A MULTIROLE CAPSULE CONCEPT

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1) STUDY BACKGROUND

During studies into the European space infrastructure British Aerospace identified a number of roles that could be conducted by a ballistic or semi-ballistic capsule. An extension study that lasted six months was conducted to explored whether these roles could be undertaken by a single system.

There where 8 major roles identified as suitable for such a capsule. They contain all the European requirements for payload recovery or manned transport. They also include two requirements from the US/International Space Station which were not included in the original NASA plans, but are now under consideration. The roles were:

1) Independent European Manned Access
2) Manned Spaceflight Technology Development
3) Unmanned Microgravity Laboratory
4) US Space Station Escape system (CERV)
5) US Space Station Contingency Access
6) MTFF and Polar Platform Service
7) European Space Station Crew Access
8) European Space Station Escape System

There are clearly advantages to the development of Multirole Systems. Although the development process is a little more difficult because of the more complex set of system requirements, and the resulting product is a little off optimum for any particular mission. The increase the utilization of the final product can lead to very substantial savings.

2) CONCEPT OVERVIEW

The first step in the process of multirole system design is the merging of the various mission requirements to give and overall specification the capsule would need to meet. The resulting vehicle features are shown in the viewgraph.

The study produced a design that met these requirements, to prove the feasibility of the concept. Viewgraph 2 shows an external view highlighting some of the main features.

The resulting Multirole Capsule is 4 meters in diameter and weighs about 7 tonnes. It has a conical shape which together with an off set center of gravity allows the capsule to fly during the re-entry. This reduces the acceleration forces on the crew to under three times Earth gravity and controls where the capsule lands.

The capsule would use parachutes to slow down to a safe speed. It would splashdown in the ocean in the same way as the American Mercury, Gemini, and Apollo capsules. The weight on return is about 5 tonnes.

The Capsule is divided into two modules; the Descent Module and the Service Module.

The Service Module is a cylinder structure that attaches to the back of the Decent Module. It houses a Solar array for the generation of electrical energy and various communication antennas. It is discarded before re-entry into the Earth's atmosphere.

The Decent Module, which is the only part of the spacecraft to return to Earth, has three sections. The forward cabin has a docking port, control thrusters, hygiene and galley facilities. The mid cabin houses the crew couches and the control equipment. The rear cabin houses the batteries, the propellant and air tanks, and a payload bay for mounting mission specific equipment.

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MULTIROLE CAPSULE FEATURES

Mass	7 tonnes in Orbit
Size	4 m Dia, 8.3 m Long (solar array deployed)
Crew	4 Normal, 6 Escape
Payload	250 - 500 kg (carried in Cabin) (1500kg unmanned microgravity)
Life	5 Day Active (+ 1 day contingency) >2 Years On-Orbit Store
Recovery	Semi-Ballistic Re-Entry Parachute to Ocean Splashdown

