SD2905 Human Spaceflight

Lecture 8, 14-2-2014

The International Space Station
Part 2 - Operation

TODAY: Learn and understand how a space station (ISS) is operated

Discussion: How do you think one operates a space station?

- From ground: Each ISS partner its own CC. (Pros and cons)
- Logistics – sending stuff there; taking care of it on the station. Spare parts on-board when things break, contingency food/water/O2,... in case a delivery fails
- Planning! Planning! Planning! Longterm, shortterm, daily work schedules – not only for crew: attitude, communication, thermal, experiments, PR,...
- Crew itself: checklists – now electronically. Crew notes. Time to prepare daily work. You do something you trained for many months, perhaps a year, ago!
- Utilization limitations:
  - Biggest bottleneck: Crew time! Aiming to get about 40 h / week ”utilization” from the three USOS crew members. (Note: Robotics – can be done from ground!)
  - Upmass & downmass also major bottlenecks
  - Power, data links

- **Control centres and groundd ops**
- **Planning**
- **Cargo vehicles**
- **Docking systems**
- **Robotic arms**
- **Crew work**
- **Utilization limitations**.

Many control centers involved with ISS

Main centers: Houston (MCC-H) and Moscow (MCC-M),
Oberpfaffenhofen in Germany for ESA (COL-CC) and Tsukuba in Japan
Others are more for specific events, like for ATV in Toulouse, France.

The Flight Director is boss for all activities
Capcom only person who talks with the crew (normally)

