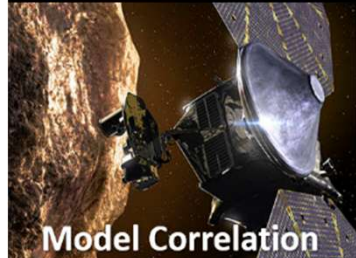
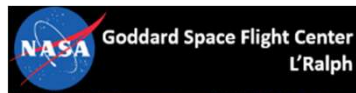
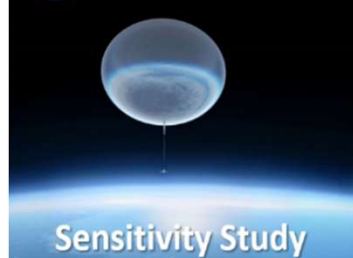
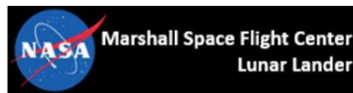




Analyze Smarter

MORE INFORMATION; BETTER SOLUTIONS



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Jacob Moulton
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Jamie Eyre
Jamie.Eyre@redwirespace.com

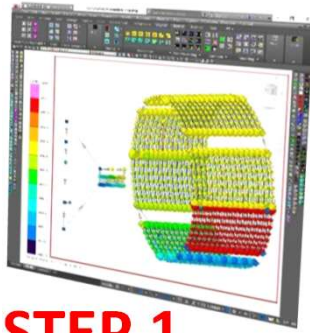
www.Veritrek.com



What is Veritrek?

REDUCED-ORDER MODELING TO ENHANCE THERMAL DESKTOP®

Thermal Desktop®



STEP 1

Select Thermal Model

Creation Tool



STEP 2

Convert to reduced-order model.

Exploration Tool

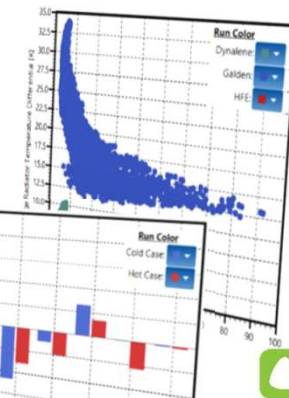
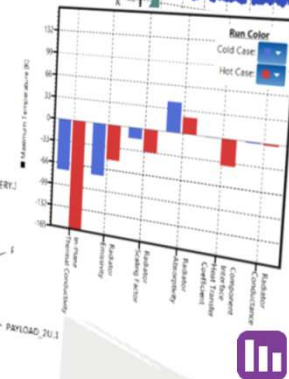
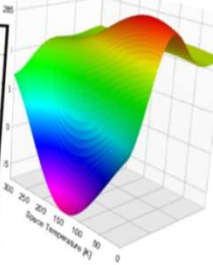
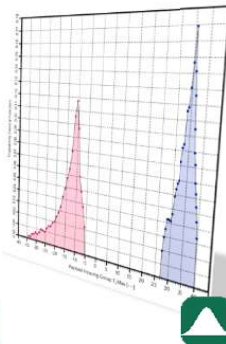
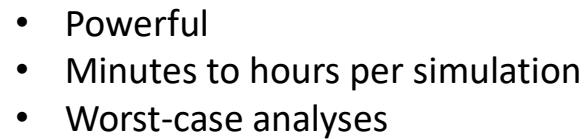


STEP 3

1000s of results in seconds.



MORE INFORMATION LEADS TO BETTER SOLUTIONS



1000s of simulations in seconds
Expanded analysis
Improved understanding



What is a ROM?

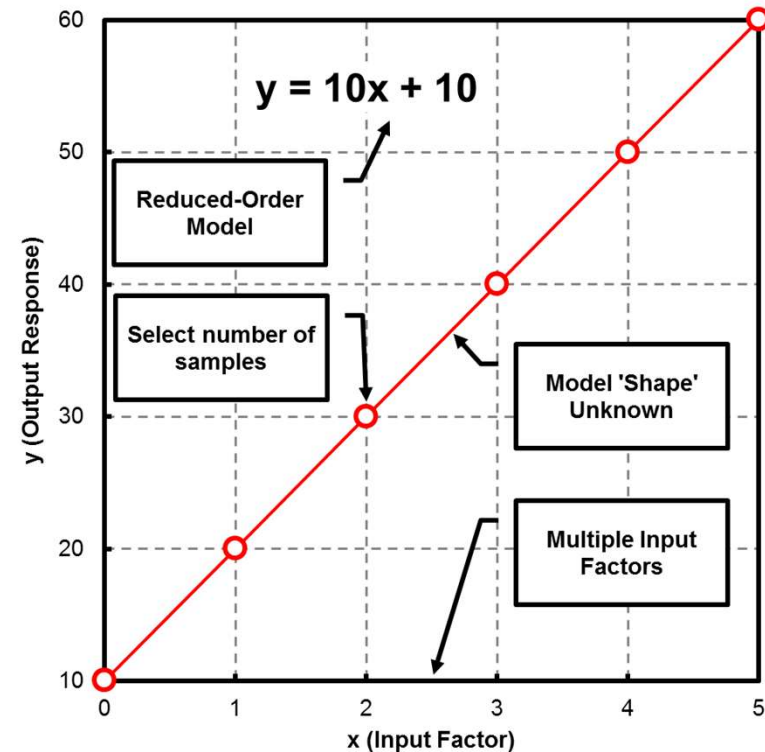
ACCURATE SURROGATE OF A HIGH-FIDELITY MODEL

A statistical emulator

- Accurate surrogate of a high-fidelity model through intelligent sampling and robust data fitting
- Sampling based on **Latin Hypercube** methods
- Data fitting based on **Gaussian-Process** methods

Veritrek Creation Tool allows for...

