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Paper Session II-A - Columbus Elements Processing Needs At KSC

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COLUMBUS ELEMENTS PROCESSING NEEDS AT KSC

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ABSTRACT

The COLUMBUS Attached Laboratory will form an integral part of the Space Station Freedom and the COLUMBUS Free Flying Laboratory will use the Space Station Freedom as a servicing base.

The COLUMBUS Attached Laboratory will be launched by NSTS in the late Space Station Freedom assembly period. This laboratory is presently planned to be launched without the complete payload, due to launch mass restrictions, requiring additional outfitting missions utilizing NASA Pressurized Logistics Carriers. The COLUMBUS Free Flyer will be launched by the ARIANE 5 and is configured to sustain nominal mission operations by HERMES visits between servicing events at the Space Station Freedom. For this purpose the NASA infrastructure will also be used for Free Flyer's upload and download processing.

This paper concentrates on the ground processing aspects for the initial delivery of the COLUMBUS Attached Laboratory, payload outfitting launches, and the periodic resupply launches for both the Attached Laboratory and the Free Flyer. It describes the acceptance approach of flight hardware at the European facilities and the concepts for shipment to and essential processing at the launch site.

Primarily addressed is the intended use of the Space Station Processing Facility for these COLUMBUS needs. A summary is presented in a scenario covering upload and download processing for the COLUMBUS elements at KSC.

1.0 INTRODUCTION

The European contribution to the Space Station Freedom will include the COLUMBUS Attached Laboratory, the COLUMBUS Free Flying Laboratory and the COLUMBUS Polar Platform. The Attached Laboratory and the Free Flying Laboratory are intended for an operational on-orbit life of 30 years to be achieved by on-orbit maintenance. The Polar Platform is designed for a 4 years mission with propellant reserve for an extension up to 6 years without on-orbit maintenance.

The Attached Laboratory will be launched by NSTS and remains permanently attached to the Space Station for fully manned operations. Servicing will be supported by the NSTS 90 days resupply cycle for up- and downloads. The initial payload mass for launch of the Attached Laboratory will be determined by the shuttle launch performance, additional payload up to full Attached Laboratory capability will be delivered during the following Space Station assembly and resupply flights.

The Free Flying Laboratory and the Polar Platform will both be launched by ARIANE 5, whereby the laboratory will interface with the Space Station Freedom for mantended servicing events in intervals of approximately 3 years, mainly for the exchange of propulsion

equipment. Nominal servicing in situ is planned to be performed every 180 days during HERMES visits.

This paper describes the ground processing support assumed at KSC for the Attached Laboratory launch and the processing of COLUMBUS system resupplies and payload increments for launches with the NSTS.

2. THE COLUMBUS GROUND PROCESSING CONCEPT

Goal for the COLUMBUS elements ground processing is to minimize the processing needs at the launch sites. Therefore the elements will be completely assembled and functionally verified in Europe at their integration sites, which are Torino in Italy for the Attached Laboratory, Bremen in Germany for the Free Flyer and Bristol in Great Britain for the Polar Platform. These activities are supposed to end with the elements in their integrated launch configurations, with the exception of not yet loaded propellants for the Free Flying elements. These configurations shall be delivered to the launch sites, to limit furhter processing needs to:

- post shipment integrity verification by visual inspection and functional checkout
- servicing to achieve the launch readiness status
- integration with the launch vehicle.

The same concept will be applied for the processing of resupplies and payload increments with system resupplies and payload increments preparation at the Element Centers for Attached Laboratory and Free Flyer in Europe.

In the following the Ground Processing Tasks are described on the example of the COLUMBUS Attached Laboratory.

3. COLUMBUS GROUND PROCESSING TASKS

3.1 Preparatory Activities in Europe

3.1.1 Verification of Equipment and Procedures

The COLUMBUS program provides for element Engineering Models (EM) for the qualification of system functions and Payload Test Facilities (PTF) for the acceptance of payload racks, whereby payload qualification will be performed on lower level. All procedures to be utilized for nominal launch site processing will be verified during preparational activities in Europe, for the initial launches as well as for resupply processing. Above tools can be used for this verification. For the operational phase this capability will be maintained in the Element Centers which provide system expertise for the processing of resupplies and payload increments. Element centers will be established in Torino for the Attached Laboratory and in Bremen for the Free Flying Laboratory. These centers will also support on-orbit operations and the integrated logistics for the elements. Payload increment integration can take place at various payload integration sites, however, the acceptance of payload increments will be performed under Element Center control.

