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## Columbus: Attached Pressurized Module Configuration-MTFF Pressurized Module Configuration

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COLUMBUS: ATTACHED PRESSURIZED MODULE CONFIGURATION  
MTFF PRESSURIZED MODULE CONFIGURATION

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ABSTRACTS

The first part of this paper describes the main technical features of the European Space Agency's Columbus Attached Pressurized Module. The Module is an integral part of the manned core of the International Space Station, and is a development of the ESA Spacelab Module. As such it is a modular 4 segment construction of 12 m length, 4 m diameter which will be launched on an NSTS flight, currently scheduled in 1994 as Station assembly flight 16.

Its internal configuration is a doubly symmetric cross section of 4 identical rack envelopes separated by standoffs carrying utilities. Being a part of the Space Station core, it has system and subsystem architectures which will be compatible with those of the other Modules. Its purpose is to provide resources for materials, fluid and life sciences payloads over a 30 year lifetime. The on-orbit payload accommodation is for up to 10,000 kg housed in up to 25 m<sup>3</sup> of rack volume, with 10 kw power and 100 mbits/sec data transfer. The module will normally be occupied by two crew working in a one atmosphere shirt-sleeve environment, operating the payloads and performing maintenance as required.

The second part of this paper describes the main technical features of the European Space Agency's Columbus Man-Tended Free Flyer Pressurized Module. The Module is an integral part of the MTFF, is based on the Columbus Attached Module design and is a development of the ESA Spacelab Module. As such it is of 6.6 m length, 4 m diameter and as part of the MTFF will be launched on an ARIANE 5 flight, currently scheduled in 1996. Its internal configuration is a doubly symmetric cross section of 4 identical rack envelopes separated by standoffs carrying utilities.

Being highly common with the Columbus Attached Module, it has system and subsystem architectures which will be very similar to those of the Station Modules. Its purpose is to provide resources for materials, fluid and life science payloads in a long duration undisturbed low gravity environment over a 30 year lifetime. This is achieved by flying an unmanned "Boomerang" orbit centred on that of the manned core of the Station, for up to 6 month periods. The on-orbit payload accommodation is for up to 5,000 kg housed in up to 12 m<sup>3</sup> of rack volume, with 5 kw power and 100 mbits/sec data transfer.

The module will normally be unoccupied by crew except for servicing periods of a few days every 6 months, at which time up to two crew may operate in a one atmosphere shirt-sleeve environment, exchanging the payloads and performing maintenance as required.

## INTRODUCTION

The Space Station program, via an iterative process, is steadily moving ahead along the definition phases, being characterized by an important mark: International cooperation. Time is mature for a program that acknowledges the existence of highly technical and technological space programs in several countries. The implementation of a program structure and the definition of a Space System that well takes into account the opportunity for an international cooperation and that gives rise at the same time to the build-up of an acknowledged national role, is amongst the real challenges Space Station program is faced with.

Canada, Japan and the community of nations comprised within the European Space Agency (ESA) are all working at the definition of their own contribution and negotiating the role their proposed elements shall have within the International Space Station. Aeritalia, as responsible for the ESA Columbus Pressurized Modules (PM), are interpreting and implementing this two-fold challenge in the definition of the two manned elements of Columbus programme:

PM-4 ATTACHED PRESSURIZED MODULE  
PM-2 MAN-TENDED FREE-FLYER PRESSURIZED MODULE

These two elements well reflect indeed the objectives approved during the January '85 ESA community Ministerial Council which states:

"To enhance international cooperation and in particular aim at a partnership with the United States through a significant participation in an international Space Station"

"To prepare autonomous European facilities for the support of main in space, for the transport of equipment and crews and for making use of low Earth orbit".

### PM-4 AS INTEGRAL PART OF ISS

PM-4, to be permanently attached to the International Space Station, represents the European contribution to the manned core of it. Starting from the initial definition of Columbus PM, this has evolved from being considered as an "External User" of the station, docked to it during initial on-orbit operations and then time-sharing its role between the previous mode and a free-flyer configuration mode.

This hypothesis was assuming largely autonomous capabilities implying as consequence several duplicated functions (e.g. Safe haven, own heat rejection capability). PM-4 definition has then evolved through a pressurized module which is now being designed to form a permanent part of the core station. PM-4 is indeed considered as a direct extension of the manned core of the International Space Station to be operated permanently docked to a free port of a berthing node as one of its three laboratory modules (i.e. NASA lab., Columbus PM-4, JEM). As such it is essential that the design of the various elements shall be optimized to be functionally coherent, operationally compatible and shall be responsive, from the utilization point of view, to the expectations of European and international users communities.

