N93-22085

3.2 Advanced Crew Rescue Vehicle/ Personnel Launch System – Jerry Craig, Johnson Space Center

The Advanced Crew Rescue Vehicle (ACRV) will be an essential element of the Space Station to respond to three specific missions, all of which have occurred during the history of space exploration by the U.S. and the Soviets:

- Mission DRM-1: Return of disabled crew members during medical emergencies.
- Mission DRM-2: Return of crew members from accidents or as a result of failures of Space Station systems.
- Mission DRM-3: Return of crew members during interruption of Space Shuttle launches.

The ACRV will have the ability to transport up to eight astronauts during a 24-hour mission. Not only would the ACRV serve as a lifeboat to provide transportation back to Earth, but it would also be available as an immediately available safe refuge in case the Space Station were severely damaged by space debris or other catastrophe. Upon return to Earth, existing world-wide search and rescue assets operated by the Coast Guard and Department of Defense would be able to retrieve personnel returned to Earth via the ACRV.

The operational approach proposed for the ACRV is tailored to satisfying mission requirements for simplicity of operation (no piloting skills or specially trained personnel are required), continuous availability, high reliability and affordability. By using proven systems as the basis for many critical ACRV systems, the ACRV program is more likely to achieve each of these mission requirements. Nonetheless, the need for the ACRV to operate reliably with little preflight preparation after, perhaps, 5 to 10 years in orbit imposes challenges not faced by any previous space system of this complexity. Specific concerns exist regarding micrometeoroid impacts, battery life, and degradation of recovery parachutes while in storage.

Current policy requires that the ACRV be operational at the onset of Permanent Manned Capability (PMC) of the Space Station. PMC is unlikely to occur before 1999, and therefore the ACRV program should be able to meet this requirement.

Dozens of special tests are planned to ensure that system designers fully understand unique aspects of the ACRV vehicle and mission requirements. For example, water egress tests will ensure that recovery of both able-bodied and injured personnel is possible after landing. Integrated systems tests will verify the operability of proposed embedded systems intended to eliminate the need for a skilled pilot and to interact with ground-based search and rescue forces. Other tests and analyses will examine issues associated with communications, data handling and power systems, landing opportunities, aero-thermal analysis and separation from the Space Station.

Johnson Space Center has initiated a Manned Transportation System (MTS) study of other issues related to the full scope of manned transportation systems. The objective of this eight-month study is to reach consensus on needs, attributes, and architecture products and thereby enhance the acceptance and subsequent implementation of the MTS study results. The MTS study is using a NASA-Industry Team (NIT) to serve as a forum for examining selected transportation issues. In March 1992, the NIT will issue a final report that:

- Quantifies transportation needs as a function of alternative space mission sets.
- Identifies and weighs the primary discriminating attributes that future transportation systems must possess.
- Describes and ranks manned transportation architecture options for each set of future space missions.
- Quantifies top-level transportation system mission requirements, such as the amount of payload and its

destination, for each mission set. This information will then be available for further studies.

- Identifies better ways of doing business.

To enhance crew safety, lessons learned from past experience should be used to guide the development of future systems. A close look at past failures reveals that most flight failures are associated with propulsion, and that half of them occur within 60 seconds of launch while vehicle altitude is below 50,000 feet. The current approach to man-rating launch vehicles relies on added redundancy, upgraded designs to correct known weaknesses, and more stringent quality control procedures. Unfortunately, these practices have been unable to prevent tragic accidents, and innovative approaches may be advisable to improve overall success rates. For example, one new approach that could be considered would use a twin C-5 air launch vehicle to carry a spacecraft mated to a three-stage solid-rocket booster to a drop altitude of 40,000 feet. The gross weight of the twin-fuselage aircraft would be about 1.5 to 1.8 million pounds, with a payload capacity (spacecraft plus boosters) of up to one million pounds. Maximum spacecraft weight at insertion into a 220 nautical mile, 28.5° inclination orbit would be 34,414 pounds, sufficient for either an ACRV or PLS vehicle. Air launches of this kind would provide a number of design and operational benefits such as reduced dynamic pressures and increased time margins for mission abort.

ACRV

Project Office

ACRV/MTS PRESENTATION

TO THE

SPACE TRANSPORTATION MATERIALS & STRUCTURES TECHNOLOGY WORKSHOP

Jerry Craig

September 23-26, 1991

NASA

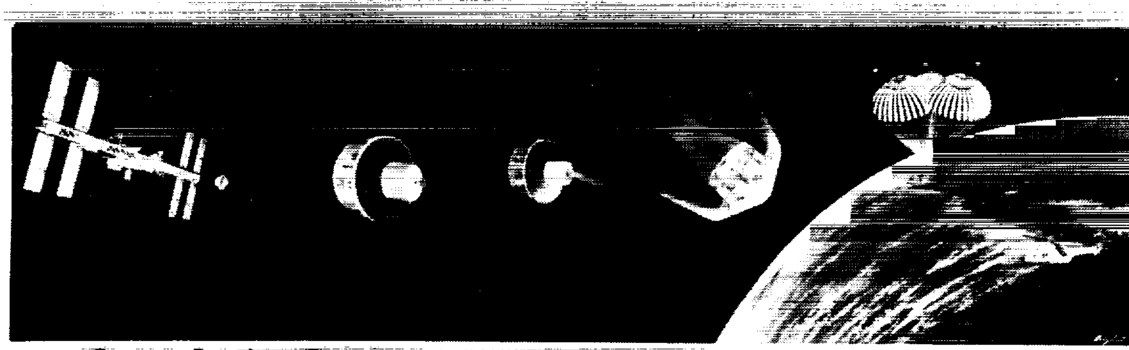
The ACRV is the Space Station Freedom Lifeboat

- Return one disabled Space Station crewmember during **medical emergencies.** (DRM-1)
- Return of Space Station crew from accidents or from **failures of Space Station Freedom systems.** (DRM-2)
- Return of Space Station crew during **interruption of Space Shuttle launches.** (DRM-3)

Each of these emergencies has occurred in manned spaceflight.

