Perform a Cost and Mass Trade Study using Veritrek™

Conducting trade studies is a common practice throughout a thermal design life cycle. Analysts want to understand which aspects of their design produce the best performing system, and managers want to understand the trade-offs between thermal performance, mass, and cost. Using Veritrek, trade studies evaluating different thermal design options can be performed faster and easier than using traditional thermal analysis techniques, which typically only analyze a few discrete worst-case scenarios. The following example demonstrates how Veritrek can be used to directly compare the thermal performance, mass, and cost trade-offs between four different thermal designs of a 6U CubeSat (two different deployable radiator configurations and either including or not including a thermal energy storage panel).

The goal of this trade study example is to find a thermal design that keeps the 1U Payload below 60°C, while meeting the mission's mass and cost budget.

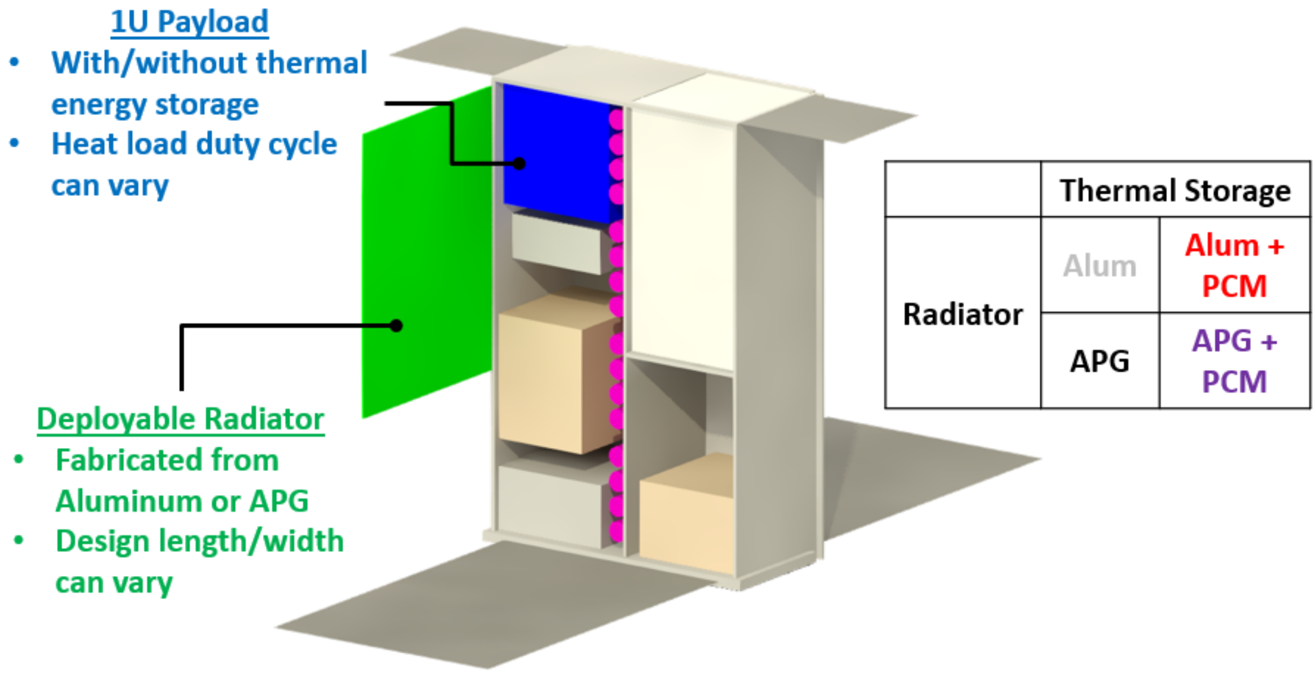
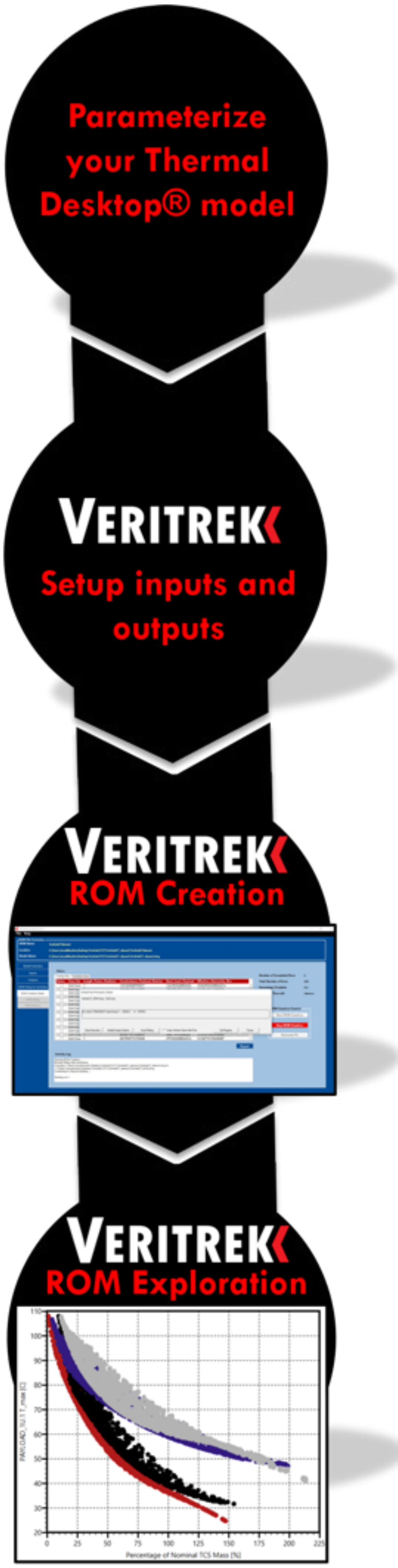


