Leak Free Joints in Propulsion Systems

Space Propulsion Technology
Assessment Workshop

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Current Baseline
Leak Free Joints in Propulsion Systems

- For fluid systems, manpower intensive operations are driven in Shuttle processing by a combination of (1) high numbers of potential leakage sources for fluid systems, (2) the use of manual methods in fluid systems certification (hands on including over a dozen approaches), (3) the criticality of systems dictating high numbers of required tests and (4) the lack of reliability of components further dictating high numbers of required tests for seals as well as components removed and replaced.

- Examples of currently required fluid verifications:
  - LOX Facilities: > 1,000 per flight (leak checks), many on purging and valve actuation systems
  - LH2 Facilities: > 1,000 per flight (leak checks), many on purging and valve actuation systems
  - MPS Processing: > 40 per flight + > 30 interfaces (caused by removal of the engine pod)
  - Shuttle Main Engines: > 80 per flight per engine + > 10 interfaces

- Even systems which only check violated joints are not immune from numerous verifications given high component failure rates or required breakage into systems as part of processing such as for hydraulic systems

Potential Solutions
Leak Free Joints in Propulsion Systems

- Simplification of systems. SSTO concepts by definition reduce potential leakage and connection sources by eliminating the integration of distinct stages or segments.

- Simplify major fluid systems such as propulsion, eliminating purges and associated ground infrastructure. The elimination of GHe inject systems, POGO systems and turbopump interseal purges further provide basic levels of improvement

- Automation of interface checkouts such as leak checks seals and sealing techniques dramatically improved over current designs.

- Welding, brazing or otherwise eliminating leak paths would eliminate the associated tasks and manpower

Potential Solutions (Cont'd)
Leak Free Joints in Propulsion Systems

- Increased component reliability. This precludes work in areas that are susceptible to damage

- Introduction of electronic systems would be a highly promising approach. Tank vent valves, as well as all vehicle valves and facility valves could be motor driven (electromechanical valves). This adds electrical connectors but drastically reduces fluid systems leakage sources and massively eliminates infrastructure (GHe/LHe and GN2/LN2 facilities, truck farms and tube banks). Electrical connectors can also more easily include self test capabilities

- Improved accessibility of failure prone components. Removal of one component to get at another component in significant cause of leaks

- Ability to perform all engine main without removing engines from vehicle. This implies accessibility and minimum use of closed compartments.

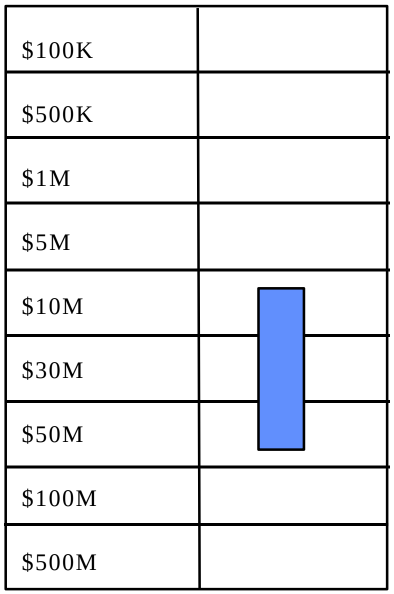
Technologies to Implement Solutions (TRLs)
Leak Free Joints in Propulsion Systems

- Today's reference is Naflex and Raco/Crevy joint designs

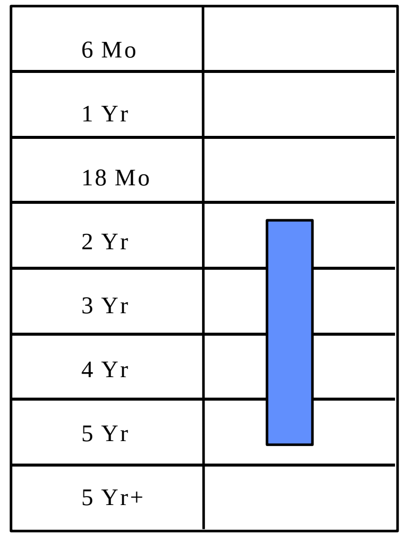
- Technologies to implement solutions (TRLs)

  - Electromagnetic coupling (3/4)
  - EMAs (5)
    - Also requires low torque values
  - Electro hydraulic actuators for high torque applications, e.g., TVC actuators (4/5)
    - Self-contained hydraulics
  - Bring health monitoring to the joint/leak path (2/3)
    - Want only maintenance by exception
  - Self-contained passive or active seal/joint adjustment designs, e.g., springs, temperature sensitive materials (4)
  - Fluid cores that change shape under operating conditions
  - Tolerant and self-aligning designs (4)
    - Torque
    - Lateral and rotational displacement
    - Temperature change
  - Better human factors (4)
    - Universal seal - no right or left - cannot be installed wrong
  - An easy to disassemble weld/braze technique (2/3)

Cost to Mature Technology
Leak Free Joints in Propulsion Systems



The lower number to address just a few of the technologies and only part of the problem. The higher amount to address the broad range of technologies and the full range of the problem.



The shorter time for the well developed solutions such as EMAs and EHAs. The longer time is required for some of the less well defined technologies.