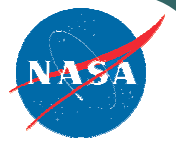
National Aeronautics and Space Administration



A Smart Thermal Block Diagram Tool

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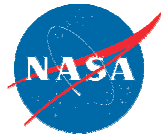
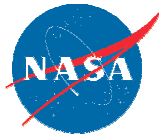
Outline



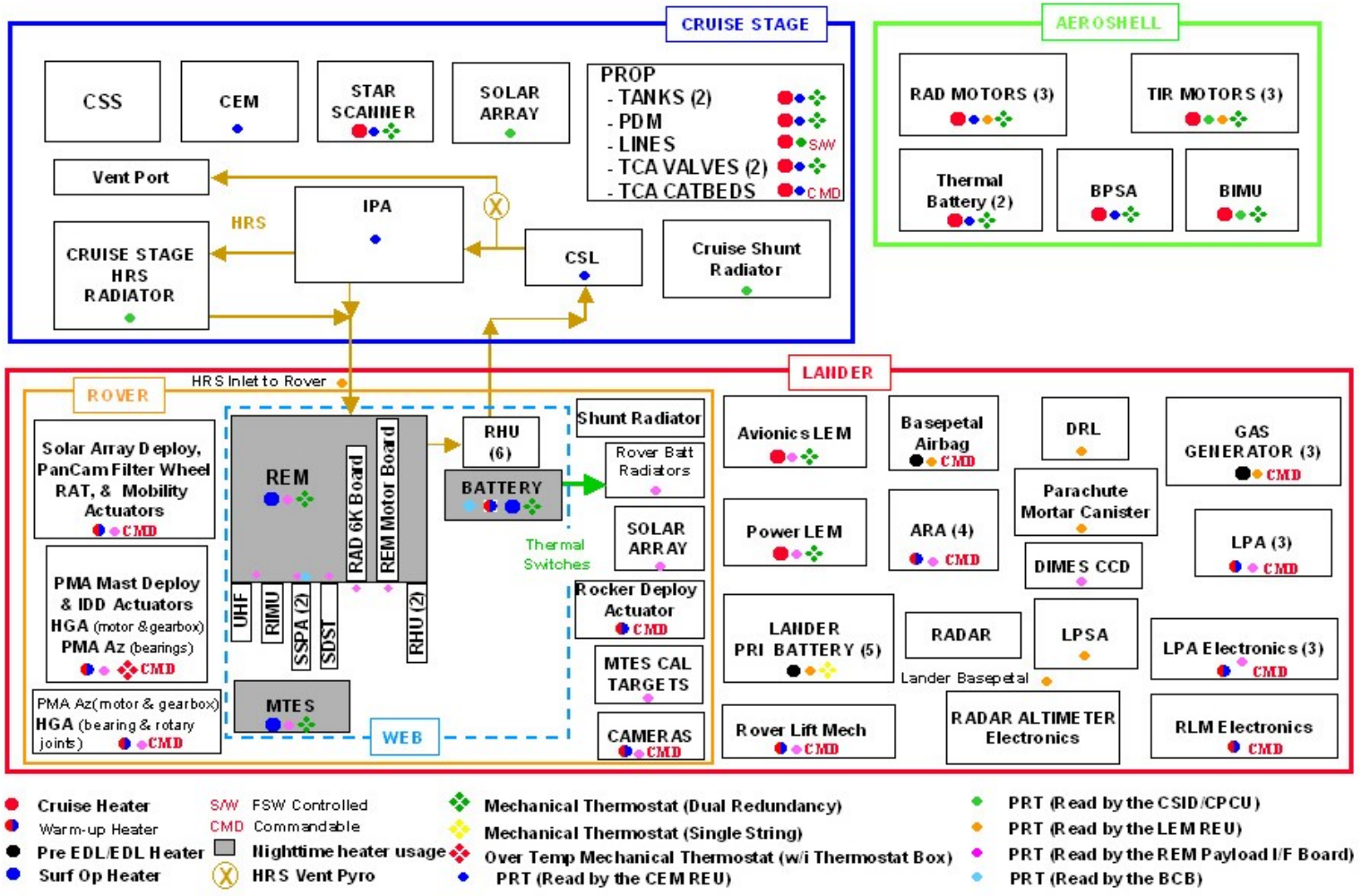
- Problem Statement
- Solution Approach & Requirements
- Tool Overview Using a Simple Example
- Conclusions