Current SRD (System Requirement Document) takes in fact into account these aspects when requesting

that "PM-4 shall be a manned pressurized laboratory permanently attached to and part of the manned core of the Space Station ...".

As an integral part of the ISS, PM-4 receives resources from ISS still maintaining the own capability to operate and control both European and International payloads.

Scope of the attached module is to provide environment and facilities for laboratory work and provide operational support to the crew.

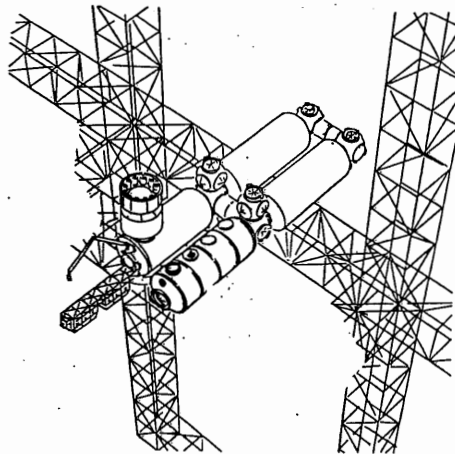


FIG. 1 - ISS ATTACHED PM-4

Two principal payload disciplines, Material Science and Life Science, have been indicated by European Payload Studies, for accommodation in PM-4. Current SRD coherently requests that "The overall purpose of PM-4 is to support the conduct of scientific experimentation and commercial exploitation which require manned interaction and intervention in a low gravity environment ...".

Still per SRD the PM shall be launched by the NSTS from the Kennedy Space Center to the manned core of the int. space station in accordance with the overall Station Assembly sequence and be then operated consistently with the Station resupply means and cycle.

The on-orbit configuration of ISS core with attached PM-4 is as in fig. 1.

### PM-2 AS INTEGRAL PART OF MTFE

PM-2 is the free-flying pressurized module that, in conjunction with the other Columbus element the Resources Module (RM), forms the Man-Tended-Free-Flying system (MTFF).

These elements are two distinct entities featuring well defined own functions and capabilities, but their interface during the operational life is so physically and functionally intimate that either one can only be defined as the integral extension of the other.

PM-2 is integrated on the ground to its resources complement and launched by Ariane 5 to operate

in an orbit nominally the same as that of the manned ISS but optimized to achieve the best micro-gravity environment.

The laboratory system provided by PM-2 supports the conduct of scientific experimentation/commercial exploitation which requires in frequent servicing and resupply by crew in a very low gravity environment.

Presence of man is only planned to be accommodated during the dedicated servicing period while more "quiet" environment is achieved by flying the MTFF system, unmanned, into a "boomerang" orbit centered on that of the manned ISS.

The complexity of PM-2 resides in the manifold functional and operational interfaces it shall have to accomplish its man-tended laboratory role.

Compatible with Ariane 5 launching interface it shall, once on-orbit, interface with a berthing node of the ISS manned core as well as with Hermes for servicing operations. It lives in symbiosis with the RM relying on it for on-orbit resources/functions such as power, gaseous consumables, TT&C, propulsion and taking care for the entire system management and control, running of experiments, housing crew members during manned periods.

Such a large scenario of elements, it in turn interfaces with, implies that PM-2 shall enhance the automation and control of many functions without loosing those architectural and performance characteristics peculiar of a manned element as previously designed, implemented and experimented for PM-4. See fig. 2.

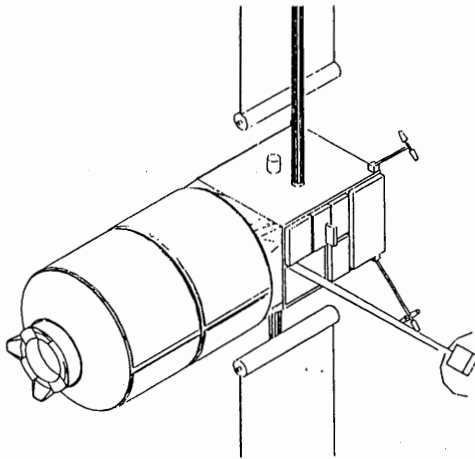


FIG. 2 - MTFF PM-2

#### PM's AS EVOLUTION FROM S/L MODULE

European Space Agency's Columbus Pressurized Modules (PM's) can be considered as a direct outgrowth of Spacelab Module, first European experience in the field of manned space systems and, as of today, still the only flown manned payload of the NSTS.

Aeritalia, a major co-contractor of MBB-ERNO during Spacelab program, has capitalized on the experience gained and has explored since 1978 the possibilities of utilizing Pressurized Modules derived from Spacelab, as elements of the Space Station. The idea in fact for Columbus program, originated around 1982 as a product of Aeritalia's Space System Group and Germany's MBB-ERNO.

