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Advanced Transportation System Studies

Technical Area 3

Alternate Propulsion Subsystem Concepts
NAS8-39210
DCN 1-1-PP-02147

Final Report
DR–4
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- Design Point
  - Cycle – FFSCC
  - Chamber Pressure – 4,000 psi
  - Sea Level Thrust – 421,000 lbf
  - Area Ratio – 70.62
  - Fuel Turbine Operating Temperature – 1,100 °R
  - Oxidizer Turbine Operating Temperature – 1,100 °R

- Characteristics
  - Fuel Rich Fuel Turbopump
  - LOX Rich LOX Turbopump
  - Jet Pump Low Pressure Pumps
  - Propellant Duct Gimbal Accommodation on Vehicle Side
  - SLIC™ Turbomachinery
  - Uncooled Powerhead
  - EMA Valves
  - Preburner Injectors Gas/Liq Impinging Jet
  - MCC Injectors Gas/Gas Co-Ax
  - Redundant Laser Igniters
  - Autogenous Pressurization on Both Sides
  - Pump Conditioning Fluid Recirculated to Tank on Both Sides

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Figure 71. Baseline Design Point and Characteristics

- Overall Procedure
  - Various Individual Design Procedures Combined at CATIA Assembly Level for Packaging and in Spreadsheet for Weights

- Two Direct Design Procedures are Used
  - CATIA Solid Model (e.g., Hot Gas Manifold)
    - Designed as Individual Component
    - Wall Thickness Calculated
    - Minimums Applied in Model
      - 1.5 Factor for Dynamic Loads Applied to Wall Thickness if Appropriate
    - Solid Volume Returned to Spreadsheet for Weights
    - In Spreadsheet
      - Density used on Solid Volume for Weight
      - 1.02 Factor and 1.05 Factor Applied to Weight
  - CATIA Assembly Model (e.g., Duct)
    - Designed at Assembly Level for Dimensions, Clearances, and Packaging
    - Dimensions Returned to Spreadsheet for Weights
    - In Spreadsheet
      - Wall Thickness Calculated and Minimums Applied
      - Other Subcomponents Calculated (Flanges, Insulation, Insulation Shields, etc.)
      - Weights Calculated from Material Choices and Dimensions

- Other Procedures are Used For Some Components and May be Combined
  - Scaled (e.g., Valves)
  - Outside Reference (e.g., STME-100 for Controller)
  - Outside Model or Correlation (e.g., SLIC™ Turbomachinery)
  - Directly from SSME (e.g., Static Seals)

Figure 72. Weight Calculation Procedures

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Component Area	SSME Weights, lbm	Adv Low Cost Eng Weights, lbm	Difference lbm	Rationale
Turbomachinery	1,725.00	1,070.01	(654.99)	SLIC™ (387), Jet Pumps (2687)
Nozzle	1,310.54	945.57	(364.97)	Essentially same weight on equal surface area basis (1,342), Ti honeycomb jacket
Hot Gas Manifolds/Inj/ Thrust Cone	953.00	621.70	(331.3)	
Propellant Ducts	822.91	201.38	(621.53)	Gimbal flex accommodation on vehicle side (198), Jet Pump (307), shorter lines and routing
MCC	438.54	450.07	11.53	
Valves	410.62	364.68	(45.94)	Uses EMA Valves. Includes Valves and Actuators
Avionics	375.00	166.74	(207.88)	Controller with FASCOS (221)
Misc	289.30	153.33	(135.97)	Proportional to weight (3.6%)
Preburners	195.75	239.04	43.29	
Gimbal Bearing	105.00	65.63	(39.37)	From Ti to Si carbide reinforced Al
Lines (Interface)	95.32	37.75	(57.57)	Simplified routing, combined recirc and repressurization, less drain
Pneumatics	76.90	0	(76.90)	EMA valves
POGO	75.13	40.41	(34.72)	Stiffer System, 25% SSME gas
Hydraulics	30.32	0	(30.32)	EMA Valves
Heat Exchanger	26.00	0	(26.00)	Part of LOX rich preburner
Igniters	26.00	6.00	(20.00)	Laser Igniters
Purge	24.39	24.39	0	Left in for ground Ops
Bleed Recirc Pumps	10.00	20.00	10.00	Add to LOX side
Static Seals	6.00	6.00	0	
	6,995.72	4,412.70	(2,583.02)	

Figure 73. Weight Comparison to SSME

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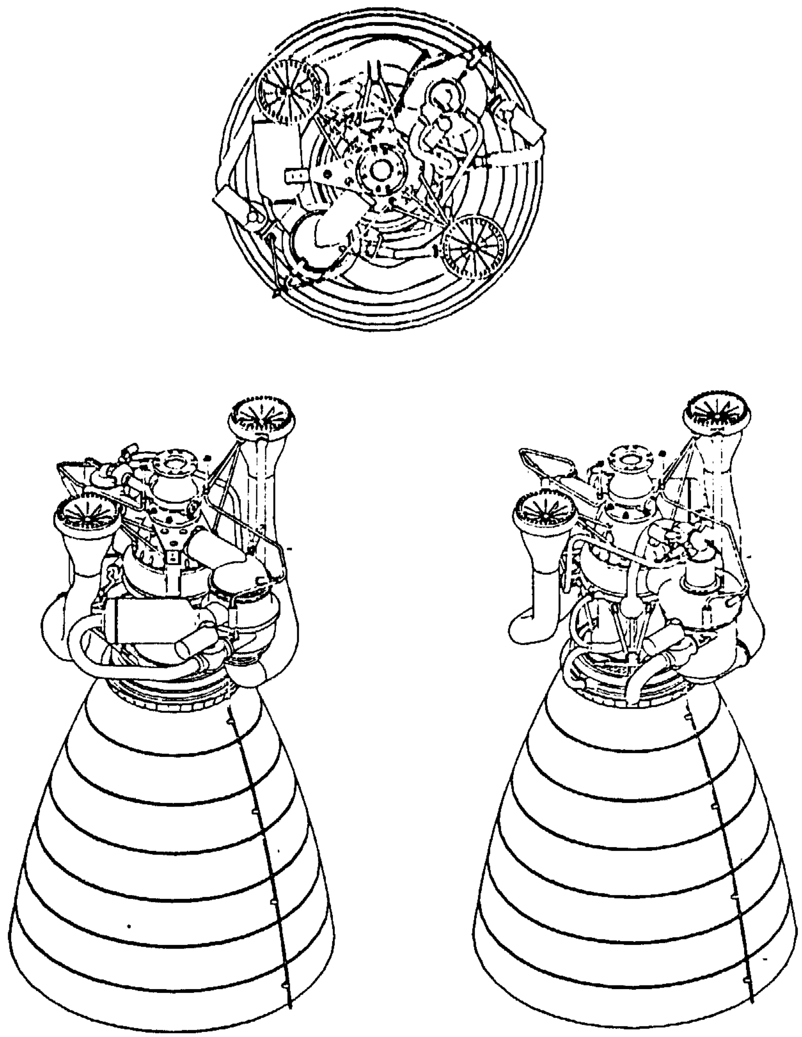

Full Flow Staged Combustion Cycle (FFSCC) Mixed Preburners Bipropellant LOX/H_2

Chamber Pressure, psi	4,000
Thrust, lbf	421,000 (SL) 486,867 (Vacuum)
Area Ratio	70.62
I_{sp}	395.4 (SL) 457.2 (Vacuum)
Weight, lbm	4,413
Diameter, in	84
Length, in	147

Figure 74. Advanced Low-Cost Engine Study Baseline Engine Configuration