Nationaal Lucht- en Ruimtevaartlaboratorium
National Aerospace Laboratory NLR

Executive summary

Columbus Payload Operations from Remote Decentralized User Support and Operations Centres

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Knowledge area(s)
Space

Descriptor(s)
Columbus Space Station
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Problem area
With the launch of Columbus in February 2008, the Columbus User Support and Operations concept was implemented. This concept is based on a distributed responsibility for operations support spread over European User Support and Operations Centres (USOCs).
In the Netherlands, the Erasmus USOC has been implemented at ESTEC, Noordwijk. The Erasmus USOC is responsible for the operations with the Columbus European Drawer Rack (EDR) and the European Technology Exposure Facility (EuTEF).

Description of work
From February until October 2008 the Erasmus USOC has supported operations with the EDR and EuTEF.
Training of new operators was continued to cover the 24/7 shifts. Some problems have been solved successfully.

Results and conclusions
The implementation of the USOC concept is evaluated based on the operations in the first seven months after the Columbus launch.
The EDR has been activated and checked out. The external EuTEF platform carrying 9 instruments, provided data for the Principal Investigators (PIs) via so-called User Home Bases (UHB) from which they could also control their experiment facility.

Applicability
This paper is applicable for the evaluation of the operational performance of the Erasmus USOC.

This report is based on a presentation held on the 59th IAC Congress, Glasgow, 29 September – 3 October 2008.

Columbus Payload Operations from Remote Decentralized User Support and Operations Centres

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Summary

The Erasmus User Support & Operations Centre (USOC) is part of the decentralized Columbus payload operations support infrastructure, and is Facility Responsible Centre (FRC) for the European Drawer Rack (EDR) inside Columbus and for the European Technology Exposure Facility (EuTEF) outside Columbus.
Since February 2008, the Erasmus USOC is operational, and performs the tasks meant to be done under the specification of the USOC concept. This USOC concept is the result of a development already started up 20 years ago, meant to provide optimal and flexible support to the users of different micro-gravity platforms of the European contribution to the International Space station. Following a recommendation of the Netherlands and Belgium, ESA decided to develop the Erasmus USOC at ESTEC with national and ESA provided contributions.

The Erasmus USOC is getting support from two Facility Support Centres (FSCs) dedicated to sub rack payloads (so-called Class 2 Payloads), in this case experiment facilities. The Belgian USOC (B.USOC) operates the Protein Crystallization Diagnostic Facility (PCDF) inside the EDR Facility; the German USOC (MUSC) provides support to one of the EuTEF instruments, namely the EXPOSE instrument. In addition, the Erasmus USOC is connected to 9 User Home Bases (UHBs), spread all over Europe, providing an interface for Principal Investigators to their instruments onboard Columbus.

The preparatory phase for operations started more than a year before the mission and was mainly focused on preparation of operational products, and training and certification of operators. Both the preparation of operational products and the certification of operators have followed a certain order of incremental steps to finally result in validated procedures and certified operators.

The payload operations, started in February 2008, should provide the proof of the operations concept followed for some years.
The presentation will address the concept and the approaches for implementation, validation, operations preparation and training. The concept will be evaluated based on the operations performed so far together with the Principal Investigators.

Samenvatting (in dutch):
De Erasmus “User Support & Operations Centre” (USOC) is onderdeel van de gedecentraliseerde infrastructuur voor Columbus payload operaties. De Erasmus USOC is verantwoordelijk voor de operaties met de European Drawer Rack (EDR) in de Columbus

module en voor de European Technology Exposure facility (EuTEF) buiten de Columbus module. Vanaf februari 2008 is de Erasmus USOC operationeel en voert alle taken uit die gespecificeerd zijn onder het USOC concept. Dit USOC concept is het resultaat van een ontwikkeling die al 20 jaar geleden is gestart en die tot doel had een optimale en flexibele ondersteuning te geven aan gebruikers van verschillende micro-zwaartekracht platformen die door Europa in het kader van het Internationale Ruimte Station zouden worden ontwikkeld. Op aanbeveling van Nederland en België werd door ESA de Erasmus USOC opgebouwd by ESTEC, Noordwijk, ondersteund door Nederland en België.

De Erasmus USOC krijgt ondersteuning van twee “Facility Support Centres” (FSCs) die specifiek ondersteuning geven aan zogenaamde “sub-rack” of “class 2 payloads”, in dit geval experiment faciliteiten. De Belgische USOC (B.USOC) opereert een eiwitkristallisatie faciliteit (Protein Crystallization Diagnostic Facility, PCDF) die geïnstalleerd wordt in de EDR. De Duitse USOC (MUSC) ondersteunt een van de EuTEF instrumenten, de EXPOSE faciliteit. Tevens is de Erasmus USOC verbonden met 9 User Home Bases (UHB) verspreid over Europa, die een verbinding geven tussen de onderzoeker en zijn instrument op EuTEF.

De voorbereiding op de operaties startte meer dan een jaar voor de missie en was voornamelijk gericht op de vervaardiging van operationele producten, en de training en certificatie van operators. Zowel de voorbereiding van operationele producten als van de training verliepen volgens een proces van stappen om tot gevalideerde producten en gecertificeerde operators te komen.

De operaties die in februari zijn gestart, zouden een test kunnen zijn van het concept zoals dat de komende jaren wordt uitgevoerd.
De presentatie behandelt het USOC concept en de manier van implementatie, validatie, en voorbereiding van operaties en training. Het concept zal geëvalueerd worden op basis van de operaties uitgevoerd tot dan, samen met de onderzoekers.

Contents

1 Introduction

In the period of 29th September till 3rd October 2008, the International Astronautical Federation organised the 59th International Astronautical Conference in Glasgow, Scotland.
This congress is organised every year and covers almost all the areas of space activities such as programmes of all the world agencies, new concepts and products, space exploration, space law, student conferences, exhibitions of the major industries and institutes, and all other issues related to space.
Under the "Microgravity Sciences and Processes" Symposium, an NLR paper was presented in session 5, "Facilities and Operations of Microgravity Experiments". This paper was based on the experiences obtained at the Erasmus USOC during the last 7 months of operations on the European Columbus Laboratory attached to the International Space Station, ISS.
The Erasmus USOC has been built up by ESA, supported by the Netherlands and Belgium. The Netherlands is represented by NLR, Belgium by the Belgium company, Space Applications Services.
The paper was prepared by the representatives of Erasmus USOC team, being:

- Z.Pronk (NLR), main author, providing the presentation at the IAC,
- P. Dujardin (NLR),
- L.Steinicke (SAS),
- J.M. Wislez (SAS), and
- J.C. Degavre (ESA).

The paper is given in appendix A of this report.

In summary the presentation addressed the following:
With the launch of Columbus in early February 2008, the Columbus User Support and Operations concept was implemented. This User Support and Operations concept is based on a distributed responsibility of operations support spread over European User Support and Operations Centres (USOCs), which concept was already initiated about 20 years ago.
In the Netherlands, the Erasmus USOC has been implemented at ESTEC site in Noordwijk. The Erasmus USOC is responsible for the operations with the Columbus European Drawer Rack (EDR) and the European Technology Exposure Facility (EuTEF).
The EDR was almost directly after launch installed and checked out. The external EuTEF platform supports 9 instrument facilities. The Principal Investigators (PIs) obtain their experiment results via so-called User Home Bases (UHB) in their laboratory environment. They could also control their experiment facility from this UHB. With this concept the PI gets a direct connection with his/her experiment, which was one of the objectives of the USOC implementation.

Some typical operational problems were discussed, in particular the power down of the EuTEF due to a safety issue with the Plegpay instrument.
In general, Erasmus successfully supported the operations with EDR and EuTEF up till October 2008.
The slides of the presentation are given in appendix B.