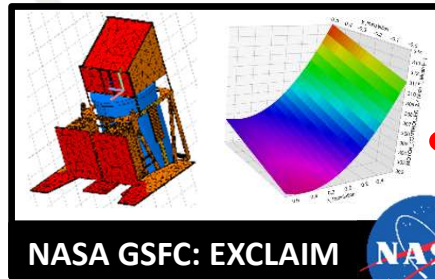
- ...the selection of multiple input factors
 - Most to date is 33
- ...to return multiple output responses
 - Most to date is 91



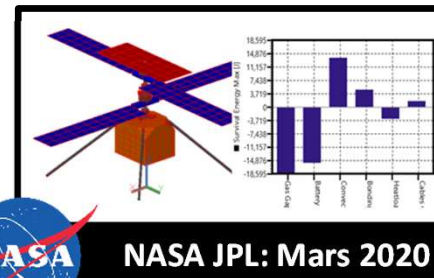


When can you use Veritrek?

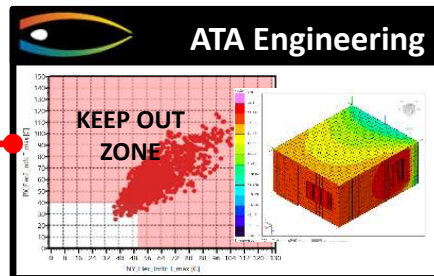
MULTIPLE AREAS OF A DESIGN LIFE CYCLE



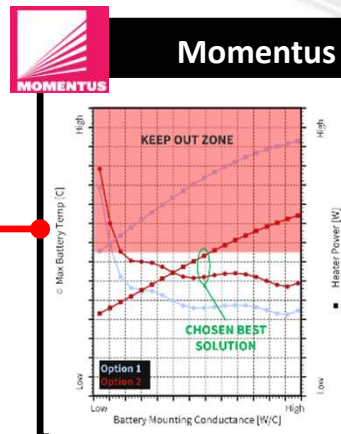
Early Design
Trade studies



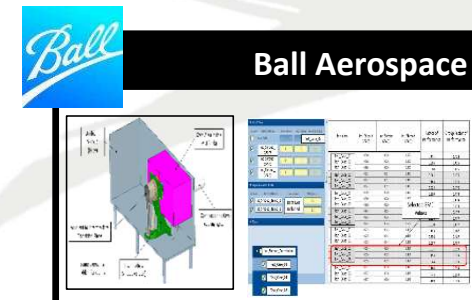
Detailed Design
Sensitivity Studies



Detailed Design
Design Optimization



Final Design
Design Verification



AI&T
Model Correlation



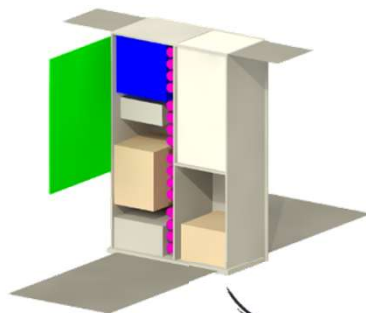
Demonstration



How to build a ROM

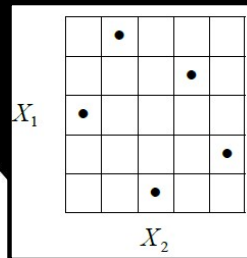
VERITREK CREATION TOOL

Thermal Desktop® 



Import symbols,
registers, nodes,
case sets, etc.

