

CIF-8

A Passive fuel-Cell Surface-power System (PaCeSS)

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EXECUTIVE SUMMARY

This effort produces a **fully-passive surface power generation capability for fuel cell technology**. The concept replaces the **actively pumped thermal management** of a state of the art (SOA) fuel cell/electrolyzer stack with a **passive 2-phase thermosyphon for heat transport** and a **passive shape memory actuating radiator for temperature management**.

The concept addresses NASA fuel cell technology roadmap needs for greater reliability and longer operating life by eliminating **life limiting** elements of SOA fuel cell system design that drive **failure modes** associated with **moving parts and control complexity**. Applications map to surface power (primary fuel cell), surface energy storage (regenerable fuel cell) and in-situ resource utilization (electrolyzer/unitized reversible fuel cell).

The first year of this effort concluded with independent demonstrations of 2-phase thermosyphon heat transport from a simulated fuel cell and temperature driven actuation of a shape memory actuating radiator. Results are in-character with underlying physics and demonstrate the potential to realize the objectives of this concept.

INNOVATION & BENEFITS

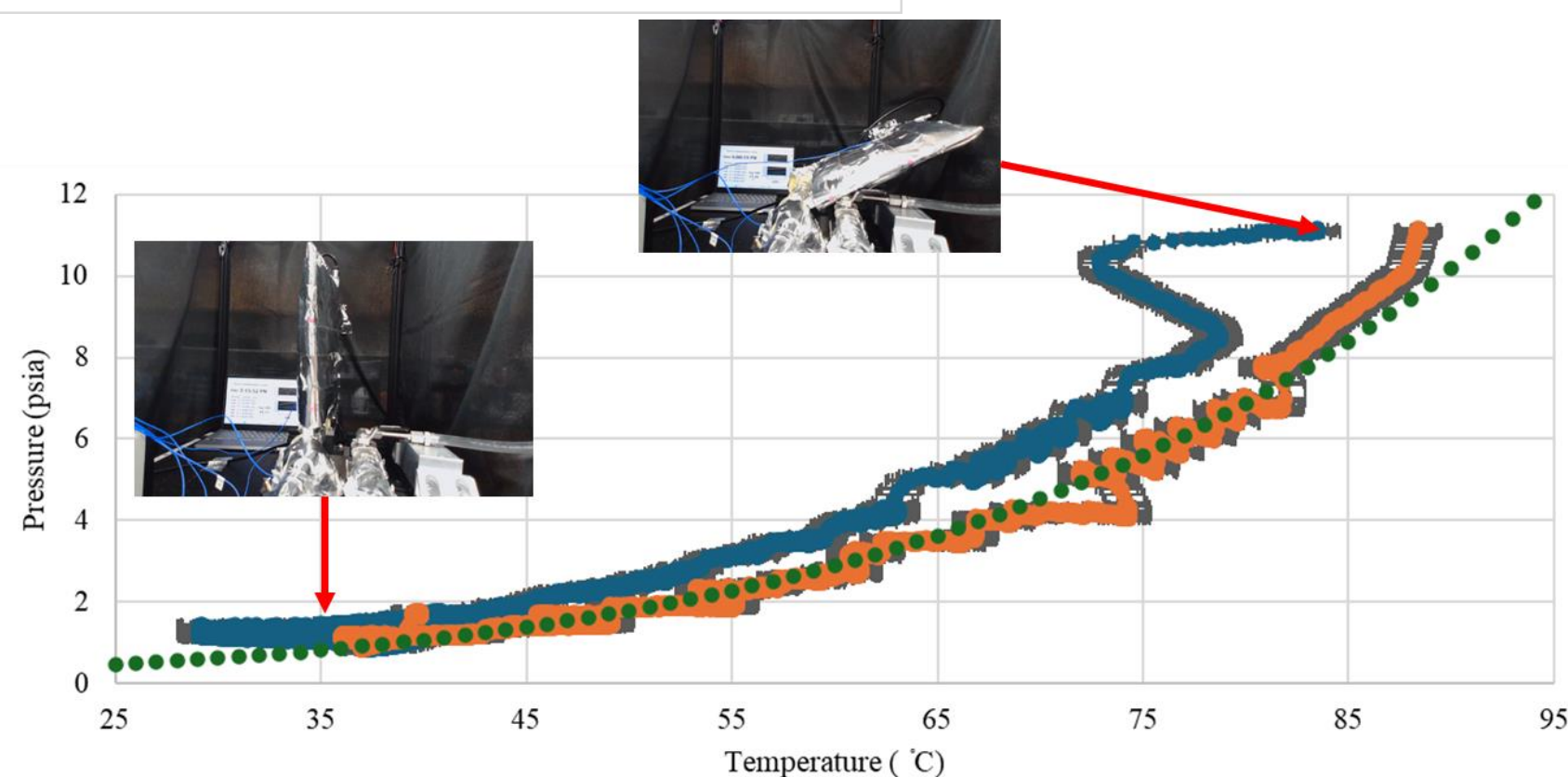
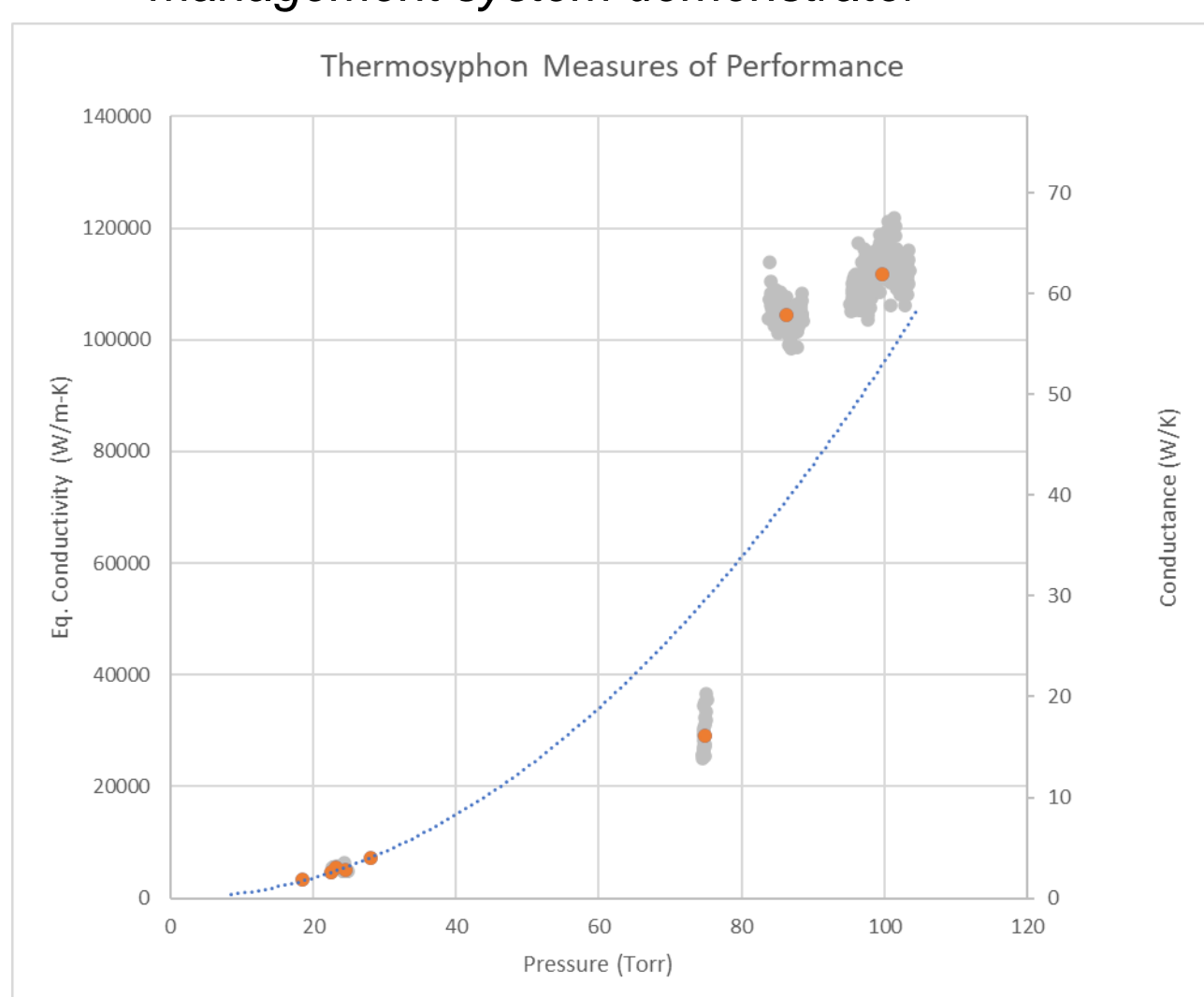
This concept broadly:

- Improves reliability and operating life by removing pumps and control valves/devices and electronics from thermal management subsystem.
- Reduces control complexity through inherently temperature dependent material behaviors (Shape memory alloy actuates between 50C and 70C)
- Improves mission flexibility (survive night, direct solar, permanent shadow) via high thermal turndown. **Applies to Moon and Mars.**