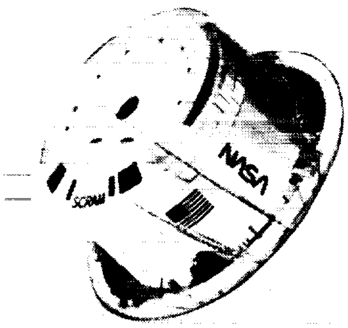
Report of the Advisory Committee on the Future of the U.S. Space Program ... *"The emergency recovery capability now planned for the Space Station is essential."*

ACRV Typical Mission Sequence

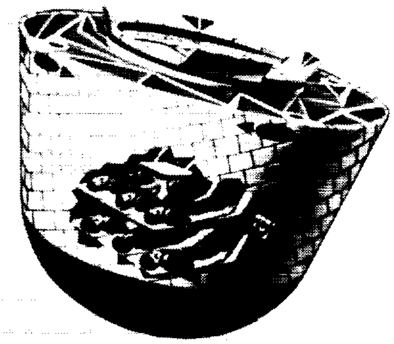


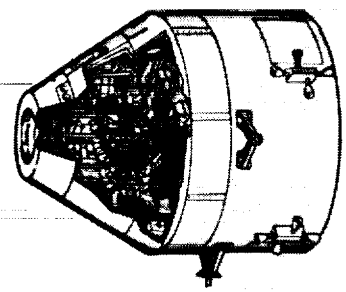
- Space Station Freedom emergency is declared
- Crew transfers from Space Station Freedom to ACRV
- ACRV isolates crew from emergency and activates lifeboat systems
- ACRV separates from Space Station Freedom and initiates deorbit
- Retrosystem is staged and entry is initiated
- Chutes are deployed and ACRV lands on Earth
- SAR forces transfer crew to safety

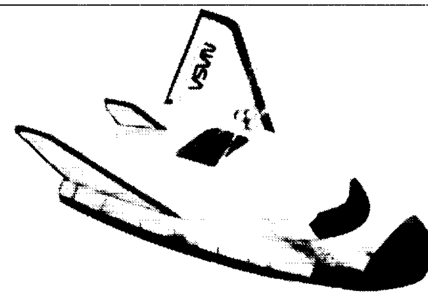
Candidate ACRV Vehicle Approaches



SCRAM VEHICLE


DISCOVERER SHAPED VEHICLE


APOLLO DERIVED VEHICLE



MID - L/D VEHICLE

Operations Approach

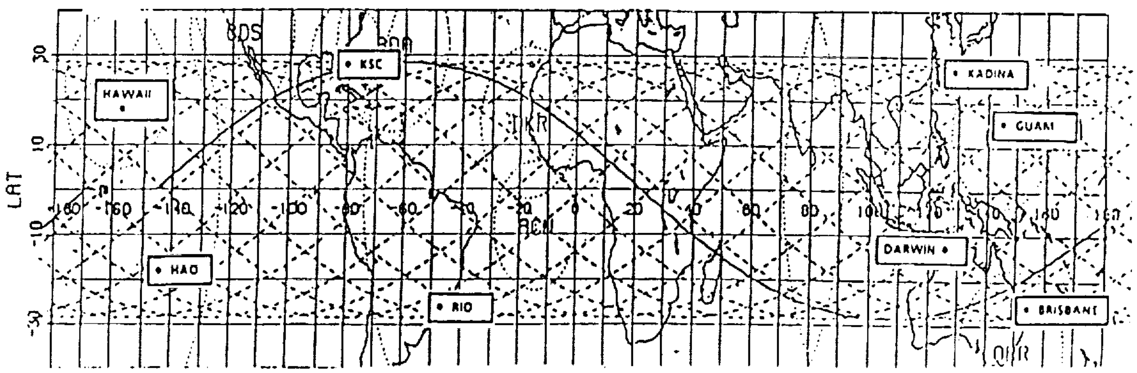
- SIMPLE, AVAILABLE, RELIABLE AND AFFORDABLE (SARA) OPERATIONAL PHILOSOPHY
  - SIMPLIFY CREW ROLE
  - ENSURE OPERATIONAL READINESS AND QUICK RESPONSE
- EMBEDDED OPERATIONS
  - OPTIMIZE USE OF EXISTING FACILITIES AND RESOURCES
  - STREAMLINE PRELAUNCH PROCESSING OPERATIONS
- EXISTING CAPABILITIES
  - USE OF FLIGHT DEMONSTRATED PROCEDURES AND TOOLS
  - EXISTING SAR CAPABILITIES
- SYSTEMS COMMONALITY
  - OPTIMIZE INTERFACES AND ACHIEVE OPERATIONAL SYNERGISM WITH SPACE SHUTTLE AND SPACE STATION FREEDOM

EMBEDDED OPERATIONS

ACRV Landing Opportunities

- GLOBAL DISTRIBUTION OF LANDING SITES PROVIDES MULTIPLE OPPORTUNITIES PER DAY
  - REDUCES WORST CASE WAIT TIME
  - PROVIDES BACKUP SITES FOR WEATHER AND MISSED DEORBIT BURNS
- SITES IN BOTH HEMISPHERES ASSURE DAYLIGHT OPPORTUNITIES
- SITES NEAR 28.5 LATITUDE CAN PROVIDE MULTIPLE OPPORTUNITIES
- ALL SITES MUST HAVE EXISTING SAR FORCES AND MEDICAL FACILITIES NEARBY

[TYPICAL SUBSET OF CANDIDATE INTERNATIONAL SITES IS SHOWN OVERLAID WITH ORBIT TRACKS FOR A 24 HOUR PERIOD]



ACRV DESIGN PHILOSOPHY

S **imple design eliminates complex systems and interfaces**

A **vailable – space-based vehicle to provide high mission availability**

R **eliable – robust design, fail-safe subsystems, utilizing proven flight space technology**

A **ffordable – designed to utilize existing mission, ground, and SAR infrastructure**

STUDY ASSUMPTIONS/GROUNDRULES:

- BASED ON A LOW LIFT/DRAG CONCEPT CALLED *SCRAM*
  (STATION CREW RETURN ALTERNATIVE MODULE)
  - SIMPLE DESIGN, GOOD FLOTATION CHARACTERISTICS
- SIZED TO TRANSPORT 8 CREW FOR 24 HOUR MISSION
- BASELINE WATER LANDER
- USE SUBSYSTEMS THAT ARE SIMPLE, AVAILABLE, RELIABLE AND AFFORDABLE
- MINIMIZE SSF INTERFACE DURING QUIESCENT MODE

