

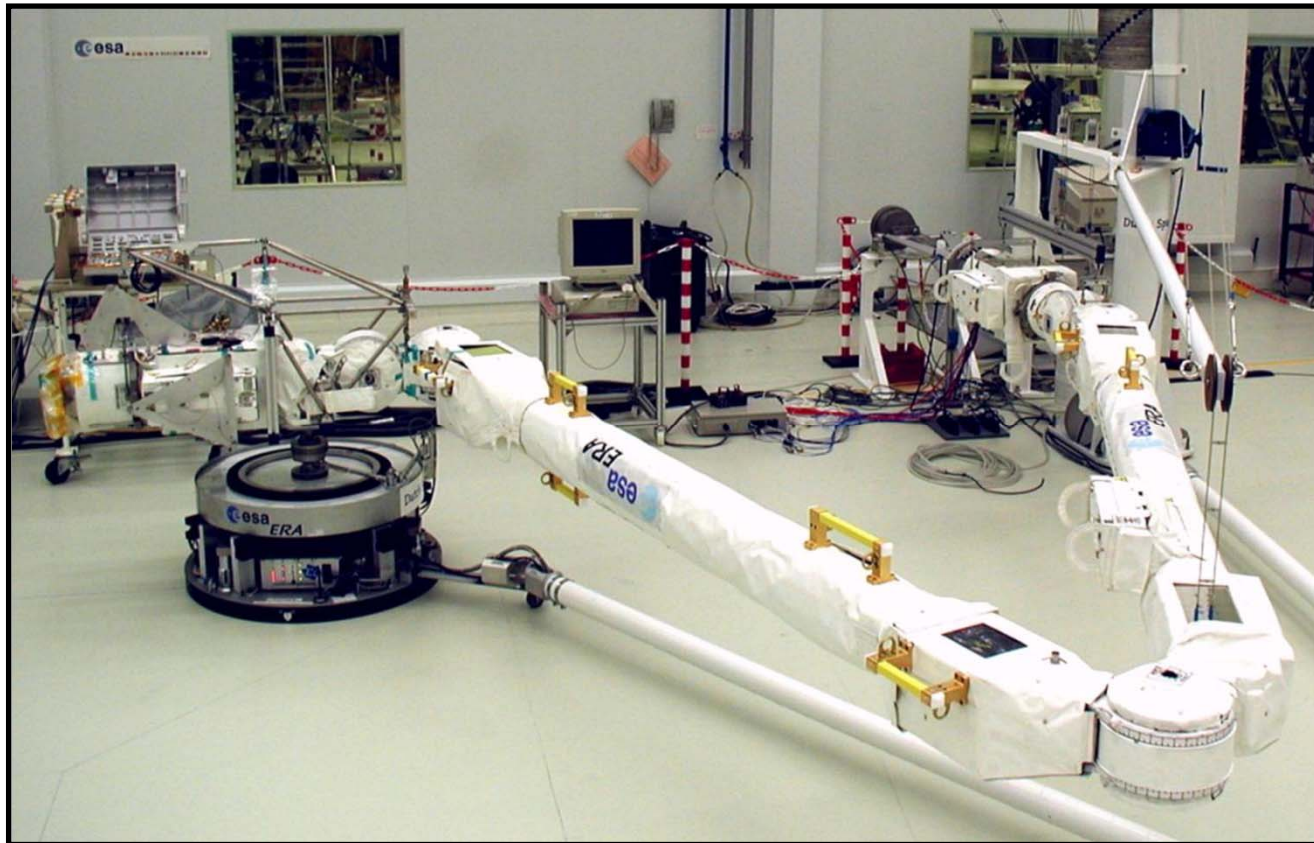
ASTRA 2013 Estec

European Robotic Arm - update -

15-May-2013

1. What is ERA?
2. ERA schedule
3. Qualification status
4. ERA operations
5. Operations Support
6. Conclusion

European Robotic Arm (ERA)



The European Robotic Arm during testing on the flat floor at Dutch Space

European Robotic Arm (ERA)