Houston

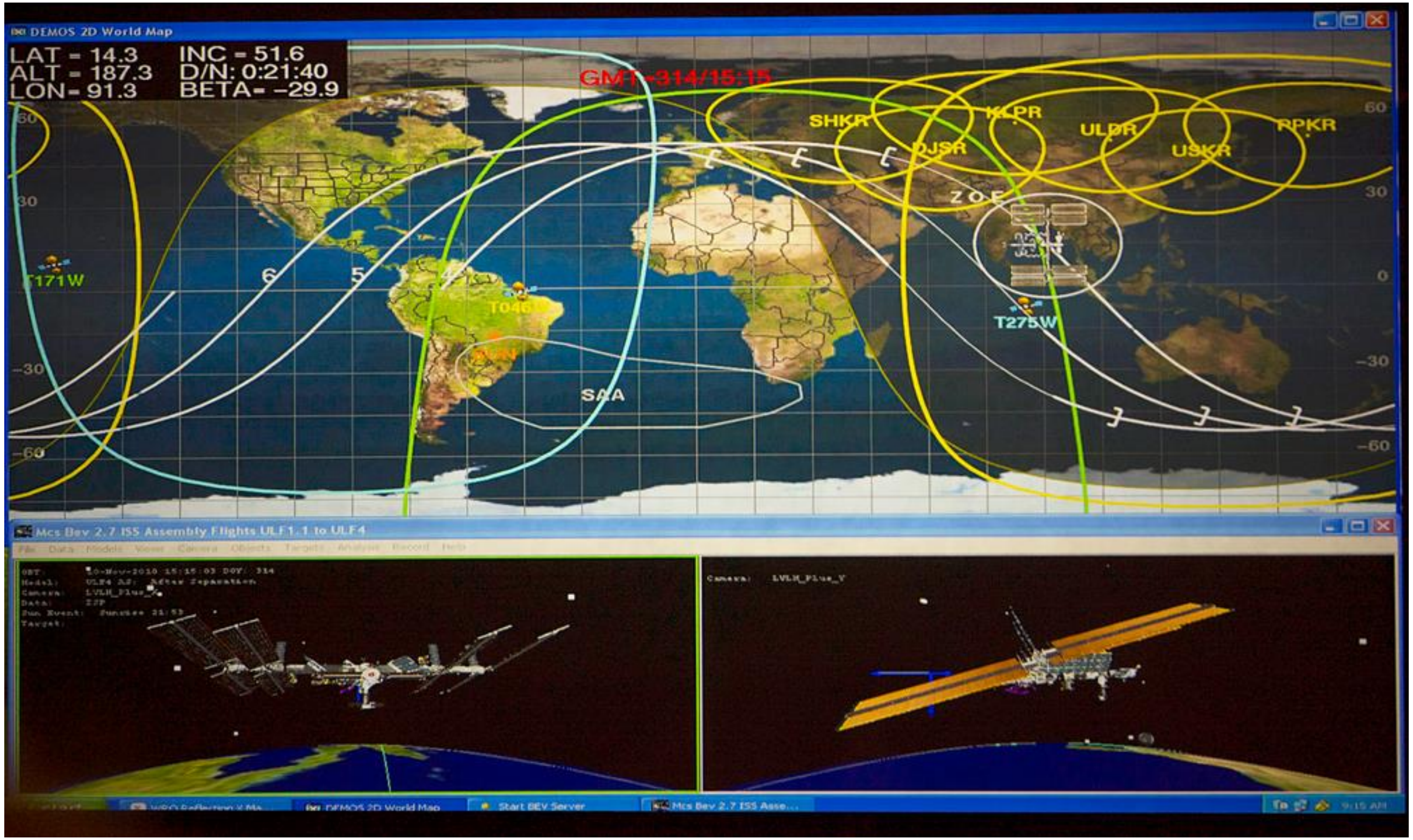
Moscow

Each main system of ISS has its own console

	ADCO GNC, MCS	**PHALCON** EPS	**THOR** TCS		**PAO** Public outreach
OSO Struc&Mech	**ODIN** C&DH	**ECLSS** ECLSS	**OPSPLAN** Planner		**CIO** ISO
ROBO Robotics	**CATO** C&T	**ISS FD** Flight Director	**CAP-COM**	**TOPO/VVO/RIO** Trajectory/Interface	
TITAN C&DH, C&T, MCS	**ATLAS** ECLSS, EPS, TCS	**EVA** EVA	**BME und Flugarzt**		**GC** Ground Systems

Each position has an unique call sign
Core positions manned 24/7

Example of screen info in the Mission Control Room



Main Screen in the ISS Mission Control Center FCR (Flight Control Room) on November 10, 2010

Daily reports from COL-CC

Columbus Control Centre (Col-CC)
Oberpfaffenhofen
82234 Wessling / Germany

Columbus Daily Operations Report

Date: 12. February 2014 GMT 043	COL-DOR_2014-02-12	Created by COL FLIGHT: Roseline Neri

Big Picture

Visiting Vehicles

Soyuz 36S docked to MRM-2
Soyuz 37S docked to MRM-1
Progress 53P docked to SM Aft
Cygnus (Orbital-1) berthed to Node 2 Nadir
Progress 54P docked to DC-1 Nadir

ISS

The International Space Station is in Standard Mode.

A double IAC (Internal Audio Controller) failure occurred during O1 shift, which resulted in loss of all S/G loops. CRONUS was able to recover the situation and reset those ATUs associated with planned activities (NASA AR 6559).

Columbus System Status

System Summary

Columbus System configuration:

Active Pump:	**WPA 1**
Active Shell Heaters:	**HCU 1**
Cabin temp control:	**CTCU 1**
Cabin environment status (average over 24 hours):	
Cabin Total Air Pressure:	747.5 mmHg
Cabin Air Temperature:	22.8 °C
Relative Air Humidity:	41.7 %
CO_2 Level:	3.37 mmHg (0.45 %)
O_2 Level:	166.6 mmHg (22.3 %)
Cabin Smoke Detector percent trip:	
SD1	28.5 %
SD2	31.3 %
TCV kick amplitude:	70 %
Active CWSA:	**CWSA 1**
Condensing mode:	**Low** since GMT 039 **CHX** inlet temp: 7 °C
Active cabin fan:	**CFA 1**
IRFA / IRSOV	**OFF / CLOSED** (IMV Node 2 STB AFT valve is CLOSED).
IRFA availability:	**AVAIL**
WOOV 4:	Encapsulated
WOOV 7 & 8:	Mk II WOOV installed

NLSOV 1 is open.
VEDD 1 & 2 are closed
VADD 1 & 2 are closed.