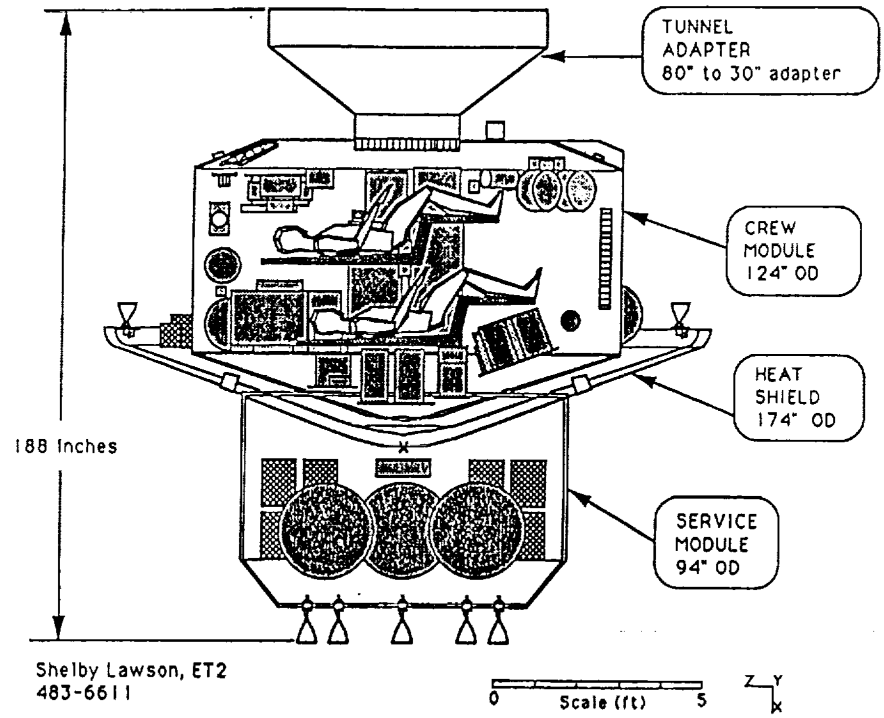
ACRV 8-PERSON SCRAM CONT.

JSC REPRESENTATIVE *ACRV* CONCEPT CONSISTS OF:

- 174" (14.5 FT) OD VIKING HEAT SHIELD
  - RCS SYSTEM
  - CREW MODULE BATTERIES
- 124" (10'4") OD CREW MODULE
  - 8 CREW AND COUCHES
  - POWER DISTRIBUTION, AVIONICS, ECLSS, CREW PROVISIONS
  - TOP AND SIDE HATCHES
- 80"TO 30" SSF/ACRV TUNNEL ADAPTER
- 94" (7 10") OD SERVICE MODULE
  - BATTERIES
  - DEORBIT PROPULSION
- MICROMETEOROID SHIELDS

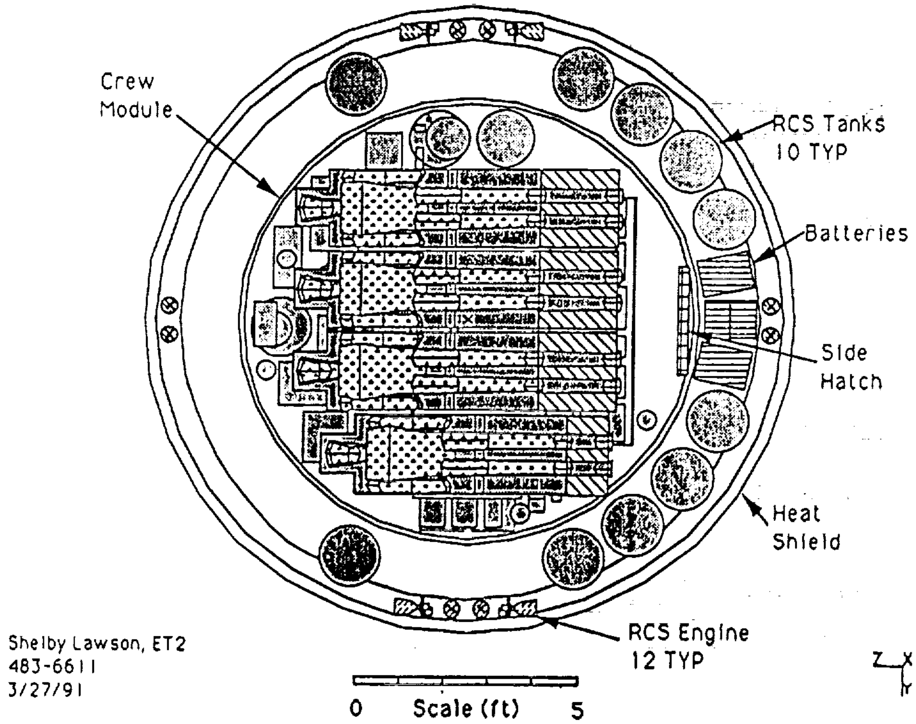
ASSURED CREW RETURN VEHICLE (ACRV)

Reference For External Integration



Assured Crew Return Vehicle (ACRV) - Top View

8 man, 24 hour mission



STRUCTURE AND TPS:

- WEIGHTS WERE ESTIMATED WITH AREAL DENSITY (LBS/SQ FT) PARAMETER BASED ON STRUCTURAL, THERMAL AND AERODYNAMIC ANALYSIS OF MODIFIED APOLLO CAPSULE. CREW MODULE, HEAT SHIELD AND SERVICE MODULE SURFACE AREAS WERE USED TO GENERATE THE WEIGHTS SHOWN IN THE MASS STATEMENT.

ACRV 8-PERSON SCRAM CONT.

STRUCTURE AND TPS:CONT.

ANALYSIS DOCUMENTED IN JSC-32025. AREAL DENSITIES AND WEIGHTS ESTIMATED BY ES (SERVICE MODULE STRUCTURE BY ET2)

STRUCTURE:
CREW MODULE: 1,552 LBS
HEAT SHIELD: 500 LBS
SERVICE MODULE: 475 LBS

TPS AND INSULATION:
CREW MODULE: 273 LBS
HEAT SHIELD: 443 LBS
SERVICE MODULE: 71 LBS

RECOVERY

- **APOLLO PARACHUTE SYSTEM AND COUCH ATTENUATION WEIGHTS REPRESENTED. ASSUME THREE ROUND PARACHUTES WITH PACKING VOLUME LESS THAN 40 LBS/CU FT.**

PARACHUTE ASSEMBLY:595 LBS

IMPACT & RECOVERY SYS.: 186 LBS

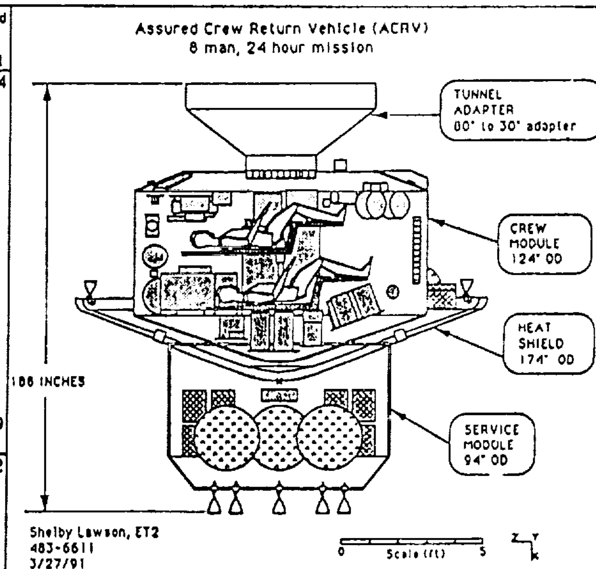
MOUNTING STRUCTURE: 156 LBS

TOTAL RECOVERY SYSTEM MASS: 936 LBS

Assured Crew Return Vehicle Mass Statement 3/18/91

NOTE: ALL MASS IS IN POUNDS.