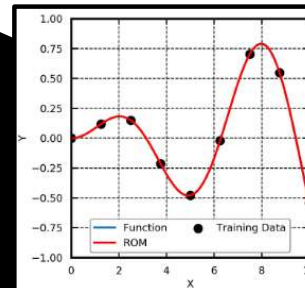
ROM Setup



Create training runs

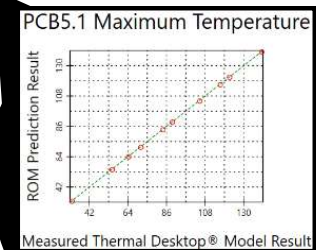
Creation Tool

Generate training data
and Perform data-fit



ROM Creation

Determine ROM
accuracy

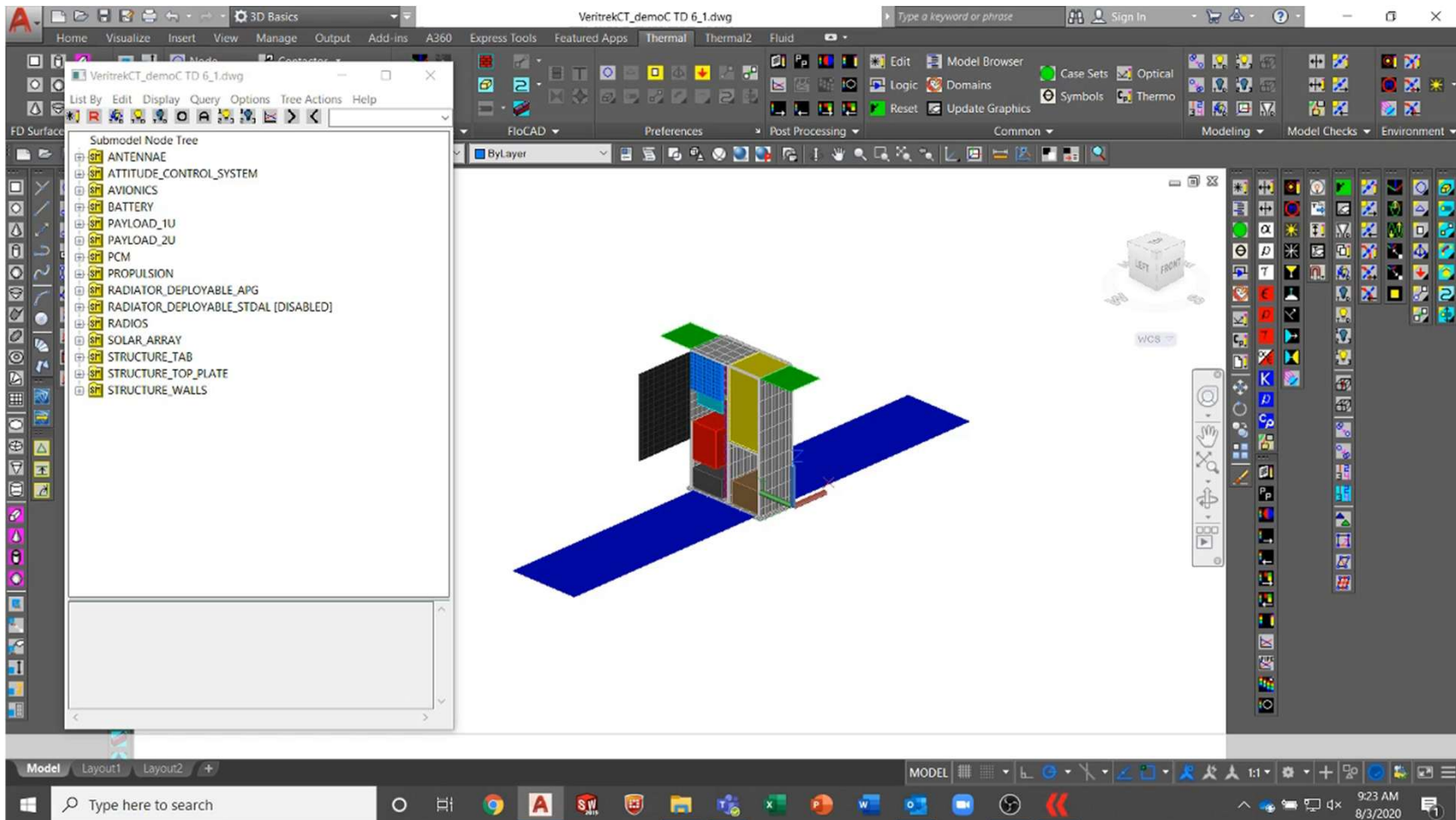


ROM Testing



Demo

VERITREK CREATION TOOL



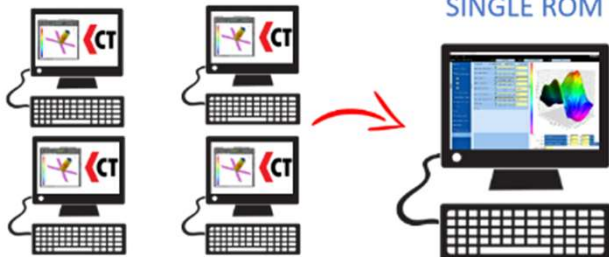


Creation Tool: Parallelization

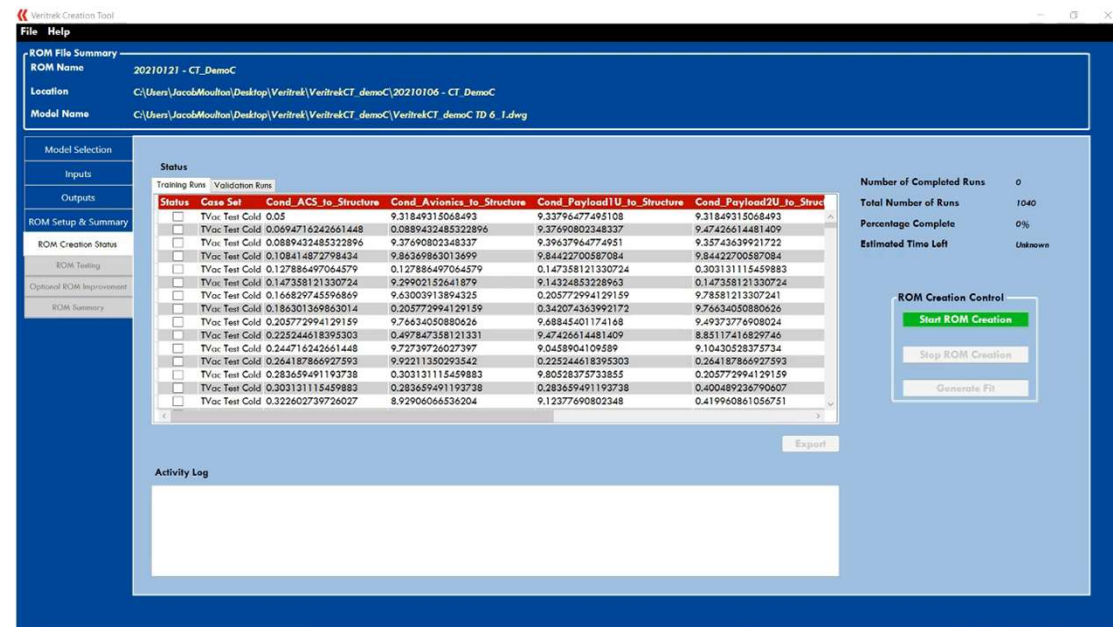
ROM Parallelization Feature