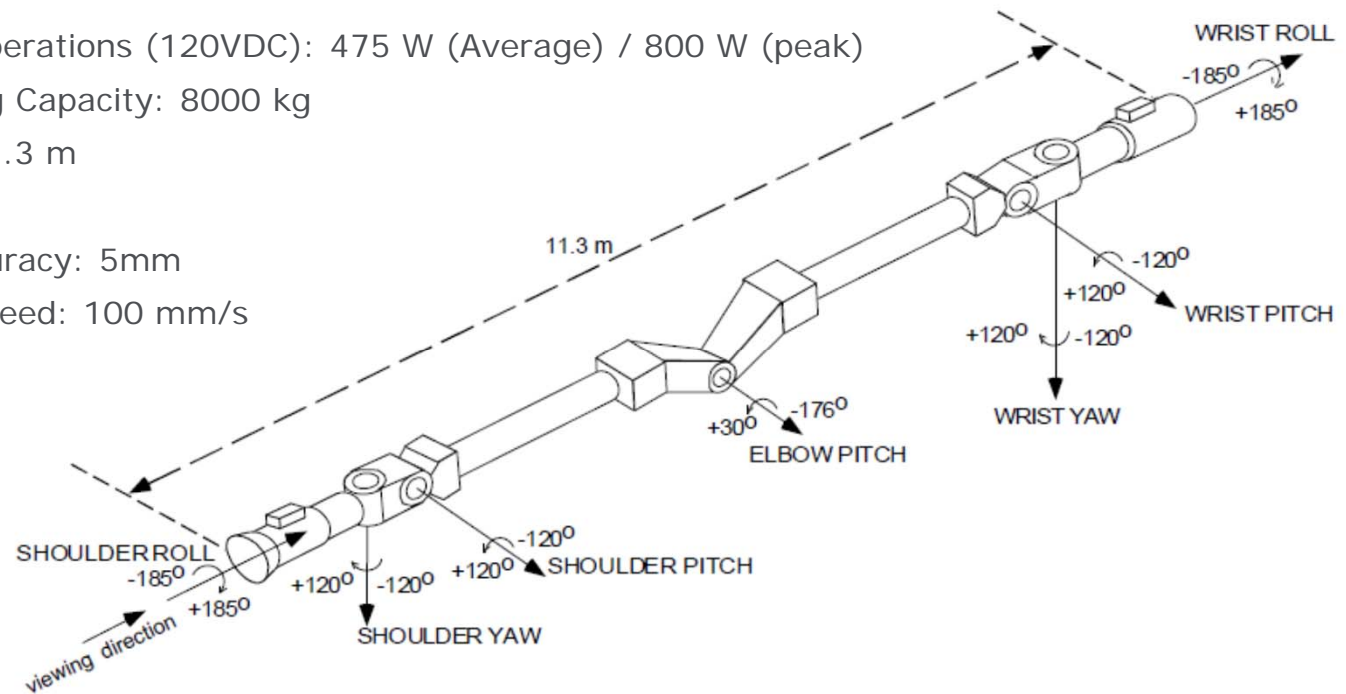


1. ERA is a robotic servicing system, which will be used in the assembly and servicing of the Russian segment of the International Space Station
2. ERA is launched on a Proton from Baikonur, together with the Russian Multipurpose Laboratory Module (MLM), which will be its home base once in orbit
3. The typical tasks assigned to ERA will be:
 - a. Assembly tasks (placement of MLM radiator and equipment airlock)
 - b. MLM Airlock Operations support, to transfer small payloads directly from inside to outside the ISS and vice versa.
 - c. ORU Replacement under IVA or EVA control
 - d. Inspection under IVA or EVA control, using ERA's infrared cameras for carrying out inspections of space station external surfaces.
 - e. EVA support, by transporting astronauts or cosmonauts to the position where they are supposed to perform their work, or from one external location to another.

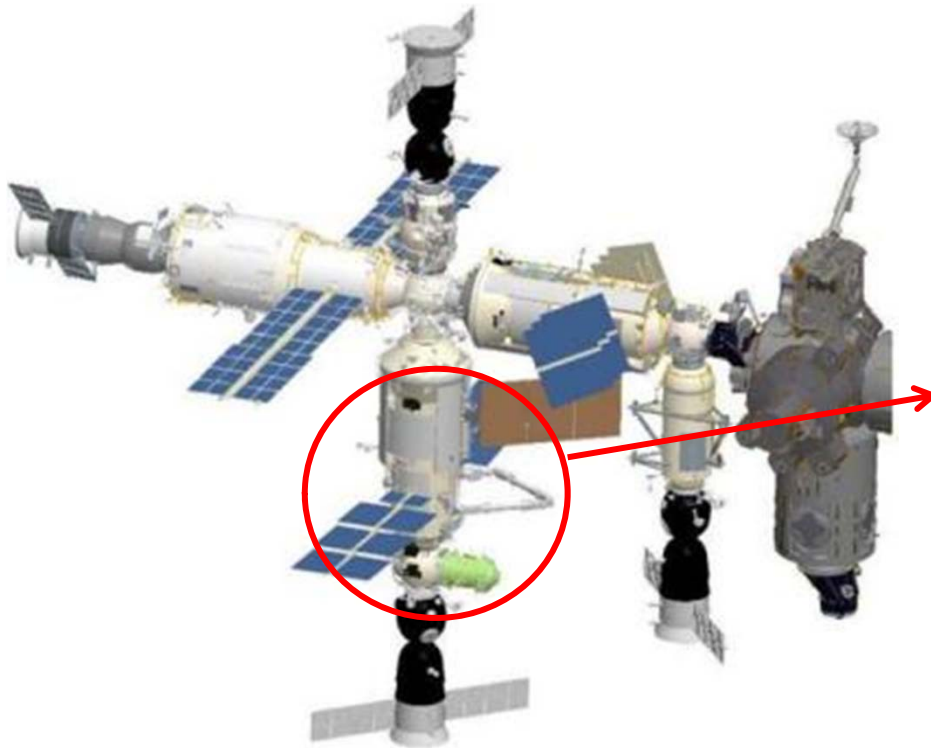
ERA - Facts



1. The arm consists of 2 end-effectors, 2 wrists, 2 limbs and 1 elbow joint together with electronics and cameras
2. Both ends act as either a 'hand' for the robot, or the base from which it can operate.
3. Mass: 630 kg
4. Power during Operations (120VDC): 475 W (Average) / 800 W (peak)
5. Mission Handling Capacity: 8000 kg
6. Total Length: 11.3 m
7. Reach: 9.7 m
8. Tip position accuracy: 5mm
9. Maximum Tip speed: 100 mm/s



ERA – Location on the ISS



1. Crew involvement in ERA Ops

- a. EVAs
- b. Activation and supervision of pre-programmed ERA operations, using, data, video and synthetic views
- c. Partly or fully manual control when needed
- d. ERA operation does not require permanent ground contact

IMMI

(INTERNAL Man Machine Interface)



Picture to be updated: IMMI SW has been ported from IBM760ED to A31p and Lenovo T61p

EMMI

(EXTERNAL Man Machine Interface)



Modes of Operation

ERA Elements	fully automatic using AS	partially manual using MAS	fully manual
arm hardware	use does not depend on Mode of Operation		
ERA Control Computer	<ul style="list-style-type: none"> - stores Auto Sequences (AS) - executes all commands 	<ul style="list-style-type: none"> - uses stored Mini Auto Sequences (MAS) - executes all commands 	<ul style="list-style-type: none"> - executes all commands
Man-Machine Interfaces	<ul style="list-style-type: none"> - select Actions & Tasks from AS - Operator commands 	<ul style="list-style-type: none"> - select Actions & Tasks from MAS - Operator commands 	<ul style="list-style-type: none"> - Operator commands <u>only</u>
ISS computers	<ul style="list-style-type: none"> - uplink and store AS - downlink telemetry 	<ul style="list-style-type: none"> - downlink telemetry 	<ul style="list-style-type: none"> - downlink telemetry
Ground infrastructure	<ul style="list-style-type: none"> - mission preparation - training of nominal missions - online mission monitoring - mission evaluation 	<ul style="list-style-type: none"> - training of nominal missions and contingency actions - online mission monitoring - mission evaluation 	<ul style="list-style-type: none"> - training <u>recovery</u> actions - online mission monitoring - mission evaluation