Today Aeritalia, having module level responsibility for the two Columbus pressurized elements, is building up an industrial team that optimizes the use of existing experience acquired by European industries during the Spacelab program and introduces, as appropriate, new skills to cover the new/modified disciplines to be implemented in Columbus Pressurized Modules.

PM's design is indeed based on the know-how, designs maturity, testing philosophy, modelling approach acquired for Spacelab module as a great level of similarity exists with Columbus modules; however similarity is not a replica as new/different design features are characterizing this latter as a system aimed at long life operations in space, with multiple and complex functional and operational interfaces.

#### PM-4 & PM-2 COMMON APPROACH

Attached Pressurized Module PM-4 and Free-Flyer Pressurized Module PM-2 are indeed two distinct products originating from the very same design approach.

The definition and analysis of requirements and necessary functions are all planned out at achieving max commonality between PM-4 and PM-2.

The development of both general architecture and specific design, ensures a high degree of modularity in the internal and external configuration layout of PM-4 and PM-2. As such the PM-2 differs from the PM-4 only in terms of:

- size
- number of standard components
- potential robotics/associated software
- reduced ECLS/crew system facilities.

When such a large commonality of functions and equipments is implemented into hardware that also maximizes modularity down to subsystem layouts level, the resulting PM-4 & PM-2 integrated concept features a very effective design in terms of development, integration, verification and cost.

The combined PM-4 & PM-2 approach at overall architecture level is illustrated in fig. 3.

Both PM versions are derived from the same "basic element" consisting of a 2-cylinder segments with one end cone closure.

PM-4 is then built-up by assembling together two "basic elements".

The "basic element" is conceived such as to obtain a symmetric internal architecture both in terms of subsystems and functions distribution.

#### PM-4/PM-2 EVOLUTIONARY CHARACTERISTICS

The importance of PM-4 and PM-2 as two products of the same integrated concept goes beyond the benefit of a cost-effective design; PM-4 and PM-2 are two indivisible steps in many other respects.

PM-4 is characterized by the continuous presence of man on-board which means possibility to test, adjust, calibrate, reconfigure, iterate on board systems and experiments within the same mission cycle. This in turn, requires the extension of space activities experience, in terms of on-orbit testing and debugging of systems, procedures, maintenance, and servicing all in preparation for subsequent PM-2 free-flying missions characterized by long undisturbed periods, low n-g levels, long process experiments, automated processes, and periodic man's attendance for servicing.

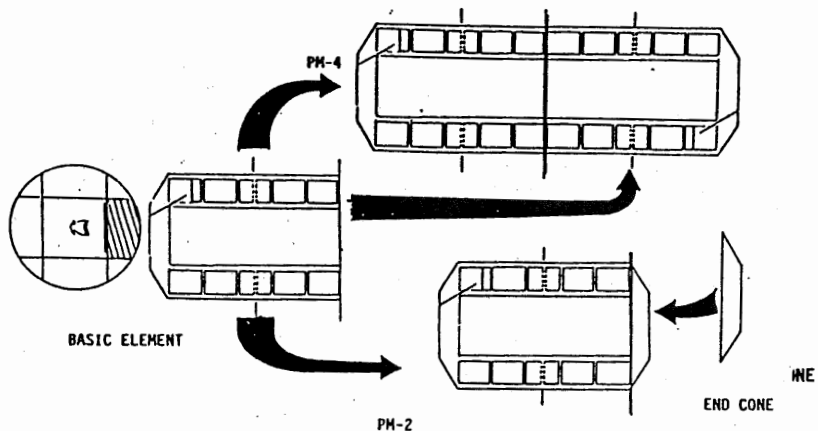


FIG. 3 - PM-2/PM-4 COMMONALITY APPROACH

PM-4 is an integral element of the ISS manned core sharing with it management and control, utilization, crew, logistics, operations, etc. PM-2, although as part of a more autonomous system (MIFP), is an enhancement of the basic ISS capabilities.

PM-4 is launchable and serviceable by the flight qualified NSTS while PM-2 involves new elements, AR-5 and Hermes, as launching and servicing vehicles respectively, to be developed and qualified.

PM-2 can be considered at the end as the natural evolution from PM-4 attached mode, just as this latter is the evolution from S/L module; a correct development phasing of these two configurations on one side and the corresponding realistic availability of Ariane 5 and Hermes is a pre-requisite for the success of Columbus program.

PM-4 OVERALL ARCHITECTURE

The attached pressurized module is a laboratory consisting of four cylindrical segments, Spacelab derived with end cones at the two extremes. It is equipped with two standard pressurized berthing ports: one for IVA crew, payload and equipment transfer via the ISS berthing node, the other at the free end of the module with permanently closed

hatch and available for berthing of other Columbus elements or external payload facilities.