DESIGN MASS SUMMARY
ACRV

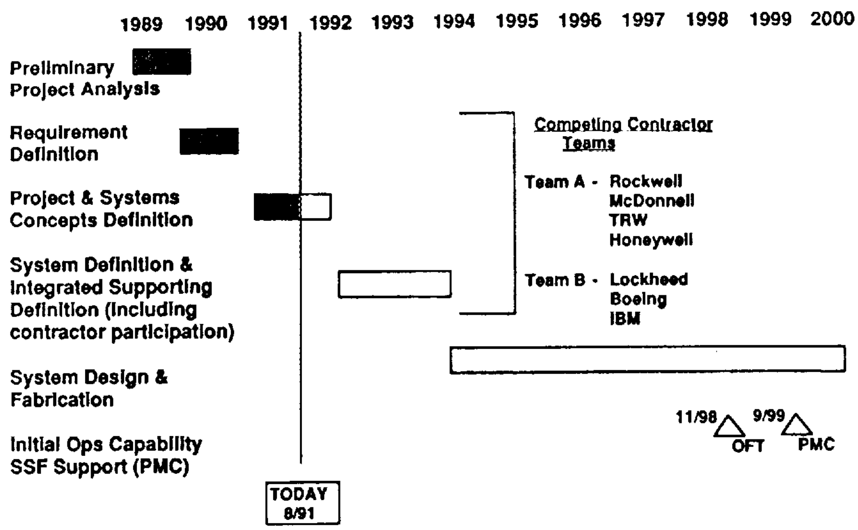


FUNCTIONAL SUBSYSTEM CODE	Crew Module	Service Module	Berthing Adapter System	FSE & ASE Equip.	Meteoroid Debris Protect
1.0 STRUCTURE	1,552	475	544	1,600	523.4
2.0 PROTECTION	1,216	71			
3.0 PROPULSION	250	302			
4.0 POWER	856	732			
5.0 CONTROL	0				
6.0 AVIONICS	990	48			
7.0 ENVIRONMENT	1,817				
8.0 OTHER	989	52			
9.0 GROWTH	1,150	252	82	240	79
DRY MASS	8,820	1,932	625	1,840	602
10.0 NON-CARGO	1,820	56			
11.0 CARGO	120	0			
INERT MASS	10,760	1,988	625	1,840	602
12.0 NON-PROPELLANT	373	0			
13.0 PROPELLANT	264	866			
GROSS MASS	11,397	2,854	625	1,840	602

NOTE:
Crew Module:
Service Module:
Berthing Adapter System:
FSE & ASE Equipment:
Micrometeoroid / Debris Protection:

Shelby Lawson, NASA JSC, M.C. ET2, phone 483-6611

ACRV Project Schedule



UNIQUE ACRV TECHNOLOGY ISSUES

- LONG TERM DORMANCY ISSUES
  - 5 TO 10 YEAR ON-ORBIT LIFETIME REQUIREMENT
    - *VEHICLE REUSE CAPABILITY FOLLOWING ORBIT STAY*
  - DEBRIS/MICROMETEOROID IMPACT CONCERNS
    - *IMPACT RESISTANT HEAT SHIELD AND STRUCTURE*
    - *ON-ORBIT PROTECTION DEVICES*
    - *RE-ENTRY CAPABILITY FOLLOWING IMPACT DAMAGE*
  - LONG TERM STORAGE OF RECOVERY PARACHUTES
  - LONG TERM BATTERY LIFE
- EMBEDDED OPERATIONS
  - NO PILOT SKILLS; AUTOMATED OPS
  - MINIMAL TRAINING
  - AUTONOMOUS VEHICLE OPERATIONS
  - EXISTING SAR CAPABILITIES

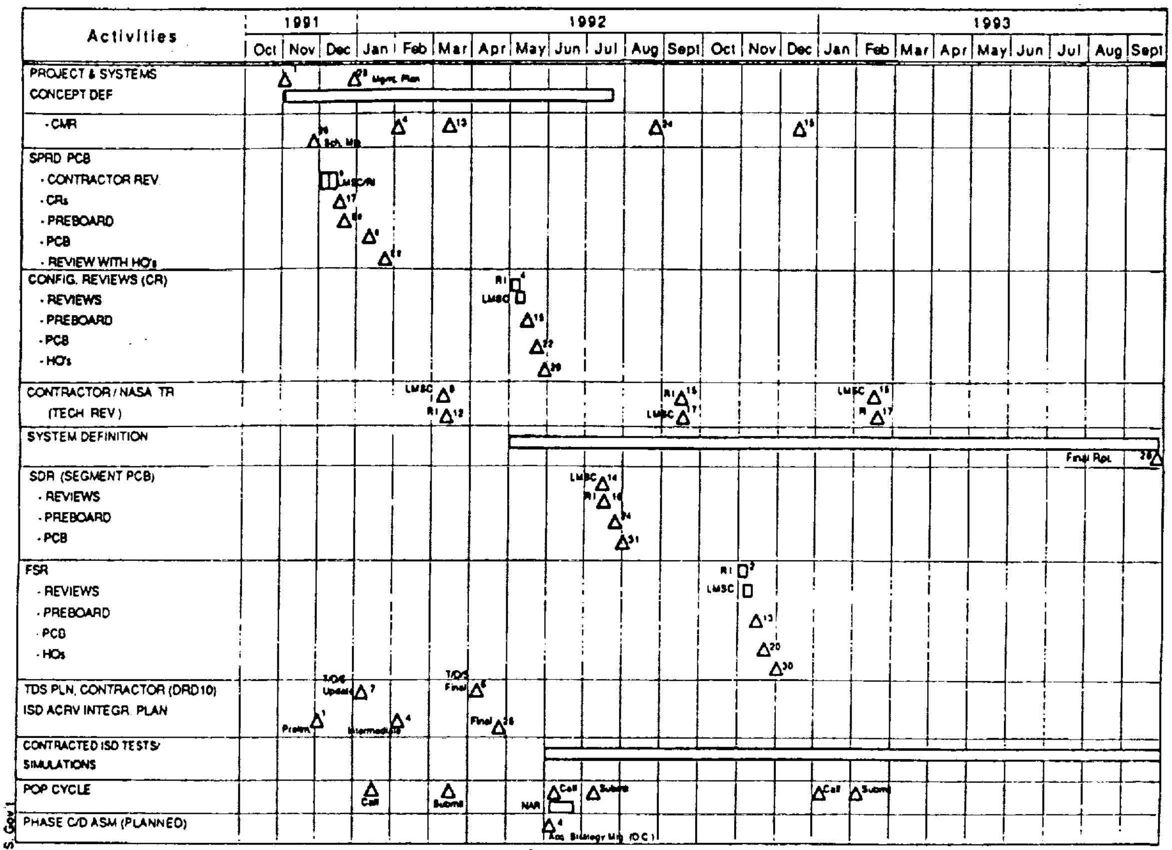
ACRV REQUIREMENTS VALIDATION TEST/SIMULATIONS