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Appendix A Paper

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COLUMBUS PAYLOAD OPERATIONS FROM REMOTE DECENTRALIZED USER SUPPORT AND OPERATIONS CENTRES

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ABSTRACT

The Erasmus User Support & Operations Centre (USOC) is part of the decentralized Columbus payload operations support infrastructure, and is Facility Responsible Centre (FRC) for the European Drawer Rack (EDR) inside Columbus and for the European Technology Exposure Facility (EuTEF) outside Columbus.
Since February 2008, the Erasmus USOC is operational, and performs the tasks meant to be done under the specification of the USOC concept. This USOC concept is the result of a development already started up 20 years ago, meant to provide optimal and flexible support to the users of different micro-gravity platforms of the European contribution to the International Space station. Following a recommendation of the Netherlands and Belgium, ESA decided to develop the Erasmus USOC at ESTEC with national and ESA provided contributions.

The Erasmus USOC is getting support from two Facility Support Centres (FSCs) dedicated to sub rack payloads (so-called Class 2 Payloads), in this case experiment facilities. The Belgian USOC (B.USOC) operates the Protein Crystallization Diagnostic Facility (PCDF) inside the EDR Facility; the German USOC (MUSC) provides support to one of the EuTEF instruments, namely the EXPOSE instrument. In addition, the Erasmus USOC is connected to 9 User Home Bases (UHBs), spread all over Europe, providing an interface for Principal Investigators to their instruments onboard Columbus.

The preparatory phase for operations started more than a year before the mission and was mainly focused on preparation of operational products, and training and certification of operators. Both the preparation of operational products and the certification of operators have followed a certain order of incremental steps to finally result in validated procedures and certified operators.

The payload operations, started in February 2008, should provide the proof of the operations concept followed for some years.

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ACKNOWLEDGEMENT

The authors want to thank Payload developers from Carlo Gavazzi Space (EuTEF), Thales Alenia Space (EDR) and Astrium/EADS (PCDF) together with the Payload Integration Managers for their contribution to the successful preparations and operations of the payloads. In addition, the authors acknowledge ESA Payload Operations Management for the approval of this paper.

1. INTRODUCTION

Some twenty years ago, when Europe planned to exploit a number of different micro-gravity research platforms, such as EURECA, the Free-Flyer, and the Columbus platform, the User Support & Operations concept was born. This concept is based on a decentralized distributed payload and experiment operations support infrastructure spread over Europe. Already from the beginning quite a number of ESA member states participated in the definition of the concept. With the final decisions on the ISS configuration at the end of the previous century also the User Support and Operations Centre (USOC) concept started its final stage of specification, design and implementation. In the mean time 9 countries finally decided to support the operations with national USOCs, operationally coordinated from the Columbus Control Centre in Munich. One of the main objectives of the USOC concept was to bring the experiment control and monitoring as close as possible to the desk of the Principal Investigator (PI).

During the last few years some elements of the USOC network were already used to support the flights and missions in the ESA so-called Interim Utilization period, amongst others with the Russian Taxi flights. Also the Erasmus USOC got the opportunity to participate in a few flights, such as in 2004 with the Dutch DELTA mission. With the launch of the Columbus module with STS 122 last February 2008, the full blown USOC concept started its operational phase and the Erasmus USOC formally became part of the final USOC network (Figure 1).

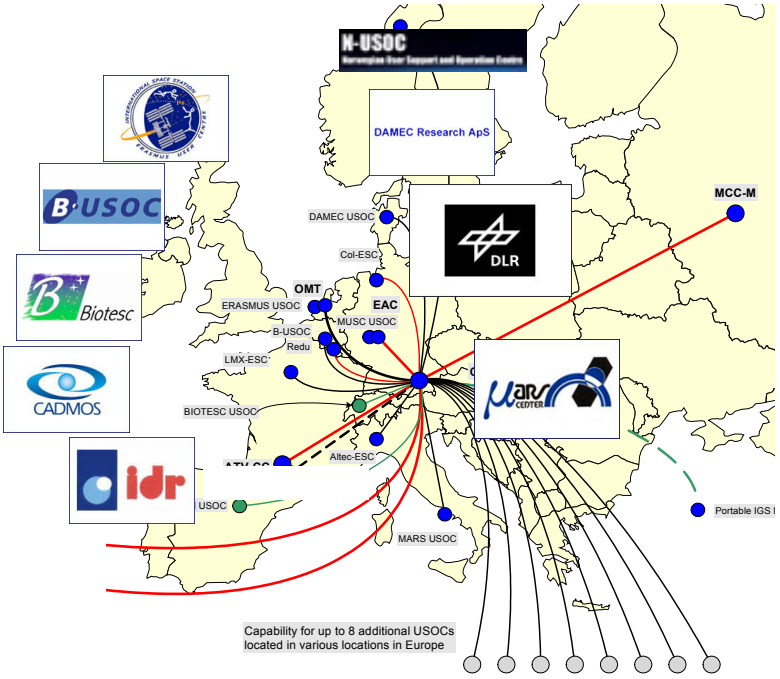

Fig. 1: The European USOC network with nine national USOCs.

The Erasmus User Support and Operations Centre, located at ESTEC premises in Noordwijk, The Netherlands, has the overall responsibility for the preparation and execution of operations for the European Drawer Rack (EDR) facility in the European Columbus laboratory and for the European Technology Exposure Facility (EuTEF) outside Columbus on the International Space Station (ISS). Directly after the coupling of Columbus to ISS and after the installation of the EDR rack and the EuTEF facility, operations at Erasmus started and due to the fact that EuTEF science is running 24 hours a day, the operations support also covers 24 hours by 7 days in a week. The responsibility of supporting all these operations requires a continuous training and operations preparation effort.
The approach and implementation of the training and operations preparations concept is explained and the results of the operations support after the launch of Columbus are presented.

2. USOC RESPONSIBILITIES

The Erasmus USOC is responsible for the operations on payloads for which the Erasmus USOC has been assigned (i.e. EDR and EuTEF). The main task is to provide the required support from mission planning and preparation via the operational phases to the post operational phase for the payload.
The ISS operational phases are identified by increments and can be considered as missions. This means that Erasmus already started their activities during strategic and tactical planning of ISS increment 16, the increment in which Columbus was launched. This preparatory phase started about a year before the start of the increment. The following generic USOC tasks can be identified:

- Support to strategic and tactical planning
- Payload integration support
- Payload operations preparation
- Payload operations training
- Payload execution level planning
- Facility health and status monitoring
- Post mission evaluation and post mission increment operations
- Reporting to ESA management
- Ground and onboard Configuration control
- Experiment preparation and promotion
- Logistic support for experiment up- and downloading.

The level of responsibility is dependent on the level of payload assignment. A USOC can be Facility Responsible Centre (FRC) and Facility Support Centre (FSC). In figure 2 the various configurations of the USOC in the Columbus operations support infrastructure are presented. Next to the FRC and FSC also the User Home Base (UHB) configuration can be seen. The UHB is on the level of a desktop workstation that provides the data direct to the Principal Investigator (PI) of an experiment.

