ASSURED CREW RETURN

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**ACRV Concept**

The Assured Crew Return Vehicle (ACRV) concept was developed, by NASA, in response to the need to provide Space Station Freedom with Assured Crew Return Capability (ACRC). The ACRC is a broad concept for assuring crew return from space which addresses both Earth-based and space-based rescue and includes space transportation systems which are currently in the United States inventory and some of which are being developed. The architecture of the ACRC is still being developed within NASA/JSC. Sufficient progress has been made to allow the ACRV part of ACRC to move ahead. The ACRV will provide on-orbit emergency capability for the Space Station Freedom crew to safely return to Earth independent of the USA Space Shuttle.

The ACRV System includes a flight segment which encompasses those items which are launched into space, a ground segment which encompasses ground support software, facilities and equipment for prelaunch, recovery and post recovery activities, and a mission support segment which includes the required mission control facilities, training and training equipment and the necessary Search And Rescue (SAR) interfaces and unique training definition.

NASA has conducted Phase A studies of the ACRC/ACRV which identified the missions for ACRV as the return of the crew from Space Station Freedom in the event of 1) illness or injury, 2) malfunction or damage to Freedom and 3) Space Shuttle stand-down. The follow-on to these studies was a Phase A Prime (A') effort, conducted by two study contractor teams, which validated the ACRV requirements and proposed doable concepts for initiating the Phase B detailed definition and preliminary design. (Planned start is October 1, 1991.)

Past space Flight experience provides a perspective and a basis for specifying future requirements.

Failures like premature hatch jettison on Mercury and Soyus -36 soft landing engine malfunction argue for forgiving designs (which allow crew survival).

Low Earth Orbit Experience in Skylab and Mir and the successful return of a sick crewman in 1985 from Solyut-7 argue for a space based crew return vehicle.
Agenda:

- The Need for Assured Crew Return
  - NASA Studies
  - Design Reference Missions
  - Historical Perspective

- System Requirements
  - Derived from the missions
  - Defined by "mother nature"
  - Specified (NSTS/ELV/SSF sited)

- Proposed Solutions to Meet Requirements
  - Medical Mission
  - Space Station Evacuation

- Key Challenges

- The Next Step
Assured Crew Return Vehicle

( ABSTRACT )

When the United States establishes the Space Station Freedom in a 200 nm orbit above the Earth in 1999 a permanent US human presence will commence. Providing a way to always bring Freedom's Crew back to Earth is the job of the Assured Crew Return Vehicle, a "life boat" that is a simple, reliable, affordable system that must always be ready to perform the return mission. Key challenges include designing for long periods of dormant space operation (Years) and then on a moments notice be ready to return the crew to an Earth landing site. Minimizing the amount of Space Station Freedom resources like power and data, while still demonstrating system return readiness, is also a major engineering challenge. The ACRV system must accommodate a deconditioned astronaut as well as an injured or ill person. The paper presents the driving requirements for the three ACRV design reference missions and the range of proposed solutions being studied by the Rockwell International study team. Evacuation timelines, hypersonic entry performance, landing attenuation systems and other unique considerations of a quick response rescue vehicle are discussed.
Assured Crew Return Capability Required when Space Station Freedom Emergency Management Capability Exceeded

+ 45-DAY CREW RESOURCES
+ SPACE STATION REDUNDANT SYSTEMS
+ DUAL RETREAT/COMMAND AREAS
+ IN-FLIGHT REPAIR/SPARES

SAFE-HAVEN CONTENTS LIST
FOOD
FOOD PREPARATION UTENSILS
WIPE
WASTE MANAGEMENT TRASH MANAGEMENT
PERSONAL HYGIENE
TOWELS GARMENTS
SLEEP RESTRAINTS
HEALTH MAINTENANCE
LIGHTING EXERCISE EQUIPMENT
COMMUNICATION EQUIPMENT
TOOLS FIRST-AID KIT

SAFE HAVEN (2 LOCATIONS)

