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N91-28213

PROPULSION STUDIES FOR ADVANCED MANNED LAUNCH SYSTEMS

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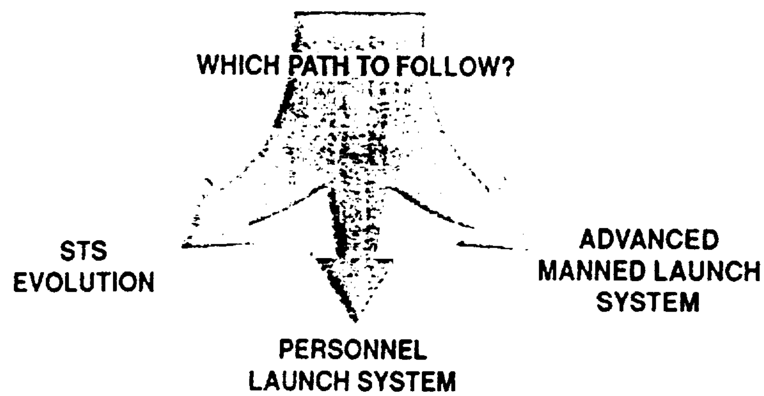
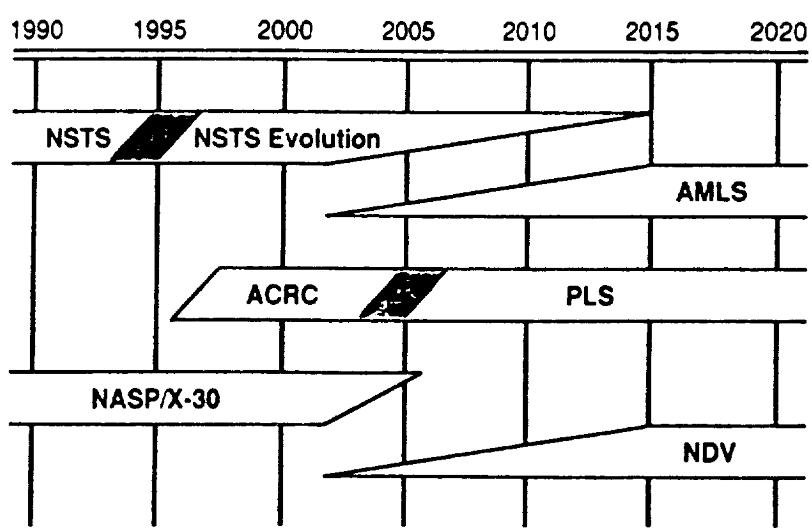
THE NEXT MANNED SPACE TRANSPORTATION SYSTEM

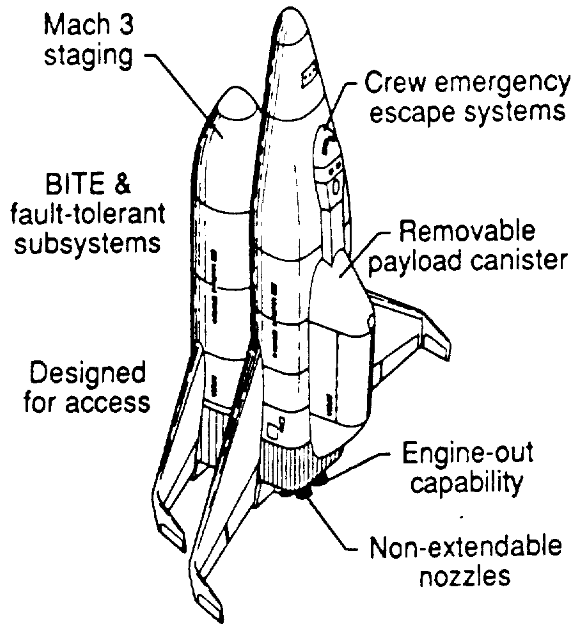
- Satisfy people/payload requirements
- Improve cost effectiveness
- Increase reliability
- Increase margins



MANNED SPACE TRANSPORTATION OPTIONS SCHEDULE



DESIGN FOR OPERATIONS, RELIABILITY AND SAFETY

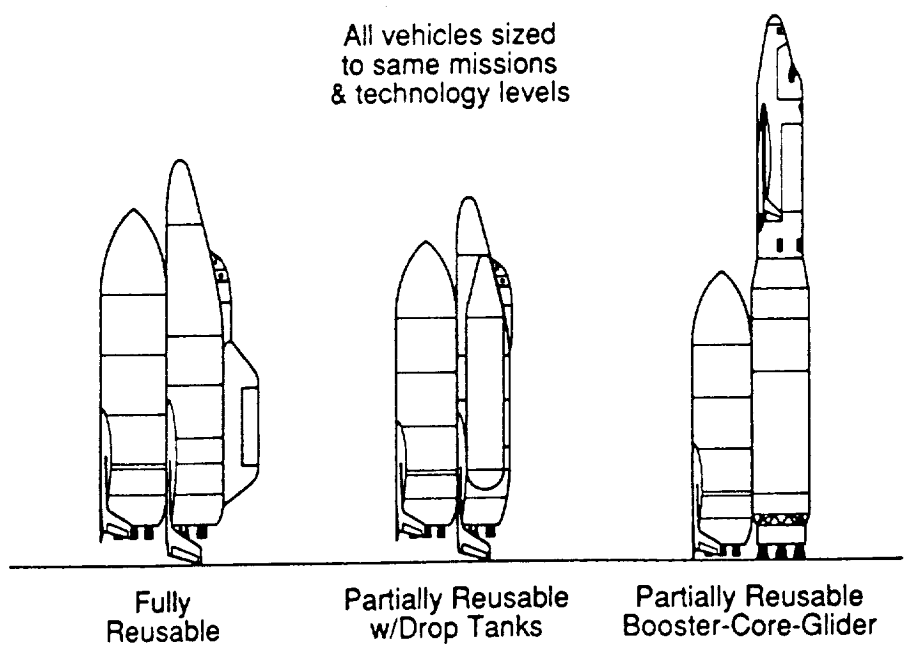


Technology Advantage Applied to:

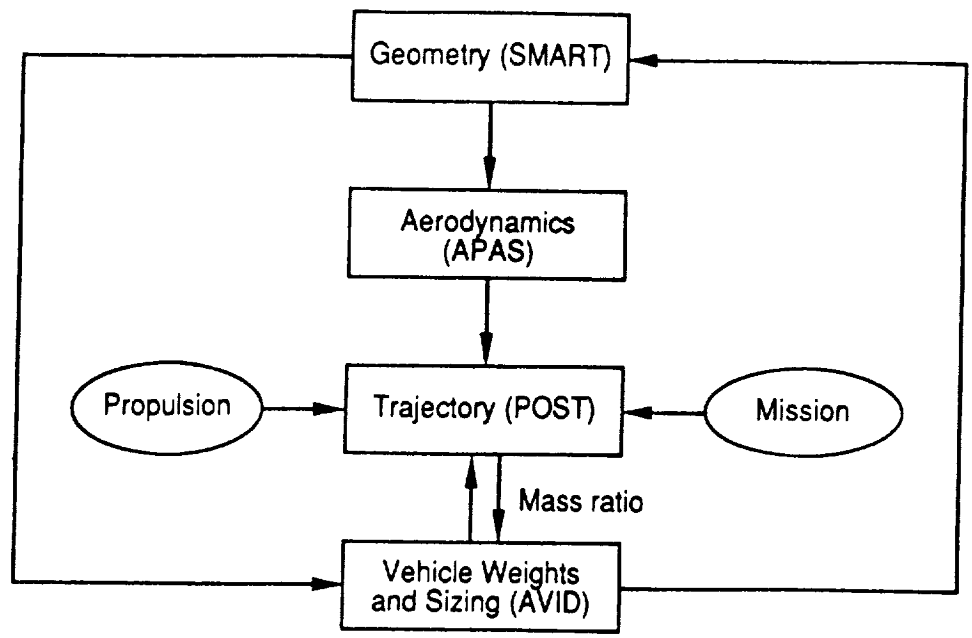
- Operations streamlining
- Robust subsystems
- Improved reliability
- Assured mission success
- Safety