- ENTRY G LEVEL EXPOSURE TESTS
  - HUMANS
  - ANIMALS
- ZERO-G EGRESS TIME (KC-135)
- WATER LANDING FLOTATION/CREW EXTRACTION FOR ILL/INJURED DECONDITIONED CREW
- LAND LANDING DESIGN CRITERIA VALIDATION
- APOLLO IMPACT G REQUIREMENT VALIDATION

ACRV WATER LANDING REQUIREMENTS VALIDATION

- INITIATIVE: CONDUCT WATER EGRESS TESTS TO UNDERSTAND DIFFICULTIES AND REQUIREMENTS
- BASIC APPROACH IS TO BUILD A SINGLE FULL SCALE TEST ARTICLE (DESIGNED IN-HOUSE) THAT HAS VARIABLE PARAMETERS (CG, MASS, SHAPE) AND THEN CONDUCT MANNED AND UNMANNED TESTS AT TEXAS A&M OFFSHORE TECHNOLOGY RESEARCH CENTER WAVE TANK
- TEST WILL PRODUCE ENGINEERING DATA ON VEHICLE HANDLING AS WELL AS WATER EGRESS DATA
- OUR ENGINEERING TEAM HAS ALREADY CONSTRUCTED A SUBSCALE WAVE TANK AND SUBSCALE MODELS PRODUCING PRELIMINARY DATA FOR TEST PLANNING AS WELL AS DESIGN OF TEST ARTICLE
- ALSO DEVELOPING ANALYTIC MODELS OF VEHICLE HANDLING USING DERIVATIVES OF NAVAL ENGINEERING DESIGN TOOLS

ACRV DEFINITION PHASE B SCHEDULE



ACRV PHASE B INTEGRATED SUPPORTING DEFINITION

NASA & THE PRIME CONTRACTOR TEAMS * (LMSC & RI) WILL:

- CONDUCT ENGINEERING AND OPERATIONAL SIMULATIONS TO VALIDATE PRELIMINARY DESIGN DEFINITION AND TO IDENTIFY & EVALUATE DESIGN OPTIONS TO REDUCE/ABATE PHASE C/D RISKS AND ENHANCE THE DOWNSELECT PROCESS

- UTILIZE NASA AND CONTRACTOR FACILITIES TO PERFORM ANALYSIS, TEST, DEMONSTRATION, AND SIMULATION TASKS ON CANDIDATE (GENERIC AND COMPETITION SENSITIVE) HARDWARE AND SOFTWARE FOR A PRACTICAL APPROACH TO .....

  - SIMPLE & RELIABLE DESIGNS
  - LOW COST, NO FRILLS APPROACHES
  - MINIMIZE DESIGN RISKS IN PHASE C/D

- CONDUCT INTEGRATED TESTS (PARTIAL OR FULL SCALE), DEMONSTRATIONS, AND SIMULATIONS TO VALIDATE EMBEDDED OPERATIONS CONCEPTS

*BOTH CONTRACTOR TEAMS HAVE IDENTIFIED SIGNIFICANT COST SHARING WITH NASA

INTEGRATED SUPPORTING DEFINITION

- THE ISD TASKS WILL BE CONDUCTED UNDER THE FOLLOWING MAJOR CATEGORIES:

	NASA	CONTRACTOR
- ENGINEERING		
- LANDING & RECOVERY	X	X
- S/W & AVIONICS	X	X
- AERO/AEROTHERMAL	X	X
- DORMANCY		X
- DEFINITION CONTRACT SUPPORT	X	
- OPERATIONS		
- EMBEDDED OPERATIONS	X	X
- SSF INTERFACES	X	X
- MAN-MACHINE & MECH. SYSTEMS	X	X

INTEGRATED SUPPORTING DEFINITION

HANDS-ON TYPE TASKS TO BE PERFORMED IN FY92 & 93

BY

NASA & PRIME CONTACTORS:

LANDING & RECOVERY ANALYSIS
AERO-AEROTHERMAL ANALYSIS
* TPS/DEBRIS IMPACT ANALYSIS
* RESERVE LITHIUM BATTERY DEVELOPMENT
GN & C/AVIONICS SUPPORT
LANDING OPPORTUNITY ANALYSIS
WATER TESTS & DEMOS
GPS/ANTENNA ANAL & TEST
COMM & TRACK SYSTEM SUPPORT ANALYSIS
DATA SYSTEMS ANALYSIS
DISPLAY & CONTROL SYSTEM ANALYSIS
SYS. & HEALTH MONITORING & FAILURE ANALYSIS (DORMANCY)
SYSTEMS ENG SIM DEVELOP
PWR DIST & CONTROL BREADBOARD

INTEGRATED SUPPORTING DEFINITION CONT.

HANDS-ON TYPE TASKS TO BE PERFORMED IN FY92 & 93
BY
NASA & PRIME CONTACTORS:

- ECLSS SUPPORT & DEMO
- SSF SEPARATION/PROX OPS ANALYSIS
- * MAT'L & PROCESS EVALUATION
- DRM DEV. & DESIGN ASSESSMENT
- FAULT TOL/REDUNDANCY MGMT.
- KC135 FLTS/MOCK-UP/EGRESS SIMULATIONS
- MED COUCH/LITTER DEVELOPMENT
- MOCKUPS & TRAINERS (1-G) DEVELOPMENT
- UPDATE STD-3000 VOL VI
- MED OPS CONCEPT PLANNING
- FLT OPS CONCEPT SUPPORT PLANNING
- * EMBEDDED OPS SIM/DEMO
- DESIGN REVIEWS & SUPPORT
- SRM & QA SUPPORT
- TOTAL DEFINITION EFFORT/KSC SUPPORT
- DDMS SUPPORT

ACRV DESIGN PHILOSOPHY

S imple

A vailable

R eliable

A ffordable

Manned Transportation System Study

Jerry Craig
NASA/Johnson Space Center
September 23, 1991

MTS Study

Objective

- To reach **consensus** on the needs, attributes, and architecture products, thereby enhancing **acceptance** and subsequent **implementation** of the study results. (In lieu of being policy makers, this can only be achieved by using a logical, measurable, and repeatable process.)