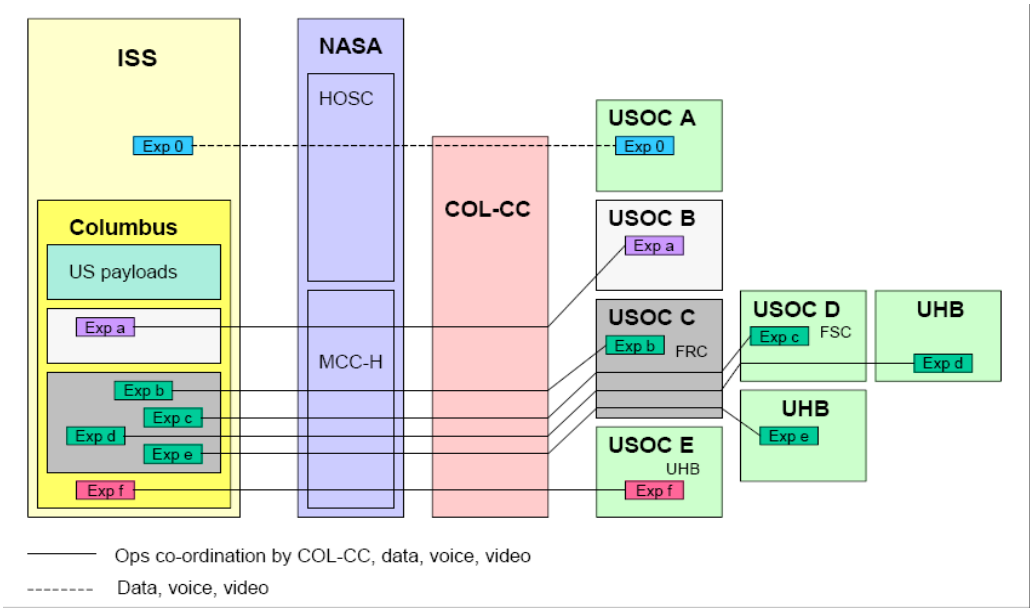

Fig. 2: USOC concept and configurations

3. ERASMUS USOC GROUND INFRASTRUCTURE

In order to be able to support the Dutch DELTA mission in 2004, the basic infrastructural elements of the Erasmus USOC were implemented. This configuration covered the connection to the ESA Interconnecting Ground System (IGS), generic Work Stations, and Local Area Network for different separated operational networks.
After the specification phase in 2005, the implementation of the Erasmus USOC started with the ground infrastructural key elements, such as the Columbus Decentralized Monitor & Control System (CD-MCS) part of the Columbus operations network, providing the capabilities to control and monitor the payloads, facilities and instruments. In addition, the development and implementation of the clean room started, used to house the EDR Engineering Model.
For the implementation a distinction was made between integration of ESA Agency Furnished Equipment (AFE) and USOC Furnished Equipment (UFE). Next to accommodation (UFE), the Erasmus USOC is also responsible for developing the payload operations support tools such as simulators to support training and validation of operational procedures, experiment operations support tools such as the EuTEF Operations Plan Authoring Tool (EOPAT) and the Tracking Tool (EOPTT). Therefore, the EDR-PCDF software simulator (EPSS) was developed in time to support EDR operations training and later the EuTEF Simulator Model (ESM) was developed to support training and validation of EuTEF operations procedures.
Since the EuTEF facility supports 9 different instrument operations with different Principal Investigators, the Erasmus USOC provided a number of UHB connections to the PI desks in order to enable them to control and monitor their experiment facilities. Since the infrastructure to support these connections was implemented rather late in the preparation phase, only limited training and verification activities could be performed. Nevertheless, the UHBs functioned very well during the first period of operations.

The ground infrastructure was integrated, tested and validated according to a incremental approach, from a local stand-alone configuration to a configuration with all the external interfaces, such as Col-CC, FSCs, UHB, and Engineering Support Centres (ESC), from where the payload and facility developers can support operations in case of engineering problems.
The level of completeness and validation of the ground infrastructure was administrated via the UIRR (USOC Infrastructure Readiness Review) and via the well knows increment reviews

(Certification of Flight Readiness, CoFR; Operations Readiness Review, ORR) a few months, respectively weeks, before the start of the increment 16, October 2007. The delay in the launch of STS122 gave some extra time to finish the implementation of the Erasmus USOC ground segment in time.

4. EUROPEAN DRAWER RACK

Columbus offers a unique environment for micro-gravity research allowing scientists to expose samples to micro-gravity for extended periods of time. Four European payload facilities were launched inside Columbus with STS-122: Biolab for biological experiments, the European Physiology Module (EPM) for human physiology experiments, and the Fluid Science Laboratory (FSL) for fluid-science experiments.
The forth payload facility, the European Drawer Rack (EDR), is a general purpose, multi-user facility and can support a wide variety of experiments, ranging from material science, crystallography, fluid science, biological and physics to technology experiments. It provides services for seven standardised Experiment Container Modules (ECMs), three of which are International Sub-rack Interface Specification (ISIS) Drawers and four are ISS Lockers. Experiments can be operated autonomously, with ground intervention, or with crew intervention. An experiment can be accommodated in Drawers or Lockers or any combination of both. Individual Drawers and Lockers can be exchanged or modified -by replacing Locker inserts- in orbit, making EDR a very flexible facility. ISS Lockers are identical to Space Shuttle mid-deck lockers which, optionally, can provide power during ascend or descend.

Cabin air is used for air cooling of locker. In addition to that, vacuum, waste gas, nitrogen gas and water cooling can be made available to the experiment payload through the front panel of the Drawer.
High rate data streams, digital video streams, and analogue video generated by experiments in ECMs are managed by EDR's Video Management Unit (VMU). The VMU can compress video data and store data temporarily. Data is sent to Columbus' High Rate Multiplexer via the High Rate Data (HRD) optical line.
The first experiment facility integrated into the EDR is the Protein Crystallisation Diagnostic Facility (PCDF). The Electronic Unit of the PCDF (PCDF-EU) has already been launched together with the EDR in increment 16. The PCDF Processor Unit (PU) will be launched February next year (Incr. 18). This PU will contain the protein samples and experiments will be performed for about three to four months from installation in EDR. The Belgian USOC (B.USOC) is Facility Support Centre for the PCDF.
Due to lack of crew time, after Columbus launch, only the EDR facility check-out and commissioning was performed on STS flight day 9. The PCDF facility was checked out and commissioned in May 2008, as part of increment 17. After the onboard software update performed in August 2008, the configuration had to be tested again. Except for some minor issues, the facility is ready to receive the PCDF-PU next year.

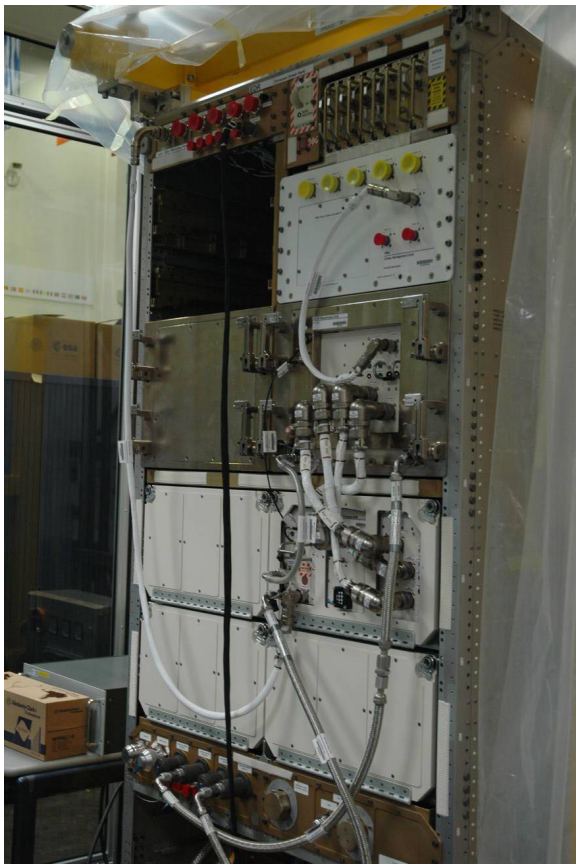

Fig. 3: Engineering models of the EDR and PCDF inserted

5. EUROPEAN TECHNOLOGY EXPOSURE FACILITY (EUTEF)

The experiments and facility infrastructure of EuTEF are accommodated on the Columbus External Payload Adapter (CEPA), consisting of an adapter plate, the Active Flight Releasable Attachment Mechanism (A-FRAM) and the connectors and harness. The experiments are mounted either directly on the adapter plate or a support structure that elevates them for optimum exposure to the RAM (direction-off light) and Zenith directions.
The facility infrastructure consists of a Data Handling and Power Unit (DHPU) and its thermal control system, which transfers the services from Columbus. It receives two feeds of 120 Vdc, one for the experiments' primary supply, and one for survival heaters. Inside EuTEF, the DHPU distributes data using a MIL-1553B interface and a serial RS422 link. Additionally, temperatures are measured autonomously at several points on EuTEF while the assembly is unpowered.
EuTEF accommodates nine experiments comprising (with investigator group):
– MEDET, investigating material degradation in space (ONERA, ESA);
– DOSTEL, performing radiation measurements (DLR);
– TRIBOLAB, investigating Tribology properties of materials in space (INTA);
– EXPOSE, research in the areas of photobiology and exobiology (various groups in Italy, Germany and France);
– DEBIE-2, performing micrometeoroid and orbital debris detection (Patria Finavitec, ESA). Shares a standard berth with FIPEX;
– FIPEX, providing an atomic oxygen detector (Univ. Dresden).
– PLEGPAY, containing a plasma electron gun payload for plasma discharges in orbit (ASI);

– EuTEMP, an experiment to measure EuTEF's thermal environment during unpowered transport from the Shuttle to the CEPF (EFACEC);
– EVC (Earth Viewing Camera), a technical demonstration of using a commercial-of-the-shelf camera for taking pictures from the earth (ESA).