Problem Statement (1/2)

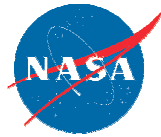


- A critical tool for identifying subsystem architecture is the block diagram
- No associative database capability to define types and quantities of subsystem resources.
- A protracted and manual process must occur to tabulate these resources and transfer them to appropriate cost estimating tools.

Problem Statement (2/2)



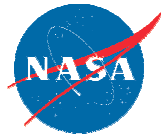
Solution Approach (1/3)



- Block diagram templates for typical JPL missions and instruments (e.g., Orbiters, Landers, Rovers) will be developed

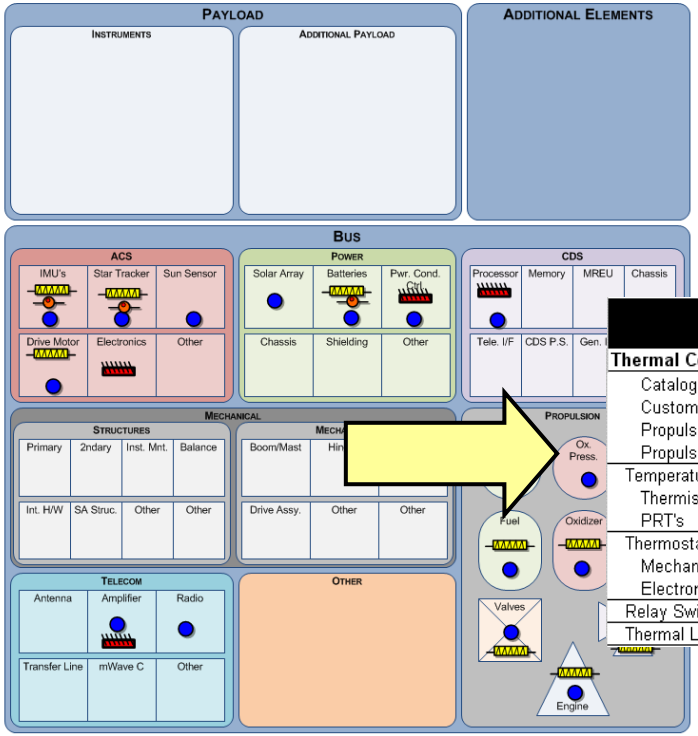
- User will have capability to select thermal subsystem resources as icons and locate each icon in appropriate engineering subsystem or payload element

Solution Approach (2/3)

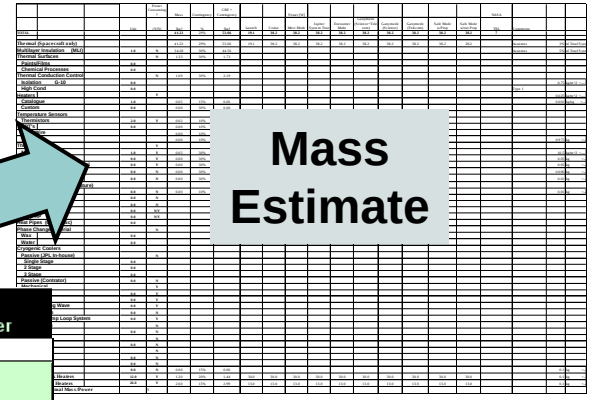


- User will have capability to edit thermal block diagram as needed
- Block diagram tool produces graphical depiction of thermal subsystem, compiles thermal subsystem resources, and determines mass & cost estimates using a JPL Thermal Cost Database

Solution Approach (3/3)

