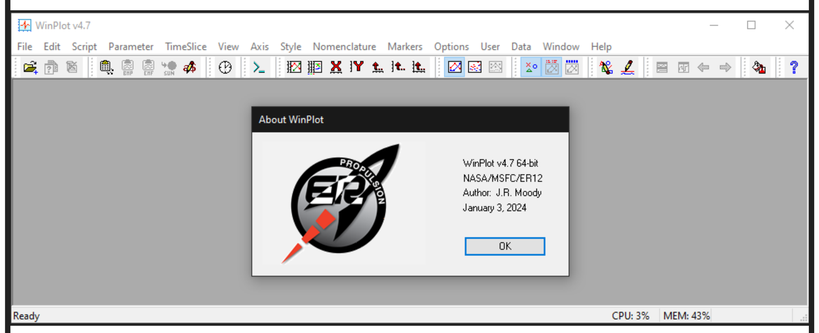
When viewing large amounts of data from complex systems, custom colors allow for intuitive interpretation and reduce cognitive load. Other aesthetic choices like trace thickness, symbols, and style help clearly tell the data's story.



Dimensional Customization

When plotting parameters with different units or significantly different magnitudes, individualized axes are necessary for clear and truthful interpretation.





Data Access

Sun Files

- Fast retrieval
- High compression
- Multiple data acquisition systems
- Microsecond precision
- Parameter and file metadata
- Event based and absolute timing

Database Directories

- Easily reference files
- Quickly add/remove files
- Share events within dbdirs

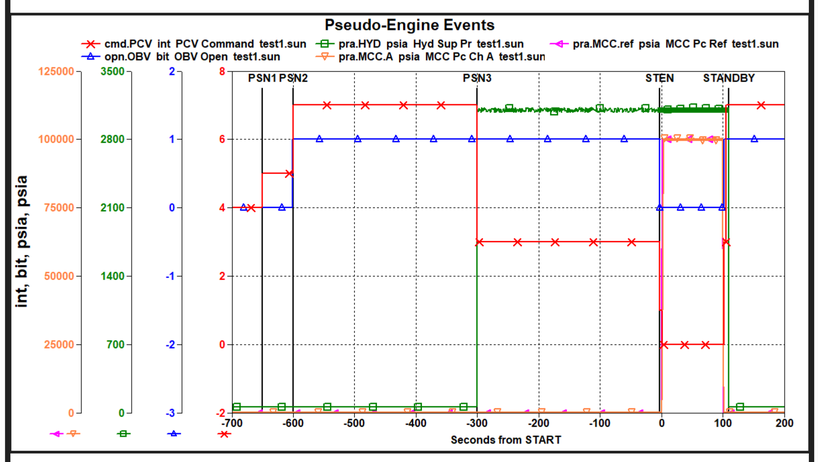
Query

- Search large databases simultaneously
- Complex search expressions
- Seamlessly plot results

Event System

Events provide the framework for effectively utilizing the temporal nature of test data.

The event-based time system allows for synchronization of many files, specification of dynamic timeframes, and automation of responses in real-time.



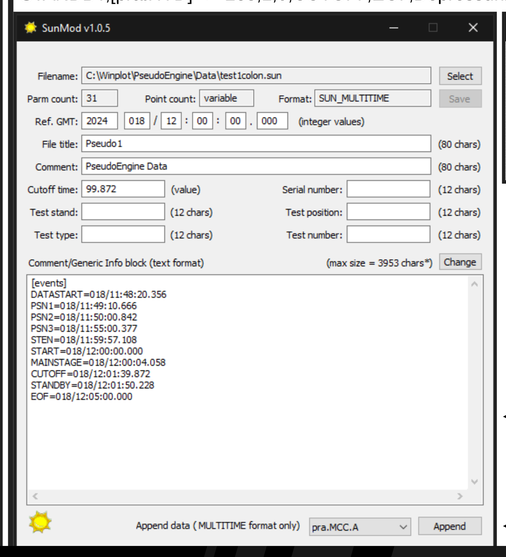
Event Creation

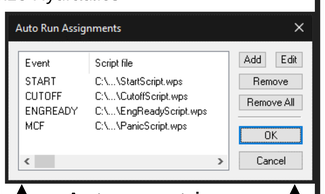
Events can be inserted real-time or post-test based on data trends or status reporting through expression evaluation.

This facilitates phase-specific analysis, anomaly investigation, and real-time status monitoring.