Not Maximum Payload

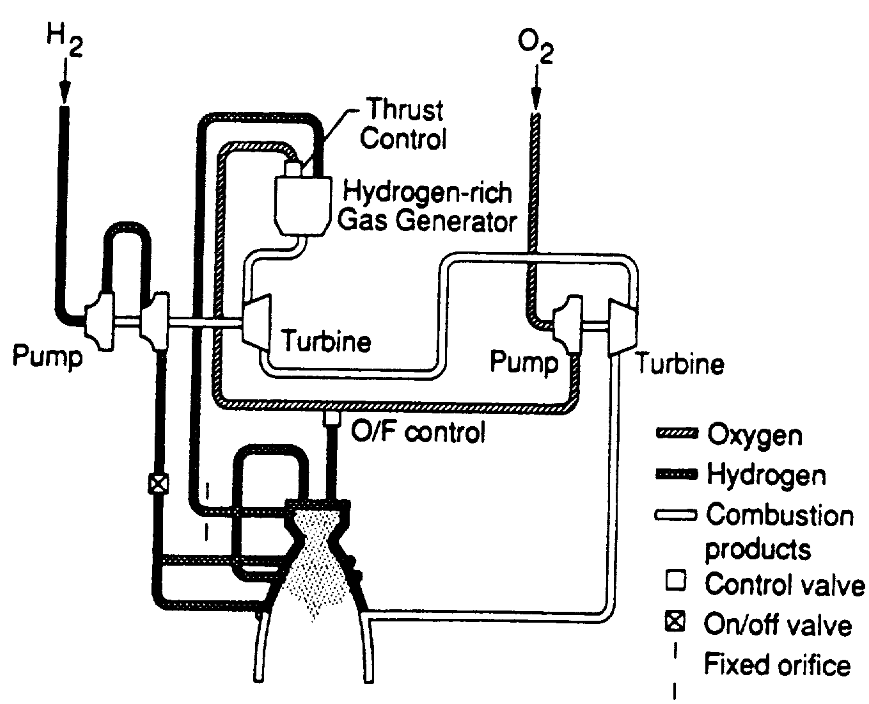
ADVANCED MANNED LAUNCH SYSTEM CONCEPTS



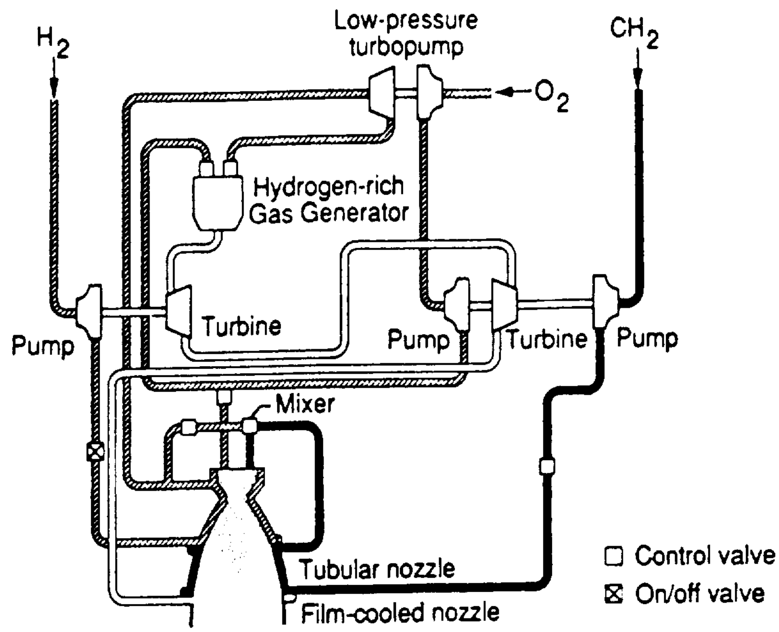
VEHICLE DESIGN PROCESS



REFERENCE STME ENGINE

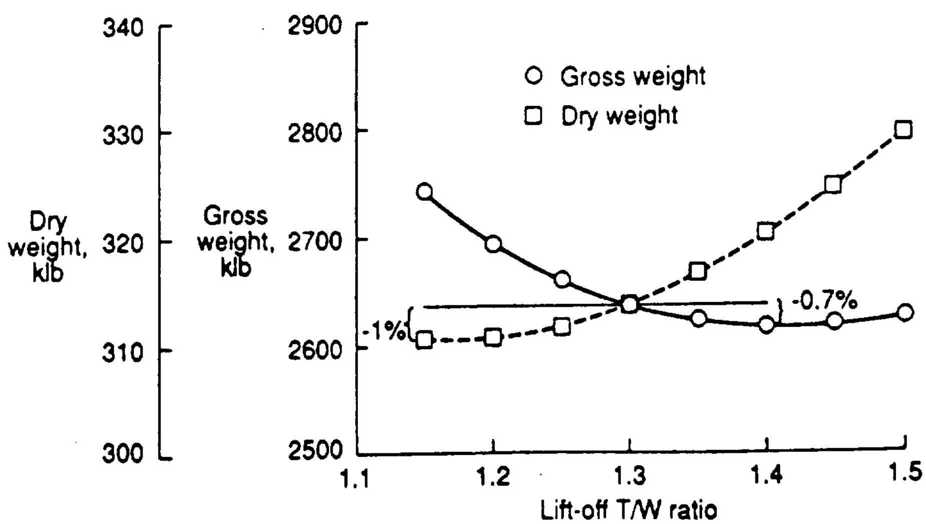


REFERENCE STBE ENGINE



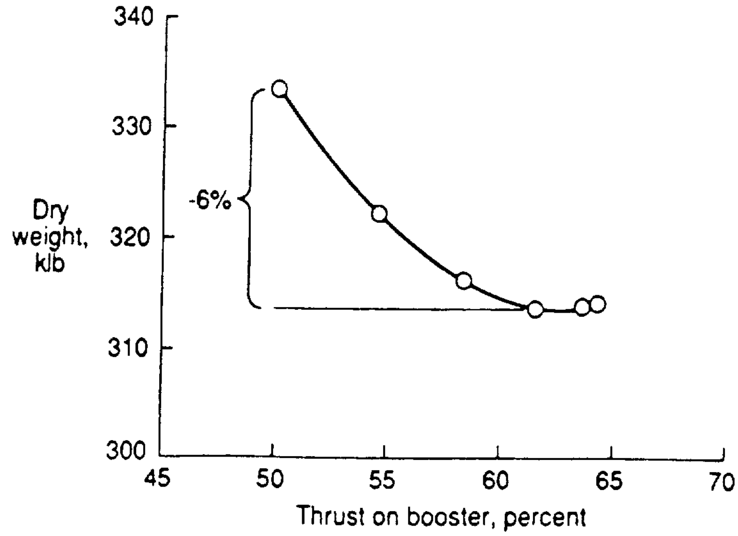
LIFT-OFF THRUST-TO-WEIGHT TRADE

FULLY REUSABLE, ALL LOX/LH_2



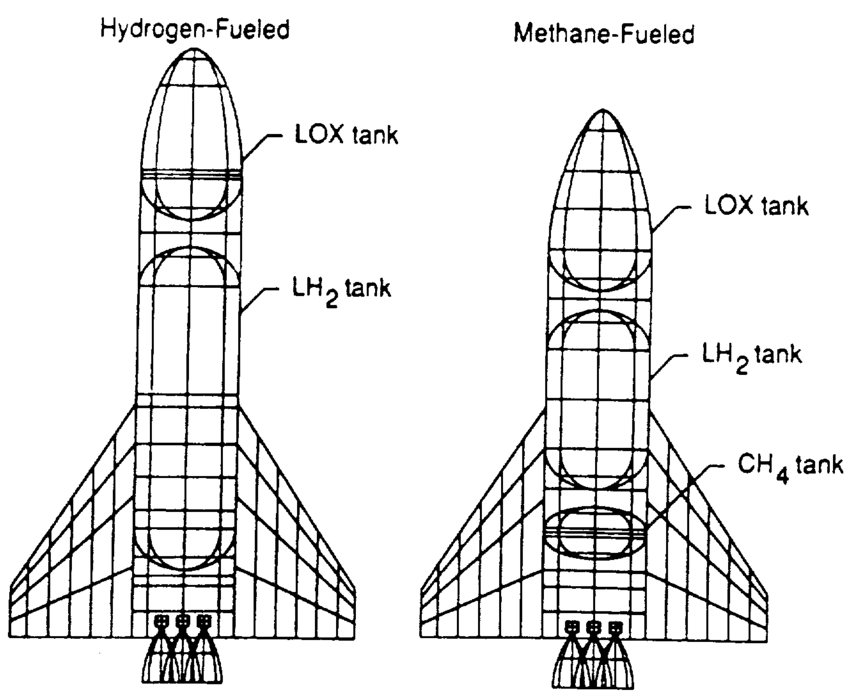
THRUST SPLIT TRADE AT LIFT-OFF

FULLY REUSABLE, ALL LOX/LH_2



- Chose 7 engines on booster, 4 engines on orbiter

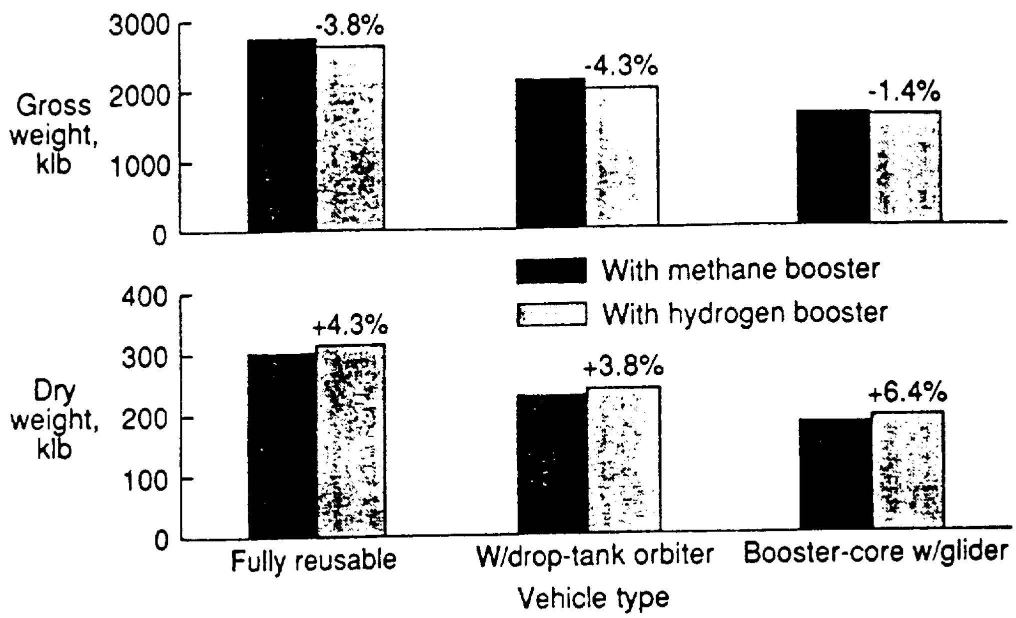
AMLS REUSABLE BOOSTERS



AMLS CONCEPT PROPULSION TRADES

SINGLE FUEL VERSUS DUAL FUEL

- All vehicles designed to same reference mission (polar, 12 klb) and same technology level