- Split large quantity of training runs into multiple instances of Veritrek and Thermal Desktop
- Reduce the time it takes to create a ROM
- Limitation: can only support as many instances as there are Thermal Desktop licenses

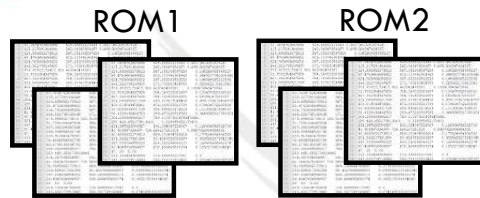
MULTIPLE INSTANCES OF
THERMAL DESKTOP AND VERITREK



SINGLE ROM



Creation Tool



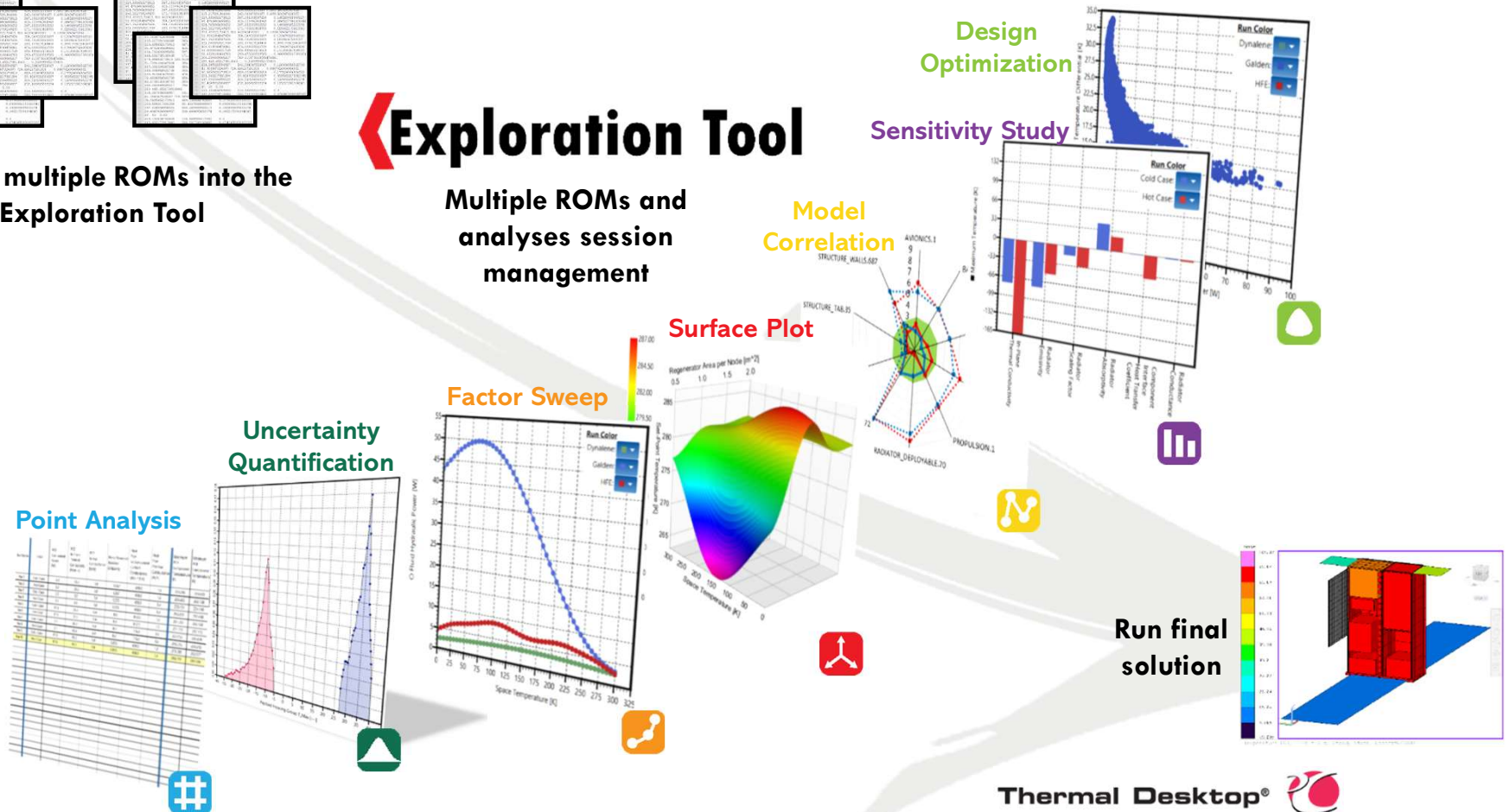
Import multiple ROMs into the Exploration Tool