+ ROUTINE CLASS I MEDICAL SUPPORT
+ LIMITED CLASS II ILLNESS SUPPORT
+ LIMITED CLASS III STABILIZATION

HMF MEDICAL COMPARTMENT

+ RESUPPLY
+ UP TO 45-DAY TURN-AROUND EMERGENCY FLIGHT
Multiple Options Considered for Space Station Emergency ACRC/ACRV Missions

EMERGENCY ACRC CERV MISSIONS
TO RETURN CREW IF:
1. MEDICAL EMERGENCIES REQUIRE IMMEDIATE RETURN OR EXCEED SPACE STATION CAPABILITIES
2. ACCIDENT / FAILURE CONTINGENCY EXCEEDS SPACE STATION SAFETY CAPABILITIES
3. NSTS LAUNCHES INTERRUPTED

ACRV COMPLEMENTS SPACE STATION EMERGENCY MANAGEMENT
Historical Perspective

1960

- Mercury T/D shock opens hatch floods capsule
- Crew Survived
  Make hatch jettison shock resistant

1970

- Soyus-1 Main chute fails
  - Crew perished
  - Stabilize before chute deploy

- Soyus-36
  - Soft landing
  - Engine malfunction
  - Shock seals save crew
  - Back up attenuation for survival

1980

- Soyus-7
  - Sick crewman returned to earth
  - Challenger
  - Booster malfunction
  - Crew perishes
  - Booster redesign and crew escape improved

1990

- International Space Station
- Soyus return vehicle docked at MIR
- Skylab
  - Return Apollo
  - Docked at Skylab
  - 5 seat Apollo rescue vehicle on pad
- ACRV (S) dock at Space Station Freedom
ACRV System requirements are derived from the three reference missions, the environments the system has to operate in and the specified requirements that further serve to bound the system design.

Of the three reference missions, the key derived requirements are forced out by the medical mission and the SSF evacuation mission. The Shuttle Orbiter unavailable mission does not produce any unique requirements.

Timeline analysis of functions to be performed are useful in driving out time critical sequences, parallel functions (which drive capacity) and additional functions.

For the Medical mission, total mission maximum time limits patient exposure to < 24 hours until arrival at a Definitive Care Medical Facility. Time limits within the 24 hour period, such as 1 hour to remove an ill person after landing limits the time in a confined capsule. Also, the time the crew can be exposed to an unfavorable landing orientation is limited to 1 minute.

The SSF contingency mission places a demand for quick isolation of the ACRV from an atmosphere threat like loss of pressure, fire or contamination. System designs should accommodate human capability to evacuate (< 2 minutes is seen as feasible for a crew of eight to evacuate). ACRV separation from an out of control Station requires < 3 minutes for ingress to physical separation. Additional time is required to accommodate thrusting to avoid SSF structural recontact.
DRM-1 Timeline Driven by Medical Requirements

1. Initial Activation and Mission Planning
   - JSC-34000, 3.1.3.2.a.1: Move incapacitated crewman from SSF to ground medical facility within 24 hours of decision

2. Ground-Space Station Communication
   - Derived from CEX 033 Mission 1 (1.2.3.10)

3. Incapacitated Crew Movement
   - JSC-34000, 3.1.3.2.c.1: Time from incapacitated crew movement to landing will not exceed 3 hours

4. Mission Execution
   - JSC-34000, 3.1.3.2.e.3/37.1.4.i: Missed entry latches 1 or more additional orbits (1.5 ± 1 hr)

5. Crew Transfers
   - JSC-34000, 3.1.3.2.e.1/37.1.32: "Time from landing to crew removal will not exceed 1 hour"

6. Medical Transfer
   - JSC-34000, 3.1.3.2.e.8: "Time from entry to medical facility will not exceed 2 hours"

7. Crew Transportation
   - JSC-34000, 3.1.3.2.e.1: Transport crew from space station to a ground medical facility within 6 hours