Approach

- Pull together representatives from NASA and industry and try to obtain consensus on the needs, attributes, and architectures
  - JSC, MSFC, LaRC, KSC
  - Boeing, General Dynamics, LMSC, Martin Marietta, McDonnell Douglas, RI under 8 month contract to JSC (Aug 91-March 92)
  - NASA Headquarters
  - Perhaps some additional industry input in specific areas

MTS Study Products

1 Quantified transportation needs as a function of the space agenda scenarios ("**IFs**") NASA may pursue from the present to 2020 (i.e., what you want the transportation system to do)

2 Determination and weighting of the primary discriminating attributes that the transportation system must possess (i.e., a "bottom-line" measure of how well the transportation system does it)

3 Due to the considerable uncertainty in our specific requirements for transportation (due to the uncertainty in our space agenda), we will

   a) determine and rank manned transportation architecture options. These architectures are a function of time and are specific to each space agenda scenario ("**IF**")

   b) determine top-level output requirements (such as amount and location of any cargo associated with the next manned transportation elements) to be used in future studies or design phases. This provides the framework for NASA and industry to determine the **optimum** solution(s) for personnel transportation to and from space.

4 New ways of doing business "better"

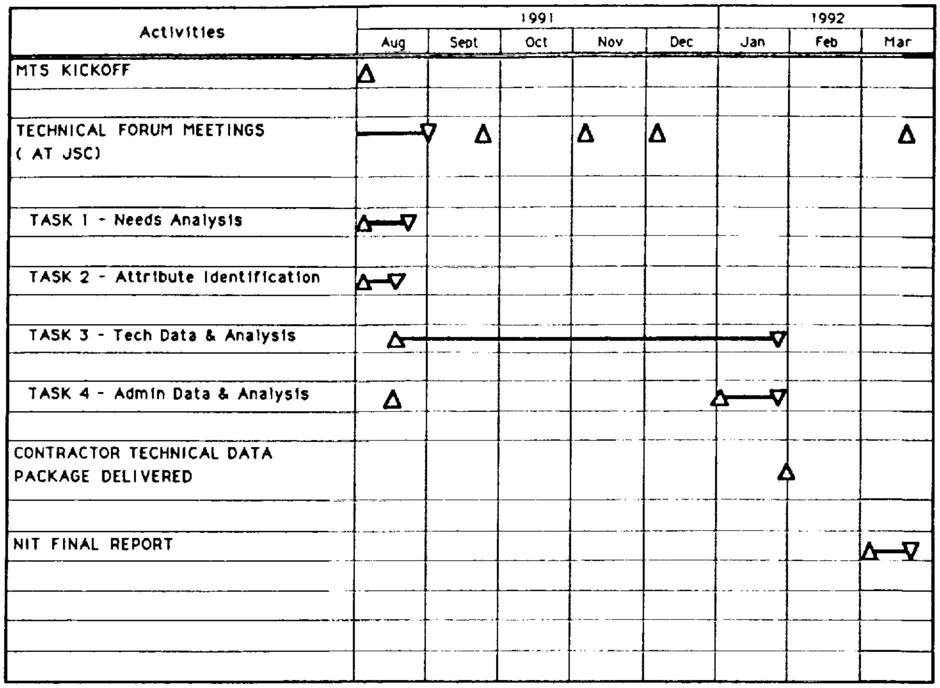
Study Approach

- NASA - Industry Team (NIT) Forum
  - Bring together the best in NASA and industry to work together to obtain maximum consensus
  - Have JSC, industry, headquarters and other centers work together in a single focused activity
- Architecture solutions will be "needs-based" as a function of the programs that may be implemented. For example,
  - **If** we just do Big Science program missions
  - **If** we do Big Science and basic SSF program missions
  - **If** we do Big Science and basic SSF program missions and SEI
- Determine and prioritize (weight) attributes desired of the potential solutions
- Assemble/develop candidate transportation element concepts that meet the need, determine the values of their attributes, assemble into architectures, and score the architectures

Note

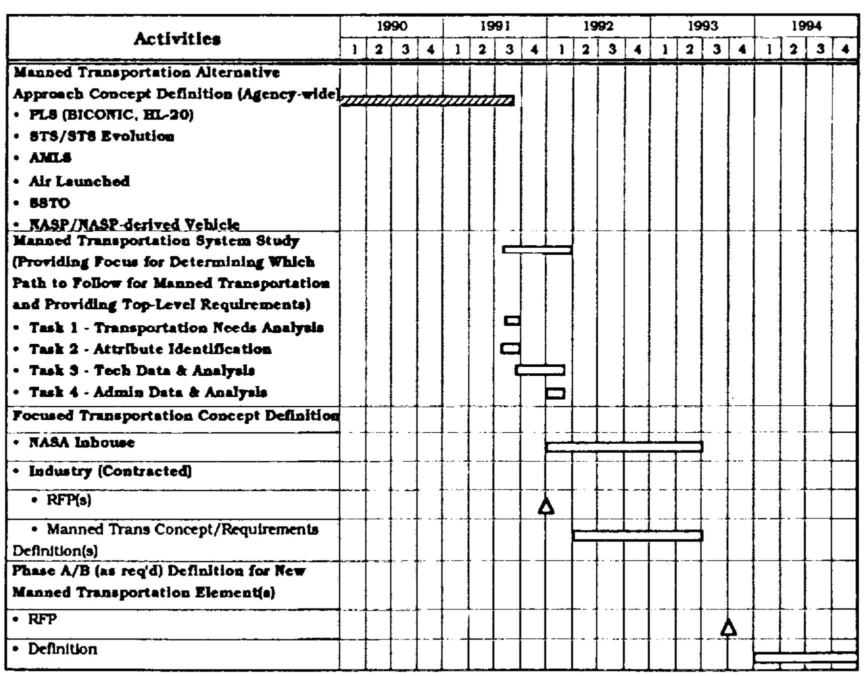
- Don't force consensus where consensus doesn't exist
- Obtain credible data to support conclusions reached

