Research Horizons Day & Research Week March 11-15, 2019

COLLEGE OF ENGINEERING
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

Research Horizons Day

Nuclear Thermal Propulsion Reactor Shutdown and Residual Heating

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Overview

Nuclear thermal propulsion (NTP) has recently become one of the leading candidate technologies for transporting humans to either Mars or the Moon by the 2030s, as it provides three main benefits:

- One-way trip times as short as 3 months
- Reduced crew radiation exposure
- Mission abort at any time during transit

One area that must be characterized is the reactor's performance following each burn in the mission cycle (Figure 1), and how much additional hydrogen would be needed during this shutdown/ cooling phase.

Explanation

This work utilizes the most recent iteration of NASA's NTP Mars mission profile with the original NERVA reactor design (Figure 2) to measure the reactor's performance over time.

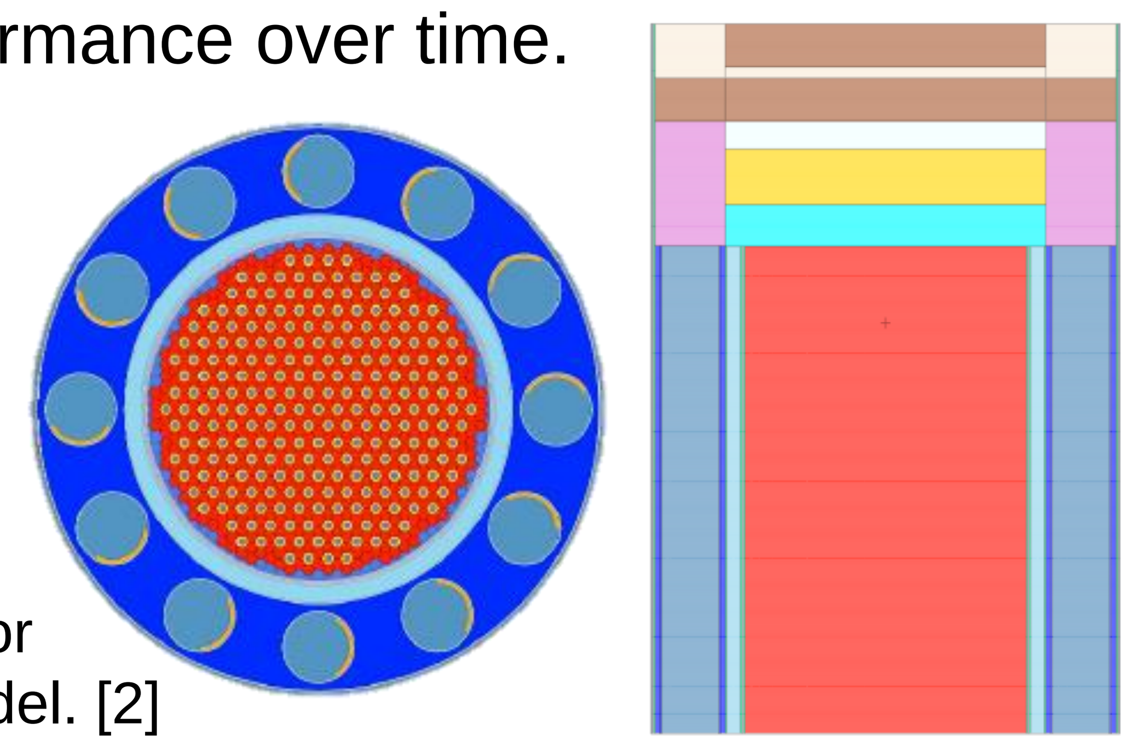
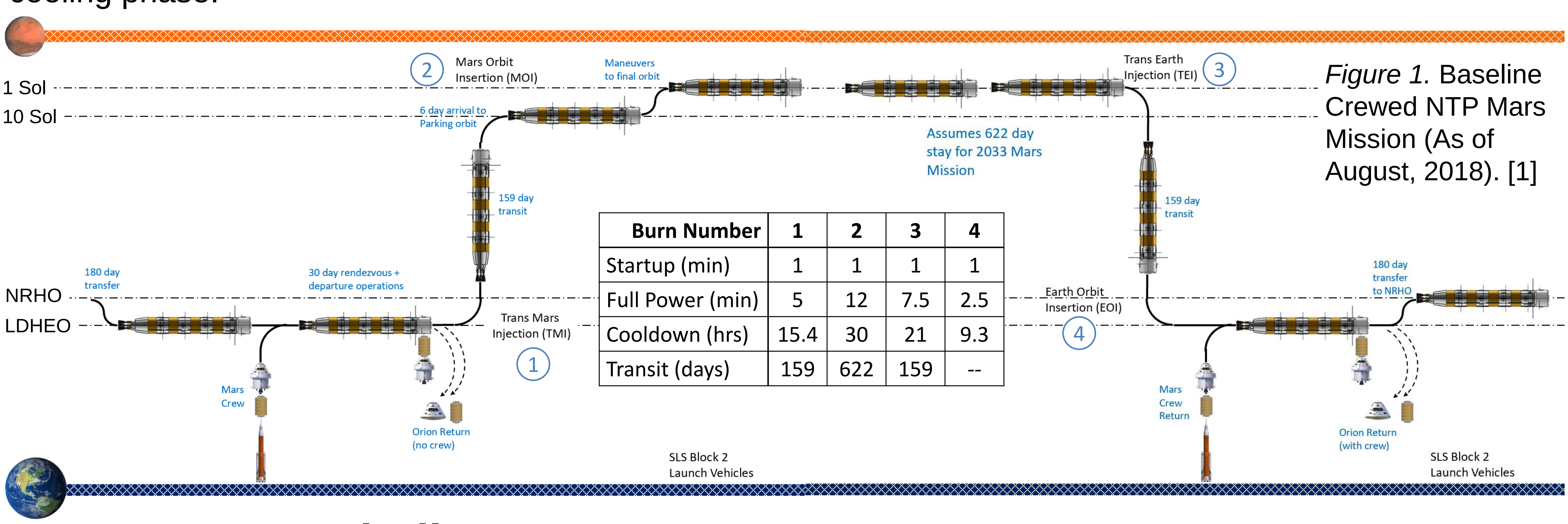