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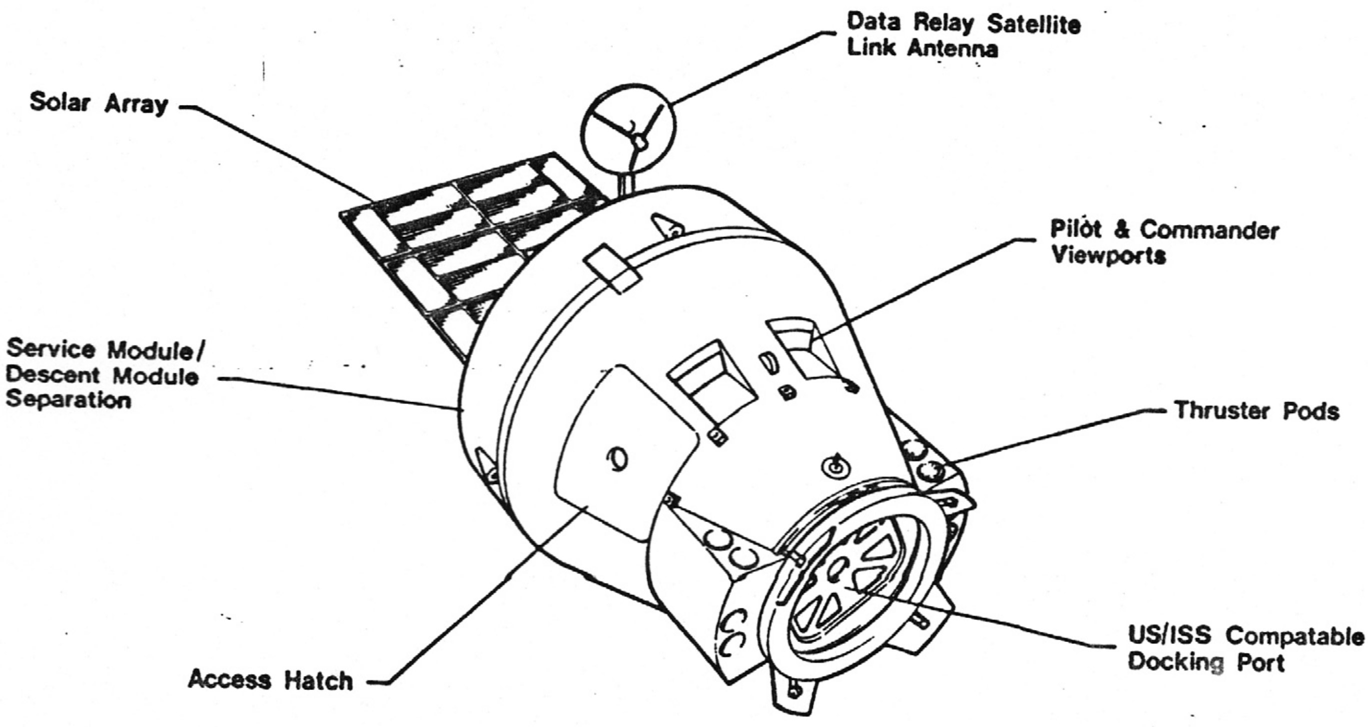
Viewgaph 1

Viewgraph 2



3) MASS BUDGET

The table opposite gives a system mass budget for the Ariane 4 manned version.

The study placed a lot of emphasis on achieving a realistic mass estimate. This was felt necessary for two reasons. Firstly mass has been the main Achilles heel of previous manned launcher proposals and must be considered a key issue in any assessment of feasibility. Secondly since parametric costing techniques are largely dependant upon mass, thus the realism of the cost estimate will largely depend upon the realism of the mass estimate.

From the start the study maintained margins at every level where a requirement specification will eventually be placed; that is system, subsystem and equipment. The system level budget shown here has two columns, the first detailing the raw estimated masses for each subsystem, the second showing the subsystem masses after equipment and subsystem level margins have been added.

The current total margin is 22% of the 7 tonne specified maximum, of this 8% has been allocated to equipments and subsystems. No margin is allocated to the payload allowance which is assumed include its own margin and only 5% to the consumables which are considered well defined. Most of the subsystems have a allocated total margin (equipment and subsystem) greater than 10%.

The study concluded that these margins were sufficiently healthy to give a high degree of confidence in the feasibility of the 7 tonne in orbit specification mass.

SUBSYSTEM	SUBSYSTEM ESTIMATED MASS (kg)	SUBSYSTEM SPECIFIED MASS (kg)	SUBSYSTEM MARGIN %
Mechanical			
Structure	895	1000	11
Thermal Protect	631	730	14
Thermal Control	64	80	20
Mechanisms	313	350	11
Propulsion	164	210	22
POPS	64	70	9
Recovery	236	270	13
Mech. Fittings	21	25	16
Electrical			
Data Management	48	55	13
S-Band Comms	18	20	10
Audio Comms	24	30	20
Ku Comms/Radar	128	145	11
Guide.Nav. & Con.	70	80	12
Power	271	310	13
Habitability			
ECLSS	185	210	12
Galley & Hygene	71	90	22
Fittings	237	270	12
Loose items	75	85	12
Caution & Warning	36	45	20
TOTAL DRY MASS	3551	4075	
Consumables	930	977	5
Payload	1000	1000	
Margin	1519 (22%)	948 (14%)	
SPEC MASS IN ORBIT	7000	7000	
Escape Tower	756	950	20
LAUNCH MASS	7756	7950	

MULTIROLE CAPSULE SYSTEM MASS BUDGET

Manned Version - Ariane 4

4) LAUNCH SYSTEM

The infrastructure study concluded that it was desirable for the earliest possible introduction of a European man in space capability and this lead to examination of Ariane 4 as a launch system.

The modifications that would be required are outlined on the viewgraph 3. The basic vehicle would require man rating which primarily involves increasing monitoring and some additional redundancy to increase system safety. The overall philosophy was envisaged as a ground only control thus there would be no facilities for crew intervention in launch system operations and they would be passengers until separation.