Directly after the installation of EuTEF outside Columbus the EuTEF check-out and commissioning procedures were executed on STS122 Flight day 9. In addition, the instruments were activated and after the activation the instruments were checked out and commissioned day by day. As a result, for most of the instruments the science procedures could be started immediately. Since the EuTEF instruments are running 24 hours day, 7 days a week, the Operations support from the Erasmus USOC were monitored and controlled according to a 24/7 shift plan.
From the moment EuTEF was switched on, it has been operational for more than 99% of the time. Up till now it was switched off for less than 20 hours for different reasons (out of more than 4000 hours).
Most of the instruments have been operating continuously during the same period (DOSTEL, EXPOSE, DEBIE2, FIPEX, MEDET, and TRIBOLAB). Some of the instruments were temporarily switched on or to specific science modes (EXPOSE, FIPEX, DEBIE2, MEDET, TRIBOLAB, PLEGPAY (~ 300 hrs), and EVC (~30 hrs)). Only EUTEMP was on for a short time after installation of EuTEF (about 10 hours).

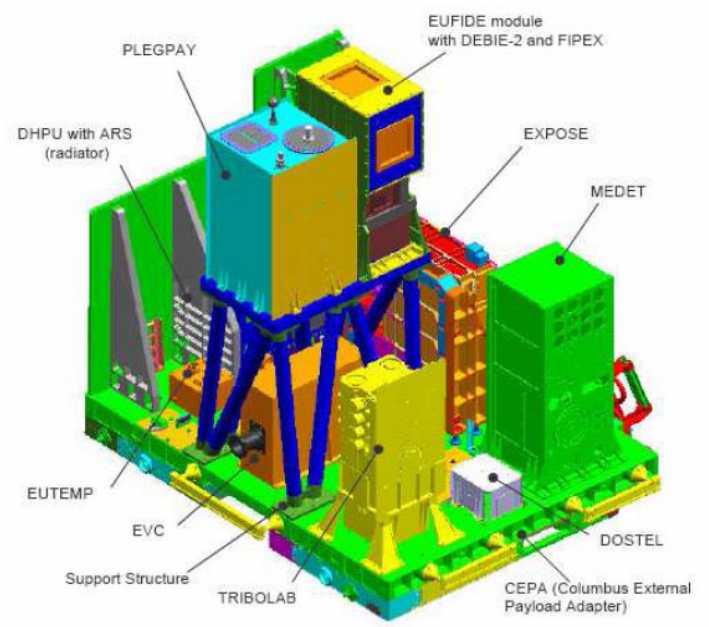

Fig. 4: EuTEF payload model (courtesy CGS)

Most of the instrument data is directly made available for the PI behind his/her UHB. The German USOC (MUSC) is however responsible as facility Support centre for the EXPOSE facility operations.
EuTEF and the EuTEF instruments can be controlled by direct commanding and via so-called EuTEF Operations Plans (EOP). The EOPs are built up from Instrument Operations Plans (IOP). The EOPs have to be validated before uploading to EuTEF. During operation executions most of the EOPs consisted of only one IOP.

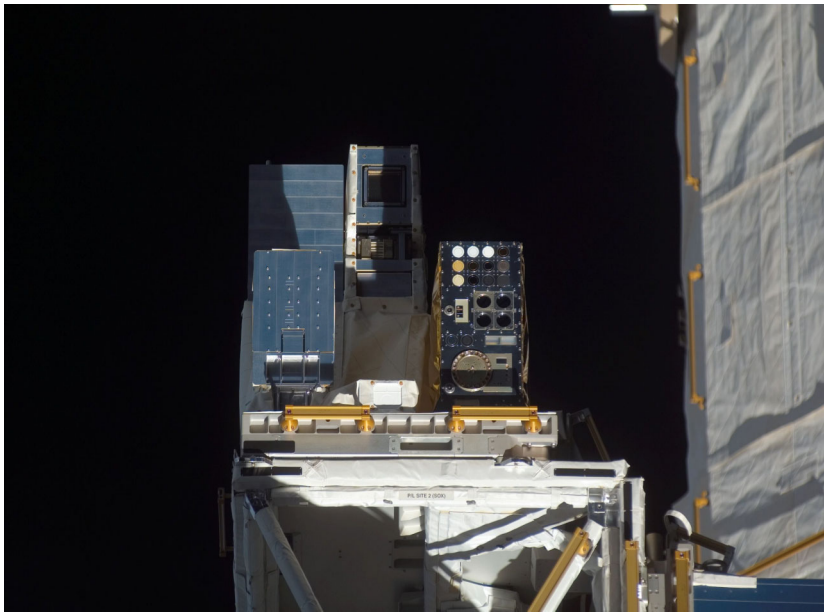

Fig. 5: EuTEF installed onboard ISS attached to Columbus (courtesy ESA)

6. OPERATIONS PLANNING AND PREPARATION

Operations planning already started in 2006 with the specification of the payload check-out and commissioning procedures. During the months before the launch the procedures had to be validated using flight representative engineering models and simulators. It was difficult to finish the EuTEF instrument commissioning procedures due to the unavailability of the EuTEF Simulator Model, which development started very late. Finally, all the procedures were validated in time, also due to the launch delay from December 2007 to February 2008.
In addition, Erasmus USOC contributed to the definition of Payload regulations and Flight Rules. During the operations, the Flight rules, in particular regarding the temperature limits of EuTEF, were subject of regular updates. Apparently, the limits were based on rough estimates after testing, that showed to become critical during real operations.

7. TRAINING, QUALIFICATION & CERTIFICATION OF OPERATORS

The Erasmus USOC maintains an operations support team consisting of an Increment Operations coordinator, at least six on-console operators to cover 24/7 shifts for two teams, and three Ground controllers to guarantee the continuous availability of the ground segment infrastructure by an 8/5 shift plan. In addition, the Erasmus USOC science coordinator is coordinating the science operations with the EuTEF instruments.
The training of the operators is implemented by a two stage approach. The first phase is the qualification of operators under the responsibility of the Erasmus USOC manager or training Coordinator. Main elements are: payload knowledge and awareness (manuals, procedures, PL regulations, flight rules, rack/facility layout and details), ground infrastructure functions and features (Operations manuals, support tools and equipments, configurations, displays), Erasmus USOC organisation and team composition (operations plan, responsibilities, shift plan, etc).
In addition, they should follow some mandatory courses provided and coordinated under responsibility of the ESA Training Control Board (TCB).
After qualification, the candidate operators are nominated for the certification phase, almost completely coordinated under responsibility of the TCB. Operators have to participate in 2-4 European Simulations, are observed and tested, normally resulting in a European or interim certification. Then they have to participate in at least two so-called Joint Multi-Segment

Training (JMST) sessions with NASA, again observed and tested for final of full certification. In the mean-time the candidate operators can participate in an On-the-Job training (OJT) where they are on console at Erasmus in a passive or active role. The whole training covers about 6-8 weeks for qualification and 3-4 months for certification.
The duration of the certification is long and therefore the Erasmus USOC introduced the so-called Operator Assistant (Ops-Ass) role who is allowed to be on console during low level shifts under the responsibility of a certified operator and who is not allowed to send any command to the payload.

The training of ground controllers is the responsibility of the Erasmus USOC. The most important element is the knowledge and experience with the ground segment. The training covers about two months from start until full responsibility for the ground segment availability. Since the USOC ground segment is a very complex system, the knowledge of the system is spread over the various GCs, since the most of the experience is obtained by implementation of functions and solving of unforeseen problems.