COLLABORATION

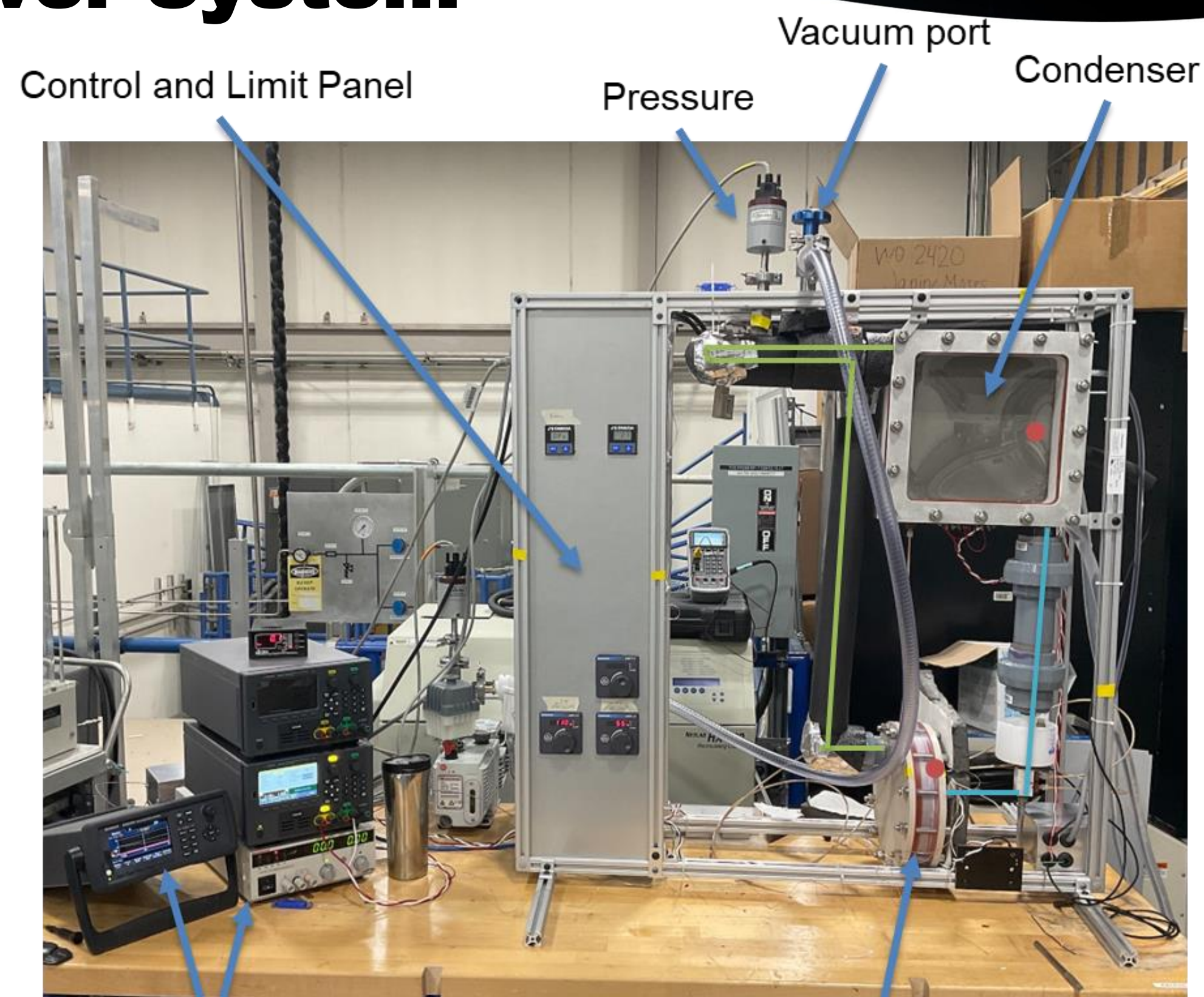
Texas A&M University (TAMU)

- Developed and demonstrated several iterations of a shape memory material tube that actuates on temperature as an element of a thermosyphon
- Developed actuating radiator thermosyphon for integration with JSC thermal management system demonstrator



• SMA Temperature • Evaporator Temperature • Water Saturation Temperature *Heating data only

Results from testing show (top) high performance heat transport from simulated fuel cell stack to heat rejection surface and (bottom) actuation of radiator corresponding temperature of working fluid in a water thermosyphon.



Data Acquisition and Power

Evaporator Prototype

PaCeSS test stand with evaporator prototype, instrumentation, and balance of plant identified.