The concept for verification of system resupplies is by use of unit testers.

3.1.2 Configuration for Transportation

The COLUMBUS elements contain a variety of potentially hazardous substances which quantities and status are regimented by international regulation for sea and air transport. They either have to be removed for separate transport or configured safe, i.e. depressurized when remaining in the system. Furthermore shock sensitive flight hardware may be removed for transport.

The status to be achieved for the Attached Laboratory subsystems is shown in Table 3-1.

SUBSYSTEM/ ITEM	TRANSPORTATION STATUS	REMARKS
ECLS	FIRE SUPPRESSION SYSTEM - HALON BOTTLES AND REL. PYRO'S - HAND HELD FIRE EXTINGUISHER SOLID AMINE CARTRIDGES FLUID LOOPS - CONDENSATE WATER SYSTEM - WATER MANAGEMENT SYSTEM	 REMOVED/SAFED REMOVED REMOVED FILLED WITH GN2 FILLED WITH WATER
TCS	COOLANT WATER LOOPS	FILLED WITH WATER
COMMS	SAFETY CRITICAL Tx/Rx BATTERY	REMOVED
GPWB	PORTABLE TERMINAL BATTERIES	REMOVED
DBM	ACTIVE/PASSIVE I/F RING SEALS	PROTECTED PROTECTED
STRUCTURE	FLOOR PANELS GRAPPLE FIXTURE	REMOVED PROTECTED

Table 3-1: Attached Laboratory Transport Status

3.1.3 Transportation to the Launch Site

Single shipments including the flight configuration and the required GSE are assumed for transports between the element integration sites and the launch sites.

For element delivery the current baseline is sea transport.

The candidate vessel type is "MS Ariana" which is in service for ARIANE launcher transportation between Bremen and Kourou. This vessels provides for roll on - roll off capability and no hoisting operations will be required in the ports.

Element resupplies and payloads may be transported by commercial aircrafts also.

Both transportation modes will have to be supplemented by road/barge transport in order to arrive from the integration sites to the overseas transportation disembarkment points, and again to arrive from the embarkment sites to the launch sites.

Table 3-2 shows the transportation route for the Attached Laboratory initial delivery to KSC. It also indicates the applied transportation mode. The total transportation time is assumed with 4 weeks.

ROUTE			DISTANCE (KM)	MODE
TORINO	-	CREMONA	360	ROAD
CREMONA	-	VENEZIA	380	RIVER BARGE
VENEZIA	-	PORT CANAVERAL	9200	VESSEL
PORT CANAVERAL	-	KSC INDUSTRIAL AREA	25	ROAD

Table 3-2: Attached Laboratory Transport Route

3.2 Processing at the Launch Site

3.2.1 General

Launch site processing falls into the COLUMBUS standalone activities and the common activities with the launch vehicle.

The standalone processing phase is considered to be performed off-line the launch vehicle schedule, and starts with the receiving activities and ends with the transportation for integration with the launch vehicle.

The common phase will start with the integration with the launch vehicle and continues until launch.

The Attached Laboratory will be processed at KSC in the Space Station Processing Facility (SSPF) standalone processing and integration with the NASA orbiter will take place at the Launch Pad. Transport between SSPF and Launch Pad will be in the NASA canister with intermediate stop in the Vertical Assembly Building (VAB) for erection to vertical.

During standalone processing the Attached Laboratory will be installed in COLUMBUS GSE. For functional verification COLUMBUS servicing equipment and EGSE will be used.

The COLUMBUS program will provide all hoisting handling GSE, the interface to NASA is the crane hook.

3.2.2 Receiving

The Attached Laboratory will arrive at the SSPF on a flatbed transporter. This configuration will be cleaned in the facility airlock prior to enter the 100 K clean area. The flight configuration will remain installed in the transportation GSE until removal for on site transport to the Launch Pad.

This configuration can be moved on air pads for entry into the SSPF high bay. The shipping container can be configured to access the Attached Laboratory exterior and interior. Prior to power on activities a thoroughly visual inspection will be performed.

In parallel the EGSE and servicers will arrive, undergo incoming inspection and will be prepared for use.

3.2.3 Assembly

The COLUMBUS ground processing concept plans assembly operations at the launch site only for installation of payloads arriving separately and items which have been removed for transportation.