8. Crew debriefing
Medical Mission Derived Requirements

1. Trauma patient stabilized
   • Decision to return to earth T-24 hr.

2. ACRV C/O & readied for receipt of patient & attendant

3. Patient + supporting attendant medical gear in at T-6 hr

4. Automatic ACRV separates phases

5. Retro Burn

6. GPS update

7. Extract

8. Hospital

Time constraint
- $\Delta T_1 < 24$ hrs
- $\Delta T_2 < 6$ hrs
- $\Delta T_3 < 1$ hr.
- $\Delta T_4 < 2$ hrs

Rational
- High survival < 24 hrs
- Low med. care in confined space
- Low attendant help 1g.
- Minimize transport time

Limit < 4 g's

G. Limits
- < 4 g entry highest practical continuous limit
- < 20x, 10y, 6z consistent with Apollo limits (back perpendicular to max. G vector)

- Ground SAR notified
- Landing site selected
SYSTEM REQUIREMENTS

Other sources of specified requirements combine with the mission derived and natural requirements to form a complete set of design to requirements. Natural requirements exist in orbit, through entry, landing and recovery. Specified requirements include infrastructure integration constraints such as, launch on a Shuttle Orbiter, provide capability to be launched on a TBD Expendable Launch Vehicle (ELV), and located on a SSF node.
### System Requirements (Cont’d)

Mother Nature provides a set of her own requirements

<table>
<thead>
<tr>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ( \leq 10^{-5} ) torr vacuum</td>
</tr>
<tr>
<td>• Earth IR, albedo, magnetic fields, atmospheric density, 11 year solar cycle</td>
</tr>
<tr>
<td>• Meteoroid particles</td>
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<tr>
<td>• Atomic oxygen erosion</td>
</tr>
<tr>
<td>• Atomic particles</td>
</tr>
<tr>
<td>• Orbit perturbation oblateness</td>
</tr>
<tr>
<td>• Orbit nodal recession</td>
</tr>
<tr>
<td>• Surface terrain, water variations, weather, winds</td>
</tr>
<tr>
<td>• Political acceptance</td>
</tr>
</tbody>
</table>

Program driven requirements are specified to complete the design set

<table>
<thead>
<tr>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Launch on Space Shuttle</td>
</tr>
<tr>
<td>• Site on Station</td>
</tr>
<tr>
<td>• Site on Station</td>
</tr>
<tr>
<td>• Design for launch on (TBD) ELV’s</td>
</tr>
<tr>
<td>• Design for Simple, Reliable, Available, affordable Characteristics</td>
</tr>
<tr>
<td>• Provide for an 8 crew man</td>
</tr>
<tr>
<td>• 30 year program (Dormant operation)</td>
</tr>
<tr>
<td>• Use NSTS/SSF to Berth</td>
</tr>
<tr>
<td>• Mate to Nodes</td>
</tr>
<tr>
<td>• Minimize use of SSF resources</td>
</tr>
</tbody>
</table>

- 55 k lbs max
- Cg constraints
- Trunnion mounts
- STS RMS/Grapple
- 60 ft
- 15 ft
Proposed Solutions to Satisfy Requirements

Solutions to satisfy all requirements are required. Operations concepts (how you are going to perform functions, the people and skills required, equipment and how activities will be integrated) together with the vehicle and facility design options must be considered.

Decisions as to where to site the ACRV flight vehicle require close coordination with the emerging Space Station Freedom (SSF) design evolution.