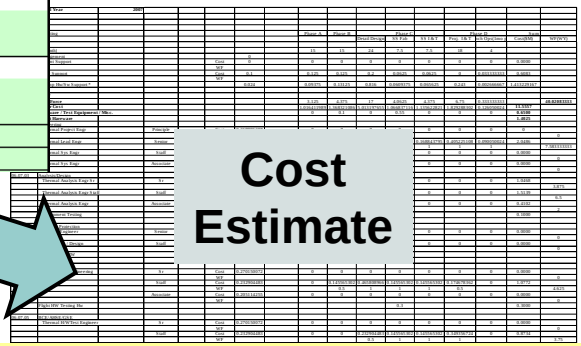


Legend		
Symbol	Count	Description
●	21	Tempsensor (PRT's)
▬	12	Heaters (Custom)
▬	4	Thermal Louvers
◆	3	Thermostats (Electronic)
◆	3	Thermostats (Mechanical)



Mass Estimate

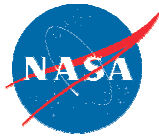
	# of Units	
	Sugg.	User
Thermal Control System		
Catalogue	0	
Custom	0	12
Propulsion Tank Heaters		
Propulsion Line Heaters		
Temperature Sensors		
Thermistors	0	21
PRT's	0	
Thermostats		
Mechanical	0	3
Electronic	0	3
Relay Switches (Heater Control)	0	
Thermal Louvers	0	4



Cost Estimate

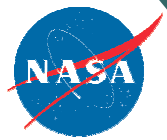
Automated compilation of thermal hardware resources that is then used for subsystem costing & mass estimation

Requirements (1/2)



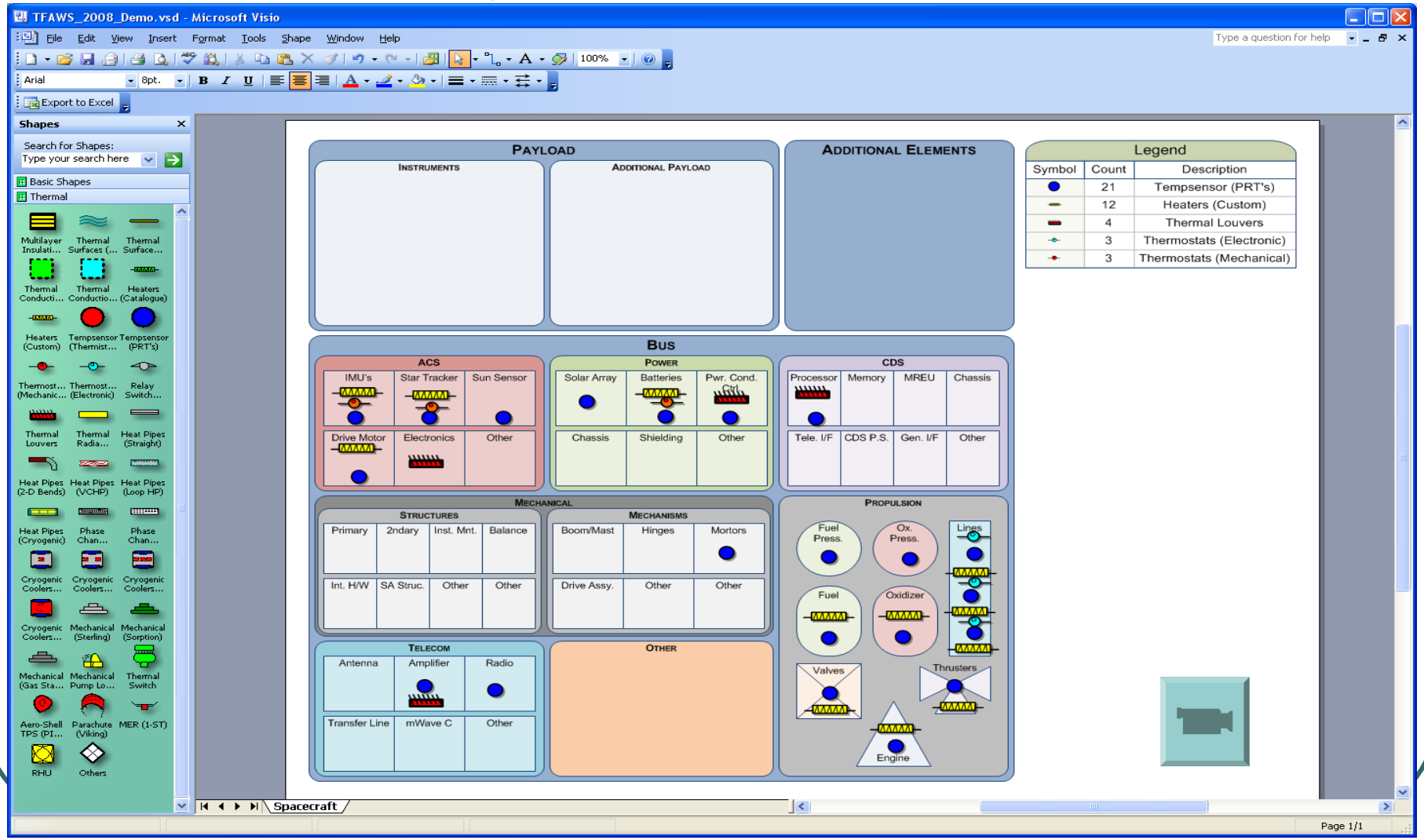
- Use existing COTS software that can be adapted to our purpose
  - MS Visio is an example of such software
- The tool shall be compatible with Team X workstations
- Block diagram development shall consider typical JPL missions & instruments (e.g., Orbiters, Landers, Rovers)
- References to engineering subsystems &payload elements shall be consistent with the JPL standard WBS