ERA – sharing of ops responsibility



1. ESA and Roscosmos are jointly responsible for development and verification of ERA missions
2. Roscosmos will be responsible for:
 - the development, including simulation, of the mission-specific composite operational procedures for the use of ERA on the RS, utilising the ERA generic procedures
 - launch of the ERA, inclusive of the launch fixation and thermal protection
 - Flight and Ground Segment Operations (including responsibility for resolution of emergency or unforeseen failures).
 - the necessary ground and flight support for the Astronauts/Cosmonauts who will participate in ERA Missions.
 - provision of real time ERA mission data to the ERA Support Centre at ESTEC
3. ESA will be responsible for:
 - support to Roscosmos for ERA aspects of mission specific composite procedures
 - processing of data transmitted from the MCC in support of ERA mission analysis
 - engineering support during the launch, checkout and flight operations;
 - this support consists of a mixture of participation by ESA personnel in Russia and backup support from the ERA Support Centre in ESTEC, The Netherlands

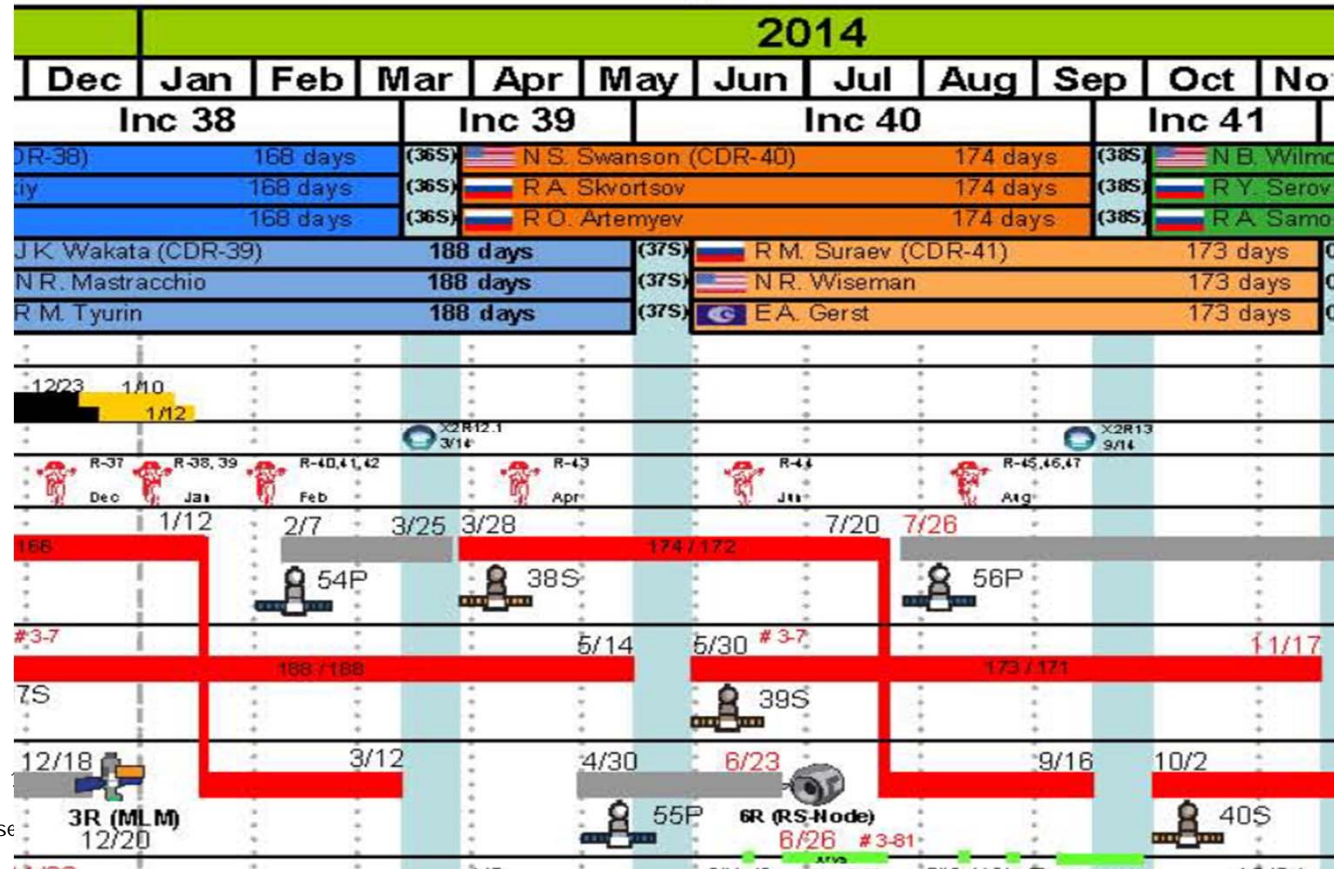
1. ERA Training Facilities

- a. Mission Preparation and Training Equipment (MPTE)
 - ERA training (dynamic) simulator with representative crew interfaces
 - At ESTEC, RSC-E and GCTC
- b. Weightless Environmental Test (WET) model
 - Underwater training model at GCTC
- c. Refresher Trainer (RTR)
 - Laptop based on-board trainer

ERA Schedule



1. SW interface verification: spring 2013, transfer Moscow-Baikonur: July'13
2. Launch 3R: 11-Dec-2013, with docking: 20-Dec-2013
3. ISS FP v25Apr: ERA deployment and In-Orbit Validation start with RS EVA#40 (Feb '14), first assembly operations RS EVA#43+44 (Apr + June 2014)



ERA delta QR took place 8 Mar – 25 Apr 2013.