Phase A studies required contractors to validate that mission derived requirements were realistic, complete and that they could be met with affordable options. The proposed solutions to issues driven by satisfying the medical mission requirements show, for example, that a 4G entry can be achieved by providing a Hypersonic aero characteristic of ~0.2 L/D and a seat back angle of >65 degrees. A range of vehicles and packaging options were utilized for this validation. Detailed entry performance data using candidate vehicles showed the design sensitivities to flight time, g levels, and other system design drivers.
Attached Operations

Initial Activation & Checkout
  • Complete Within 6 Hours Of Handover From Orbiter

Periodic Checkout
  • Approximately Every 90 Days
  • Pre-Programmed Automated C/O Sequences
  • Schedule To Coincide With Orbiter Supply Flight
    - New Crew/Fresh Training
    - Include Planned Maintenance With C/O
  • Incorporate Crew Refresher Training Activity Into C/O Sequences When Practical

On Orbit Maintenance
  • Planned Or Unplanned

Emergency Drills/Training
  • Emergency Evacuation Drills
    - May Involve Flight Controllers
  • Basic Refresher Training (Incorp. Into Periodic C/O When Practical)
    - Sequence Initiation
    - Auto Intervention
    - Landing Site Selection
ACRV/SSF Configuration Interfaces Have Been Recommended

- Nodes 1 and 2 zenith ports are recommended

- Level III WP-2 PDR Baseline Truss Location is Recommended
## Medical Mission Concerns

<table>
<thead>
<tr>
<th>Medical Mission</th>
<th>Issue</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accommodate</strong></td>
<td><strong>Specific Equipment Required Per Illness</strong></td>
<td><strong>NASA Contractor Panel Defining Range Of Equipment - Provide Supporting Utilities</strong></td>
</tr>
<tr>
<td>- III Crew And Medical Equipment</td>
<td><strong>Capabilities</strong></td>
<td><strong>Full Capability Prior To Entry Post Entry TBD</strong></td>
</tr>
<tr>
<td><strong>≤ 4g Entry</strong></td>
<td><strong>Best Way To Limit</strong></td>
<td><strong>L/D &gt; = .19</strong></td>
</tr>
<tr>
<td><strong>TBD Landing Attenuation</strong></td>
<td><strong>Ill Crew Limits</strong></td>
<td><strong>Limit Seat</strong> &quot;Back Angle&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Provide Range Of Solutions, Let $ vs Capability Set Limits</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Demo Soft Landing Systems</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Limit Seat</strong> &quot;Back Angle&quot;</td>
</tr>
<tr>
<td><strong>Extract ≤ 1 Hr.</strong></td>
<td><strong>Design's Different</strong></td>
<td><strong>Conduct Mockup SIMS</strong></td>
</tr>
<tr>
<td>- Water/Land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Configuration</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Transport ≤ 2 Hr.</strong></td>
<td><strong>SAR Capability</strong></td>
<td><strong>Summarize Capability</strong></td>
</tr>
<tr>
<td></td>
<td>Varies At Different Sites</td>
<td><strong>Use In ACRV System Sizing</strong></td>
</tr>
</tbody>
</table>
Moderate L/D Limits Entry g And Provides Cross Range

LIFTING BODIES
ENTRY ACCEL < 2 g

APOLLO-CLASS ENTRY ACCEL < 3 g

DISCOVERER/ MODIFIED SCRAM CLASS ENTRY ACCEL ≈ 4 g

BALLISTIC CLASS > 7g
Seatback Angle And Deconditioning Influence Design Solution

[Graph showing acceleration levels over time for different conditions: Tolerance with back angle at 60° to the RFV, normal subjects, deconditioned crew members.]
Vehicle Concepts Refined In Support Of Phase A' Studies