The upper two stages of the Ariane would probably require some structural strengthening to carry the 8 tonne launch mass and the new aerodynamic configuration. The VEB would also need some attention for similar reasons.

The Launch system would need to provide some escape provisions in the event of a launch emergency. This would take the form of an escape rocket to pull the capsule away from the launcher. The rocket would be built into the upper fairing which protects the docking port and thruster pods during the aerodynamic flight phase. It is sized to carry the Descent Module to a height of 2 kilometers in the event of a "from the pad" abort. This type of system was used on the Apollo spacecraft and on the Soyuz spacecraft. The Soyuz system has been used successfully in actual emergency situations.

The study included that for a ballistic capsule that produced a symmetrical aerodynamic loading, Ariane 4 would make a suitable manned launcher. The basic vehicle would have over 12 years operational experience and development problems that occur on any new system will have been ironed out. Although Ariane's success rate to date is lower than that desirable for manned operations it should be noted that none the failures have resulted in the immediate break up of the vehicle and escape could have been achieved by separation followed by a parachute descent. Thus the crew would not have been placed in any significant risk

After Ariane 5 is operational, there would be an option to use this to launch a modified version of the Multirole Capsule with increased performance. There were a large number of options for such a system an the study did not produce a single design concept. The most attractive range of options involved leaving the Descent Module in its original form, while enlarging the Service Module to include a payload bay. This would be integrated with a Transfer Vehicle/Upper stage of the type under currently study as part of the Ariane 5 system.

If the payload capability of Ariane 5 is maintained at 15 tonnes then such a system could have an external payload capability of around 5 tonnes. The system would also provide a significant payload to Polar orbit sufficient to conduct Polar Platform servicing missions.

Other launchers where also briefly considered by the study. The most significant being the STS for delivery of Escape Capsules to the US Space Station. A Shuttle launch would involve an alteration of the Service Module structure to interface with the payload bay trunnion mounting system. The front of the capsule would be supported by an airborne support structure which would also house the STS interface electronics.

Viewgraph 3

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ARIANE 4 LAUNCHER ADAPTIONS

System	-	New Aerodynamic Configuration Performance After Modifications Revisions for Manned Safety
Fairing/SPELDA	-	Deleted
Escape System	-	New Element
VEB	-	New Design ° Strengthen for Increased Payload ° Add new MRC Interface Unit ° New Equipment Layout
3rd Stage	-	Possible Strengthening for Increased Payload Mass
2nd Stage	-	Possible Strengthening for Increased Payload Mass

Overall Philosophy: Soviet (crew are passengers), rather than US (cre can "pilot" launch system. This minimizes launch system modifications

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5) SUBSYSTEMS

5.1) MECHANICAL

Viewgraph 4 summarizes the main features of the mechanical subsystems. The general philosophy was to employ conventional technology, and no areas of significant technological risk were identified.

There are two propulsion subsystems. One, called POPS (Proximity Operations Propulsion Subsystem), is a cold gas system mounted in the Service Module and would be used when the Capsule is close to the Space Station or other sensitive system. The second, called PIPS (Primary Integral Propulsion Subsystem), is a bipropellant system mounted entirely in the Descent Module. The 12 400 N thrusters are mounted two pods at the forward end. There is no main engine, deorbit and other major maneuvers are conducted with the 4 forward facing reaction control thrusters.

Viewgraph 4

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MECHANICAL SUBSYSTEMS

Structure	- Conventional Aluminium Honeycomb, Aluminium Machined Frames, FRP Service Module Cylinder
Thermal Protection	- Ablative Heat Shield, Cork Insulation, Multi-Layer Blankets
Thermal Control	- Heaters, Water/Glycol Fluid Loop
Mechanism	- Station Compatable Docking Port, Side Hatch
Primary Integral Propulsion	- MMH/NTO Bipropellant System, 12 Thrusters
Proximity Ops Propulsion	- N_2 Cold Gas, 16 Thrusters
Mechanical Fittings	- Equipment Bolts, Grab Handles etc
Recovery	- 4 Parachutes + Flotation Equipment

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5.2 HABITABILITY SUBSYSTEMS

Viewgraph 5 shows the main features of the habitabilty subsystems. The main driver on these was the long in orbit storage lifetime which lead to the selection of high pressure gas storage of the ECLSS atmosphere consumables as opposed to cyrogenic storeage. The storeage tanks (which share a common design with the Propulsion gas tanks) are mounted in the base of the Descent Module.