Very few requirements changes over recent years, but major I/F change:

4011: US Shuttle + SPP (Science Power Platform) => Proton + MLM

4187: Operation of MLM equipment airlock

4189: Black stripe on one of the booms (to distinguish them)

4184: ISS laptop change

4167: extension of shelf life

1103/4190: collision avoidance improvements

+

Upgrade of ground segment

Hardware/Software repairs and upgrades

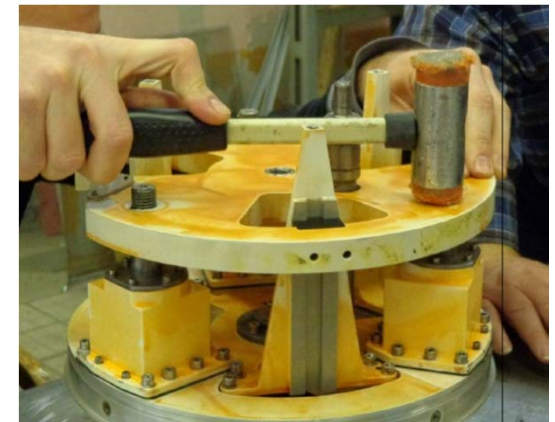
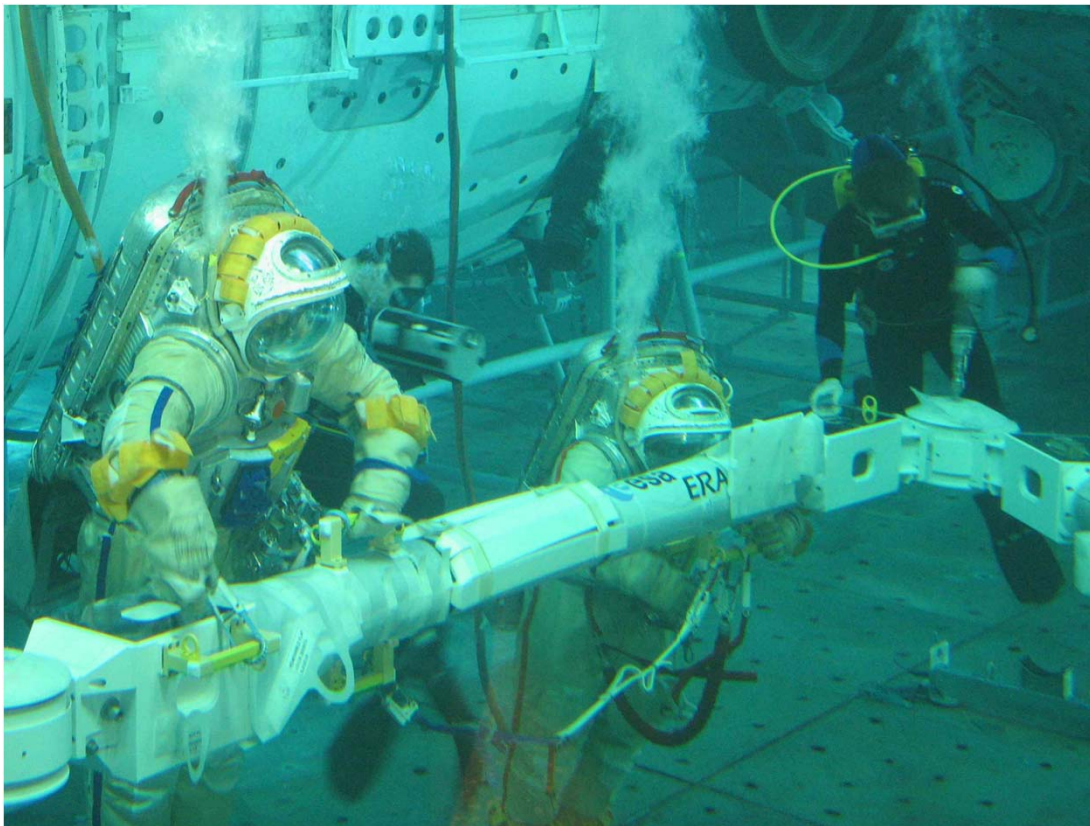
Integration in Russia

Operations planning / mission preparation / ops products delivery

WET model in Star City - repair



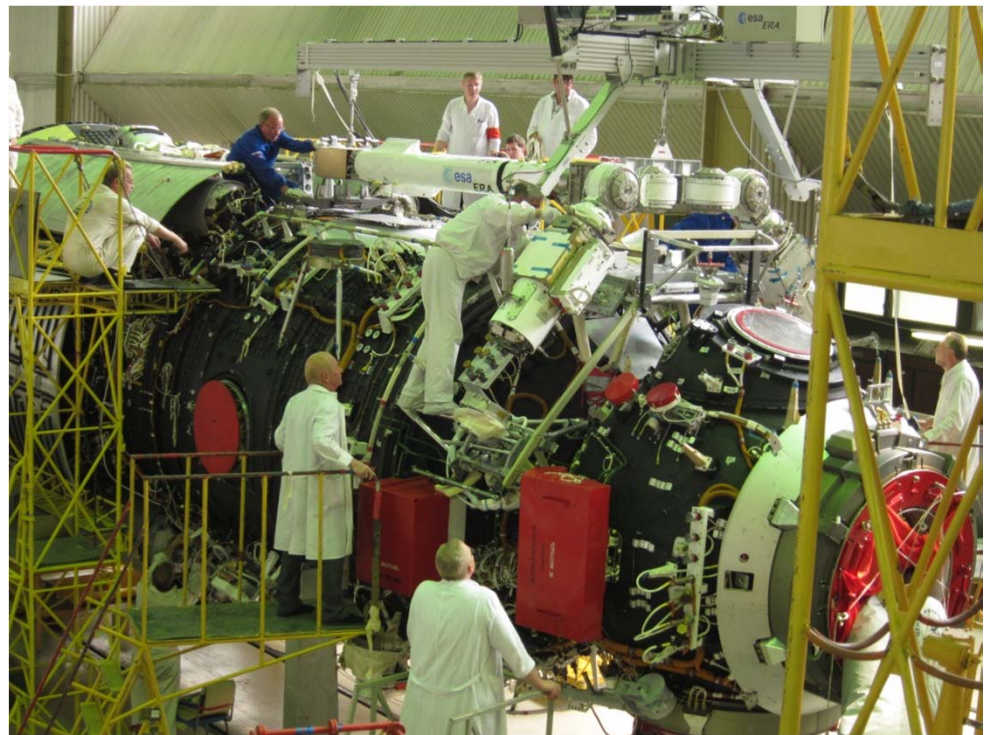
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Integration in Moscow