<table>
<thead>
<tr>
<th>KEY REQUIREMENTS</th>
<th>MODIFIED SCRAM</th>
<th>DISCOVERER</th>
<th>APOLLO SHAPE</th>
<th>LIFTING BODY</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREW/NUMBER OF VEHICLES</td>
<td>8/2</td>
<td>8/2</td>
<td>8/2</td>
<td>8/2</td>
</tr>
<tr>
<td>HYPERSONIC L/D</td>
<td>.19 -.21</td>
<td>.19 -.21</td>
<td>.40 -.50</td>
<td>1.2 - 1.4</td>
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<tr>
<td>ENTRY G'S</td>
<td>3.5 - 4.2</td>
<td>3.5 - 4.0</td>
<td>2.3 - 2.7</td>
<td>1.2 - 1.4</td>
</tr>
<tr>
<td>DE-ORBIT PROPULSION</td>
<td>EXPENDABLE SERVICE MODULE</td>
<td>INTEGRAL</td>
<td>EXPENDABLE SERVICE MODULE</td>
<td>INTEGRAL</td>
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<tr>
<td>RECOVERY</td>
<td>CONVENTIONAL PARACHUTES &amp; RETROS</td>
<td>CONVENTIONAL PARACHUTES &amp; RETROS</td>
<td>CONVENTIONAL PARACHUTES &amp; RETROS</td>
<td>AERO</td>
</tr>
<tr>
<td>LANDING</td>
<td>LAND OR WATER</td>
<td>LAND OR WATER</td>
<td>LAND OR WATER</td>
<td>RUNWAY</td>
</tr>
<tr>
<td>FLT VEH WT, LB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRY</td>
<td>12,674</td>
<td>15,035</td>
<td>13,293</td>
<td>18,169</td>
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<tr>
<td>LANDED</td>
<td>14,332</td>
<td>16,783</td>
<td>14,976</td>
<td>19,937</td>
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<tr>
<td>SM DRY</td>
<td>2,146</td>
<td></td>
<td>1,952</td>
<td></td>
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<tr>
<td>SM WET</td>
<td>6,425</td>
<td></td>
<td>3,877</td>
<td></td>
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<tr>
<td>COMMENTS</td>
<td>PACKAGING CONFIRMED</td>
<td>PACKAGING CONFIRMED</td>
<td>PACKAGING CONFIRMED</td>
<td>PACKAGING BASED ON NO INTERNAL ATTENUATION</td>
</tr>
<tr>
<td></td>
<td>LIMITED X RANGE</td>
<td>LIMITED X RANGE</td>
<td>REDUCED L/D AND X RANGE</td>
<td>NO INTERNAL ATTENUATION</td>
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<tr>
<td></td>
<td>RETROS TO PREVENT TUMBLE</td>
<td>LANDING STABILITY ISSUE</td>
<td>RETROS PREVENT TUMBLE</td>
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<td></td>
<td>AERO COMPAT. L/D</td>
<td>AERO COMPAT. L/D</td>
<td>AERO COMPAT. L/D</td>
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</table>
Concepts Used in Phase A' Trade Studies

- Packaging Viable
- CG Compatible with Planned Entry Angle of Attack
- Space for Crew Attenuation
8-Crewmember Discoverer Meets Packaging And Performance Requirements

- SUFFICIENT SPACE FOR SUBSYSTEMS/INSTALLATIONS
- CAN FLY WITH 20 DEGREES - 30 DEGREES ALPHA (L/D .19 - .21)
- ENVELOPE DIMENSIONS
  - DIAMETER = 176 IN
  - LENGTH = 155 IN
- AVAILABLE FOR COUCH STRUT ATTENUATION
  - CREW X-AXIS = 0-6"
  - CREW Y-AXIS = 0-1"
  - CREW Z-AXIS = 0-6"
- TWO HATCHES (TOP)
Example Flight Vehicle Showing Packaging Concept

Note: Some Options Include Detachable Service Module
Flight Vehicle Characteristics
vs.
Hypersonic L/D

[Graph showing flight time versus hypersonic L/D with specific values marked: Max G and Fit Time]
Entry and Landing Attenuation

Decelerating from approximately 25,000 ft/sec orbit velocity to zero vertical and horizontal velocity after landing can be accomplished using a variety of deceleration systems. Trade trees are used to define and link and keep track of options during the trade process.

Concepts are described, operations specified and designs in terms of components weights/sizing/quantities are analyzed and costed.