- Boosters use methane or hydrogen as main propellant (STME/STBE engine)



ADVANTAGES OF THE ALL-HYDROGEN VEHICLE

- Reduced development costs
  - Delete STBE-type engine development (traded off against slightly increased vehicle dry weight)

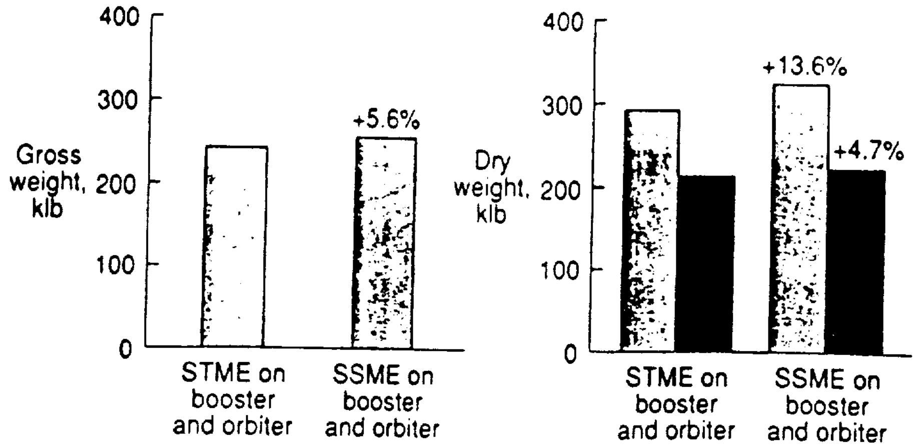
- Reduced production costs
  - Increased line production of one type of engine

- Simpler operations
  - Common engine systems used on both stages
  - Elimination of hydrocarbon fuel and associated storage, handling, and management organization structure

- Environmental factors
  - Hydrogen fuel cleaner burning
    - Reduced engine maintenance
    - Elimination of detrimental hydrocarbon exhaust byproducts