ERA_Installation_on_MLM_1.mp4



European Space Agency

Mission preparation (Robcad and ERA simulator)



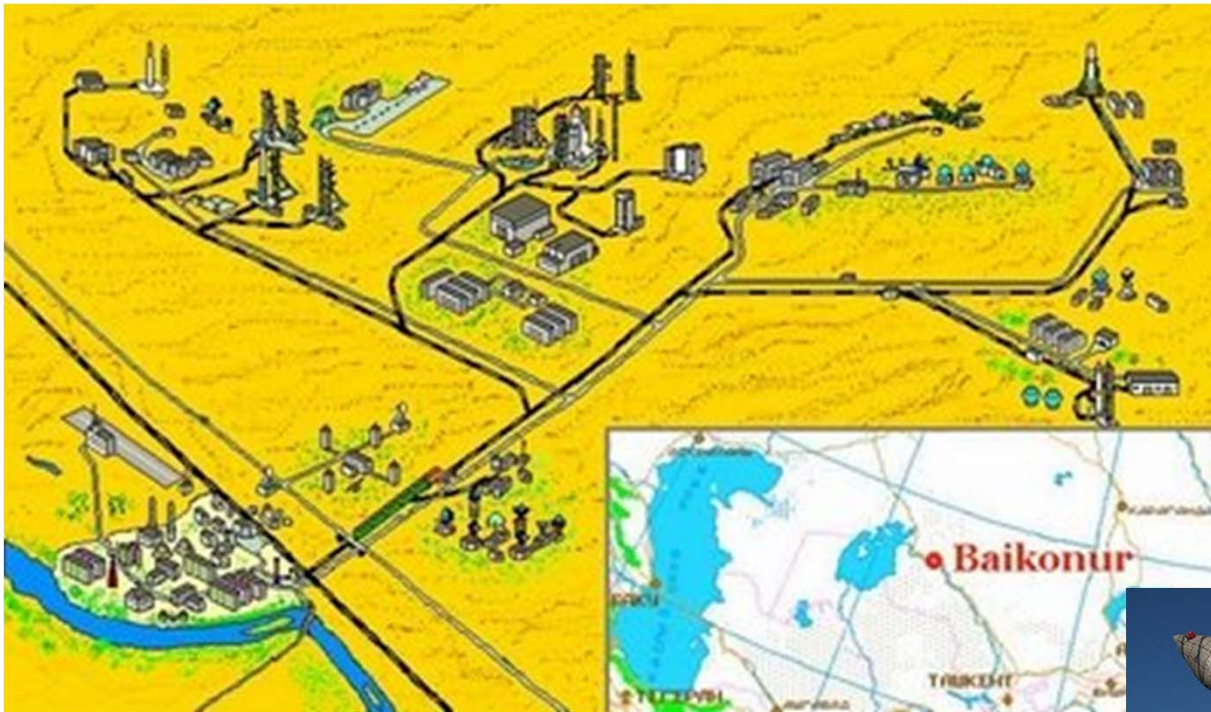
Suggested position for the cosmonaut

The different views are shown.

The views are fixed.

The cosmonaut from this position can see the BP2, the clearance between EE1 part of ERA and SA, the BP1, the clearance between EE2 part of ERA and SA.

Baikonur



Now looking forward to launch!

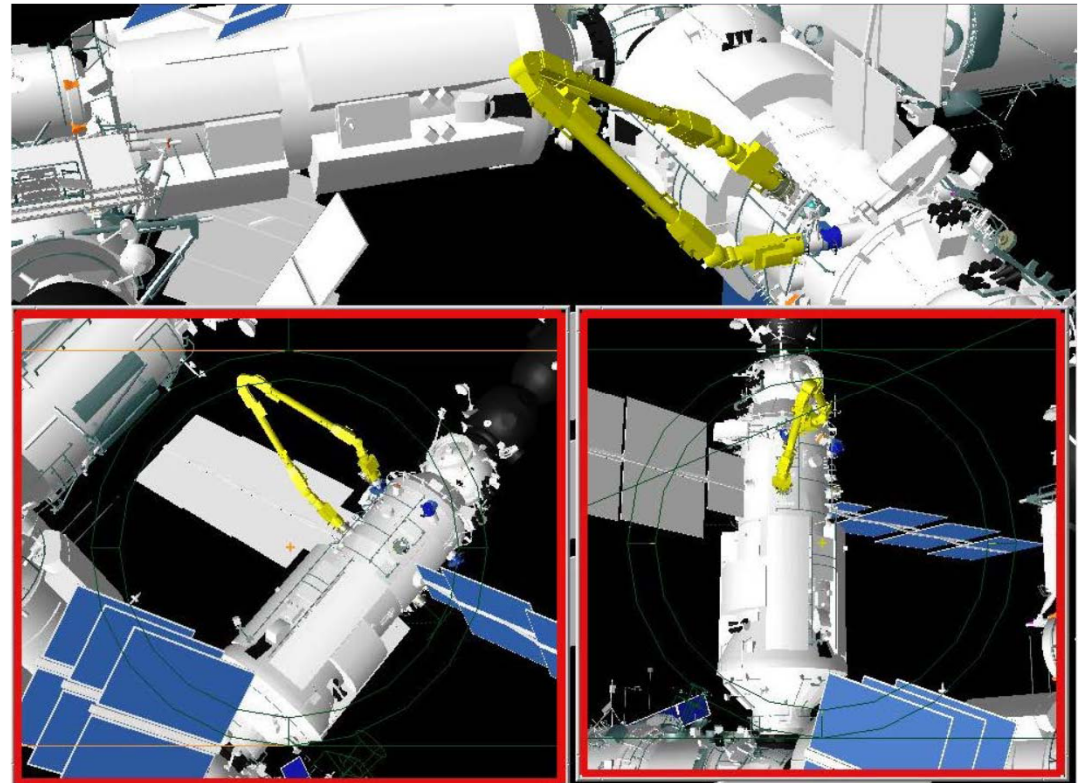
Non-technical tasks like medical emergency planning in Baikonur...