The external configuration layout can be described as in fig. 4 where the main architectural ingredients are shown.

The basic cylindrical segments, developed for Spacelab to fit the physical and dynamic envelope of the NSTS cargo bay, remain essentially unchanged in terms of materials, manufacturing process and overall dimensions.

The cone design, still evolving from Spacelab, is adapted to interface with the large new docking/berthing adapter and to provide a suitable hatch clearance.

The module is equipped with fittings for transportation in the NSTS cargo-bay and for deployment/handling/retrieval between cargo-bay and ISS port. Closure hatches are provided at the two egress routes complying with operational and functional requirements of the ISS.

Protection against space particles is assured by means of a "two wall design" system consisting of the basic PM shell, combined with a shielding element having a "bumper" effect.

An experiment airlock for exposure of payloads to the space environment and also planned for transfer of tools/payloads and equipment ORU's to and from outside space, is installed in the PM.

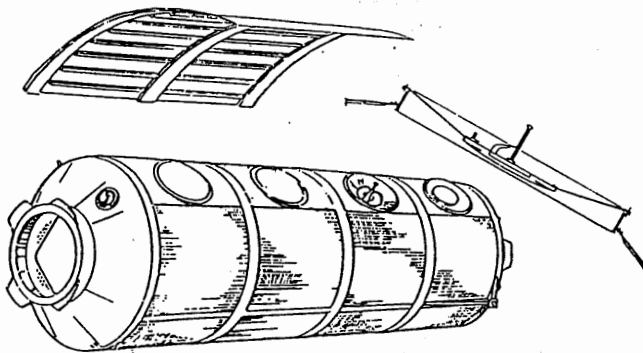


FIG. 4 - PM-4 EXTERNAL CONFIGURATION

One view-port is also installed in each cone with an option for optical window quality. The PM internal architectural layout has been driven by several fundamental guidelines including human factors standards, long life of PM element by periodic maintenance and replacement of components and equipment, payload accessibility and easy exchangeability.

The "1-g configuration principle" is adopted that was used by Spacelab and is in line with the ISS internal configuration requirement.

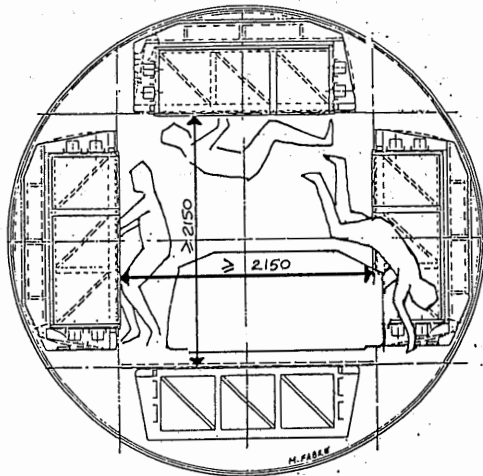
A four stand-offs configuration has been selected providing double symmetry in the PM cross section and giving the possibility of installation of four identical rack structures in the left, right, ceiling and floor areas.

Fig. 5 shows the cross section of PM with the principal dimensions.

Internal racks are shaped such as to maximize the use of the available volume and designed to be a multi-use device for different applications such as basic structure for:

- payload accommodation
- subsystem installation
- storage provision
- crew work station
- work bench
- subfloor subsystem eqpt installation

Each rack has the capability to be hinged for rack access from the rear, for inspection of the utility lines and utility interfaces and for inspection of the pressure shell internal surface.



tioning are provided with a utility interface assembly and are installed in the PM locations where a utility interface station is available.

The payload and subsystem "modules" are installed in the racks by use of sliding devices to make them withdrawable and extractable/replaceable at "module" level, i.e. the ORU principle. The rack integrated with eqpt is also considered an ORU, therefore its interfaces are standardized in all the PM locations and with the Logistics Module/Carrier.

Rack size fully compatible with 19" equipment standardization is shown below.

The PM internal architecture is shown in fig. 6. Subfloor racks are used to locate the subsystem equipments that require noise attenuation and all the equipment that does not need frequent access. They are covered by floor panels which are designed to be removable and to provide accessibility for maintenance and replacement of the subsystem ORU's. The equipments are arranged such that easy access is assured to all failure susceptible assemblies.

The subfloor is equipped with the same mechanical interfaces used for the side racks to permit installation of racks dedicated to storage or rack skeleton structures used as support structures for installation of subsystem equipment and components.

The overhead area provides volume for accommodation of payload racks with limited power and heat dissipation required and of storage racks/compartments.