Nominal DMS configuration:

MMU Master:	**MMU 2**	
MMU Slave:	**MMU 1**	
HRM:	**Nominal Core**	HRM LAN I/F enabled (AUTO_SELECT)

Vital DMS configuration:

VTC Master:	**VTC 1**

System Activities

The DMS log file of GMT 042 was downlinked.

FE-3 Mike Hopkins successfully performed the following routine maintenance activities:
CDA & PPRA Inspection & cleaning and RGSH cleaning using the ISS wet/dry vacuum cleaner. He was supported from ground with SUP Outlet operations, Cabin Smoke Detector Monitoring Management and VCA1 operations. During the activity he stated that he was trying to avoid touching FSL but that it was difficult with the vacuum cleaner handling. MARS OPS was informed.

Columbus Stowage/Mechanical Activities

No activities.

Columbus Laptop and PIP activities

No activities.

Columbus ESA Payload Status

SOLAR

Science Status: Sun Visibility Window (SVW#74) on-going. Two calibration scripts were completed for SOLSPEC. Due to shadowing caused by the expected Space Station Remote Manipulator System (SSRMS) operations. One measurement script was repeated for SOLSPEC. However, the second attempt, which had only 12 minutes of tracking, proved to be unsuccessful as well.

The scientific goal of the SOLAR instruments is to measure the solar spectral irradiance. The SOLSPEC instruments measures the solar spectrum irradiance from 180nm to 3000nm. The aims of this investigation are the study of solar variability at short and long term and the achievement of absolute measurements. The goal of the SOLACES experiment is to measure the solar spectral irradiance of the full disk from 15 to 220 nm at 0.5 to 2 nm spectral resolution. By an auto-calibration capability, it is expected to gain long term spectral data with a high absolute resolution.

Power: Feeders 1 & 2 are ON
Mode: SCM
SOLACES: Nominal
R/T CMD: CFN15613, CFN 15621

SOLAR was transitioned to Pointing Mode (PM) for a series of SOLACES and SOLSPEC measurements. SOLSPEC measurements were aborted due to SSRMS shadowing event.

These SSRMs shadowing events are due to scheduled robotic operation within SOLAR field of view and have been expected.

Following these, SOLSPEC calibrations were performed. SOLAR was then transitioned to Setup and Configuration Mode (SCM).

The previous aborted SOLSPEC measurement was repeated at a later time. However it was again unsuccessfully due to shadowing.

FSL / FASES

Science Status: FASES operations continued with the completion of processing ITEM-S17 (liquid composition of 0.5% water – 99.5% paraffin with 0.05% surfactant concentration).