SSME VERSUS SINGLE-POSITION STME

FULLY REUSABLE, ALL LOX/LH_2 VEHICLE



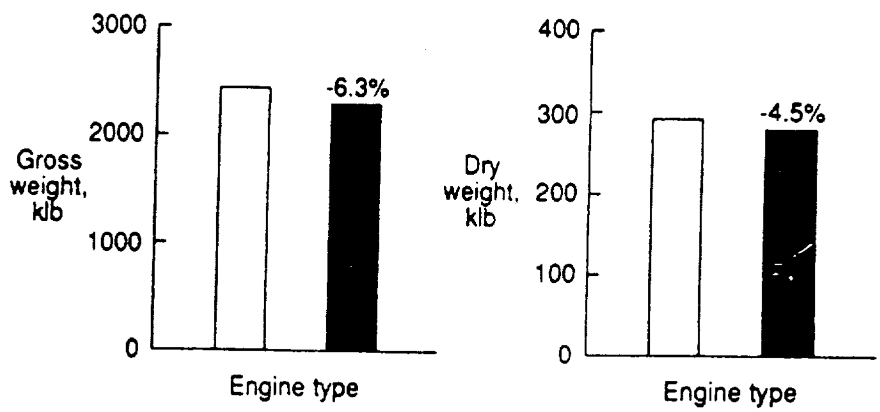
- Cases use current, unmodified SSME
- OF ratio is 6.0 for SSME and STME
- ε = 77.5 for SSME, ε = 60 for STME
- Both cases have engine-out capability

☐ Including propulsion weight

■ Without propulsion weight

DUAL-POSITION NOZZLE TRADE

FULLY REUSABLE, ALL LOX/LH_2

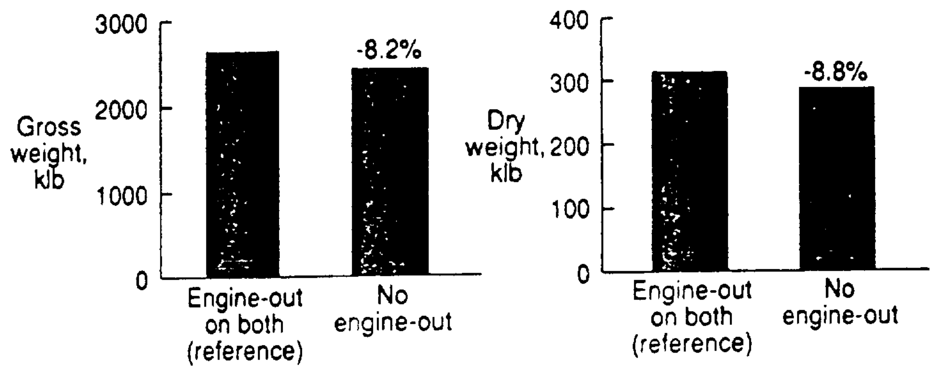


☐ Single-position nozzle (ε = 60), corrected I_{sp}

■ Dual-position nozzle (ε = 60/120), on orbiter

ENGINE-OUT CAPABILITY TRADE

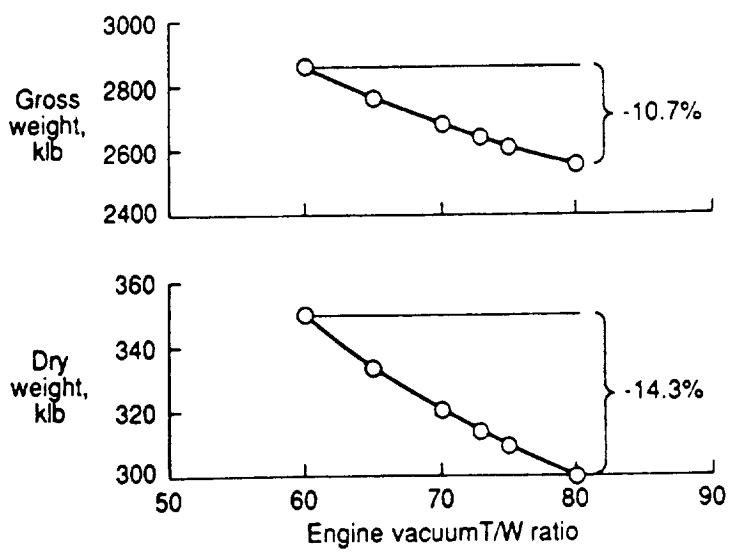
FULLY REUSABLE, ALL LOX/LH_2 VEHICLE



- At least 4 engines required on both the booster and orbiter
- Increased vehicle reliability brings about:
  - Quantitative reduction in recurring costs
  - Qualitative increase in crew and mission safety