8. OPERATIONS EXECUTION

In fact the on-console operations started with the execution level planning activities during the STS 122 flight. From that moment the Erasmus USOC operations team started with partly 24/7 shifts.
Directly after the commissioning of EuTEF instruments (at FD#9), the science operations with EuTEF started and continuous operations support was a fact. Some instruments are running almost continuously, some instruments are running under different controllable modes and some are running only under direct commanding, allowed to be sent in direct command windows.
As agreed with the Columbus control centre (Col-CC) every day a direct command window was planned for Erasmus including a High Rate Data downlink activity, which allowed us to take pictures from the earth with the Earth Viewing Camera (EVC) and to download the data. In addition, a longer command window was agreed every Thursday to allow Erasmus to perform more complex command sequences and starting of EuTEF EOPs.
Every week, under the responsibility of the Erasmus EuTEF science coordinator the so-called EuTEF Operations Conference is being held with the operations team, the PIs and the ESA Mission Science Office team. Here the last week operations are discussed and the next week operations are planned.

During the last six months a number of problems occurred regularly which required full attention and adequate intervention of the Erasmus operations team in the facility status. In general, the problems could be solved in time and after some months the procedures to solve the problems became more mature. A few problems will shortly be explained.

When the ISS beta angle (angle between ISS orbit plane and the sun vector) became very high (above 55 degr), the EuTEF facility was hardly warmed up by the sun and the survival heaters started up very late due to a design issue. This caused EuTEF almost going beyond a temperature limit specified in a flight rule and requiring EuTEF to be switched off. Accurate monitoring of EuTEF temperature sensors and lots of communication with the Flight Control Team at Col-CC were needed to prevent EuTEF from switching off.

Sometimes the EuTEF Milbus goes into an undefined mode which causes unreadable data from EuTEF. The best solution was found to graceful shutdown the power feeder to EuTEF, switch it on again and switch on the instruments according to the last configuration. Actually this is not a problem except for loss of some science data for some instruments. Problems may arise (and this happened once) if the situation occurs in combination with another off-nominal situation or

temporarily required switch off (in this case during undocking of Shuttle). This almost causes a very low temperature of EuTEF which would not allow EuTEF to be switched on again.
In general, the conclusion is that the temperature of EuTEF is very critical and a main issue for monitoring and control of EuTEF. Despite the problems found and the recovering periods the overall availability of EuTEF (powered) is above 90%.

Fig. 6: Erasmus team on console.

9. CONCLUSIONS

The possibility for PIs to control and monitor their instruments from their laboratory desks let us conclude that the original objective of the USOC concept to bring scientists very close to their instruments is almost fulfilled. The limited accessibility of EuTEF for direct commanding (1 hour a day) can be seen as a real limitation, but has never been subject of discussion.

Given the results up till now, the conclusion can be drawn that the Erasmus USOC could provide optimal support to the EuTEF science objectives by keeping the system available at a rather high level.

The present concept for training, qualification and certification of operators is still under discussion due to the high load (3-4 months) on team and candidates to obtain the certification status.

In general, the Erasmus USOC performance can be identified as good given the status of their payloads and the support to science operations and distribution of science data.

Appendix B : Presentation

Dedicated to innovation in aerospace

Columbus Payload Operations from Remote Decentralized User Support & Operations Centers

Evaluation of Erasmus USOC operations support activities after Columbus installation

by Zeholy Pronk
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ERASMUS USOC
Co-authors:
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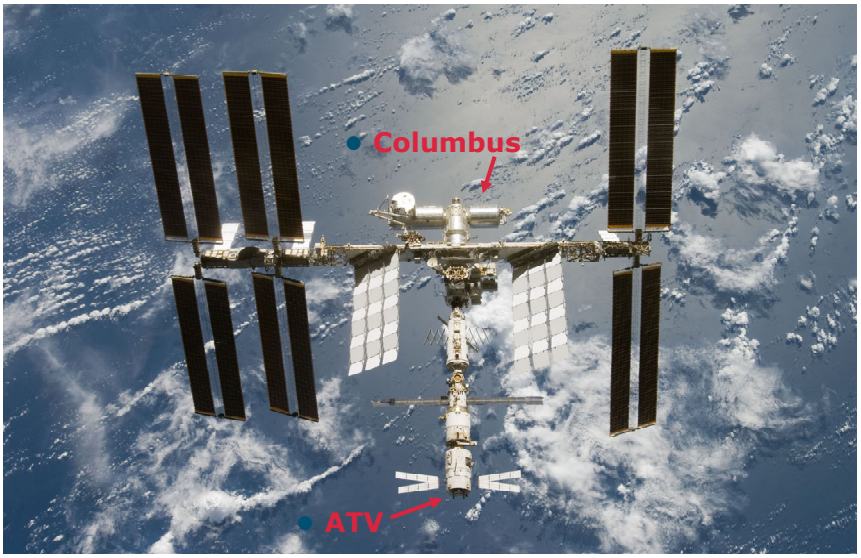
J.C.Degavre (ESA/ESTEC, The Netherlands)
P.Dujardin (NLR, The Netherlands)

Overview

- User Support & Operations Centre (USOC) concept
- Erasmus USOC
- European Drawer Rack (EDR)
- European Technology Exposure Facility (EuTEF)
- Experiences on Operations
- Conclusions

International Space Station (ISS)



ISS Columbus; USO concept

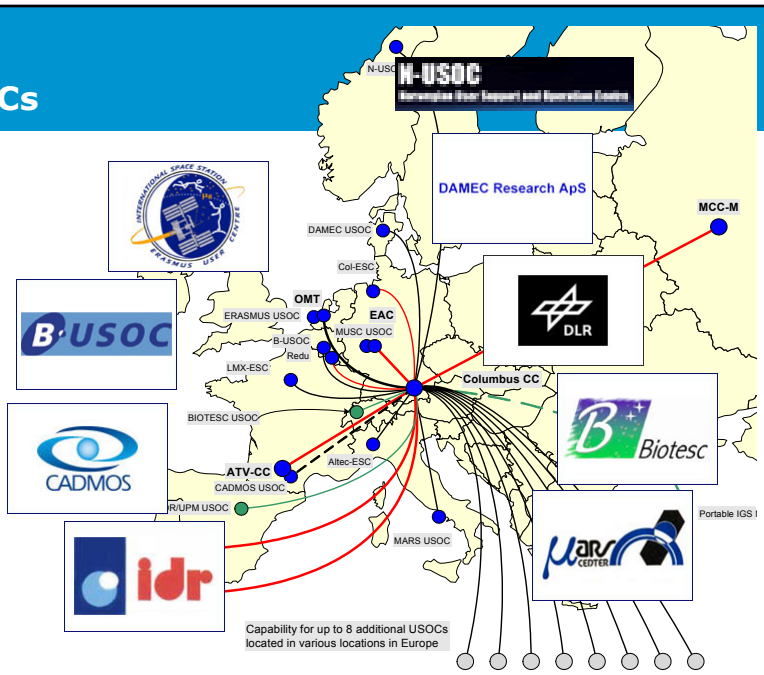
User Support & Operations concept born ~20 years ago:

- Large variety of possibilities for micro-g experiments
- Concept for decentralized utilization and user support
- Responsibility of all Payload/Experiment operations assigned to a USOC

USOC task:

- Strategic and tactical planning support
- Payload integration
- Preparation and training of payload operations
- Training of operators
- RT Planning and execution of payload operations
- Evaluation of operations
- Payload logistics, maintenance, configuration control