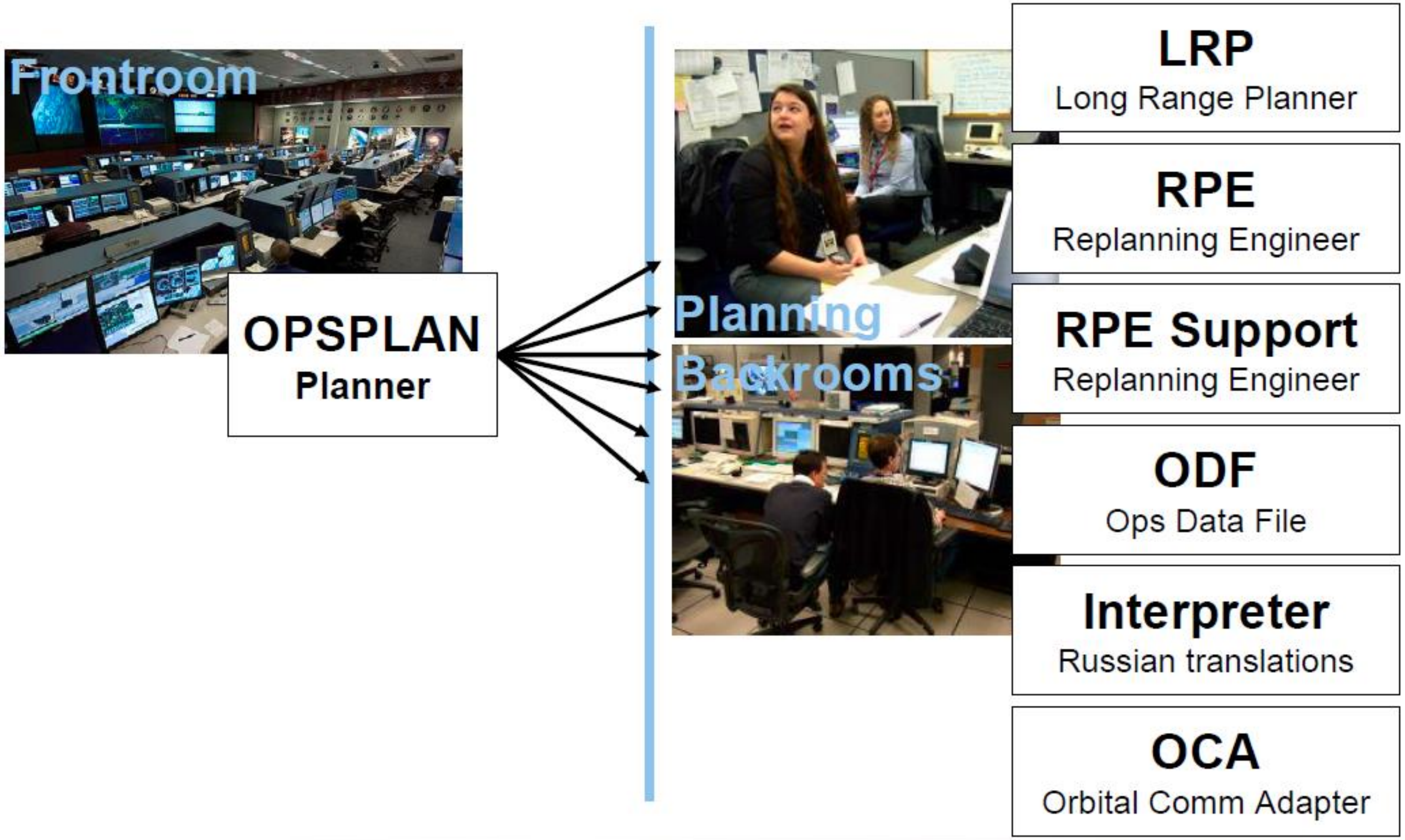
The scientific goal of FASES is to characterize liquid/liquid interface Surfactant adsorption dynamics, drop/drop interactions and the behavior of the liquid film between the drops. FASES also aims to study droplet dynamics and evolution of the droplet size distribution during emulsion destabilisation. Systematic studies on model emulsions will allow developing methods for the evaluation and prediction of systems stability.

FSL is OFF.