For the Attached Laboratory no need for payload integration has been identified yet. Remaining activities are the re-installation of items identified in Table 3-1.

3.2.4 Servicing

Servicing will be limited to fill and pressurize those loops which have been emptied or depressurized for shipment in order to comply with transportation regulations. This may be the case for all pressurized loops, but it is assumed that liquids can remain in the system for transportation with the exception of fuel. Loops which have been emptied will be filled with inert gas, usually GN2.

This concept would also prove tightness of loops by comparing pre- and post transport pressure values.

In this case the transport phase itself will be considered as a "pressure decay test" which allows for a measurement of leakage by determination of the difference in amount of fluid within the loop or by change of pressure of the loop itself. Once at the launch site a tightness verification is accomplished by comparison between pressure levels before and after transportation.

If a significant leak rate is identified, corrective actions will be initiated, supported by COLUMBUS GSE.

For the Attached Laboratory servicing of condensate water and waste water lines is identified.

3.2.5 Checkout

For element ground checkout it is assumed that a complete functional verification of all system functions has been performed on system level in the Assembly, Integration and Verification (AIV) phase, which leaves no open work or unsolved problems.

This limits the extent of launch site checkout to:

- post transportation integrity verification
- verification of launch readiness
- NASA required interface verifications to be supported by launch site provided simulators.

Element integrity will be verified by visual inspections supported by measurement and calibration readings in the receiving inspection and by the execution of a system checkout. This checkout is based on a reference test which has been conducted as part of the element AIV program on the integrated configuration. Launch site checkout will be a repetition of this reference test using already proven procedures. For this checkout the Attached Laboratory must be adequately serviced and the full EGSE capability must be provided.

The verification of end to end communication (element at launch site to mission control center or user home bases) is not necessarily a ground processing requirement, but may be demanded by Mission Control or system users.

Eventually required CITE testing with the purpose to verify all physical and functional interfaces between the orbiter and the payload is questioned, since COLUMBUS hardware will be launched passive.

3.2.6 Integration with Launch Vehicle

The integration process with the launch vehicles will be strictly determined by the launch organizations in charge. As such the associated handling, structural mating and functional verification of affected interfaces are considered to be performed under launch site's responsibility with launch site GSE.

As a goal COLUMBUS processing demands shall be terminated prior to integration with the launch vehicle. Exceptions may be planned late access activities which are considered to be negotiable with the launch organization.

The Attached Laboratory will be installed into the NSTS orbiter cargo bay at the launch pad. The orbiter will be in the vertical orientation and the Attached Laboratory will be handled by NASA GSE. Verification will include the integrity of mechanical interfaces only.

3.2.7 On-Site Transportation

For transportation between launch site facilities the COLUMBUS flight hardware has to be packed in principle in the same way as for delivery to the launch site. At KSC the NASA canister is assumed for the transportation following the processing in the SSPF. COLUMBUS GSE, however, may be used for resupply and payload increment transportation.

4. COLUMBUS ELEMENT PROCESSING NEEDS AT KSC

Having introduced the COLUMBUS ground processing concept and the approaches for ground processing tasks performance the following COLUMBUS flight hardware configurations are identified for launches with the NSTS:

- o the Attached Laboratory equipped with all subsystems and a potential initial payload with a total launch mass of max. 17 metric tons,
- o the initial payload supplement, making up to a total initial on orbit payload of 10000 kg accommodated in the equivalent of 40 single racks,
- o system and payload resupplies configured as orbital replaceable units (ORU), which can be double racks or smaller subunits and various sized containers for consumables and payload samples.

In the following some basic requirements for the use of KSC facilities are summarized for the each of these hardware configurations.

4.1 Attached Laboratory Processing

Goal for the launch campaign duration is 5 months from arrival at KSC until lift off. During this time a European resident team of approximately 70 persons has to be accommodated. For element standalone processing in the SSPF 15 calendar weeks are assumed. The required floor space is shown in Figure 4-1.

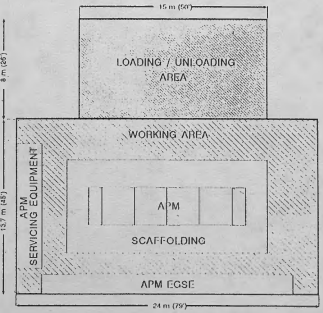

Figure 4-1: Attached Laboratory Accommodation in SSPF for Standalone Processing

This figure indicates the accommodation of COLUMBUS EGSE and servicing equipment in the high bay area. Specific resources relative to power consumption, communication and consumables are not yet defined.