USOCs

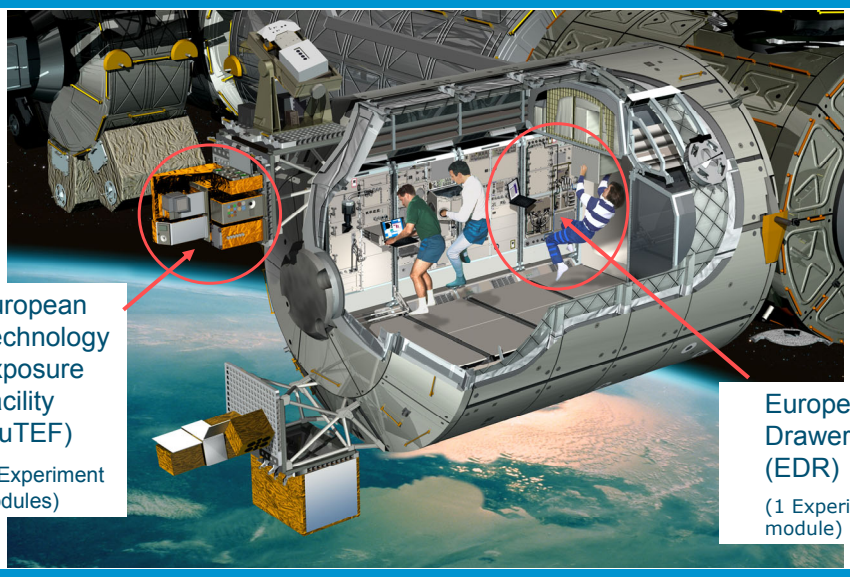


ISS Columbus USOCs

- **Erasmus USOC is one of the nine European USOCs.**
- **Erasmus built up and operated by Dutch/Belgium consortium.**
- **Facility Responsible Centre for 2 Columbus Facilities**
  - European Drawer Rack (EDR)
  - European Technology Exposure Facility (EuTEF)

ISS Columbus (launched 20080207)

Columbus: 5 internal racks; 2 external facilities



European Technology Exposure Facility (EuTEF)

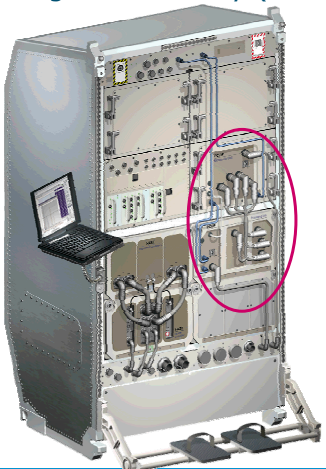
(9 Experiment modules)

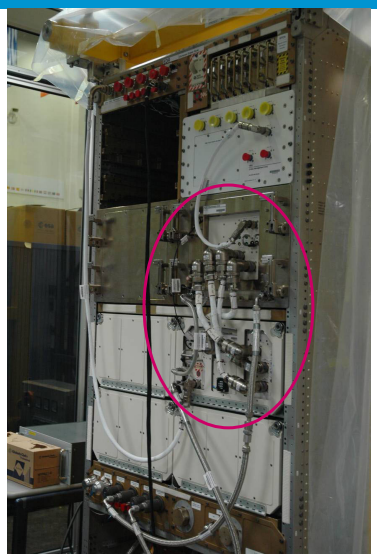
European Drawer Rack (EDR)

(1 Experiment module)

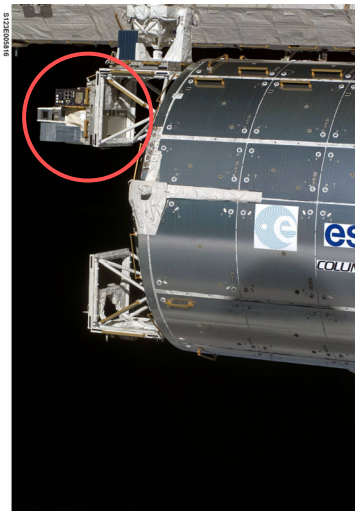
ISS Columbus (European Drawer Rack, EDR)

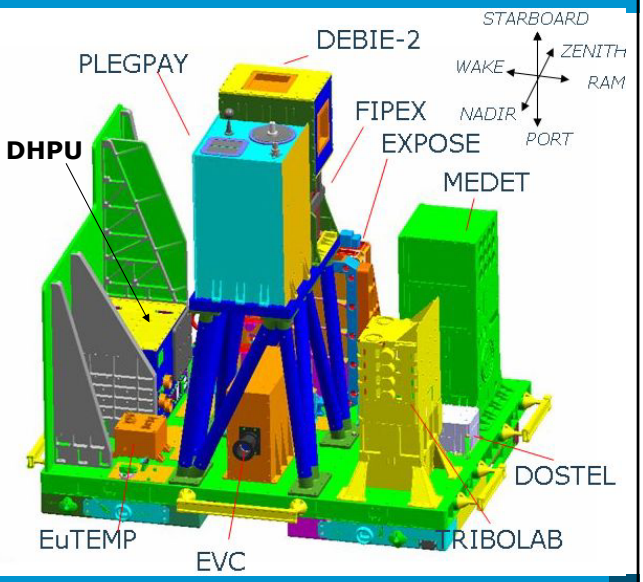
- **Experiments:**
  - EDR: Protein Crystallization Diagnostic Facility (PCDF)



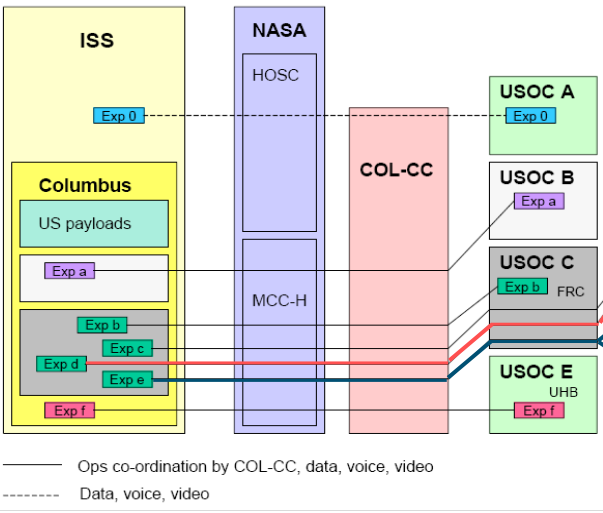


ISS Columbus (European Exposure Technology Facility, EuTEF)





Erasmus USOC: Responsibilities



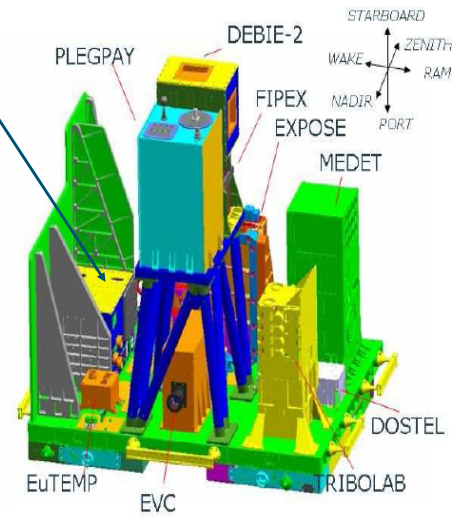
FRC: Facility Responsible Centre
FSC: Facility Support Centre
ESC: Experiment Support Centre
UHB: User Home Base

EDR/PCDF: 1 experiment facility

EuTEF: 9 experiment facilities

EuTEF operations

- **DHPU is central Data Handling & Power Unit**
  - Data communication
  - Power/energy
  - Temperature control
- **99 % operational from launch/installation until 2008/09/01 (24/7 shifts)**
- **From 2008/09/20 intermittent powering**