R/T CMD: CFN15622

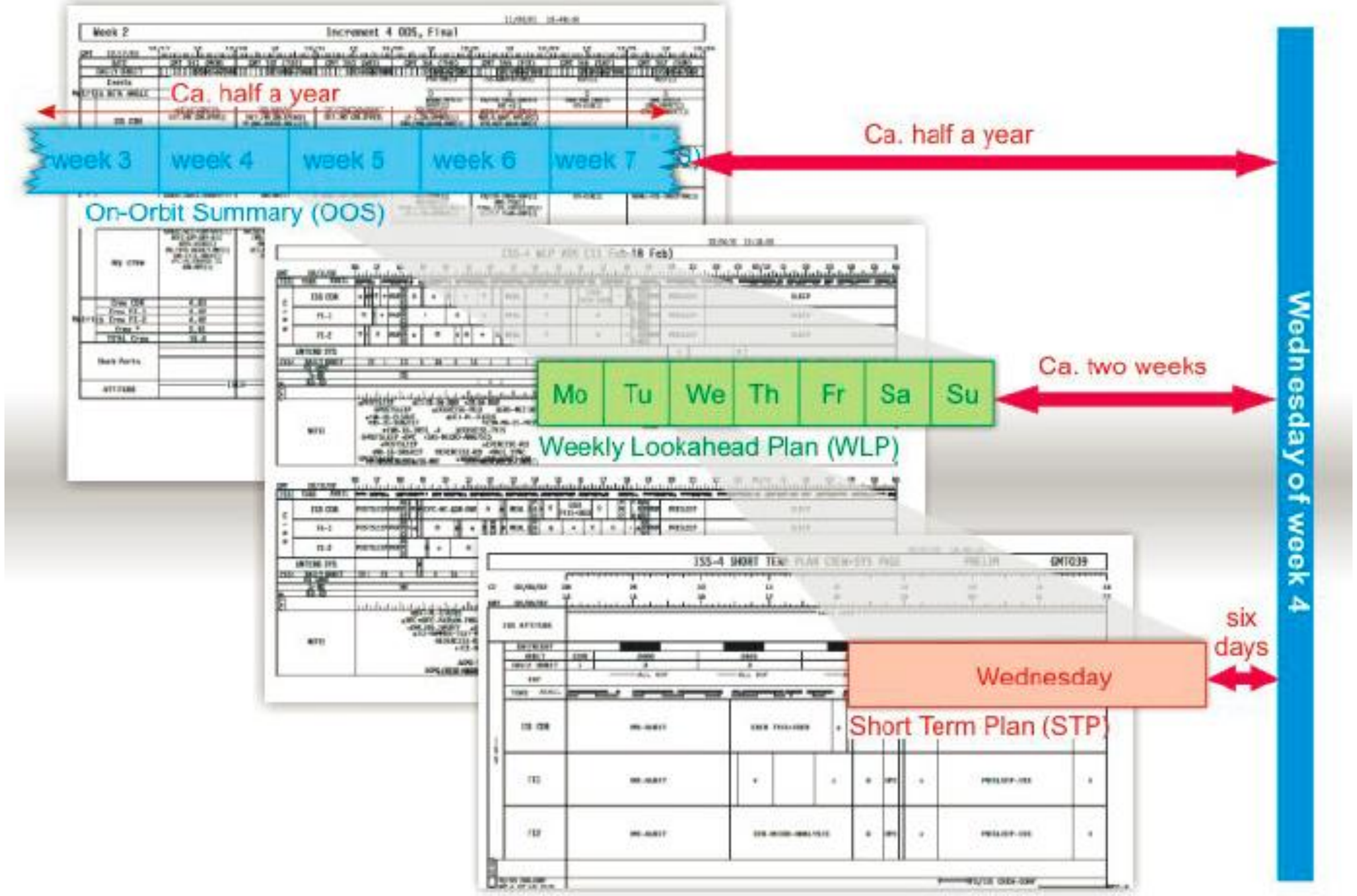
FASES Science Run on-going with S17 run. Upon completion of the run FSL rack was deactivated.

