Hydrocarbon Engine Development Activities

49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference
July 16, 2013
SLS Advanced Booster

- SLS Program investigating potential hydrocarbon fueled systems for a future advanced booster

- Advanced Booster Engineering Demonstration and Risk Reduction (ABEDRR) building hardware and conducting tests
Aerojet Oxygen-Rich Staged Combustion

- **Proposed Booster:**
  - LOX/RP liquid engine booster
  - Engines – three 1.1Mlbf AJ1E6 engines per Advanced Booster
  - Oxygen Rich Staged Combustion cycle

- **Engine configuration:**
  - 1.1M lbf class Oxygen Rich Staged Combustion (ORSC) engine
    - Dual chamber design

- **Common engine solution for SLS, Atlas V, & Antares**
Oxygen-Rich Staged Combustion Demo

- Risk Reduction Task: Full scale combustion stability demonstration test (550 klbf thrust chamber)

- NASA and Air Force Collaboration
  - NASA contract with Aerojet to fabricate and integrate test article
  - Air Force Research Laboratory (AFRL) to provide two oxygen rich preburners
    - Leverages and extends products from the AFRL Hydrocarbon Boost (HCB) program

- Testing planned for FY16 at NASA Stennis test stand E-1

*Largest LOX/RP combustion stability test in U.S. since F-1A*
Dynetics/PWR – Modernized F-1

- Gas Generator testing at Marshall complete
- Build simplified turbopump assembly
- Powerpack testing of GG and TPA at SSC spring 2016
- Build a modern Main Combustion Chamber spring 2015
F-1 Gas Generator Testing
NASA and Air Force Collaboration on American Kerosene Engine

- NASA and USAF Space and Missile Systems Center (SMC) have partnered to study potential synergy on an American Kerosene Engine

- ABEDRR contractors to study extensibility of SLS Advanced Booster liquid engine concepts to AF EELV architectures

- Key study objectives –
  - Technical feasibility, DDT&E plans and risks
  - Cost and schedule estimates

- Results due late spring 2014
NASA & Air Force Collaboration on Hydrocarbon Boost Tech Demonstrator

- Partnership for water flow testing
  - NASA MSFC Inducer Test Loop Facility
- Leveraging technical NASA turbomachinery expertise
- Collaborative modeling of liquid rocket engine environments
- Long Life IPS
- Close Coupled Hyd. Turbines
- Integrated, Multi-Speed TPA
Engine Controller Long Range Vision
- “Universal” Controller

- RS-25, J-2X, F-1 (candidate), etc.
- Single channel option
- Offers controller development efficiencies
- Reduces cost, schedule & development risk (design maturity)
- Economies of scale due to common parts across programs
- Configurable based on
  - Boards installed
  - Software loaded

- Common Chassis/Backplane/Connectors
  - “Single Qual” option – populate with additional board types and Qual during a single Qual test
- Modular circuits
- Some common PWA designs between programs
- Modular software
- Common construction
- I/O & operation – tailored to specific program
Structured Light Scanning Development

- Replaced difficult measurements with scanning to help reduce performance uncertainty (throat and exit areas).
- Structured light introduced to sub-tier vendors to modify tube dies to integrate supply chain (i.e., reduce turn around time for nozzle assembly).
- Structured light used to generate machining code and match machine at PWR.
- Developing new optical techniques to augment traditional engine measurements.
- Training and implementing as a new technique for Rocketdyne Personnel.
- Completing study to advance structured light as a quality acceptance tool. Implementing > 5:1 time savings.

Reducing the Development Cycle for Hardware
Selective Laser Melting Development
Ancient technology or youth movement?