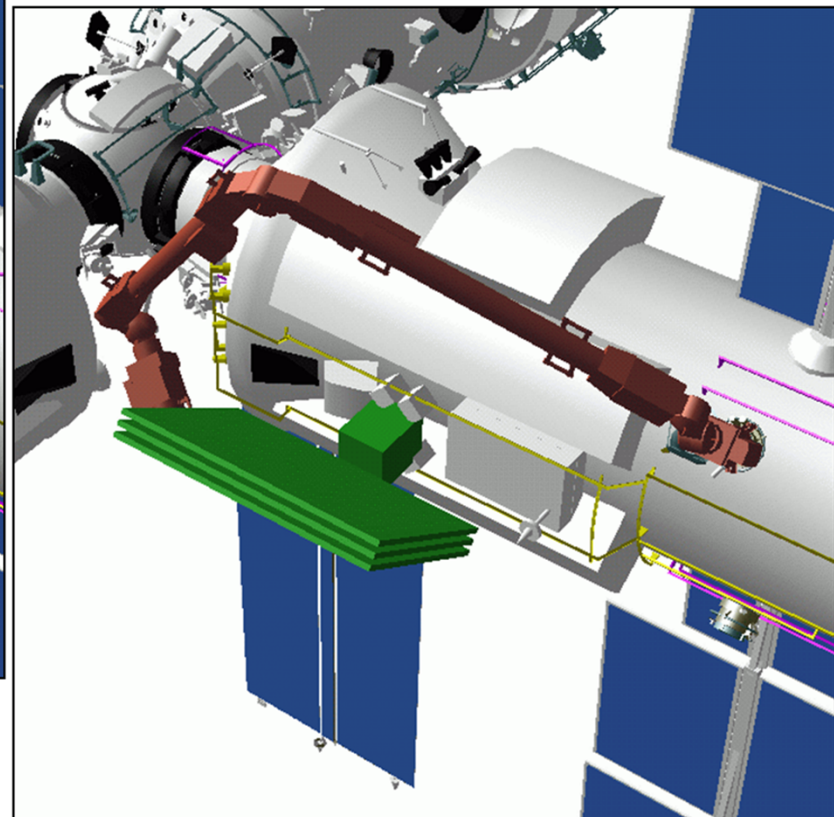
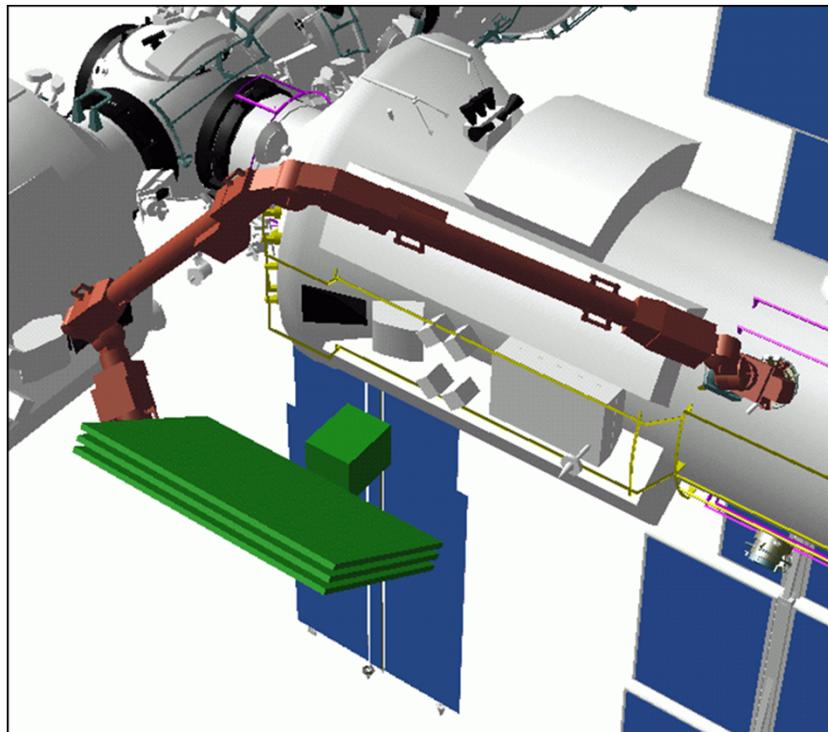
In-Orbit Validation



