N91-28243

PRESENTATION 4.2.7

# HISTORICAL PROBLEM AREAS - LESSONS LEARNED

# EXPENDABLE AND REUSABLE VEHICLE PROPULSION SYSTEMS

STPSS PANEL ON DEVELOPMENT, MANUFACTURING AND CERTIFICATION

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## Expendable Launch Vehicle Lessons Learned

- **Avoid Single String Systems**
- **Design Must Be Inspectable**
- **Qual By Flight Usage Not Acceptable**
  - No Margin Demonstrated
  - Must Qualify All Components to Needed Level
  - Either Meet Specs or Change Specs
- **Use All-Welded Feed Systems**
  - Maintenance of Cleanliness During Changeout
  - Scavenging Components as Source of Spares
  - Multiple Checking Wears Things Out

## Expendable Launch Vehicle Lessons Learned (concl)

- Dynamic Envelope Must Accommodate
  - Stacking of Tolerances
  - Deflections
  - Margin
- Provide Needed Instrumentation
  - Must Know Flight Environments for Every System
- Overall Systems Integrator Needed (Also Applies to Reusable Systems)
  - Interfaces Between Independent Contractors
  - Integrate 2 to 3 Sigma Parts
- Concerns
  - Pogo Suppression
  - Pyrotechnics Checkout
  - Proper Circuit Testing

## Upper Stage/Transfer Vehicle Lessons Learned

- Must Meet Safety Requirements
  - Difficult for New Vehicle & Almost Impossible for Prior Design ELV-Launched Vehicle
  - Vehicle Really a Space-Operating LV
  - Across Board Two Failure Tolerance May Not Be Reasonable
- Should Not Let Politics Drive Systems

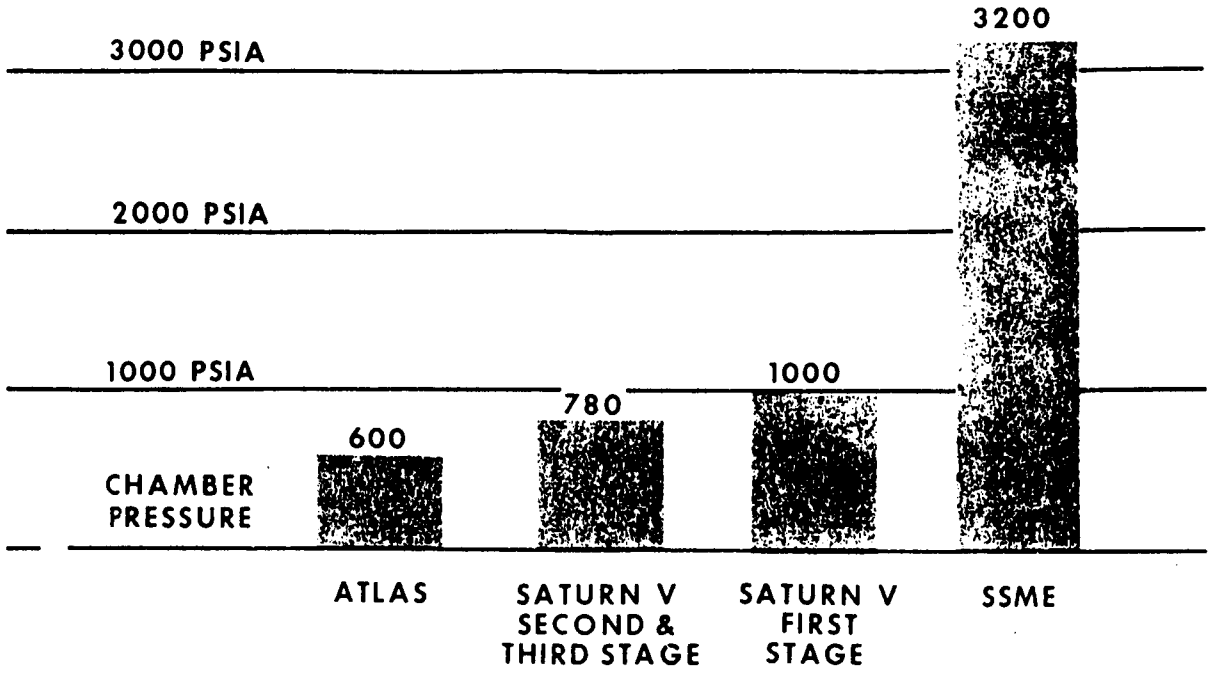
# Shuttle Systems - Dynamics

- **External Tank**
  - **Propellant Dynamics During ET/Orbiter Separation for RTLS**
  - **Required Low-g Drop Tower & KC-135 Testing**
  - **RCS Orbiter Translation & Aerodynamic Forces Sufficient For Separation**
- **External Tank**
  - **Had Natural Convection Recirculation System**
  - **Replaced With Bubbling Helium Up Feedline (Saved 400 lbm)**
- **RCS Tanks**
  - **Extensive Ground Development Program (Element, Subsystem, System)**
  - **Structural Fatigue and Flow Dynamics**
    - Vibration Testing
    - Flow Splitting In Multiple Paths
    - Simultaneous Thruster Firing

# Shuttle Systems - Reuse

- **External Tank**
  - **One of Best Performers Since Not Reused**
- **RCS Tanks (OMS Tanks)**
  - **Specifically Developed for Orbiter**
  - **Extensive Ground Development Program (Element, Subsystem, System)**
  - **Qualified for Full 100-Mission Life**
  - **Included Structural Fatigue & Flow Dynamics Testing**
  - **Excellent Reuse History**
  - **N2O4 Flow Decay No Problem**
    - **Use Proper Purity & Handling**
    - **Follow Established Processes & Procedures**
- **Components**
  - **Many Were Really Expendable Component Designs**
  - **Others Were Exponential Extrapolations (e.g. SSME)**
  - **Usually Not Qualified for Full Duration & Operating Environments**
  - **Result: Rebuild Rather than Reliable Reuse**

## HIGH PRESSURE OPERATION REDUCES WEIGHT, COST




## Reusable System Issues & Lessons Learned

- **Material Property Database Lacking for Operational Environments**
  - Both Fatigue & Flow Life
  - Data Was Extrapolated or Estimated
  - Didn't Understand Reuse & Long Life
  - Verification/Diagnostics Not Available
- **Life Unknown**
  - Design to Life with Margin to Cover Unknowns
  - Margin Must Include Degradation
    - Debris
    - Wear & Tear
    - Atomic Oxygen
  - Qualify for Full Duration
  - Fleet Leader Concept Has Shortcomings

## Summary

- Need Materials Property Database Covering Operational Environments
- Need Fault Tree
  - Does Fix Ripple Through System & Cause Problem
- Need Accurate Lessons-Learned Database (Must Transfer to Young Engineers)
- Two Major Issues Are Long Life & Reusability
  - Need History & Diagnostics
  - Technology Process Inadequate