ENGINE THRUST-TO-WEIGHT RATIO TRADE

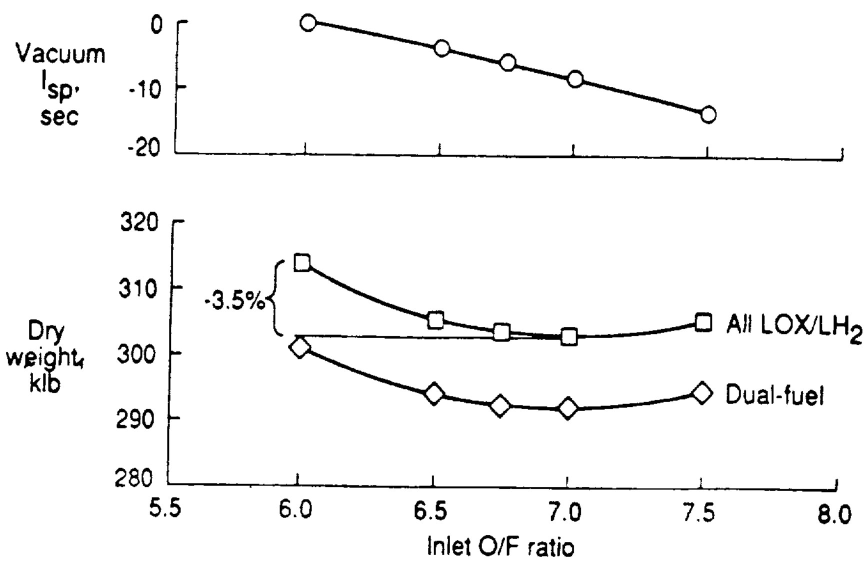
FULLY REUSABLE, ALL LOX/LH_2



- Constant O/F ratio and I_{sp} for all cases

AMLS OXIDIZER/FUEL RATIO TRADE

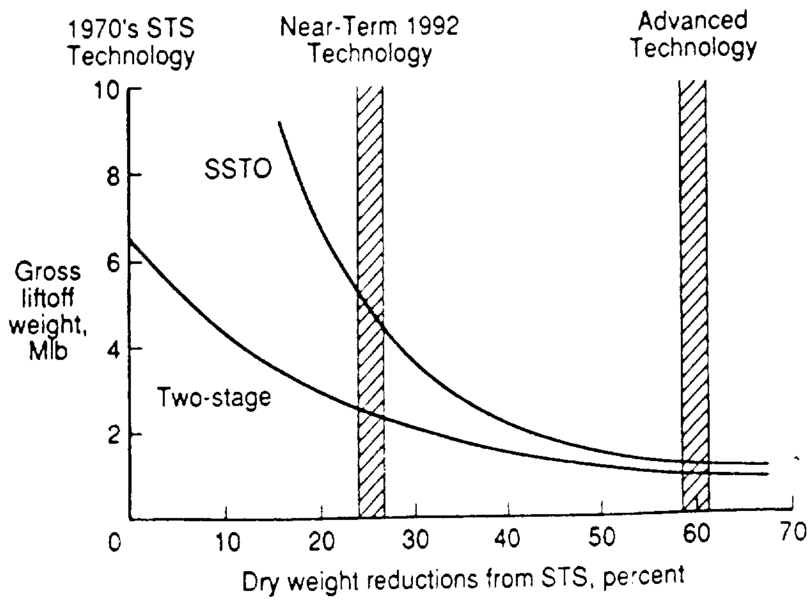
FULLY REUSABLE



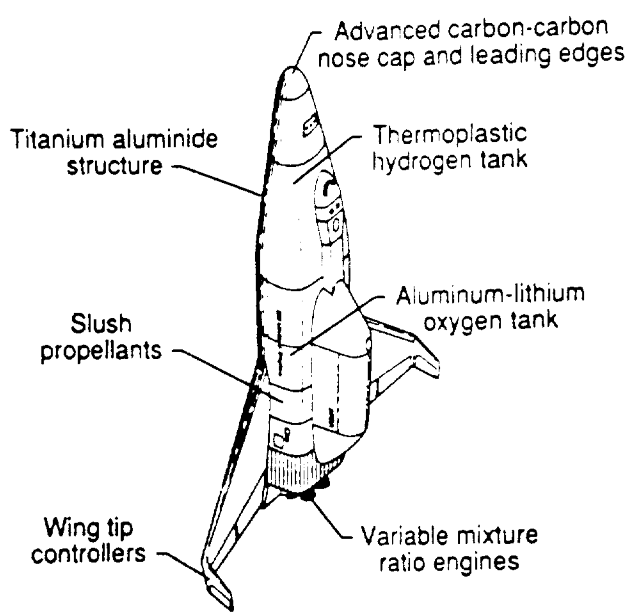
CONCLUSIONS

- Development of a new hydrocarbon booster engine (like the STBE) for next-generation manned systems may not be cost effective
- Development of a new hydrogen engine (like the STME) for next-generation manned systems could prove cost effective for use as a main (and booster) propulsion system
- Use of a dual-position nozzle would probably not be beneficial for a design-for-operations system like AMLS
- An increase in oxidizer-to-fuel ratio from the current SSME level of 6 to approximately 7 would be beneficial in reducing future launch system weights

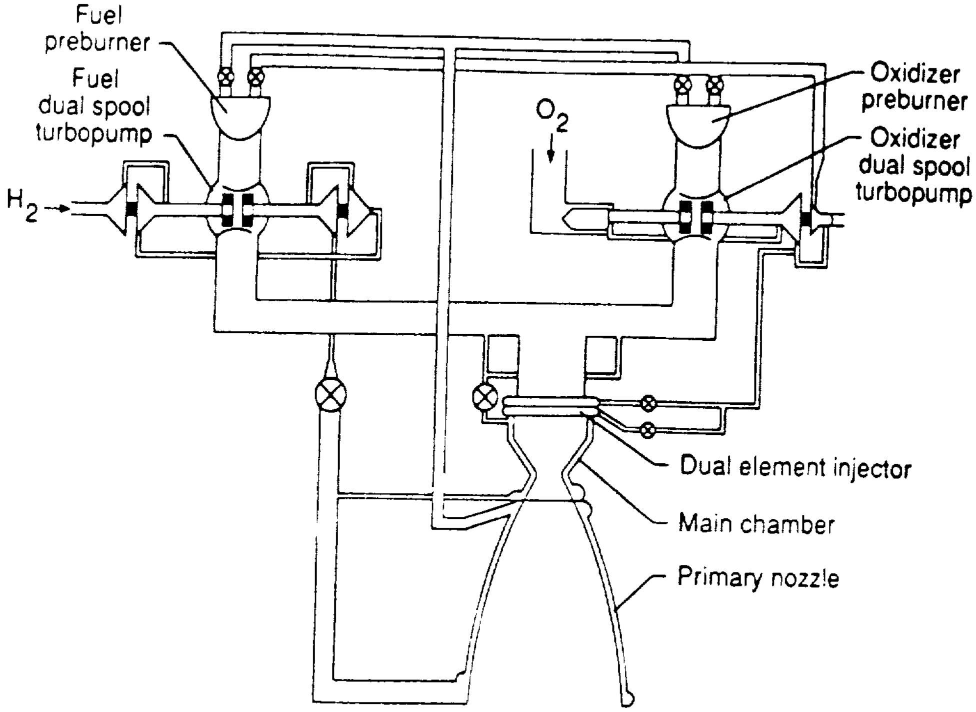
TECHNOLOGY EFFECT ON ROCKET LAUNCH VEHICLE WEIGHT