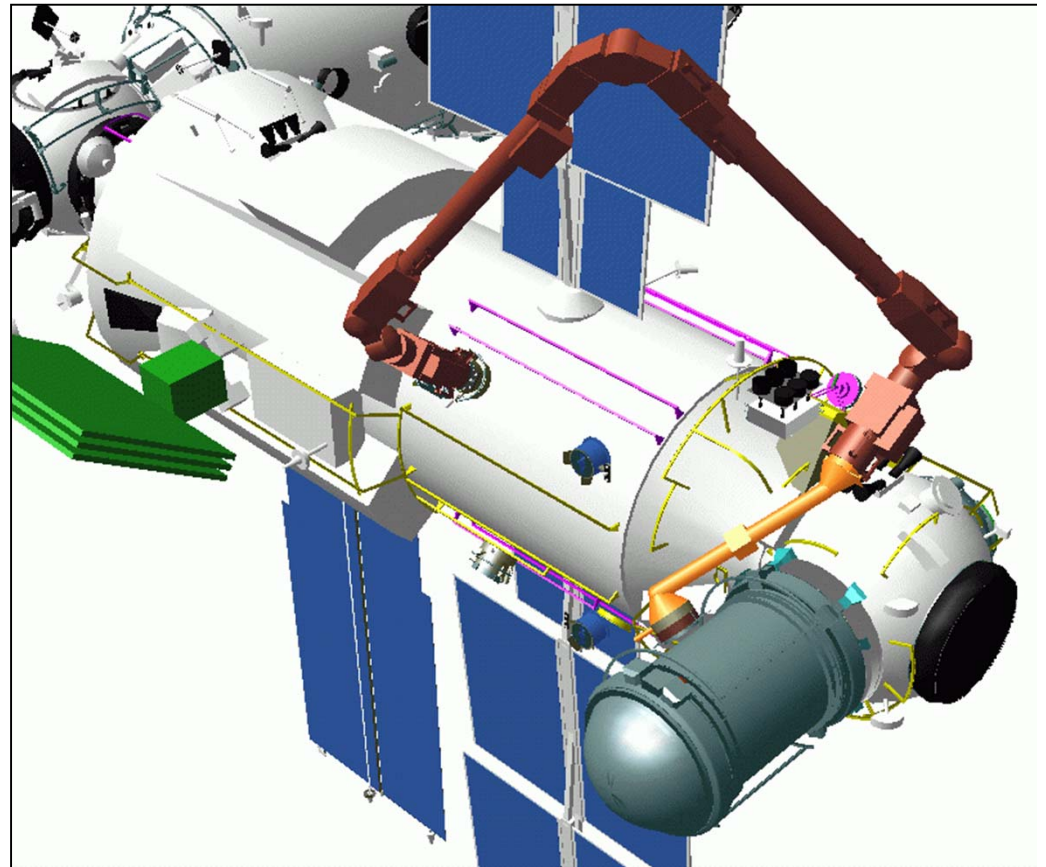
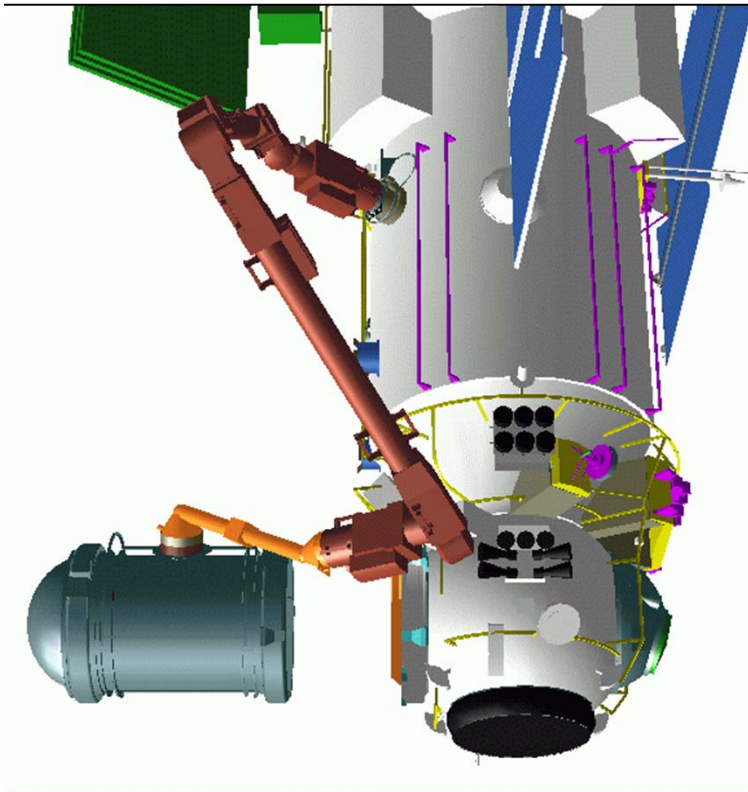
1. Test the safing function (HES)
2. Relocation from launch to MLM hibernation and installation of small items
3. Tests MMIs communication
4. Brake run-in
5. Perform basic motion function
6. Demonstrate payload removal/installation
7. Declare readiness for Radiator and Airlock installation