Exploration Tool

Multiple ROMs and analyses session management

How to use a ROM

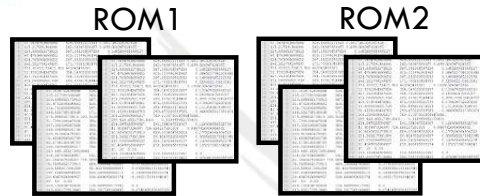
VERITREK EXPLORATION TOOL



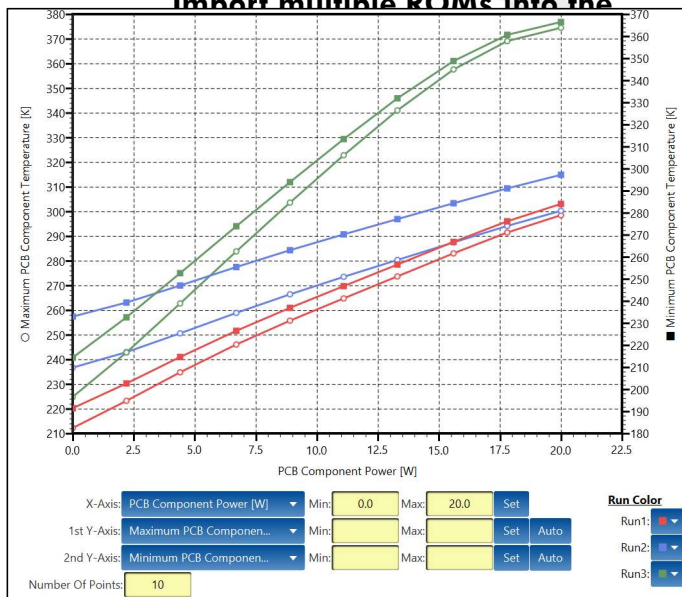
Thermal Desktop®



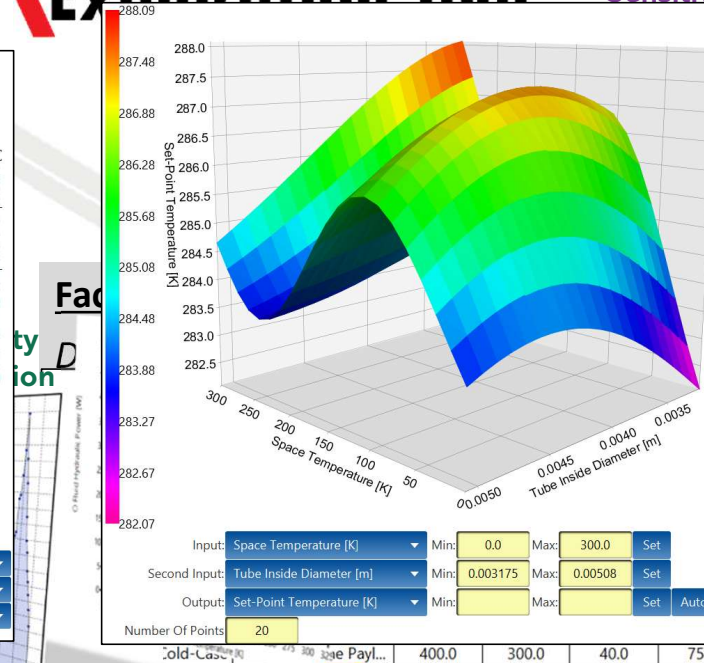
Creation Tool



Import multiple ROMs into the



Exploration Tool

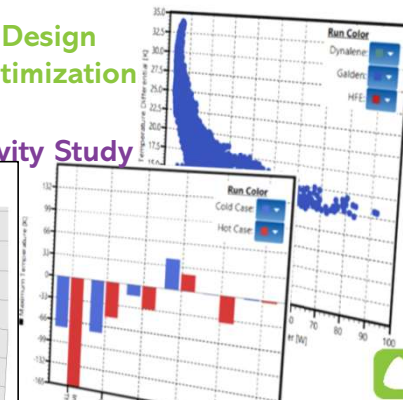


How to use a ROM

VERITREK EXPLORATION TOOL

Design Optimization

Sensitivity Study

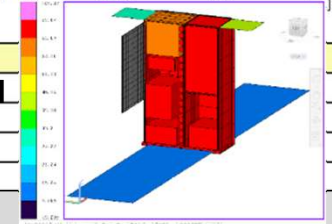


Analysis

determine trade-offs and relationships

	Radiator Absorptivity	Radiator Emissivity	Radiator Scaling Factor	Radiator Conductance [W/K]	Maximum Temperature [K]	Minimum Temperature [K]	Maximum Temperature Difference
Run 1	0.050	0.100	0.1		21.9		
Run 2	0.500	0.900	0.3		17.8		
Run 3	0.100	0.300	0.3		23.2		
Run 4	0.200	0.500	0.5		29.4		
Run 5	0.300	0.700	0.8		32.4		