Figure 1: Thermal Desktop® model used to perform the cost and mass trade study

Veritrek gives analysts a more complete understanding of their thermal design's behavior (not just stacked worst-case scenarios) by providing a high-fidelity depiction of the entire design space. This provides the team with better information to make efficient performance decisions, and allows managers to confidently consider the thermal performance, mass, and cost trade-offs to make the best data-driven decision.

This example shows: 1) how the Veritrek Creation Tool is used to create a reduced-order model (ROM) that captures the various thermal design options (Steps 1-4), and 2) how the Veritrek Exploration Tool is used for rapid trade study analyses (Step 5).



Step 1: Parameterize your Thermal Desktop® model. Include the thermal design changes you want to study as symbols in your Thermal Desktop® model, and setup registers to track the mass and cost of each design change.

Step 2: Set up your ROM's input factors in the Veritrek Creation Tool.

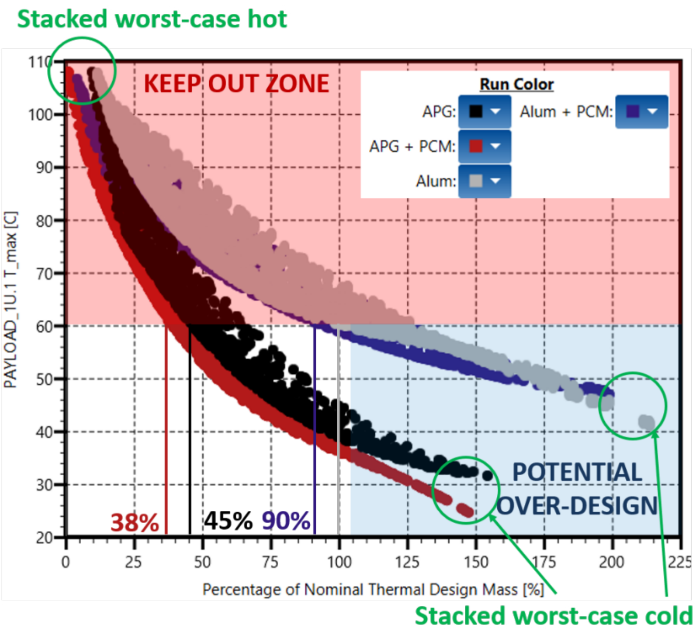
Name	Nominal	Min	Max	Type
Deployable Radiator Type	N/A	APG	Std Al	Categorical
PCM Option	N/A	0	1	Categorical
Payload Heatload [W]	15	15	60	Continuous
Payload OnTime [s]	1500	1000	5000	Continuous
Radiator length [mm]	167	50	350	Continuous
Radiator width [mm]	224	25	225	Continuous

Step 3: Set up your ROM's output responses in the Veritrek Creation Tool. Veritrek can easily include non-thermal responses such as mass and cost.