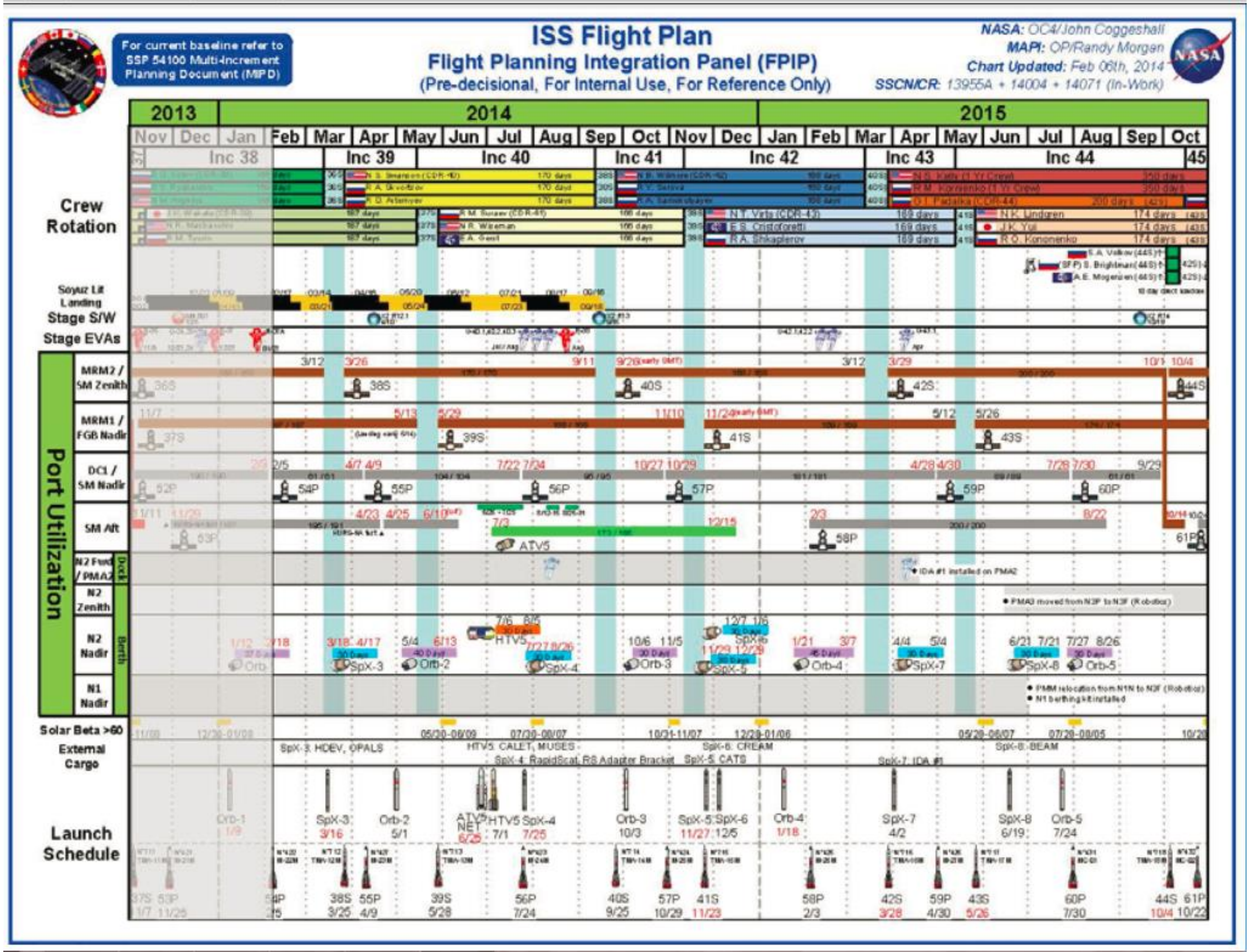
”Back rooms”, planners and various boards support the operations