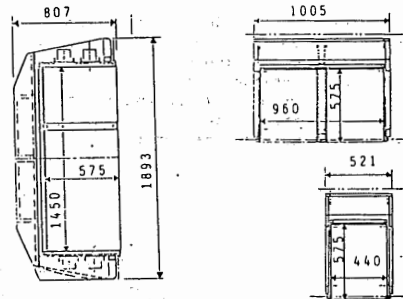


FIG. 5 - TYPICAL CROSS SECTION

It can also be removed and replaced for maintenance, servicing and reconfiguration purposes. All the racks holding equipment or payloads requiring power, data/command transfer, temperature condi-

The overhead racks are, for standardization and reconfigurability reasons, of the same shape and size of the side racks including provision for all the utility interface installation and therefore capability of active interface.

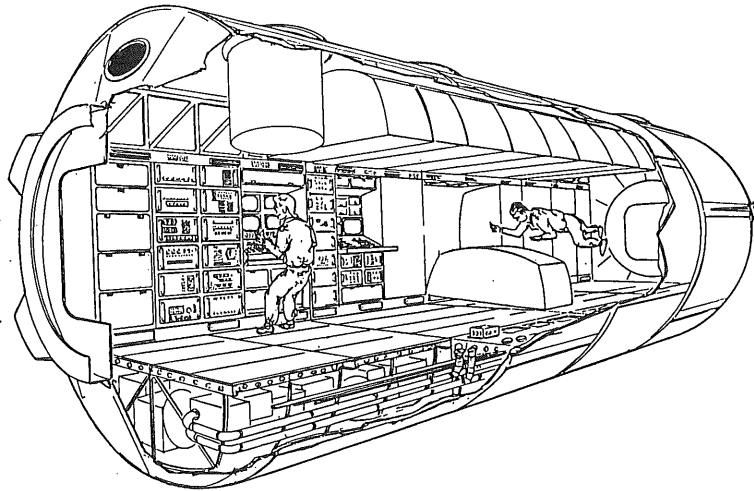


FIG. 6 - PM-4 INTERNAL CONFIGURATION

PM-4 FUNCTIONAL CONCEPT

PM-4 system, according to its definition as integral part of ISS, is operated as an element with full on-orbit autonomy for normal operations (excluding failures) by crew, with ground control override capability. It relies on the ISS for consumables supply, power supply, heat rejection, communication up/down link stream. During nominal conditions PM-4 is operated with "open hatch", while, in contingency case, PM-4 system can also be operated in a "closed hatch mode" maintaining utility interfaces with the ISS such as power, data, consumables.

Two crew members will nominally operate the PM-4 systems and payloads on a one shift per day basis, after initial PM-4 assembly and activation mission and P/L integration mission. Servicing operations are currently planned on 90 day cycle

with logistics resupply delivered by the ISS Logistics Module/NSTS.

PM-4 functional concept is based on four functional buses: Power and data buses, thermal and air cooling loops, as represented in a schematic form in fig. 7 where also utility interfaces with the ISS and functional interfaces among the main subsystems are indicated.

Four information management levels perform and control on-board functions according to a hierarchical organization built-up to reduce dependency from ground control and minimize the need for on-board crew involvement, whilst still allowing at the same time crew overriding capability and intervention at all functional levels. The nature and criticality of PM-4 as a continuously manned system has lead to the implementation of caution & warning functions as an independent functional assy using a dedicated link to activate directly safing recovery functions and alert the crew.

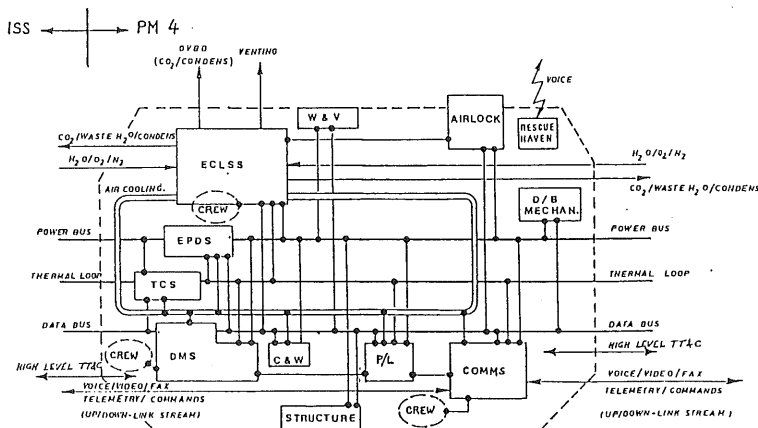


FIG. 7 - PM-4 FUNCTIONAL LAYOUT

PM-4 avionic system is based on a distributed intelligence concept functionally organized in order to fit within the hierarchical approach defined above.