MTS Study Schedule



Manned Transportation Long Range Schedule

(Calendar Years)



MANNED TRANSPORTATION DESIGN PRINCIPLES TO ENHANCE CREW SAFETY

LESSONS FROM HISTORY

LAUNCH SYSTEMS - DEMONSTRATED SUCCESS/FAILURE

- MAJORITY OF FLIGHT FAILURES ARE PROPULSION
- FIFTY PERCENT OF ALL FAILURES OCCUR WITHIN FIRST 60 SECONDS AND BELOW 50,000 FEET
- HIGH DYNAMIC PRESSURES ASSOCIATED WITH GROUND LAUNCH CONTRIBUTE TO RAPID BREAK-UP WHEN FAILURES OCCUR -- REACTION TIMES ARE RELATIVELY SHORT

- SATISFACTORY ABORTS FROM LOW ALTITUDE FAILURES ARE EXTREMELY DIFFICULT
- SUCCESS RATES ARE EXTREMELY LOW COMPARED TO OTHER SYSTEMS -- CONFIRMED BY HIGH INSURANCE RATES
- IMPROVEMENTS IN SUCCESS RATES ARE ESSENTIAL FOR FUTURE MANNED SPACE LAUNCHES

LAUNCH SYSTEMS - PRIMARY REQUIREMENTS

MISSION TYPE	PRIMARY REQUIREMENT
MANNED SPACECRAFT	RELIABILITY (CREW SAFETY)
UNMANNED CARGO - FREQUENT FLIGHTS	OPERATING COST
HEAVY HEAVY CARGO - INFREQUENT FLIGHTS	DEVELOPMENT COST

* MISSION SUCCESS IS CRITICAL TO ALL TYPES

MAN-RATING APPROACH TO LAUNCH VEHICLE SAFETY

- ADDED REDUNDANCY WHERE NEEDED AND PRACTICAL
- DESIGN FIXES FOR ALL KNOWN DESIGN WEAKNESSES
- EXTRA QUALITY CONTROL TO MINIMIZE PROCESS FAILURES

- MAN-RATING APPROACH ALONE HAS NOT PROVEN EFFECTIVE
- MAN-RATING APPROACH IS NECESSARY BUT NOT SUFFICIENT

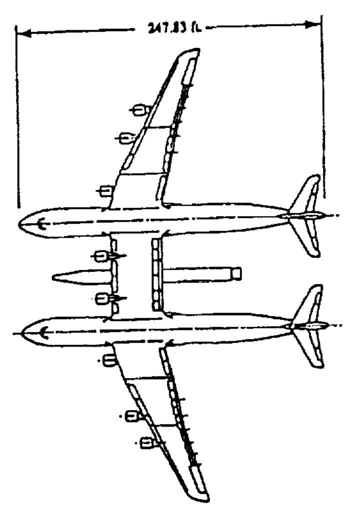
PURPOSE OF CASE STUDY

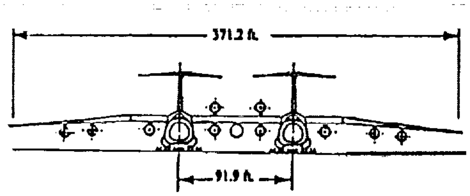
- DEMONSTRATE THAT A LARGE INCREASE IN RELIABILITY IS FEASIBLE
- IDENTIFY ANY MAJOR IMPEDIMENTS TO FEASIBILITY (SHOW-STOPPERS)
- AIR LAUNCH WITH SOLID ROCKETS NOT THE ONLY SOLUTION

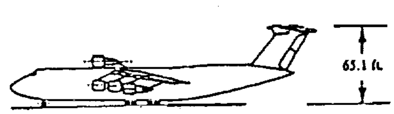
TWIN C5 AIR LAUNCH VEHICLE

FINAL VERSION

Speed	0.68 - 0.7 Mach
Payload	0.7×10^6 - 1.0×10^6 lbs.
OWE	0.673×10^6 lbs.
Gross weight	1.47×10^6 - 1.82×10^6 lbs.
AR	10.63

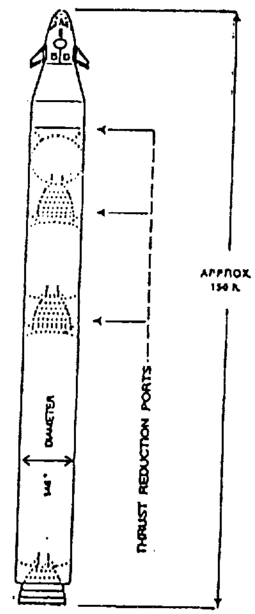






AIR LAUNCH VEHICLE CONFIGURATION

		3 Stage
Spacecraft		
Launch wt. (lb)		45,624
Insertion wt. (lb)*		34,414
Stage 3		
Total wt. (lb)		88,021
Propellent wt. (lb)		80,000
Visp. sec.		301.6
Inert wt. (lb)		8,021
Stage wt. (lb)	750	
Motor wt. (lb)	7,271	
Stage 2		
Total wt. (lb)		218,790
Propellent wt. (lb)		200,000
Visp. sec.		293.1
Inert. wt. (lb)		18,790
Stage wt. (lb)	2,095	
Motor wt. (lb)	16,695	
Stage 1		
Total wt. (lb)		757,379
Prop. wt. (lb)		687,605
Visp. sec.		283.5
Inert. wt. (lb)		69,774
Stage wt. (lb)	3,257	
Motor wt. (lb)	66,517	
Gross Ignition wt. (lb)		1,111,806
* To 220 n. mi. 28.5°		



MAJOR PARAMETERS

PARAMETER	VALUE	RATIONALE
SIZE OF SYSTEM	~1,000,000 POUNDS	LARGEST PRACTICAL ADAPTATION OF EXISTING AIRCRAFT
AIRCRAFT CHOSEN	TWIN C5	VERY LARGE HIGH-WING AIRCRAFT
DROP ALTITUDE	40,000 FEET	
ROCKET DESIGN	3-STAGE SOLIDS	ADAPTATION OF EXISTING SOLID MOTORS

SPACECRAFT

ASSUMPTIONS

- SPACECRAFT PROVIDED FUNCTIONS -- STS CONCEPT
  - GUIDANCE, NAVIGATION, AND CONTROL
  - COMMUNICATIONS, DATA MANAGEMENT, AND TRACKING SYSTEMS
  - PYROTECHNIC SEQUENCING, SAFE AND ARM FUNCTIONS, EXCLUDING INDEPENDENT RANGE SAFETY STAGE REQUIREMENTS
  - THERMAL PROTECTION DURING ASCENT (NO SHROUD)
  - PROPELLENT AND THRUST FOR ORBITAL INSERTION AND CIRCULARIZATION
- SPACECRAFT WEIGHT AT INSERTION (220 N.MI., 28.5°) = 34,414 POUNDS
  - FOR REFERENCE:

PLS LIFTING BODY, 10 PEOPLE	34,354
PLS BICONIC, 10 PEOPLE	30,524
ACRV, LAUNCH CONFIG., 8 PEOPLE, EST.	27,000

LOW DYNAMIC PRESSURE CONSIDERATIONS

- THE MAXIMUM DYNAMIC PRESSURE ENCOUNTERED WITH AN AIR LAUNCHED MANNED SPACECRAFT IS APPROXIMATELY 1/3 TO 1/2 THAT ENCOUNTERED WITH GROUND LAUNCH
- FLIGHT VEHICLE STRUCTURAL BENEFITS OF LOW DYNAMIC PRESSURES
  - LOWER Q'S WILL TEND TO REDUCE THE Q-ALPHA OF THE LAUNCH VEHICLE WHICH IN TURN WILL REDUCE THE OVERALL BENDING MOMENT INDUCED INTO THE STRUCTURE
    - LOWER AXIAL LOADS ON THE FLIGHT VEHICLE STRUCTURE
    - LOWER DELTA PRESSURES ACROSS THE SKIN OF THE FLIGHT SYSTEM
    - LOWER INITIAL PRESSURES IN THE VENTED FLIGHT SYSTEM COMPARTMENTS
- IMPROVED ABORT SYSTEM AND CREW REACTION TIME MARGINS

LAUNCH VEHICLE FLIGHT ENVIRONMENTS

LAUNCH SYSTEM	LIFTOFF T/W	MAXIMUM DYNAMIC PRESS., PSF	MAXIMUM AXIAL ACCELERATION, G'S
SHUTTLE	1.4	720	3
DELTA II-7920	1.25	1205	5.9
TITAN IV	1.3	950	5.6
ATLAS I	1.2	650	5.5
AIR LAUNCH 2 STG.	1.39	*296	3
AIR LAUNCH 3 STG.	1.32	*327	2.77

* NOTE: LOWER MAXIMUM DYNAMIC PRESSURES ARE SIGNIFICANT

AIR LAUNCH DESIGN CONSIDERATIONS

- USES ROCKETS WHERE ROCKETS ARE EFFICIENT, AIRBREATHERS WHERE AIRBREATHERS ARE EFFICIENT
- MAY PERMIT CROSSING CERTAIN THRESHOLDS
  - LARGE MONOLITHIC SOLID MOTORS
  - FIXED NOZZELS
  - FULLY REUSABLE BOOSTERS
- THESE FACTORS SHOULD BE EVALUATED IN THE CONCEPTUAL DESIGN PROCESS

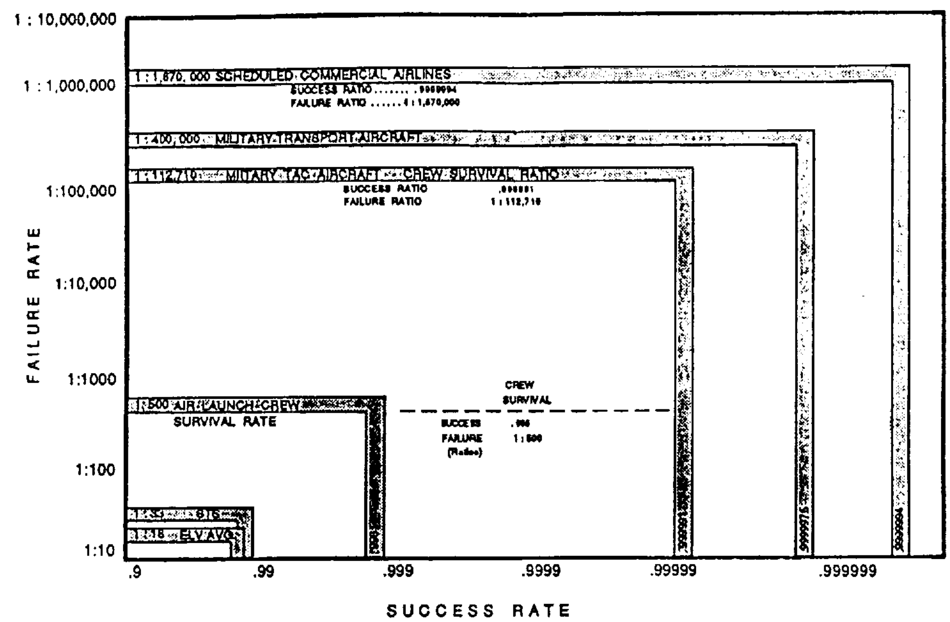
ASSUME HISTORICAL AVERAGE RELIABILITY

LIQUID PROPULSION SYSTEMS	.9896
SEGMENTED SOLID MOTORS	.9910
MONOLITHIC SOLID MOTORS	.9983
AIRCRAFT TURBOFAN ENGINES	.9999+

ABORT CHARACTERISTICS

	LV-A	LV-B W/ABORT CAPABILITY	AIR LAUNCH
FRACTION OF FAILURES ABORTABLE (ASSUMED)			
LIQUID PROPULSION SYSTEMS	-	.7	-
SEGMENTED SOLID MOTORS	-	0	-
MONOLITHIC SOLID MOTORS	-	-	.5
TURBOFANS	-	-	.9999
FRACTION OF ABORTS SUCCESSFUL (ASSUMED)			
LIQUID PROPULSION SYSTEMS	-	.9	-
SEGMENTED SOLID MOTORS	-	0	-
MONOLITHIC SOLID MOTORS	-	-	.9
TURBOFANS	-	-	.9999

SUGGESTED RELIABILITY GOALS FOR SPACE LAUNCHED SYSTEMS 1991 -- 2000 & BEYOND



ASSESSMENT OF FEASIBILITY

- NO MAJOR SHOW-STOPPERS HAVE BEEN IDENTIFIED
- POTENTIAL EXISTS FOR SIGNIFICANT IMPROVEMENT IN FLIGHT CREW SAFETY
- LIFT CAPABILITY OF 30,000 LB. TO 220 NMI. CIRCULAR AT 28.5° INCLINATION IS FEASIBLE
- *AIR-LAUNCH WITH SOLID ROCKETS NOT THE ONLY SOLUTION*
  - *BETTER SOLUTIONS ARE PROBABLY ATTAINABLE*