Planning, planning, planning

From years ahead, to real-time updates

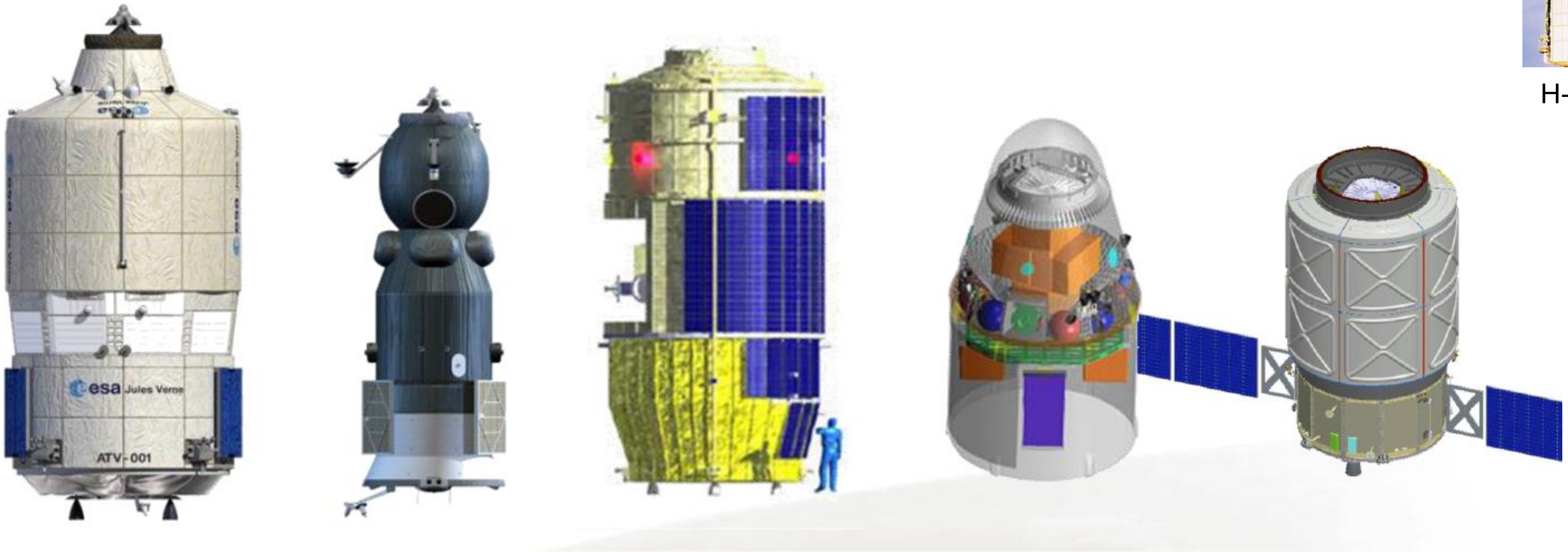




For current baseline refer to SSP 54100 Multi-Increment Planning Document (MIPD)
ISS Flight Plan
Flight Planning Integration Panel (FPIP)
(Pre-decisional, For Internal Use, For Reference Only)
NASA: OC4/John Coggeshall
MAPI: OP/Randy Morgan
Chart Updated: Feb 06th, 2014
SSCN/CR: 13955A + 14004 + 14071 (In-Work)
2013
2014
2015
Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
Inc 38
Inc 39
Inc 40
Inc 41
Inc 42
Inc 43
Inc 44
45
Crew Rotation
Soyuz Lit Landing
Stage S/W
Stage EVAs
Port Utilization
MRM2 / SM Zenith
MRM1 / FGB Nadir
DC1 / SM Nadir
SM Aft
N2 Fwd / PMA2
N2 Zenith
N2 Nadir
N1 Nadir
Solar Beta >60
External Cargo
Launch Schedule

The current ISS Cargo vehicles


H-II launcher



ATV
(Automatic Trasner Vehicle)

Progress

HTV
(H-II Transfer Vehicle)