The distribution of data necessary for the control and management of the overall system, including P/L, is supported by two Local Area Networks (LAN), one mainly dedicated to the distribution of data for system and subsystem performance and the other essentially dedicated to P/L needs. The two LAN's are connected together by bridges to provide the system management function with the monitoring and control capability of the overall vehicle.

Gateways on the LAN's enable monitoring and control of the PM-4 to be accomplished from other modules of the ISS.

General characteristics of the PM-4 subsystems are shown on table 7.

#### PM-2 GENERAL DESCRIPTION

Due to the similarity of several functions between PM-4 and PM-2 and to the design commonality largely implemented at any appropriate level, PM-2 is described only in that it differs from PM-4.

#### OVERALL ARCHITECTURE

The free-flyer pressurized module consists of two Spacelab derived cylindrical segments with two end-cone closures. Unlike PM-4, it offers one pressurized berthing port at the forward end, utilized for crew access and P/L equipment transfer during manned servicing periods. The aft port, separatable by EVA, allows utility resource supply via connectors but features no hatch. The 100 sq. meter external surface is covered by micrometeoroid/space debris protection integrated with a radiator system and thermal insulation blankets.

No experiment airlock and viewport are foreseen in the PM-2, due to the infrequent presence of crew on-board.

The internal layout basically does not differ from the attached PM-4 having reconfirmed the same 1-g, four stand-offs, double symmetric configuration as well as the concept for subsystems and payloads distribution in the subfloor, cabin and rack areas.

#### FUNCTIONAL CONCEPT

Functionally PM-2 system is also based on a four buses/loops concept offering an orbit autonomy for servicing with crew and permitting ground control override capability. During nominal conditions PM-2 is unmanned and completely automated.

It relies on RM for consumables supply, power supply, navigation attitude/orbit control, and data stream, according to the functional scheme of fig. 8 where the expected interfaces ISS, NSTS and HERMES are also shown.

From the operational point of view after insertion into its final orbit PM-2 subsystem activation and operation will be conducted by ground command and automation; P/L operations will also be conducted by ground commanded automated operations, by automatic sequence control or by robotics. To guarantee a maximum low gravity operational time, servicing of MTF is currently planned for accomplishment on 180-day intervals including refuelling, RM servicing and PM-2 subsystem and P/L servicing.

For these operations Hermes, NSTS and NSTS/ISS scenarios are being analyzed.

General characteristics of the PM-2 subsystems are shown on tables 1-6.

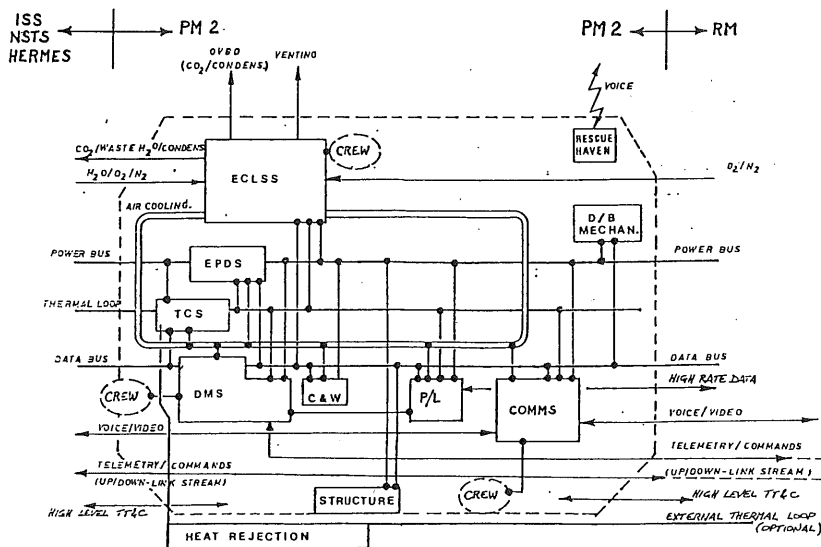


FIG. 8 - PM-2 FUNCTIONAL SCHEME



#### CREW ROLE & SYSTEM

Columbus Pressurized Modules are space laboratory systems characterized by the continuous or infrequent presence of man on board for attending and supporting P/L and system management, control and servicing operations, reconfiguration and resupply. This implies the modules, depending on their final destination, shall be designed and equipped according to standard manned systems requirements ensuring habitability conditions on one side, providing all necessary features and means to perform laboratory work on the other side.

PM's Crew System is therefore a distributed system consisting of subsystems and equipments for crew habitation and interfaces which provide a productive and sustained working environment; basic habitation facilities and rest areas are instead based in the core ISS and/or in NSTS, HERMES cabins.