Run final solution



Thermal Desktop®





How to use a ROM

VERITREK EXPLORATION TOOL

Point Analysis

Run	Case	Area	Volume	Mass	Energy	Power	Pressure	Temperature	Velocity	Acceleration	Displacement	Strain	Stress	Frequency	Phase	Amplitude	Mean	StdDev	Min	Max
1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

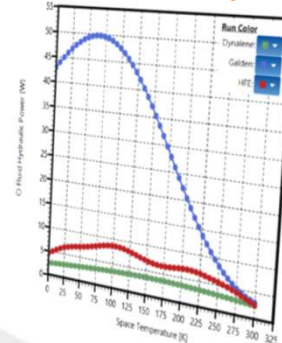


Point Analysis

Determine bounded-case scenarios for required design envelope

- Calculates output data directly impacted by selected input factors
- Populates a table of input factors and corresponding output responses

Factor Sweep

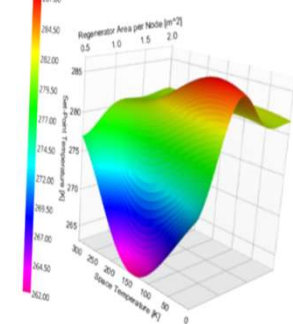


Factor Sweep Analysis

Determine trade-offs and relationships within a design space

- Performs a parametric sweep of calculated output responses
- Plots output responses over the given range of a single input variable

Surface Plot



Surface Plot Analysis

Determine trade-offs and relationships within a design space

- Performs two parametric sweeps of calculated output responses
- Plots output responses over the given range of two input variables



Determine input factor impact and influence in a design space

- Calculates average impact each input factor has on an output response
- Plots a Pareto chart-style bar graph comparing output sensitivities to input factors

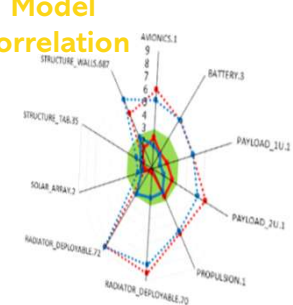
Determine design parameters fall within the required design envelope

- Selects random input combinations, within a defined range, to produce single output response points
- Plots points of output responses and produces a Pareto Front



Determine combination of variables to correlate a thermal model to test data

- Produces input factor combinations to yield desired output responses within user-defined test parameters
- Populates a table of possible input combinations and determines best performing results

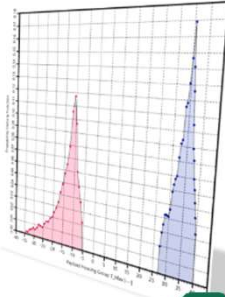




How to use a ROM

VERITREK EXPLORATION TOOL

Uncertainty Quantification



Uncertainty Quantification Analysis

Determine the uncertainty of a model

- Calculates the statistical likelihood of key output responses falling within a defined range
- Plots the distribution of results for a selected output response over a range of input factors

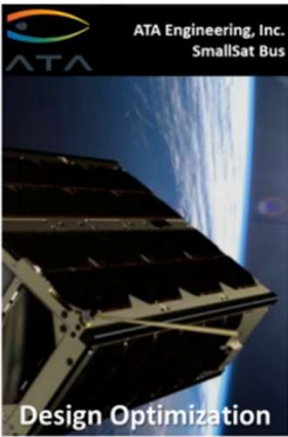
www.Veritrek.com



Demo

VERITREK EXPLORATION TOOL

VERITREK



www.veritrek.com





Case Studies



Momentum: Vigoride

Veritrekk provided insight into confident design decisions

Veritrekk helped close the PCM thermal design prior to CDR and allowed for early investigation into future mission planning.

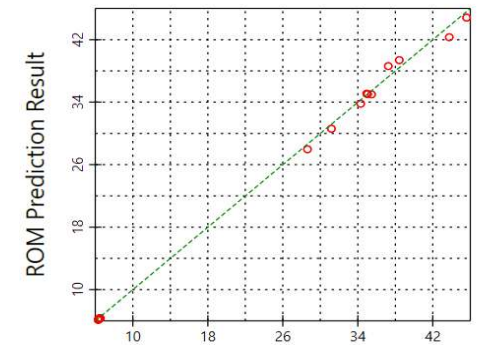


ROM Profile:

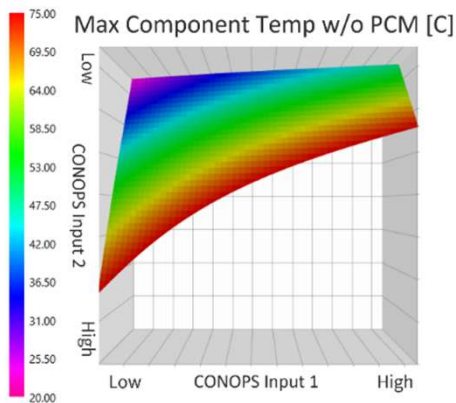
- 7 Input Factors
- 28 Output Responses
- 212 training runs