Figure 2. NERVA reactor computer model. [2]

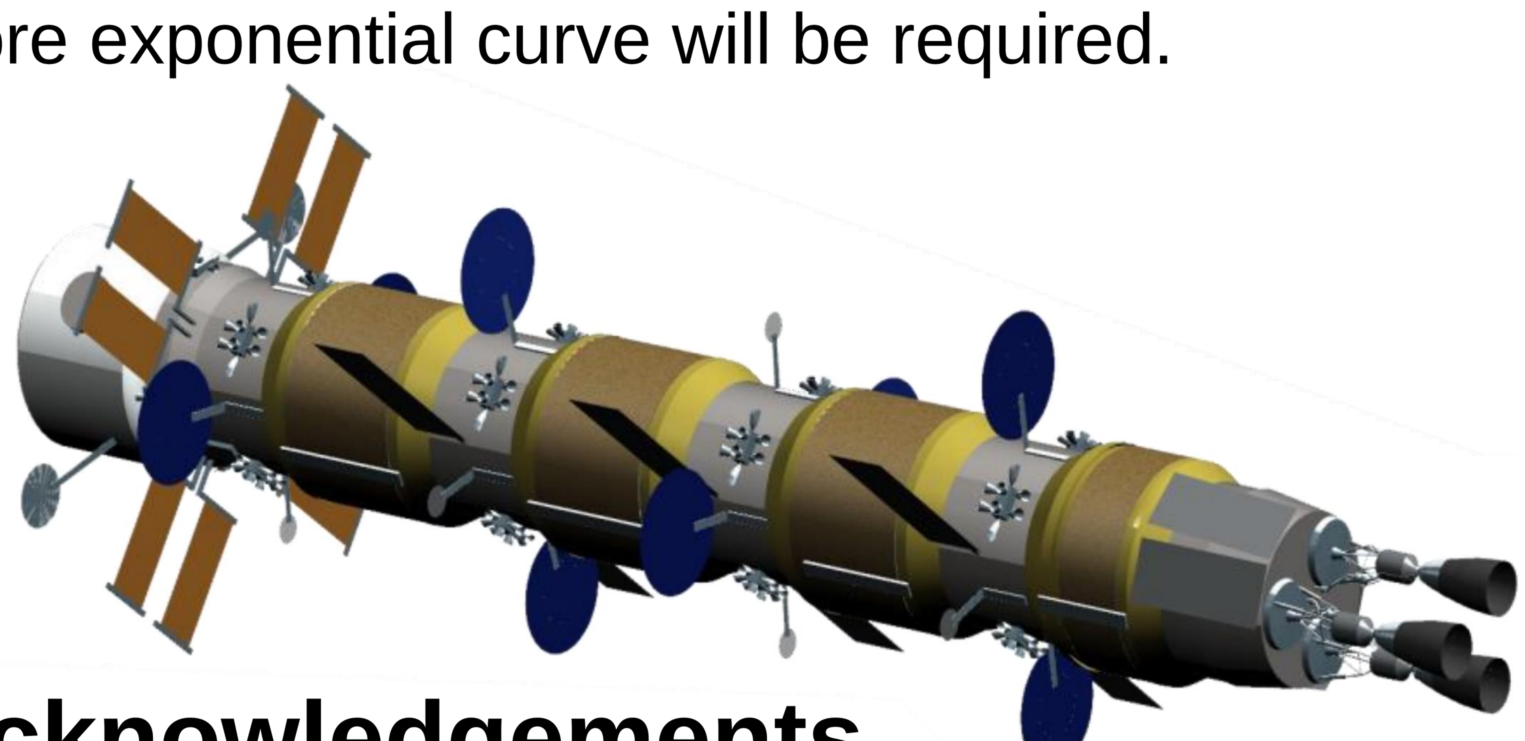


Burn Number	1	2	3	4
Startup (min)	1	1	1	1
Full Power (min)	5	12	7.5	2.5
Cooldown (hrs)	15.4	30	21	9.3
Transit (days)	159	622	159	--

Figure 1. Baseline Crewed NTP Mars Mission (As of August, 2018). [1]

Key Findings

Initial results are in good agreement with other reports (Figure 3). However, when compared to the shutdown profile of the original NERVA engine (purple line), these plots underestimate the total residual power by almost two orders of magnitude. The author hypothesizes that this difference is due to all recent models assuming either instant or constant shutdown of the reactor, when in fact a more exponential curve will be required.