The Galley and Hygiene facilities were designed to be relative civilized, closer to Shuttle Standards than he primitive arrangements on 1960's capsules. They are located in the forward compartment of the Descent Module and the architecture allows for a privacy screen during use of the facilities.

Viewgraph 5

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HABITABILITY SUBSYSTEMS

Galley & Hygene -	Packaged Food, Water Supply, Hand Wash, Male/Female Toilet
ECLSS -	1 atm O_2/N_2 Mixture, Semi-Closed Loop O_2 and Air Makeup Stored as Pressurized Gas Shuttle-compatable H/ Charcoal Cannisters
Caution & Warning-	Fire Detection & Control, Back-up Atmosphere Monitor, Hatch Status
Fittings -	Seats, Screens, Lighting, Support Racks etc
Loose Items -	Contingency Equipment, Tools, Video System, Flight Manuals etc

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5.3 ELECTRICAL SUBSYSTEMS

Viewgraph 6 shows the main features of the electrical subsystems. Viewgraph 7 is a block diagram of the electrical architecture showing the relationship of all the electrical units to each other.

The primary power is generated by a solar array which extends from the rear of the spacecraft. A Solar array was selected over fuel cells for the following reasons.

* Cost
* The unsuitability of cryogens for long in orbit store
* The ability of the stored spacecraft to be self powered and not impact on the Space Station power budget.

Eclipse power is provided by 4 batteries in the Descent Module these also provide the power for the system after separation from the Service Module.

The Data Handling Subsystem is based around a serial databus (either 1553 or OBDH). The subsystem's other functions include:

* Generate baseband signal for the comms systems
* Provide two "intelligent" terminals
* Record flight information

The Guidance Navigation and Control subsystem uses a redundant pair of Inertial Reference Units as the primary source of attitude and position data. These units are updated by calibration against data from a Global Positioning System Receiver. Other sensors are a star mapper and a sun sensor which provide control signals for the maintenance of a fixed attitude with respect to the Stars or the Sun respectively. The star mapper can also be used during rendezvous maneuvers. The GNC also contains the flight control computer which is capable of controlling all the mission flight phases without manual intervention. A manual override is also provided; this gives direct control over both the PIPS and the POPS.

There are three communications subsystems. A UHF for EVA voice communications, this is integrated into the internal audio communication subsystem. An S-Band omnidirectional for direct ground communication carrying voice and telemetry. The third system is a direct link with a Data Relay Satellite, probably at Ku Band, that would transmit video in addition to voice and telemetry.

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ELECTRICAL SUBSYSTEMS

Data Handling & Control	-	Utilities LAN, Control Consoles
S-Band Comms	-	Omni Coverage for Audio & Telemetry
Audio Comms	-	Internal Intercom, EVA UHF Comms
Guidance, Nav & Control	-	Inertial Reference Unit with GPS Update Star Mapper & Sun Sensor Control Computer, GNS LAN
Ku Band Telecom /Radar	-	Directional High Data Rate Comms via DRS
Power Generation & Distribution	-	29V, 700 watt Average Solar Array + Battery