CUSTOMER SUCCESS STORY

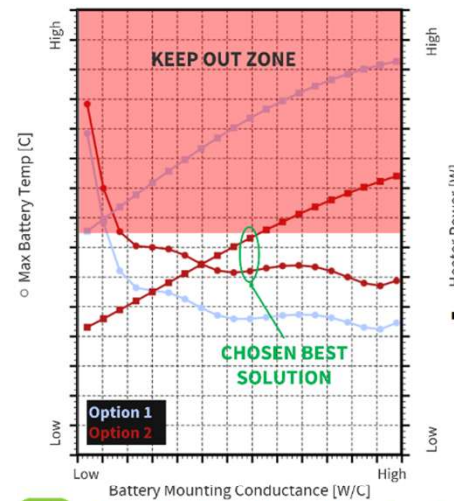
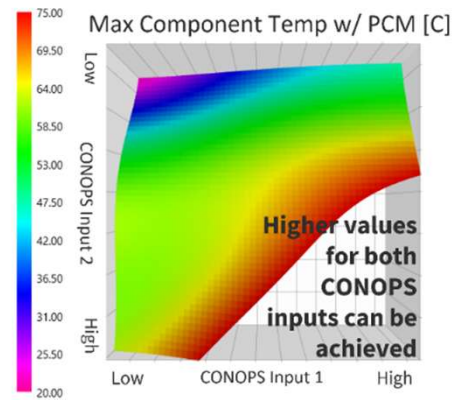
BATTERY T_{Max}



Measured Thermal Desktop® Model Result



Surface Plot Analysis



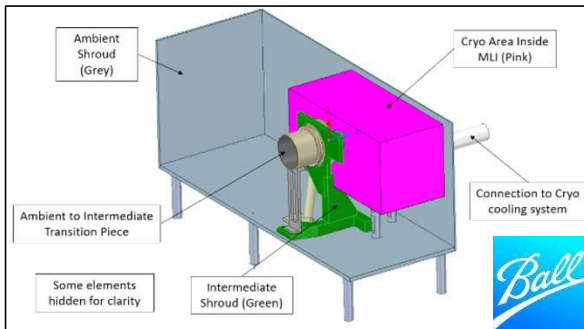
Optimization Analysis



Ball Aerospace: IRAD

NEW CUSTOMER SUCCESS STORY

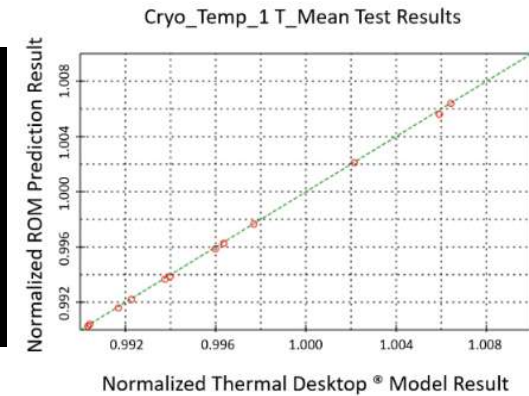
Veritrekk enabled more in-depth correlation of thermal testing



“Each ROM creation and correlation effort took 1 to 2 days, an effort that would have taken 3 to 4 weeks using traditional guess-and-check approaches.” TFAWS 2021.

ROM Profile:

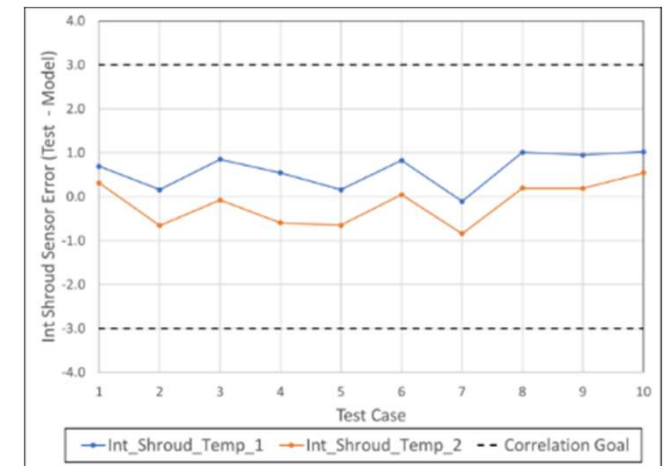
- 16 Input Factors
- 17 Output Responses
- 208 training runs