The following four areas are included at least:

- Basic Habitability
- Crew Work Stations
- Window and Viewport
- Crew Support Equipment

Crew Work Stations are the principal support given to the crew in answering to their principal activities in PM-4 and PM-2. Three major groups have been identified differing in that they provide diverse functions to the crew.

Master Control Stations: these ensure command and control of the module and, as required, of all ISS and MTFF; communication between PM's and other space or ground elements; Caution and Warning; System and Payload Management.

General Purpose Work Bench: this is a work station where tools and equipment are available to allow a crew member to perform routine technical tasks.

Portable Work Station: these are for activities crew members shall accomplish in precise areas of the module, where there are equipments that can only be operated directly.

WINDOW & VIEWPORT. This subsystem is responsible for the provision of the viewing facilities to support observation task and to a different extent, also recreation activity: it is a typical PM-4 feature.

CREW SUPPORT EQUIPMENT is any other type of equipment, tools that is not included in a specific work station.

#### P/L CHARACTERISTICS

PM-4 and PM-2 have as common overall purpose the support to the conduct of scientific experimentation and commercial exploitation in a low-gravity environment.

Differences exist in the level of requested micro-gravity, in the need for more or less frequent man interaction and consequently in the different level of automation in the P/L mission process. Both laboratories however are meant to be used "user friendly". Their design considers the European P/L mission models as reference but also considers compatibility with available international P/L models.

Experiment payload is generally accommodated in the cabin racks and more precisely in lateral racks when a high power requirement exists, in ceiling racks lower power consumers.

A comparative scheme between PM-4 and PM-2 characteristics in terms of P/L requirements, resources and accommodation criteria is illustrated in table 7.

#### ACKNOWLEDGEMENT

Acknowledgement is due to Aeritalia engineering team which has contributed to the preparation of this paper, to astronaut G.P. CARR and to architect M. FABRE which are supporting Aeritalia team in the definition of PM's architectural and functional criteria.

TABLE 1  
GENERAL CHARACTERISTICS

° ORBIT (KM/INCLINATION)	463/28.5 DEG.	TBD/28.5 DEG.
° MICROGRAVITY LEVEL	10 <sup>-5</sup> G F < 1HZ 10 <sup>-3</sup> G F > 100HZ LIN. INCR 1HZ ≤ F ≤ 100HZ	10 <sup>-6</sup> G F < 1HZ 10 <sup>-4</sup> G F > 100HZ LIN. INCR 1 ≤ F ≤ 100 HZ
° MASS (KG)		
- PM	15.500	9.300
- P/L PROVISIONS	10.000	5.000
° VOLUME (M <sup>3</sup> )		
- P/L DEDICATED	27	14
- CREW COMPARTMENT	56	31
- S/S'S, LINES, STORAGE	62	33
° CREW		N/A EXCEPT SERVICING
- NOMINAL	2	
- MAX	3	
° DIMENSIONS (M)		
- TOTAL LENGTH	12.7	6.6
- DIA PRESS. SHELL	4.06	4.06

TABLE 2  
ENVIRONMENT CONTROL LIFE SUPPORT SYSTEM

	PM-4	PM-2
- RESOURCES:	FROM ISS	FROM SERVICING BASE
° Gaseous Nitrogen and Oxygen		
° Potable and Hygiene Water		
- WASTE PRODUCTS:	TO ISS	TO SERVICING BASE
° Waste hygiene water		
° Condensate and waste CO <sub>2</sub>		
- MAIN PERFORMANCES:		
° 1 Atm shirt-sleeve environment	x	x
° Distributed ECLSS	x	x
° SAWD system for CO <sub>2</sub> removal	x	
° LIOH system candidate		x
° Rack cooling	4	2
° Cabin cooling	2	1
° OVBD of condensate, waste water and CO <sub>2</sub> in emergency only		
- MAIN FUNCTIONS ON BOARD PM:		
° Atmosphere Pressure and Composition Control	x	x
° Module Temperature and Humidity Control	x	x
° Atmosphere Revitalization	x	x
° Water and Waste Management	x	x
° Fire Detection and Suppression	x	x
° Monitoring and Control	x	x
- RESCUE HAVEN:		
° Sustaining of N crew members up to 12hours (1 hour with no resources)	3	2

TABLE 3

THERMAL CONTROL SYSTEM

	PM-4	PM-2
- ACTIVE THERMAL CONTROL Heat collection and transport	OWN TASK	OWN TASK
- PASSIVE THERMAL CONTROL External and internal module insulation	OWN TASK	OWN TASK
- MONITORING & CONTROL Sensors and Control Unit	OWN TASK	OWN TASK
- HEAT REJECTION	ISS TASK	OWN BODY MOUNTED HYBRID RADIATORS
- DISTRIBUTION LAYOUT Heat collection and transport via two water loops interfacing with cold plates, heat exchan ges, avionic and cabin loops	x	
HX Interface water loops to ISS thermal bus for heat transfer		
One water loop with same functions as PM-4		
HX interface with ISS thermal bus		x
HX interface with external freon loops		
Heat collection and rejection of RM heat		

TABLE 4

DATA MANAGEMENT SYSTEM

HIGHEST LEVEL IN AVIONICS ARCHITECTURE BASED ON DISTRIBUTED INTELLIGENCE/LOCAL  
AREA NETWORK/NETWORK INTERFACE UNITS/STANDARD ACQUISITION UNITS.