ADVANCED SSTO VEHICLE TECHNOLOGIES



PRATT & WHITNEY VMR FLOW SCHEMATIC



ADVANCED VARIABLE-MIXTURE RATIO ENGINE

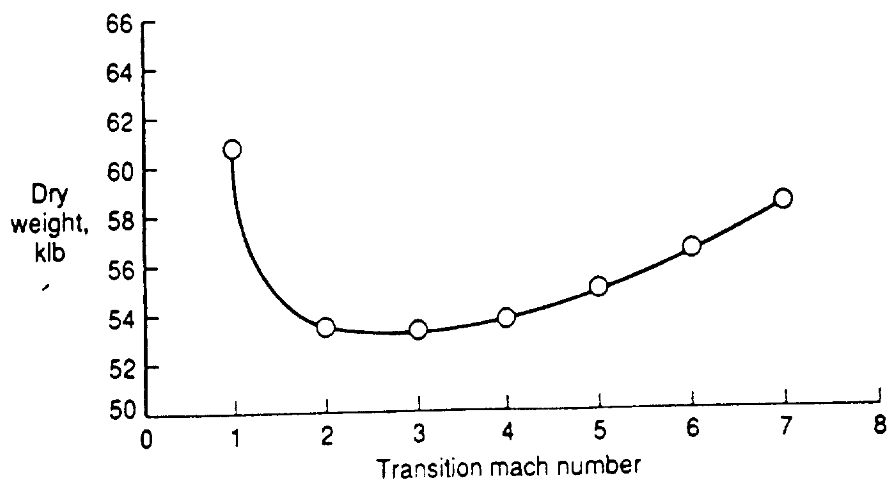
HYDROGEN/OXYGEN

Mode	1	2	SSME (109%)
O/F Ratio	12	6	6.026
Nozzle	Retracted	Extended	Single-position
Expansion Ratio	40	150	77.5
Vacuum Thrust, lb	254,500	176,900	512,300
Vacuum Isp, sec	362	467	452
Chamber Press., psia	4,000	2,700	3260
SL Thrust, lb	234,580	142,832*	417,300
SL Thrust/Weight	109.5	66.68*	60