Impact

Current estimates of the total additional hydrogen needed to cool the reactor range from 600-2,000kg per burn. For a single mission with 4 burns, the amount of hydrogen required must be more accurately predicted, as it could have significant impacts to the overall mission design.

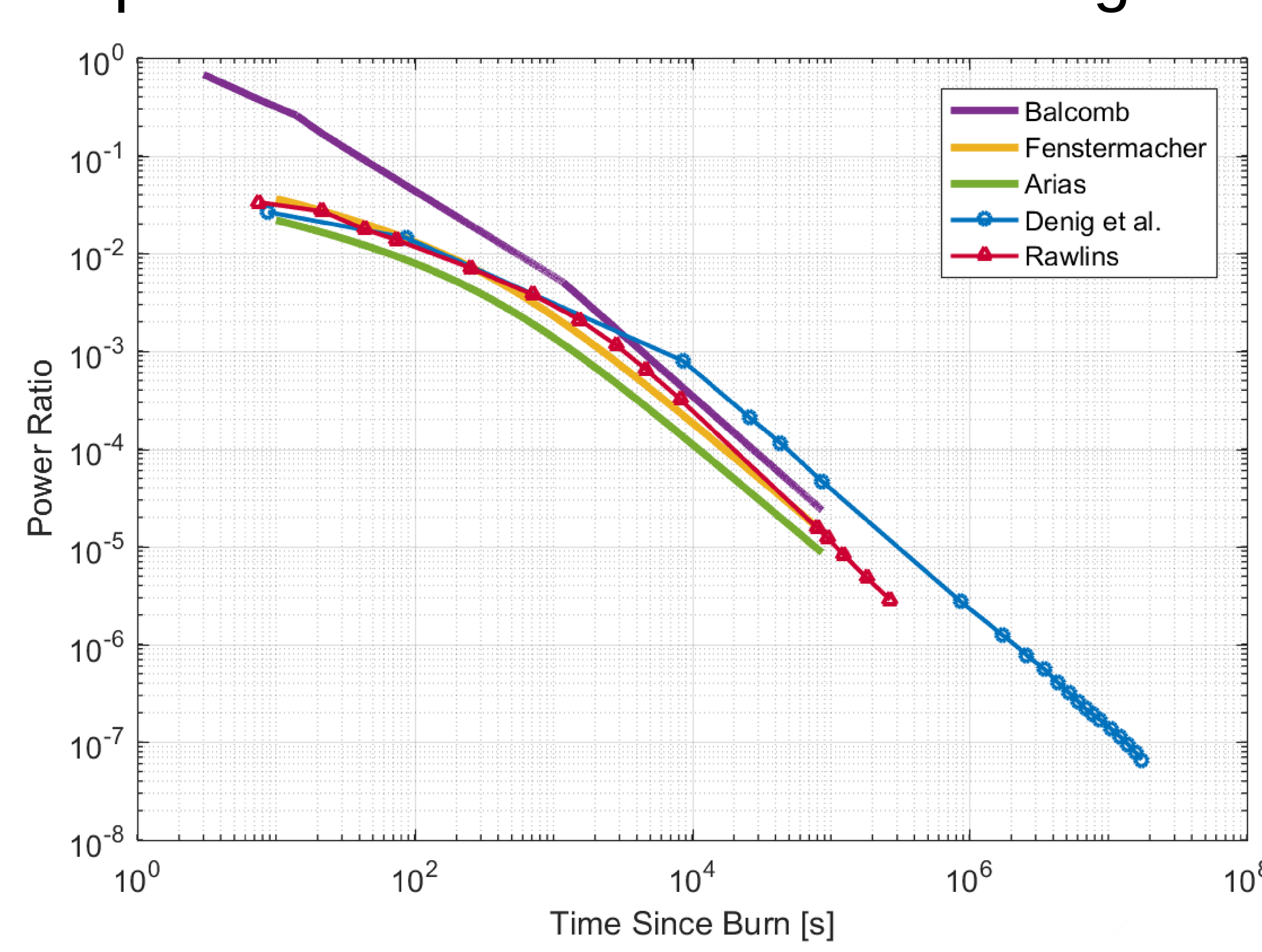


Figure 3. Comparison of recent residual heat analysis with original NERVA data.

Acknowledgements

Advisor: L. Dale Thomas, ISEEM Department

[1] Stephens, 2018, AIAA 2007-5618.
[2] Schnitzler, 2007, 20180006377.

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