OUTCOMES & INFUSION

Outcomes

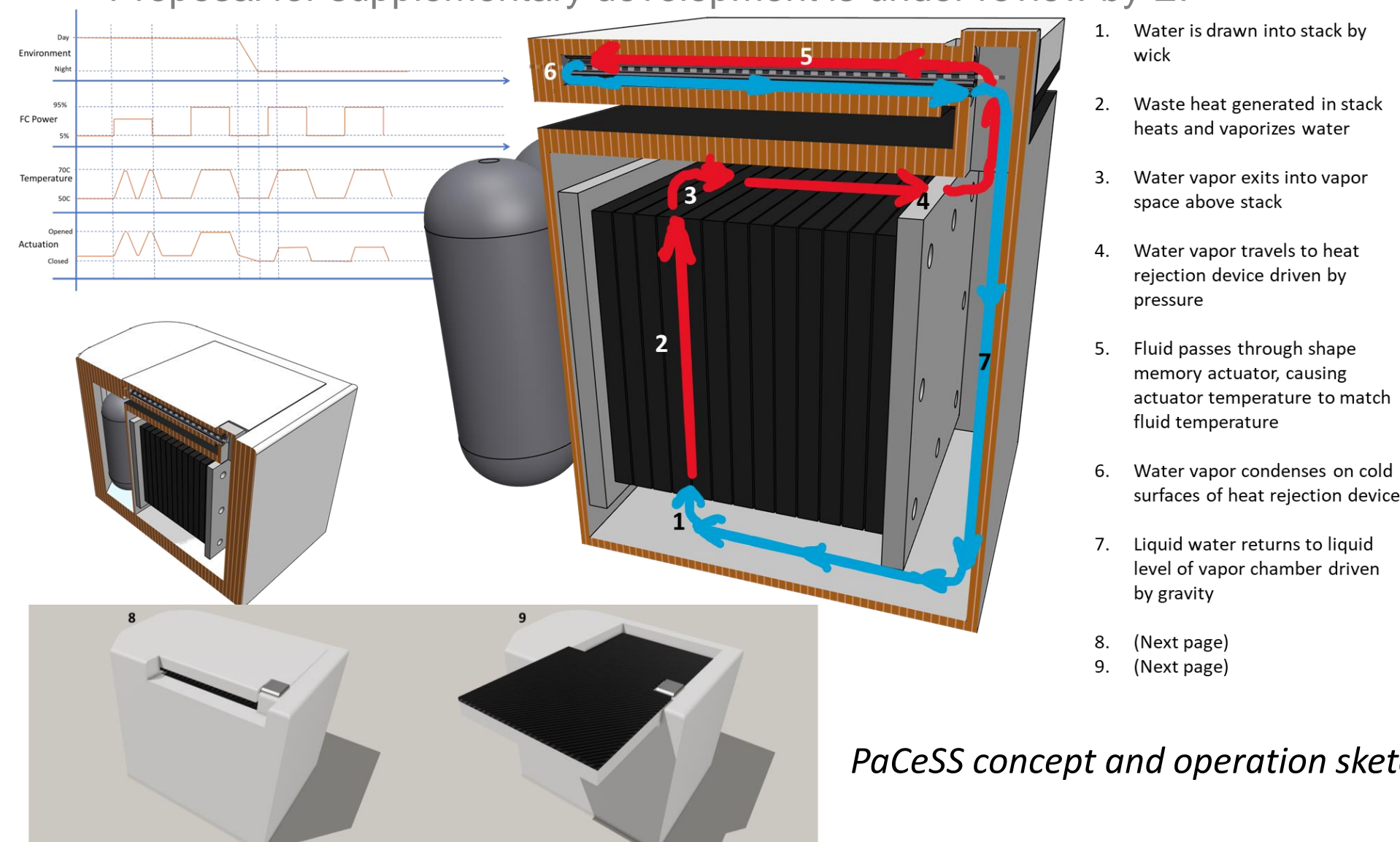
- Developed a complete fuel cell thermal management system prototype, including
 - Prototype evaporator design integrated into a simulated fuel cell stack and thermosyphon demonstrator
 - Prototype actuating radiator/condenser designed into an independent thermosyphon demonstrator
- Built, instrumented, and demonstrated test readiness of prototype systems
- Demonstrated through testing at JSC that prototype transports heat as intended from fuel cell stack to condenser
- Demonstrated through testing at Texas A&M University that actuating radiator element acts on temperature communicated by 2-phase fluid in thermosyphon

Infusion

Supported UH/TAMU on adaptable structures proposal to Texas Space Institute

NEXT STEPS

- Testing continues to understand system behavior over the full bounds of operation.
- Year 2 development has been funded through the EIF program
- Proposal for supplementary development is under review by EP



PaCeSS concept and operation sketch

DAA# 20240013991

NTR# 1694447882