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PRESENTATION 4.3.5

The Propulsion System Is The Key to Airline-Like Operation of ETO Vehicles

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Operational Efficiency Panel

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Agenda

Efficient Engine Operations

- Steps for improved operability (ALS)
- LCC/lb payload is figure of merit
- Current practice is major cost driver
- Single stage to orbit approach
- Propulsion & vehicle technologies have emerged to allow SSTO operation
- Conclusions for improved operability

ALS STME Improved Operability

OEPSS Concern	Aerojet ALS Approach
• Hydraulic & pneumatic actuation	Electrical actuation for valves & TVC
• Accessibility	Modularity access
• Lack hardware integ. & commonality	Commonality of lines, valves, bellows, seals
• Gimbal system	Gimbal system
• High maintenance TPA	Robust, low temp. turb., hydrostatic bearings
• Pressurization systems	Autogenous GOX & GH2 HEX
• Helium gas purge	Purge - He spin start & GOX inj. conditioning
• Preconditioning system	No chilldown
• Contamination	Filters & quality control

Operationally Efficient Propulsion System Steps In Progress

Figure of Merit Is LCC/LB Payload

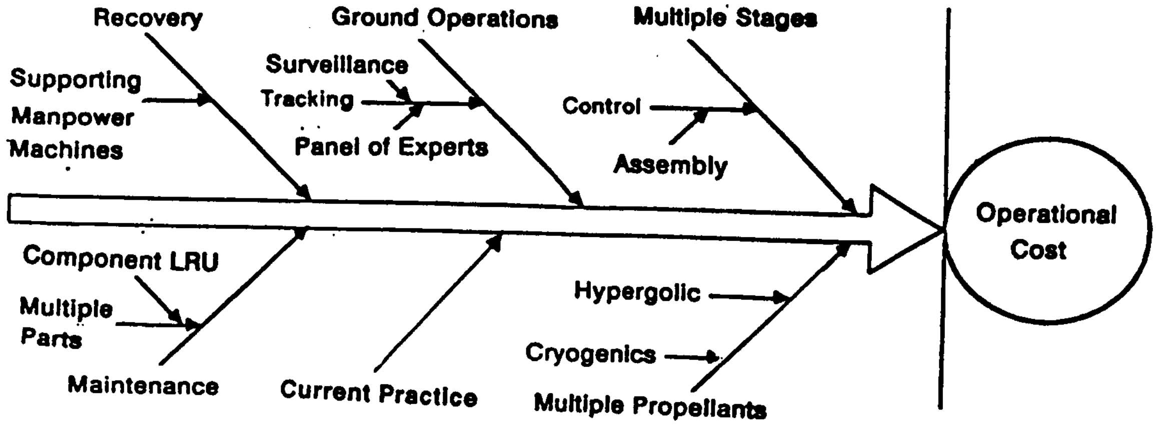
- o Payload → High Performance
- o Life Cycle Cost
  - o Dev Cost (Non/Recur)
  - o Production (Recur)
  - o Ops Cost (Recur)
    - -- Preparation
    - -- Launch
    - -- Recovery
    - -- Refurbish
    - -- Problem Solve
    - -- Consumables

ALS → Low Cost

Toward Manless Launch

ALS Trades Performance For Low Cost

Current Operational Cost Is Labor-Intensive



Innovate Utilizing Space Shuttle Experience

Current Practice Is Major Cost Driver

Propulsion Systems & Shuttle Vehicle

- o 1970 technology and operations
- o Schedule & cost inhibit change

ALS - One Approach To Reduce Cost

- o Trades performance for low cost
- o Applies operations advances to current practice

Multiple Stages Is Major Cost Driver

- o Cost of developing, servicing, maintaining, launching, tracking and recovery of numerous stages is high.

- o Single stage (SSTO) vehicle has highest potential for low LCC/lb payload for reusable systems.

- o For purpose of stimulating panel discussion let's examine SSTO vehicle operation goals.

  - o Examine engine requirements to identify technologies & operation goals

Goal Is Fully Automated Operations

Approach for Development

Dedicated X-Vehicle - Alt./Parallel Approach

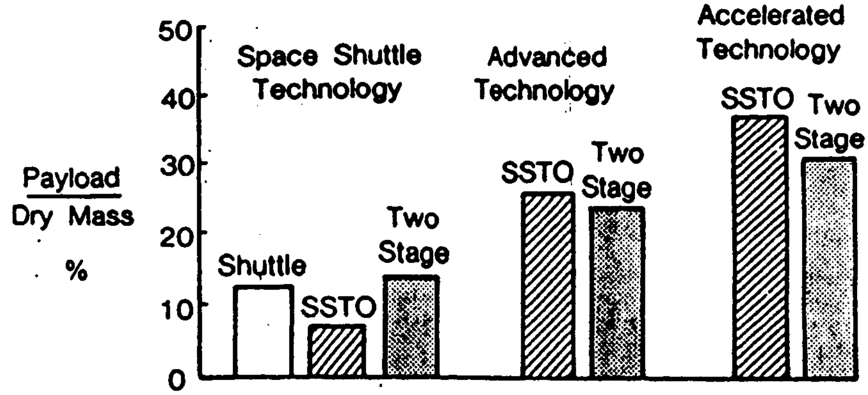
- o No payload or schedule commitment
- o Used as test bed to improve operations
  - o Propulsion & vehicle systems
  - o Incremental improvements allowed