MAIN FUNCTIONS:	PM-4	PM-2
- SYSTEM/MISSION MANAGEMENT	X	X
- COORDINATION OF SYSTEM,SUBSYSTEMS AND P/L ACTIVITIES	X	X
- DATA DISTRIBUTION	X	X
- SYSTEM HIGH LEVEL REDUNDANCY MANAGEMENT	X	X
- DATA BASE MANAGEMENT PROVISIONS	X	X
- TELEMETRY PREFORMATTING AND RECORDING	X	X
- TELECOMMANDS AND UP-LINK DATA DISTRIBUTION	X	X
- ISS DATA INTERFACE	X	
- RM & SERVICING VEHICLES DATA INTERFACE		X
- TREND ANALYSIS	X	X
- TIME REFERENCE DISTRIBUTION VIA LAN	X	X
- OVERALL MTFE FUNCTIONAL MGNT		X

TABLE 5

ELECTRICAL POWER DISTRIBUTION SYSTEM

	PM-4	PM-2
- POWER SOURCE	ISS-TASK	RM-TASK
- POWER DISTRIBUTION	PM-4 TASK	PM-2 TASK
- POWER LEVEL TOTAL AVERAGE PAYLOAD AVERAGE	20KW-120VDC 10KW-120VDC	10KW-120VDC
- BUDGET (KW)		
- DISTRIBUTIONAL LAYOUT	2-25 KW NOMINAL BUSES 1 EMERGENCY BUSES	2-25KW NOMINAL BUSES 1 EMERGENCY BUS

TABLE 6  
COMMUNICATION

FUNCTIONS:	PM-4	PM-2
- VOICE TRANSMISSION/RECEPTION, DISTRIBUTION AND RECORDING	X	X
- VIDEO TRANSMISSION/RECEPTION, DISTRIBUTION, DISPLAY & RECORDING	X	X
- FAX RECEPTION AND RECORDING	X	X
- DATA MUX/DEMUX AND BUFFERING	X	
- TELECOMMAND RECEPTION AND DISTRIBUTION	X	
- DATA/AUDIO/VIDEO I/F WITH RM FOR MUX/DEMUX AND TRANSM/REC		X
- HIGH LEVEL TT & C LINK	X	
- TX/RX FOR SAFETY CRITICAL LINK	X	
- AUDIO/VIDEO I/F WITH ISS	X	
- AUDIO/VIDEO I/F WITH SERVICING VEHICLES		X

TABLE 7  
PAYLOAD CHARACTERISTICS

PM-4	PM-2
Manned operated material, fluid and life science experiments	Automatic operated material, fluid and life science experiments
$10^{-5}g$ $f < 1Hz$	$10^{-6}g$ $f < 1Hz$
$10^{-3}g$ $f > 100Hz$	$10^{-4}g$ $f > 100Hz$
Log linear extrapolation $1 \leq f \leq 100$	Log linear extrapolation $1 \leq f \leq 100$
<u>TYPICAL P/L MISSIONS</u>	<u>TYPICAL P/L MISSIONS</u>
MAT: metallurgy laboratory fluid science laboratory crystallization laboratory	MAT: metallurgy laboratory fluid science laboratory crystallization laboratory transport properties
LIF: - incubator - cooler/freezer - bioprocessing facility - human facility - animal research facility - biological laboratory - gravitational bio facility	LIF: - protein crystal growth - gravitational bio laboratory - CELSS test facility - radiation bio-experiments - aquarack - biotech. facility
COMMON: - general purpose WB - storage - scientific airlock - vacuum/venting	COMMON: - storage - vacuum/venting
OTHER: - control for attached P/L	
<u>POWER</u>	<u>POWER</u>
10KW continuous average 12KW peak	5 kw continuous average TBD peak
<u>CREW</u>	<u>CREW</u>
- 2 dedicated crew-men in timelined operation - up to 10000 Kg mass	- unmanned except for 2 men for 5 days every 6 months - up to 5000 Kg mass
<u>VOLUME</u>	<u>VOLUME</u>
- 25 m <sup>3</sup>	- 12 m <sup>3</sup>