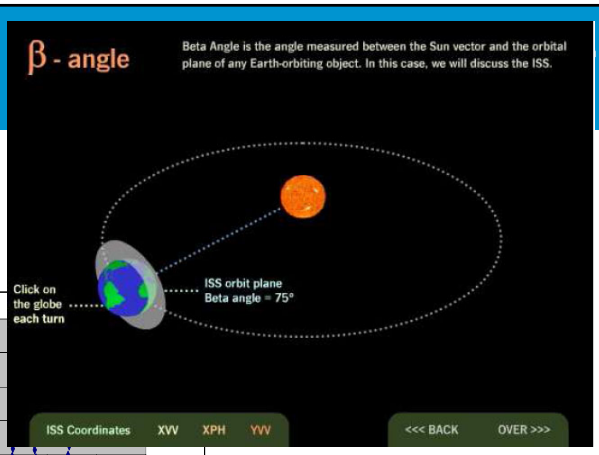
EuTEF

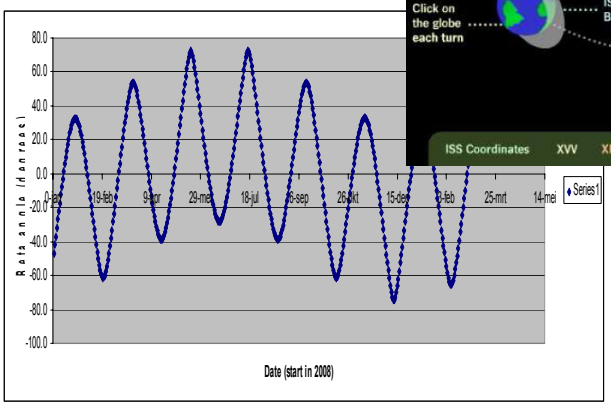
- **operational till mid 2009**

Experiences on Operations Execution

- **Directly after EuTEF activation, operations support based on 24/7 shifts**
- **Direct 1-hour command windows planned every day of the week and long command window on Thursday (4 hours)**
- **Weekly operations plan with EuTEF Operations Conferences**
- **Main problems up till now:**
  - Onboard SW update needed directly after launch
  - Communication problem with DEBIE2 on RS422
  - Milbus error regularly occurred, requiring a power cycle
  - Temperature control of EuTEF very critical, in particular during high ISS beta angles
  - Due to a high qualification value for one of the PlegPay instrument devices, possibly resulting in a 'catastrophic' failure, EuTEF has been switched off since September 1st.

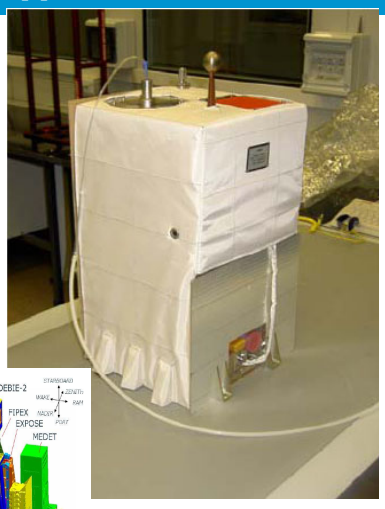
ISS Beta angles

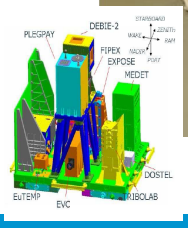




EuTEF Instruments (PlegPay)

- **PlEGPAY (Plasma Electronic Gun PAYload for plasma discharge)**
  - Measuring electrostatic dis-charging of gasses in LEO
- **Operations:**
  - Long duration tests
  - All (un)docking operations
  - ~ 400 hours
  - Safety issue since Sept 2008





Status and future

- **After launch of Columbus:**
  - EDR activated and tested; waiting for PCDF (early 2009)
  - EuTEF activated, tested and operational
  - ETF instruments activated, tested, and operational
  - running EuTEF science
  - Getting experiences with the operational constraints
- **Future:**
  - ERB2 camera in 2009, FASTER in EDR (2010)
  - Urey Miller experiment in Micro-gravity Science Glovebox (MSG)
- **Erasmus USOC is operational as FRC, FSC en UHB to support facility and experiment operations.**

●?

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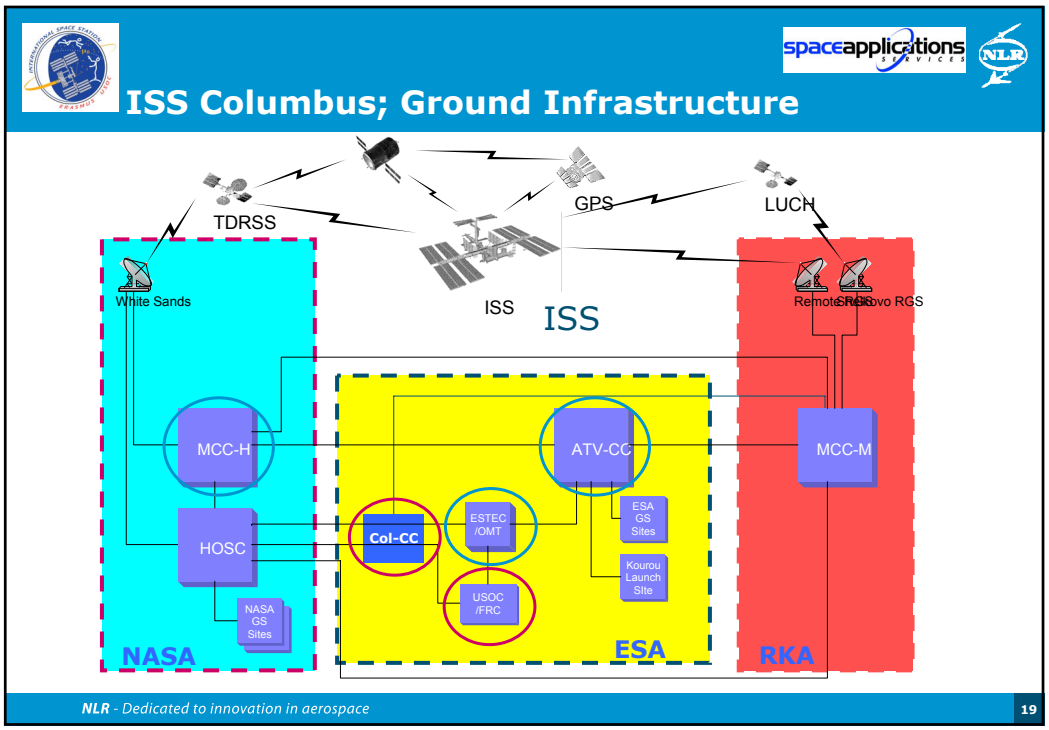
- **Back-up slides**

ISS Columbus USOCs

- **Erasmus USOC is one of the nine European USOCs.**
- **Erasmus built up and operated by Dutch/Belgium consortium.**

- **The ESA geographical distribution for support to Micro-gravity research:**
  - Biology: MUSC (G) + BIOTESC (Swiss)
  - Physiology: CADMOS (Fr) + DAMEC (D)
  - Fluid physics: MARS (It) + IDR/UPM (Esp)
  - Material science : MUSC(G)+CADMOS (Fr)
  - Plant research: N-USOC (No)
  - Miscelaneous: B-USOC (Belgium)
  - Miscelaneous: Erasmus USOC (NL/B)


ISS Columbus; Ground Infrastructure
spaceapplications
TDRSS
GPS
LUCH
White Sands
ISS
ISS
Remote Sites
Korolev RGS
MCC-H
HOSC
NASA GS Sites
NASA
Col-CC
ESTEC /OMT
USOC /FRC
ATV-CC
ESA GS Sites
Kourou Launch Site
ESA
MCC-M
RKA
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19


spaceapplications
esa
MSG
MSL
Melfi
EDR
EPM
FSL
ETC
Biolab
Eutef
Export
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Solar
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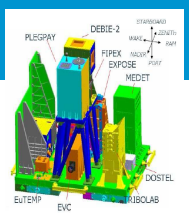
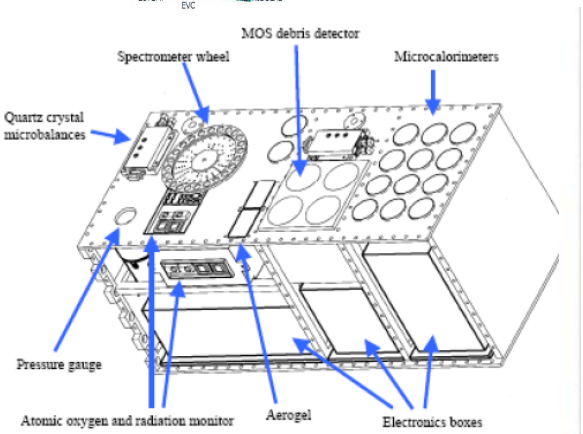
EuTEF Instruments