Name	Type	Min	Mean	Max
PAYLOAD_1U.1 [C]	Node Temperature			✓
Percentage of Nominal TCS Mass [%]	Register			✓
TCS Cost [$USD]	Register			✓

Step 4: Create and test your ROM in the Veritrek Creation Tool. This is performed automatically by Veritrek.

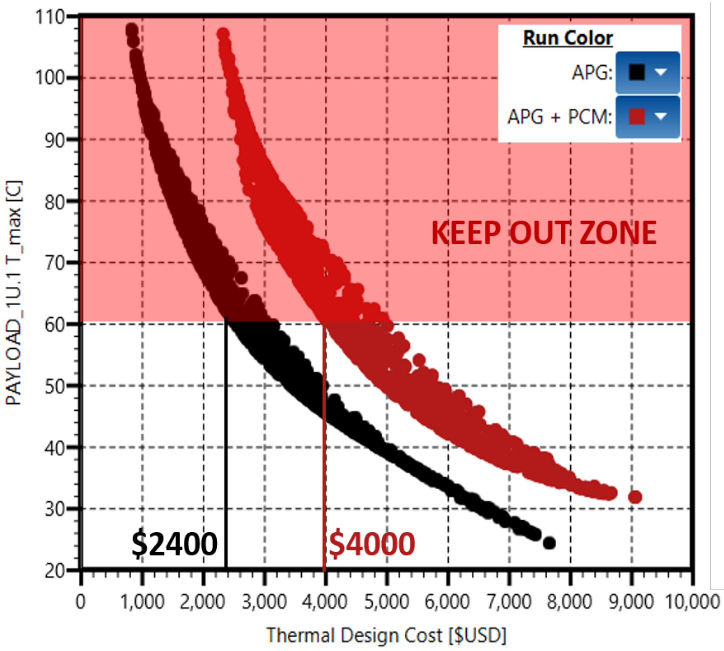
Step 5: Use the Veritrek Exploration Tool's Optimization Analysis feature to understand the trade-offs of each option and choose the best thermal design. In this example, four runs were setup to replicate the four different thermal designs: 1) APG radiator, 2) Aluminum radiator, 3) APG radiator and PCM on the 1U Payload 4) Aluminum radiator and PCM on the 1U Payload.



Step 5a: Observe trade-offs between thermal performance and mass.

In this example, the payload's duty cycle was fixed and only the size of the radiator was allowed to vary; however, this is easily modified in the Veritrek Exploration Tool.

The Optimization Analysis feature quickly produces payload temperature and thermal design mass results for several thousand radiator sizes, and provides a visual representation of the entire design space for the thermal design options. There are multiple radiator sizes that can meet the temperature requirement; however, results show that choosing an APG radiator can reduce the thermal design mass by **55% (without a PCM panel on the 1U Payload) or 62% (with a PCM panel).**



Step 5b: Observe trade-offs between thermal performance and cost.

To understand the trade-offs of including a thermal energy storage on the 1U Payload, a second Optimization Analysis was performed. One can see that choosing a thermal design consisting of an APG radiator and a thermal energy storage panel would reduce mass by **7%** according to results from Step 5a, but it will cost an additional **$1600** as seen in 5b.

A combination of the results from 5a and 5b provided the manager with the information needed on the trade-offs between thermal performance, mass, and cost to confidently determine which thermal design option should be used for the mission.

By performing a trade study with Veritrek, it was easy to directly compare four different thermal designs to identify several options that keeps the 1U Payload below the 60°C temperature limit, while also understanding how those different options impact the mission's mass and cost budget. By using Veritrek's Optimization Analysis feature, the team was able to understand the entire design space, find an optimal design that was not built off stacked worst-case scenarios, and confidently make the best design decision to achieve mission success.

Get Started