Final selections are made after costs are known and the cost of meeting requirements quantified and refined based on cost benefit considerations.
## Deceleration System Velocities & Options to Attenuate

<table>
<thead>
<tr>
<th>Orbit</th>
<th>Altitude (Kft)</th>
<th>- Velocity -</th>
<th>Deceleration Systems</th>
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<tbody>
<tr>
<td>Entry Interface</td>
<td></td>
<td>Horizontal {ft/sec} Vertical</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td></td>
<td>25,000</td>
<td>400 ft/sec</td>
</tr>
<tr>
<td>280</td>
<td></td>
<td></td>
<td>65 ft/sec</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td>640 ft/sec</td>
</tr>
<tr>
<td>10,000 ft</td>
<td></td>
<td></td>
<td>270 ft/sec</td>
</tr>
<tr>
<td>6,000 ft</td>
<td></td>
<td></td>
<td>30 ft/sec</td>
</tr>
<tr>
<td>25 → 10 ft</td>
<td></td>
<td>50 (wind)</td>
<td>30 ft/sec</td>
</tr>
<tr>
<td>Earth surface</td>
<td>0 + 0 → - 0</td>
<td>50 → 0</td>
<td>30 → 0</td>
</tr>
</tbody>
</table>

- Deorbit retros
- Aerodynamic
- Parachutes
- Parafloils
- Soft landing retros
- Airbags
- Couch pads
- Struts
- Crushable Structure
Alternative Tree - System Design Options

PARACHUTE (1.0) — RETROROCKETS (3.0) — COUCH-STRUTS/PAD (5.0)

WATER

PARAFOIL (2.0)

PARACHUTE (1.1) — RETROROCKETS (3.1) — COUCH-STRUTS/PAD (5.4)

LAND

PARAFOIL (2.1)

PARACHUTE (1.1) — RETROROCKETS (3.1) — COUCH-STRUTS/PAD (5.4)

AIRBAGS (4.0) — COUCH-STRUTS/PAD (5.2)

PARAFOIL (2.0)

PARAFOIL (2.1)

PARAFOIL (2.2) — COUCH-STRUTS/PAD (5.7)

EXT STRUTS (6.0) & DPLY IV/S — COUCH-STRUTS/PAD (5.8)

PARAFOIL (2.2) — COUCH-STRUTS/PAD (5.9)
Ballistic Parachute Definition (1.0)

**DESCRIPTION**
- Conventional 3 main chute system
- Similar in design to Apollo ELS
- Can tolerate single-chute failure

**OPERATION**
- Drogues deployed at approximately 24 KFT
- Drogue chute disreefed
- Mains 1st stage deployed & reeled
- Drogues released at 10,000 FT
- Mains 2nd stage disreefed
- Mains fully deployed at 6000 FT

**ITEM**
- Drogue chutes, bag & lines
- Pilot chutes, bag & lines
- Main chutes, bags & lines
- Main cutters

**QUANTITY**
- 2 sets
- 3 sets
- 3 sets
## Parafoil Definition (2.0)

**DESCRIPTION**
- MODERATE GLIDE RAM AIR CHUTE
- AVERAGE STABILIZED GLIDE OF L/D = 3
- ALT FOR FLARE = 70 FT
- 1.59 PSF WING LOADING

**OPERATION**
- DROGUES DEPLOYED AT APPROX 24 KFT
- DROGUE CHUTE DISREEF
- 1st STAGE DEPLOYED & REEFED
- DROGUES RELEASED AT 10,000 FT
- 2nd STAGE DISREEF
- FULLY DEPLOY >6000 FT

<table>
<thead>
<tr>
<th>ITEM</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DROGUE CHUTES, BAG &amp; LINES</td>
<td>2 SETS</td>
</tr>
<tr>
<td>PILOT CHUTES, BAG &amp; LINES</td>
<td>3 SETS</td>
</tr>
<tr>
<td>MAIN CHUTES, BAGS &amp; LINES</td>
<td>3 SETS</td>
</tr>
<tr>
<td>MAIN CUTTERS</td>
<td>3 SETS</td>
</tr>
</tbody>
</table>
Airbags Definition (5.0)