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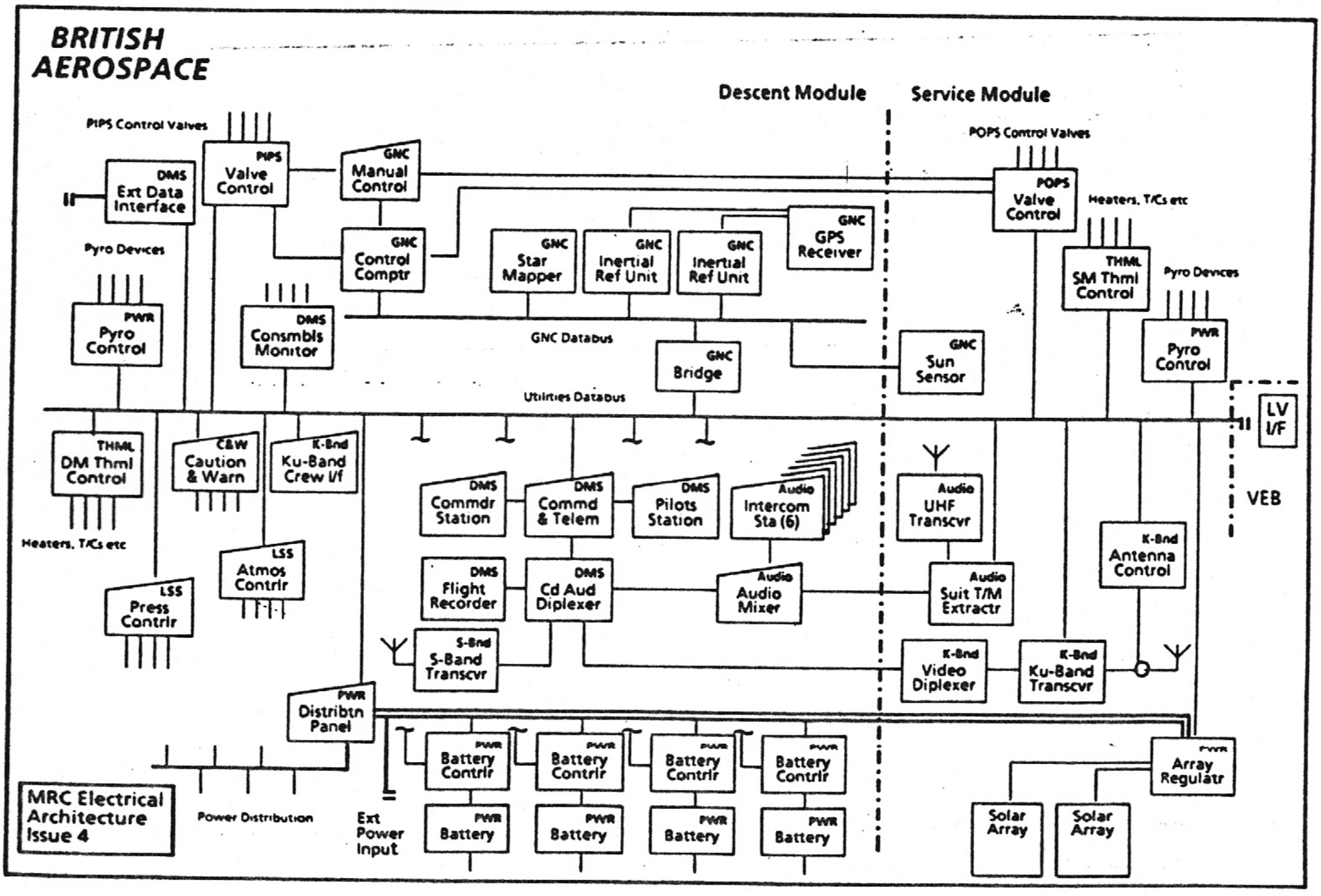
Viewgraph 6

Viewgraph 7



6 MICROGRAVITY VERSION

One of the roles identified by the infrastructure study for a capsule was as an unmanned microgravity laboratory. This role would require a distinct version of the capsule and the modifications needed to achieve this are shown in Viewgraph 8. The study confined itself to identifying the minimum modifications to achieve a useful system, many further modifications could be made to improve payload, power, and microgravity environment but at additional development. Clearly further studies and definition of the financial environment would be required to identify the optimum system.

The payload would be around 1.5 tonnes. Main payloads would be housed in canisters that would be mounted in the same position as the crew couches (using the same structural interface). Smaller "Get Away Special" type payloads could be mounted in the forward cabin. The mission duration would be determined by the payload's impact on the ECLSS. If a life science mission is flown which consumes oxygen then the mission life would be limited to around two weeks. If the requirement is restricted to maintaining cabin pressure only the mission could be extended to a few months. If the mission is flown with the cabin pressurized then six months or more would be possible.

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MICROGRAVITY VERSION MODIFICATIONS

- 6 Main Payload Cannisters replace Crew Couches
- Secondary Payload mounted in Forward Cabin
- 2 Additional Panels on Solar Array (1 kW Payload Power)
  + Additional Batteries
- Delete
  - Subsystems: Audio
    - Caution & Warning
    - Galley & Hygene
  - Equipments: Commander & Pilot Stations
    - GNC Manual Control
    - Ku Band Crew Interface
    - External Data Interfaces
- Add Payload Data Acquisition Subsystem

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Viewgraph 8

7 PROGRAMME

The study outlined a development programme assuming the Ariane 4 launcher. The main was to explore the earliest possible operational date, and to demonstrate that the system could be available in a timeframe compatible with the identified roles on the US Space Station. A summary of this programme is shown in viewgraph 9.

It assumes a Phase A start at the beginning of 1988 and leads to the first flights, including one manned flight, in 1993. A total development programme of just under six years.

Viewgraph 9