Requirements (2/2)



- Thermal subsystem resources shall be mapped one-to-one with the existing JPL Thermal Cost Database
- Output shall be directly usable or importable into the Thermal Cost Estimating Tool

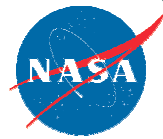
Block Diagram for Earth Orbiter



Thermal Control Elements Used

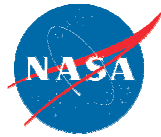
	# of Units	
	Sugg.	User
Thermal Control System		
Catalogue	0	
Custom	0	12
Propulsion Tank Heaters		
Propulsion Line Heaters		
Temperature Sensors		
Thermistors	0	21
PRT's	0	
Thermostats		
Mechanical	0	3
Electronic	0	3
Relay Switches (Heater Control)	0	
Thermal Louvers	0	4

Thermal Cost Tool
Hardware Mass Estimate



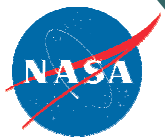
	Specific Masses		CBE	Cont.	PBE
	Sugg.	User			
Thermal Control System			**15.80 kg**	**26%**	**19.9 kg**
Heaters					
Catalogue					
Custom	0.05 kg/unit	0.05 kg/unit	0.60 kg	30%	0.78 kg
Propulsion Tank Heaters					
Propulsion Line Heaters					
Temperature Sensors					
Thermistors	0.02 kg/unit		0.42 kg	15%	0.48 kg
PRT's					
Thermostats					
Mechanical	0.02 kg/unit		0.06 kg	15%	0.07 kg
Electronic	0.01 kg/unit		0.03 kg		0.03 kg
Relay Switches (Heater Control)					
Thermal Louvers	0.98 kg/unit	0.98 kg/unit	3.92 kg	15%	4.51 kg

Thermal Hardware Cost



- The same hardware tally information was imported into a JPL thermal hardware cost database & an estimate was computed
- Results were withheld due to the proprietary nature of this information

Conclusions



- A block diagram tool was developed & it produces graphical depiction of thermal subsystem, compiles thermal subsystem resources, and determines mass & cost estimates using the JPL Thermal Mass & Cost Databases
- This results in a rapid & controlled process for Pre-Phase A thermal design conceptual definition