Test Case	Int_Shroud GFAC3	Int_Shroud GFAC2	Int_Shroud GFAC1	Factor of Performance	Group Factor of Performance
Test_Case_01	0.968	0.326	0.500	0.111	0.425
Test_Case_02	0.968	0.326	0.500	0.305	0.425
Test_Case_03	0.968	0.326	0.500	0.008	0.425
Test_Case_01	0.627	0.351	0.470	0.261	0.470
Test_Case_02	0.627	0.351	0.470	0.184	0.470
Test_Case_03	0.627	0.351	0.470	0.024	0.470
Test_Case_01	0.969	0.320	0.492	0.209	0.474
Test_Case_02	0.969	0.320	0.492	0.463	0.474
Test_Case_03	0.969	0.320	0.492	0.474	0.474
Test_Case_01	0.940	0.324	0.477	0.477	0.477
Test_Case_02	0.940	0.324	0.477	0.477	0.477
Test_Case_03	0.940	0.324	0.477	0.477	0.477
Test_Case_01	0.735	0.344	0.487	0.143	0.487
Test_Case_02	0.735	0.344	0.487	0.336	0.487
Test_Case_03	0.735	0.344	0.487	0.007	0.487
Test_Case_01	0.554	0.359	0.461	0.331	0.529
Test_Case_02	0.554	0.359	0.461	0.154	0.529
Test_Case_03	0.554	0.359	0.461	0.044	0.529
Test_Case_01	0.877	0.330	0.476	0.166	0.559
Test_Case_02	0.877	0.330	0.476	0.224	0.559
Test_Case_03	0.877	0.330	0.476	0.169	0.559

Intermediate shroud correlation
20,000 ROM iterations produced
4500 solutions within +/- 1K
across 10 different test cases

Correlation Analysis





NASA JPL: Mars Helicopter Thermal Design

Veritrekk enabled evaluation of thermal design sensitivities



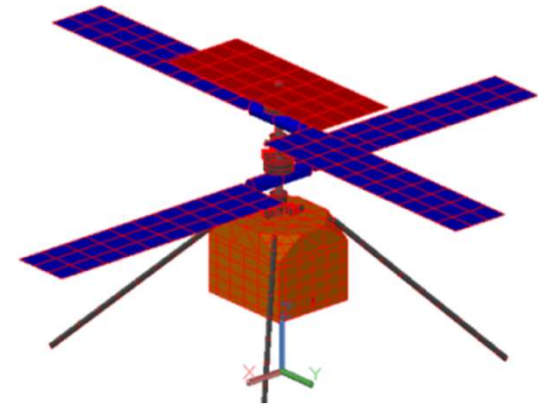
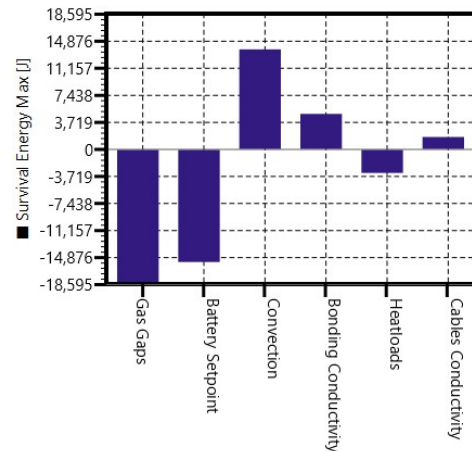
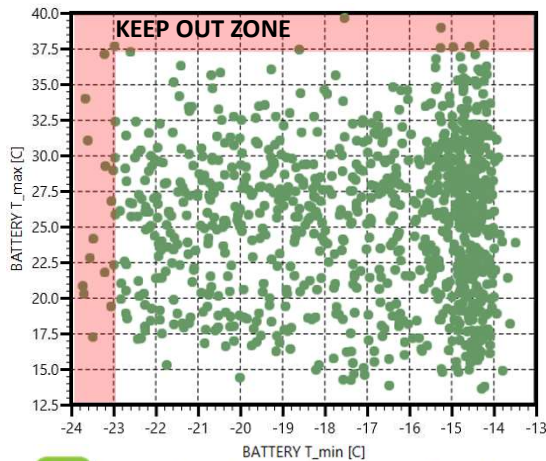
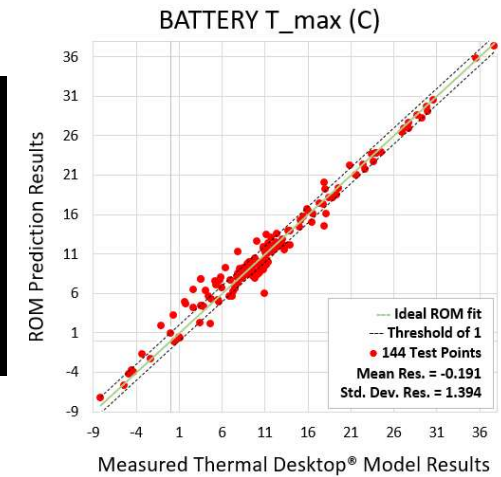
"It would have taken over 4 months to obtain the same level of information that Veritrekk provided in 10 days."

NASA JPL, TFAWS 2018

ROM Profile:

- 6 Input Factors
- 36 Output Responses
- 452 training runs
- 248 hours

CUSTOMER SUCCESS STORY





SOFTWARE INFORMATION



Conclusion

VISIT WWW.VERITREK.COM FOR MORE INFORMATION, CASE STUDIES, AND PUBLICATIONS

Start your 30-day free trial of Veritrek

- **Current Version: 4.3.1** supports compatibility with Thermal Desktop up to 2024 R2
- **Coming soon in 2026!** Version 4.4.0 will support compatibility with Thermal Desktop versions 2024 R1 through 2026 R1
 - *Developmental version available upon request*
- Contact Jamie.Eyre@rdw.com for more information and to request your free trial

Hands-on Session

Monday 3:00-5:00 pm

Madison Boardroom