Single Stage Vehicle Offers Airline Type Operation

- o Condition monitored
- o Idle mode checkout
- o Pilot/computer-aided control

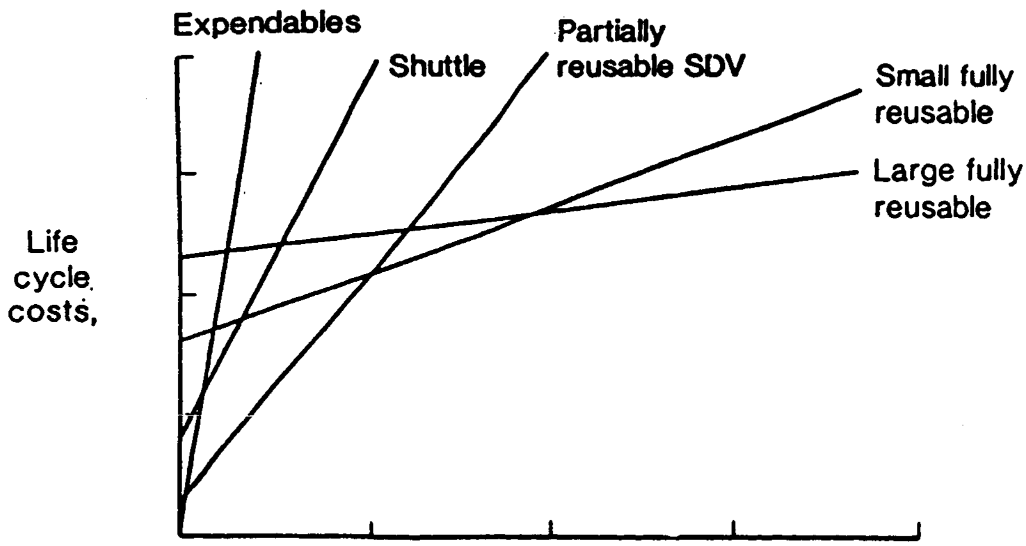
TECHNOLOGY IMPACTS ON VEHICLE DRY MASS EFFICIENCY

Payload 30 Tons



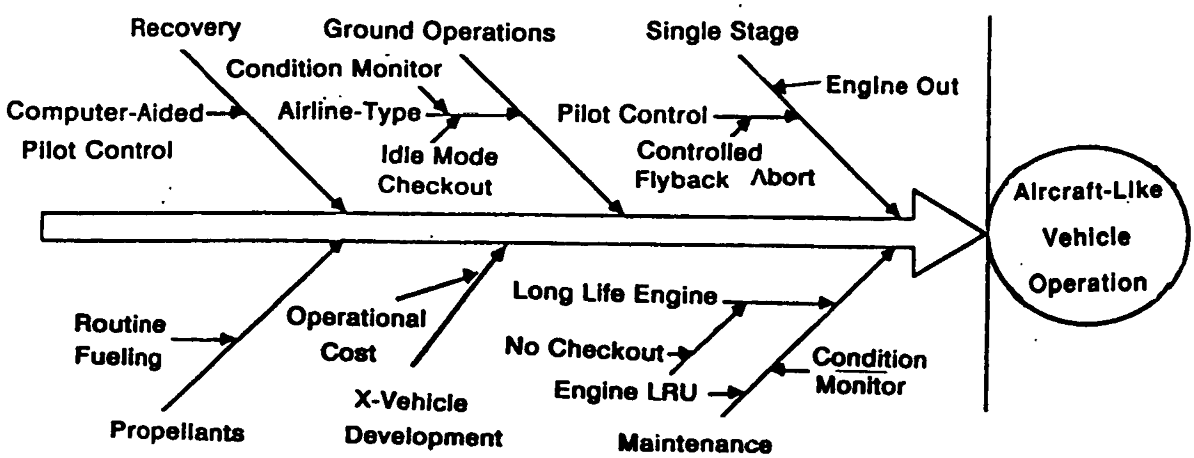
Key Technologies	SSME Al Tankage Al Structure Limited use of Composites	Dual Fuel/Separate Engines Al Tankage Warm and Cold Structure Composites	Dual Fuel/Integral Engines Al Composite Tankage Warm Structure Composites

LIFE CYCLE COST COMPARISONS



Total payload capacity

Single Stage to Orbit Approach



SSTO Approaches Aircraft - Like Operation

How Do We Make An SSTO Propulsion System Operationally Efficient?

- o Utilize STGG to increase turbine life
- o Utilize hydrostatic bearings to increase pump life
- o Optimize engine cycle to reduce turbine temperature
- o Utilize SDI thrust chamber technology
- o Use all welded joints (no leakage)
  - o self diagnostic automated condition monitor
  - o no observation points or LRU
- o No gimbal - thrust modulate engines for TVC

Technologies Have Emerged To Allow SSTO Operation

GenCorp
Aerojet
TechSystems

Efficient Propulsion System Operations

Conclusions

- Major advances are being made with ALS engine cost.
- Existing artificial interfaces do no permit improving ALS propulsion system operability.
- Must have dedicated X-ALS to continue improving operations.
- Minimum LCC/lb payload will eventually be achieved with SSTO operation.
- Must have dedicated X-SSTO to perfect engine, vehicle, and operations.

The Challenge is Here and We Must Meet It.