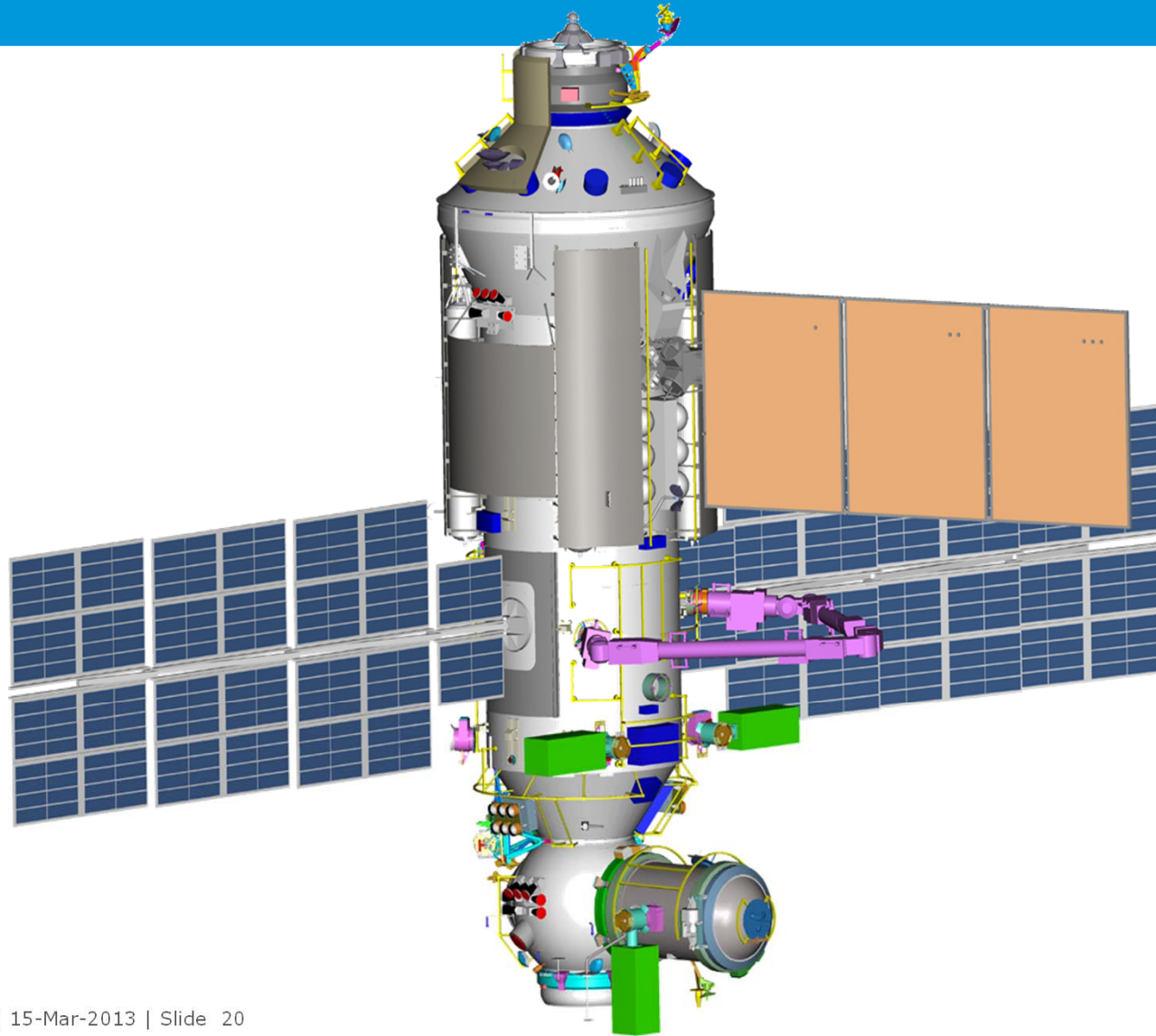
Radiator Installation



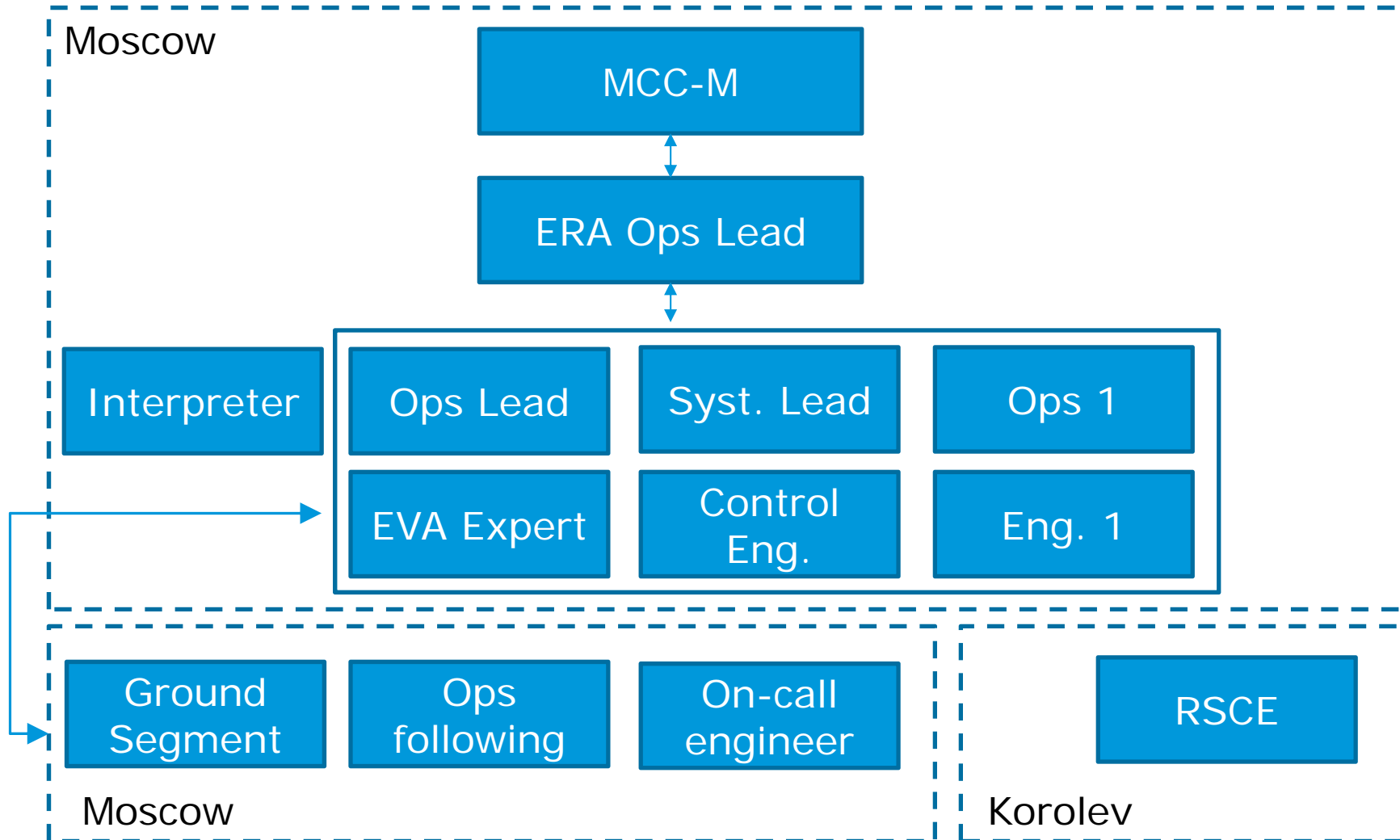
Air-Lock Installation



ERA on MLM



ERA Operations Support



Overview of Sustaining Engineering Activities

- starting after airlock mission of June 2014



1. Flight Operations
 - a. Mission preparation
 - b. Model development and maintenance
 - c. Training
 - d. Mission execution and evaluation
2. Maintenance of on-orbit equipment
 - a. Flight Software maintenance
 - b. Flight hardware maintenance
3. Maintenance of ground equipment
 - a. MPTE hardware and software maintenance
4. System Upgrades
 - a. On-orbit flight software upgrades
 - b. Ground segment hardware and software upgrades
5. Decision taking and change management

Conclusion



1. ERA is made ready for launch on MLM-Proton
2. ERA up-date on-going (SW – HW)
3. ERA operations are prepared
4. Close to launch as ever!

Questions?