During standalone processing the Attached Laboratory will remain installed in COLUMBUS GSE which provides for mobility by air pads inside the SSPF. As such hoisting requirements are depending on the internal facility arrangements. For the Attached Laboratory including container hoist load of 40 metric tons are estimated with a maximal envelope of 15 meter length, 5.1 meter width and 5.2 meter height.

The hoist load for the transfer of the Attached Laboratory from COLUMBUS GSE to KSC GSE will be max. 17 metric tons, the overall dimensions 4.5 meter diameter and 13 meter length.

Storage area of about 4520 sq ft will be required for element container and hoist fixture.

4.2 Initial Payload Supplement Processing

The Attached Laboratory payload will be accommodated in double racks. Delivery of equipped racks from the various payload integration sites to KSC is assumed. The number of racks which can be accommodated for one outfitting launch is not known yet, nor if one or more outfitting missions will be required. A team of 25 persons is assumed for processing, composed of system and payload specialists. The required floor space for standalone processing is shown in Figure 4-2.

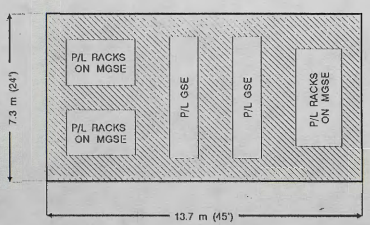

Figure 4-2: Floor Space For Payload Increment Processing

It is assumed that no more than 3 double racks will be processed at the same time, while others are stowed off-site the processing area.

For installation into the launch carrier KSC provided GSE is assumed.

4.3 Resupply Processing

The annual allowable uploads masses for European resupplies for Attached Laboratory and Free Flyer servicing at the Space Station launched with the NSTS are currently under negotiation. However, it is assumed that every pressurized logistics carrier launch will be partially used for COLUMBUS needs, which results in ground processing of resupplies up and downloads every 90 days.

A European core team is assumed to be resident at KSC to perform routine processing for launch preparation and after landing of returned items and to procure consumables.

A permanent processing area is assumed available at KSC of the size shown in Figure 4-2.

For the processing of propellant equipment for the Free Flying Laboratory also a hazardous processing area will be required.

5. COLUMBUS GROUND PROCESSING SCENARIO FOR NSTS LAUNCHES

At current the dates and sequence for COLUMBUS element launches are under negotiation between ESA and NASA. Therefore a timephased scenario cannot be established yet. According to the present COLUMBUS baseline the Attached Laboratory will be launched first, followed by the Polar Platform and the Free Flying Laboratory. With the event of the Attached Laboratory launch the resupply cycle of 90 days starts with the next achievable Pressurized Logistics Carrier (PLC) launch and will continue throughout the operational on orbit lifetime. This will have to satisfy all pressurized upload demands for both Laboratories.The Unpressurized Logistics Carrier (ULC) will be used for the exchange of external ORUs of both elements which may first happen for the Free Flying Laboratory after 2 years of on-orbit operations.

The basic scenarios for ground processing of the identified COLUMBUS hardware configurations planned to be launched by NSTS are summarized in Figure 5-1.

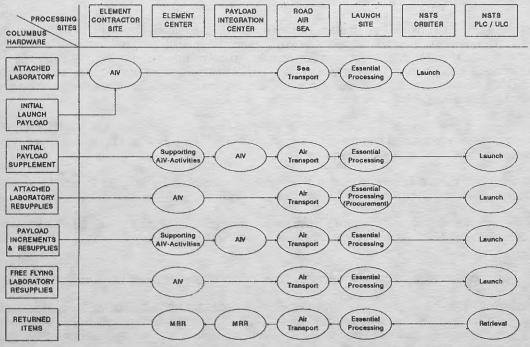

Figure 5-1: COLUMBUS Ground Processing Scenraios for NSTS Launches

6. SUMMARY

It shall be noted that this paper can only give a snapshot of the present COLUMBUS ground processing planning, which is based on assumptions concerning COLUMBUS element configurations and launch site and launch services/capabilities.

These assumptions need to be validated in ongoing design efforts in Europe and by the results of further ESA/NASA negotiations.