- **MEDET (Material Exposure & Degradation Experiment)**
  - Atomic Oxygen (O^2)
  - Meteorites
  - Thermal load
  - Surface degradation (C
  - Thermo-optical charact
  - Effect of outgassing
  - Micro particles
  - Debris
- **Onera/CNES (France)**
- **Operaties:**
  - Different modes
  - Interactive
  - ~300 – 500 hrs



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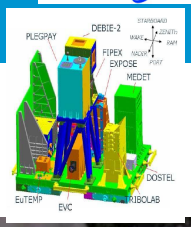
EuTEF Instruments



- **DOSTEL (DOSimetry Telescopes Radiation Measurement)**
  - Measurement of charged particles
- **Univ-Kiel/DLR (Germany)**
- **Operations: continue**

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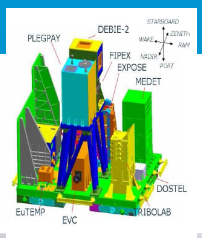
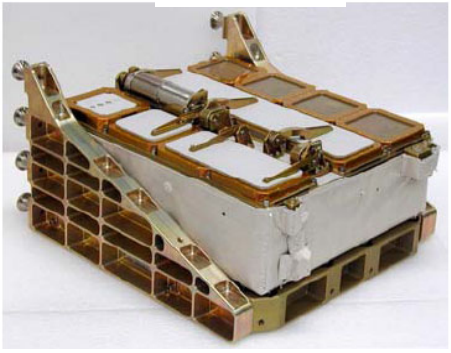
EuTEF Instruments

- **TRIBOLAB (Tribology Properties of Materials)**
  - Solid/Fluid systems
  - Effect of micro-g, launch, vacuum, radiator, ISS environment
  - Thermal coatings
  - "Pin On Disk" experiment "Ball Bearing" experiment
- **INTA (Spain)**
- **Operations:**
  - interactive with specific commands.
  - Sensitive for ISS operations/docking
  - ~300 – 500 hours

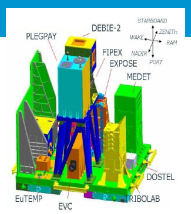
EuTEF Instruments

- **EXPOSE (EXPOSE-E)**
  - Influence of space environment on biological samples
  - 5 exp'ts (LIFE, ADAPT, PROCESS, PROTECT, SEEDS)
  - Controllable lids
- **Institutes from Germany, France, Italy**
- **Operations:**
  - Decentralized from MUSC (Germany)
  - Continue with different modes



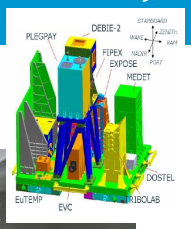


EuTEF Instruments

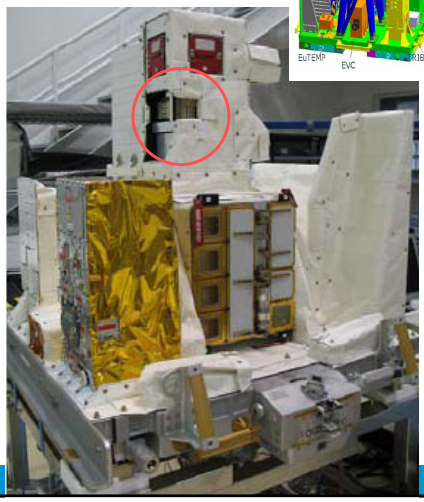


- **DEBIE2 (DEBri In orbital Evaluator-2)**
  - Detector for measuring micro-meteorites debris)
  - Plasma and pies-electric detection
  - Measuring of impact and pressure/energy
- **European Space Agency (ESA)**
- **Operations:**
  - Continue measurements
  - Different sensor configurations
  - Problem with communication

EuTEF Instruments

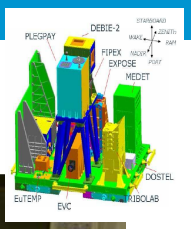


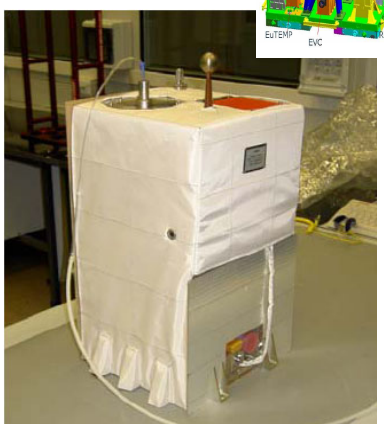
- **FIPEX (Flux (Phi)-Probe-Experiment)**
  - Atomic Oxygen Detector
  - Aggressive types of Oxygen till 500 km (O2, O, O+)
- **TU Dresden (Germany)**
- **Operations:**
  - Specific series of commands
  - ~300 – 500 hrs



EuTEF Instruments

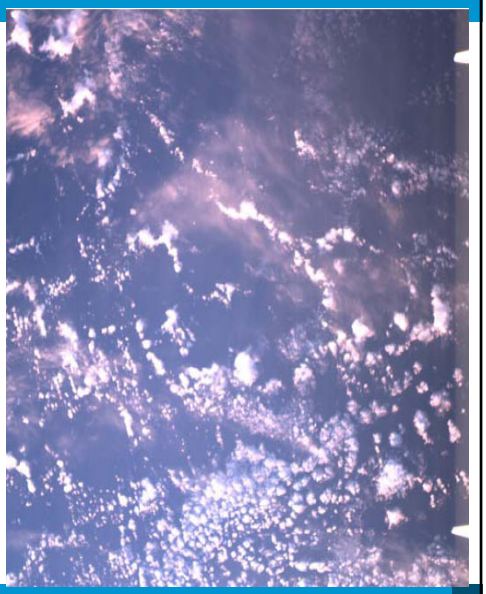
- **Plegpay (Plasma Electronic Gun PAYload for Plasma Discharge)**
  - Measuring electrostatic dis-charging of gasses in LEO
  - Reference exp't with Xenon gas
- **Thales Alenia Space (Italy)**
- **Operations:**
  - Long duration tests
  - All (un)docking operations
  - ~ 300 – 500 hours
  - Safety issue since Sept 2008



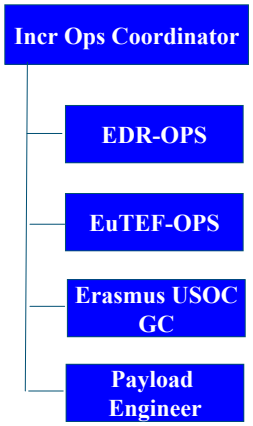


EuTEF Instruments

- **EUTEMP (EuTEF Temperature measurement)**
  - Measuring temperature during installation of EuTEF (from disconnection from Shuttle pallet till power-on of Columbus heaters)
  - EFACEC/Portugal
  - ~ 10 hours
- **EVC (Earth Viewing Camera)**
  - "COTS based" equipment to make pictures from Earth every 20 sec for PR purposes
  - ESA/ESTEC/CGS-Italy
  - ~ 30 hours



Erasmus USOC Operators Roles



- **Tasks/responsibilities:**
  - Increment Operations Coordinator:
    - Management & coordination
  - EDR/EuTEF OPS:
    - Payload Commanding, Control & Planning
    - On-line interaction with CoI-CC
  - Erasmus USOC GC:
    - USOC Ground Support Facilities/IGS/etc
  - EDR/EuTEF PL Engineer:
    - Off-line payload specialist
    - control of Engineering Model

Training, Qualification & Certification

- **ESA Astronaut Centre/Training Control Board:**
  - USOC Training, Qualification & Certification Plan (roles, requirements, approach)
  - Coordination of certification events (courses, European Sims, Joint Multi-Segment Training sessions)
- **Erasmus USOC (training Coordinator):**
  - Training & Qualification Program (USOC specific tasks/responsibilities, Payload knowledge/procedures/flight rules, etc)
  - USOC/Payload courses, Stand-Alone Sim sessions
- **Duration:**
  - Qualification: Operator, Ground Controller (6 – 8 weeks)
  - Certification: Operator (5 – 6 months)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