**DESCRIPTION**
- Deployable externally mounted airbags
- Vertical killed by controlled deflation
- Horizontal killed by sliding
- Lateral bags deployed for stability & side loads
- Lateral bags provide post impact stabilization for water landings

**OPERATION**
- Horizontal & vertical velocities sensed
- Controller determines airbag pressure
- Bags are deployed at altitude
- Airbag plugs blowout at TD to start deflation
- Parachutes released just after TD
- Vehicle slides until it stops

**ITEM** | **QUANTITY**
--- | ---
Main bags | 4-12
Pyro gas generators | 12
Lateral bags | 4
TPS pyro cutters | 1 set
Closeout/Initiator assembly | 1 set
Space Station Freedom Evacuation Mission

Unique requirements added by this mission are the need to quickly isolate from atmospheric induced contamination. Then separate. The need to separate may have been driven by an unlikely (but conceivable) loss of SSF control. Separation analyses using assumed rollrates show sustained velocities of .8 ft/sec will allow ACRV to clear solar arrays for rollrates of .2 degrees/sec.
## Space Station Freedom Evacuation

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Issue</th>
<th>Proposed Solution Or Derived Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evacuate SSF</td>
<td>Time Depends On Cause</td>
<td>Do The Best You Can</td>
</tr>
<tr>
<td></td>
<td>- Time Depends On Cause</td>
<td>Isolate First ($\leq$ 2 Min)</td>
</tr>
<tr>
<td></td>
<td>- Atmospheric</td>
<td>Separate 2nd ($\leq$ 3 Min)</td>
</tr>
<tr>
<td></td>
<td>- Fire - Depress</td>
<td>Thrust To Clear Structure</td>
</tr>
<tr>
<td></td>
<td>- Toxin</td>
<td>Provide Ground Survival Gear</td>
</tr>
<tr>
<td></td>
<td>- SSF Out Of Control</td>
<td>TBD</td>
</tr>
<tr>
<td></td>
<td>Ground Targeting Not Optimum</td>
<td>Automatic ACRV activation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Periodic self-checkout to ensure operational readiness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>System failure rates $\leq$ TBD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide 18Hr Space Loiter (24 Hrs RCS Sizing)</td>
</tr>
</tbody>
</table>
SSF Contingency

- Lolter in space \( \leq 10 \text{ hrs} \)
- \( \leq 3 \text{ hrs phasing entry} \)
- \( \leq 3 \text{ hrs contingency} \)
Analysis Shows That Off-Nominal Conditions Impact Separation Design Concepts

- Separation was analyzed for off-nominal SSF roll rates.
- Separation impulse was assumed to be provided by springs.
- Required ACRV impulsive velocity is determined by SSF roll rate.
Key Challenges

- Operationally ready vehicle after long term dormancy
- Supportable system over 30 year life
- Low cost of ownership throughout system life that will see people changes, political changes (landing sites) and program changes/uses
- Of course, for contractors to win Phase C/D production contracts at competitive price
The Next Step Is Being Taken

The Phase B preliminary design includes sufficient analysis, Test & Demonstrations to prove the selected concepts can be built within schedule and cost limits at low risk. This step starts October 1, 1990. Armed with the specifications developed by these studies, NASA will issue an RFP for the design and manufacture of the ACRV whose first operational flight will be coincident with the Permanent Manning of Space Station Freedom. Hopefully, it will never have to be used. But, if called upon, the ACRV will provide assured crew return.
Phase B Test and Demo Planning Progressively Matures with DRD-10 Planning and Submittals

- DR-10 Submittal
  - 4/90
  - 9/91

- Phase A' Requirements
  - Initial Early T&D Input
    - 10/91

- Phase B
  - SRR 8/90
  - SDR 10/91
  - DR-10 Submittals
    - 9/91
  - FSR 7/92
  - 9/92

- Preliminary Design
  - 3/93

- Tests and Demos
  - 1st Flight Test 2/99
  - 1st Operational Flight 6/99

- Design / Mfg
  - Test / Deliver

- Denotes Early T&D Inputs/Updates
References