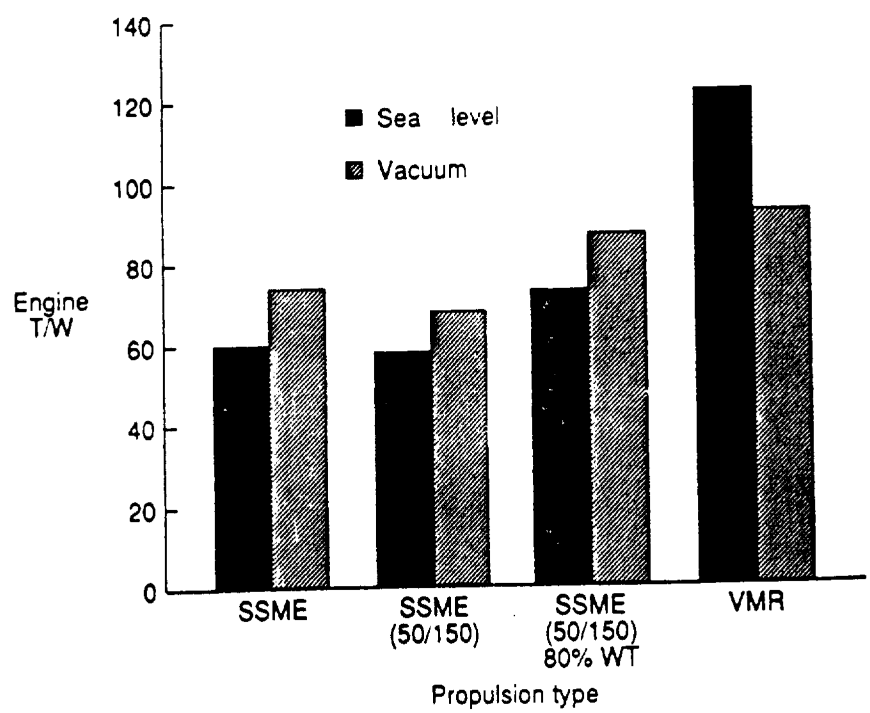
*Area ratio of $\varepsilon = 40$

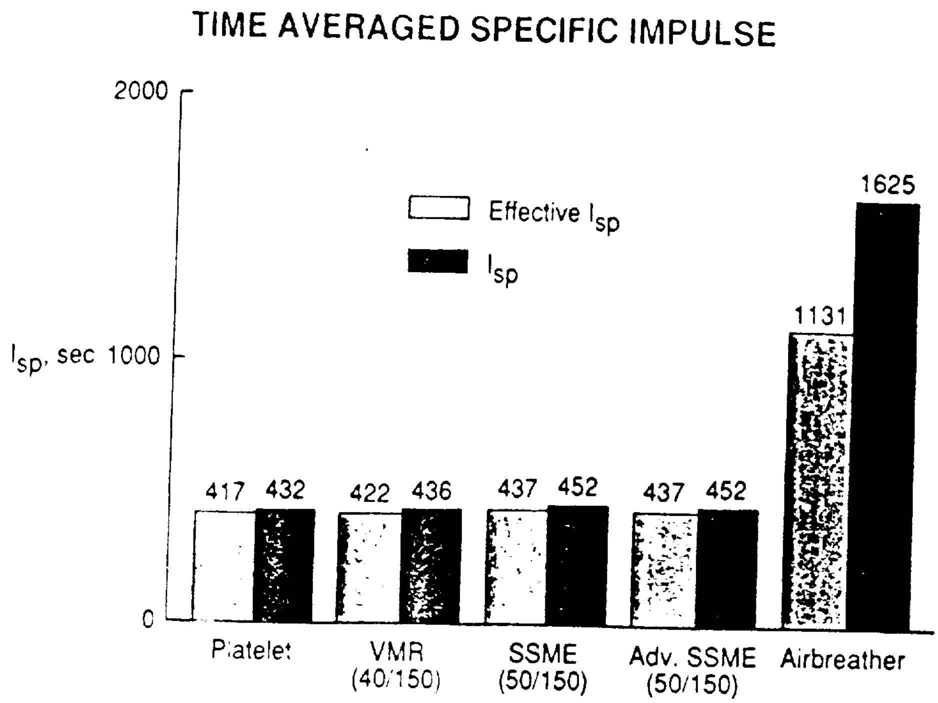
TRANSITION MACH NUMBER TRADE (VMR ENGINE)

INITIAL TRADE

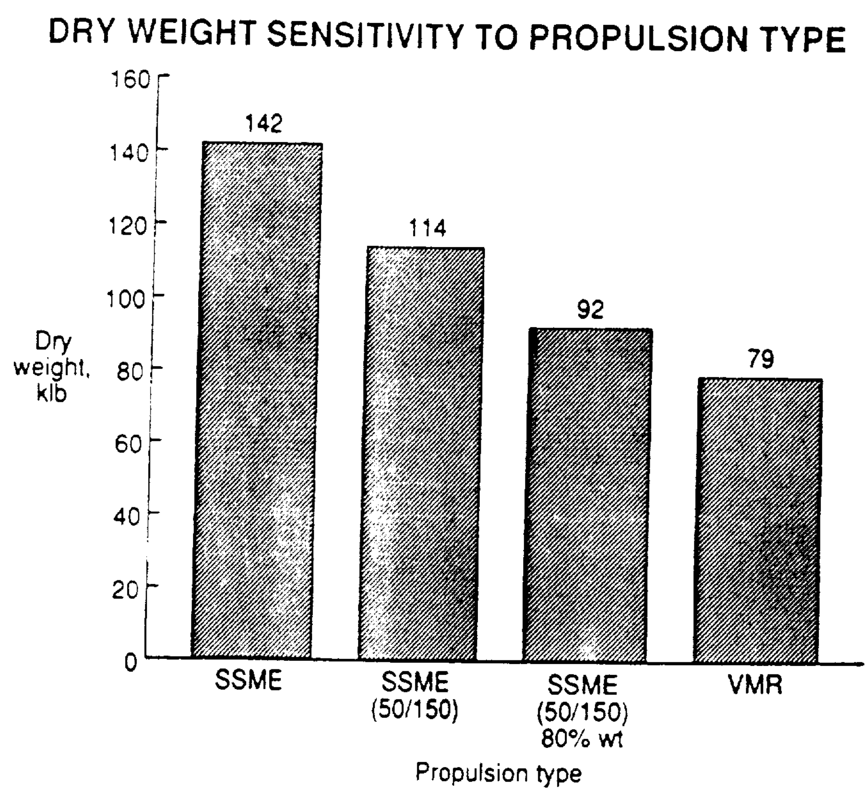


COMPARISON OF PROPULSION CHARACTERISTICS





TIME AVERAGED SPECIFIC IMPULSE
2000
Isp, sec 1000
0
Effective Isp
Isp
417
432
422
436
437
452
437
452
1131
1625
Platelet
VMR (40/150)
SSME (50/150)
Adv. SSME (50/150)
Airbreather



DRY WEIGHT SENSITIVITY TO PROPULSION TYPE
160
140
120
100
80
60
40
20
0
Dry weight, klb
142
114
92
79
SSME
SSME (50/150)
SSME (50/150) 80% wt
VMR
Propulsion type

CONCLUSIONS

- Application of advanced technologies could allow introduction of rocket-powered SSTO vehicle for 2015 IOC
  - Low dry weight compared to two-stage and airbreathers
  - Lower operation costs than two-stage
- Application of variable-mixture-ratio technology and cooled, vaneless turbines could greatly benefit advanced vehicles
  - Lower specific impulse
  - Higher T/W ratio
  - Higher bulk density

NATIONAL AEROSPACE PLANE (NASP)