Example event evaluation criteria:

```
;Event name,Specification,Max # of Occurances,Can re-occur after n seconds,
    Beginning at time,Ending at time,Comment
PSN1,[cmd.PCV] >= 5,1,0,BOF,EOF,PCV Command
PSN2,([opn.OBV] >= 1) && ([opn.FBV] >= 1.),1,0,PSN1,EOF,Bleed Valves Open
PSN3,[pra.HYD] > 2e3,1,0,PSN2,EOF,Pressurize Hydraulics
STEN,[cmd.PCV] = 1,1,0,PSN3,EOF,PCV Command
START,[pra.MCC.ref] = 6e4,1,0,STEN,EOF,MCC Pc Command
MAINSTAGE,([pra.MCC.A] >= 99500) || ([pra.MCC.B] >= 99500),1,0,START,EOF,Full Thrust
CUTOFF,[pra.MCC.ref] = 6e4,1,0,MAINSTAGE,EOF,MCC Pc Command
STANDBY,[pra.HYD] <= 2e3,1,0,CUTOFF,EOF,Depressurize Hydraulics
```





Auto runs trigger scripts in response to events for instant real-time analysis

Events can be manually added to file metadata and viewed using SunMod

The Seven Elements of Flight Rationale

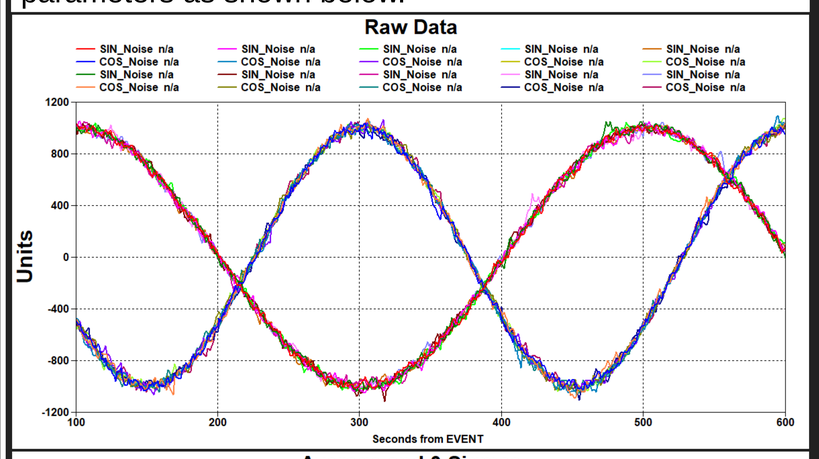
#	Element	Element Expanded
1	**Solid technical understanding**	Physics-based or root cause understanding of issue, based on engineering data
2	**Condition relative to experience base**	Experience base includes full-scale flight, ground test, or qualification-level tests
3	**Bounding case established**	Using physics-based understanding, determine the bounding case
4	**Self-limiting aspects**	Physical reasons why it can't get any worse than the bounding case or show the part is fail-safe
5	**Margins understood**	Adequate margins, ideally not substantially reduced from baseline
6	**Assessment based on data, testing, and analysis**	Final risk assessment based on test data and analysis, not gut feel or expert opinion
7	**Interactions with other elements and conditions addressed**	Address interactions with other conditions (MRB, changes, technical issues), and vehicle elements

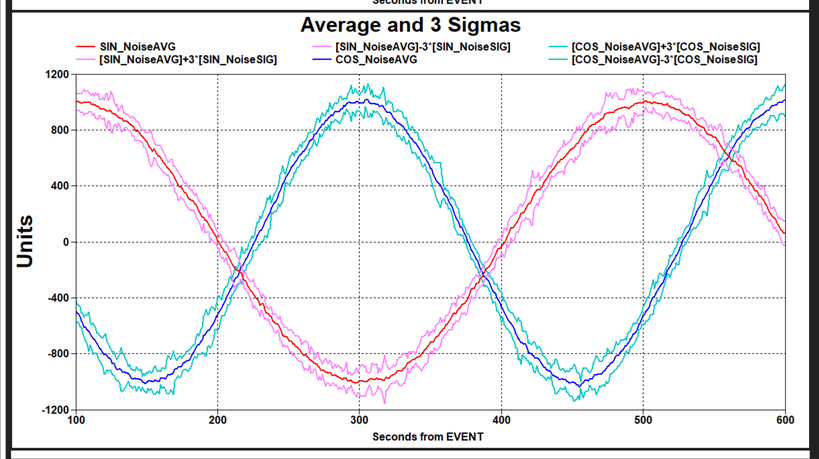
Calculations

In addition to basic arithmetic operations, analysis often requires logical, bitwise, temporal, rounding, smoothing, and curve-fitting expressions. WinPlot also provides REFPROP integration and external functions, often writing in Python, MATLAB, or C.

These expressions may be used in the WinPlot interface and scripts, but they may also be applied in the SunCalc program to generate new files from multi-step calculations.

Like SunCalc, the WinSig program generates new data files. However, it creates extremely useful statistical parameters as shown below.





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