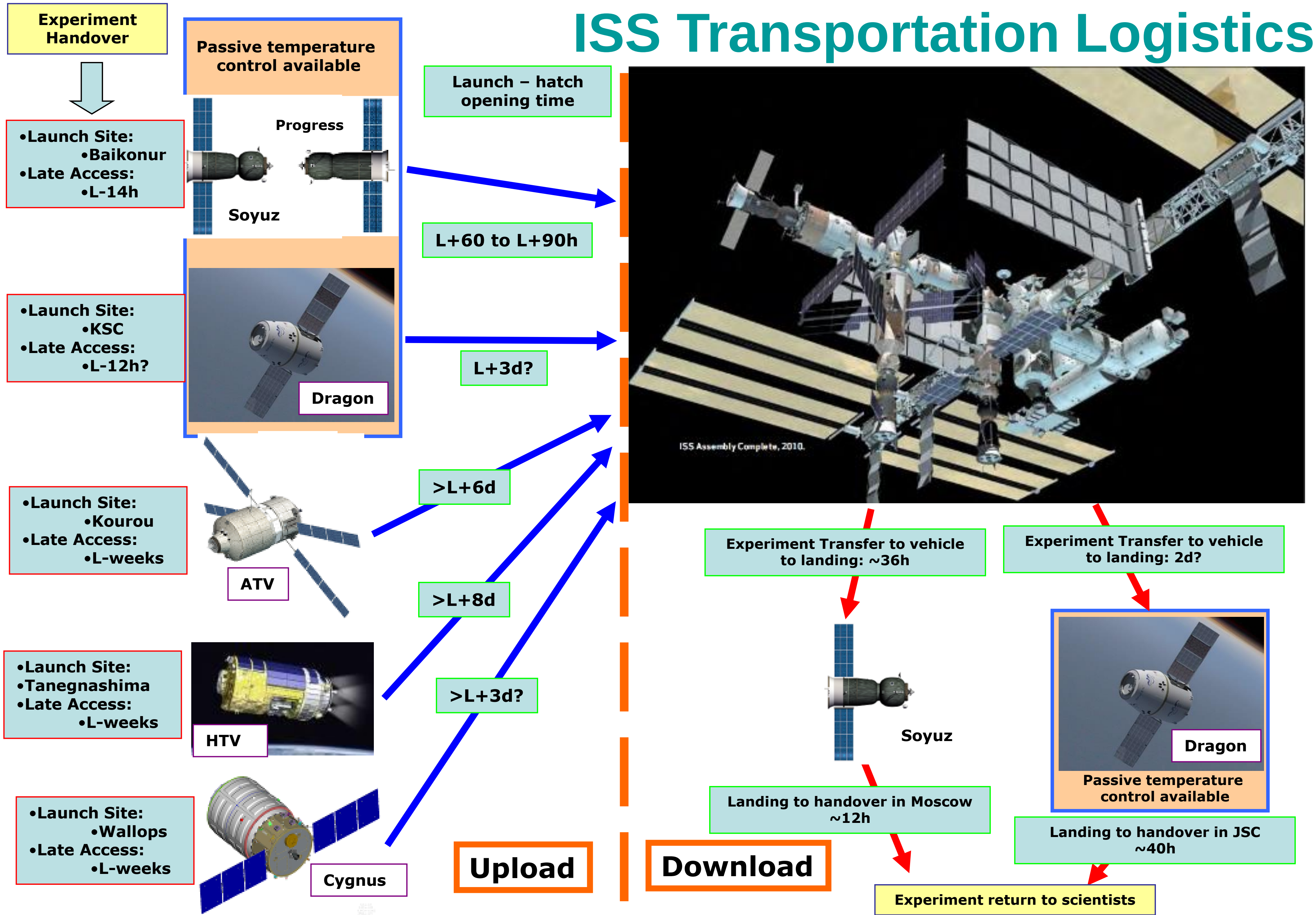
Dragon

Cygnus

ISS Cargo ship capabilities

Vehicle (Parner)	Launch mass (t)	Payload mass (t)	Volume (m^3)	Dock/berth
ATV (ESA)	20.0	7.6	48.0	Docks automatic to ISS aft end (ROS)
Progress (Russia)	7.15	2.35	7.6	Docks automatic to a Russian port (possible manual take-over)
HTV (Japan)	10.5	6.0	42.0	Grappled by SSRMS and berthed to a CBM port
Dragon (US)	8.0	3.0	10.0	Grappled by SSRMS and berthed to a CBM port
Cygnus (US)	5.0	2.0	18.7	Grappled by SSRMS and berthed to a CBM port

CBM = Common Berthing Mechanism



ISS Transportation Logistics
Experiment Handover
Passive temperature control available
•Launch Site: •Baikonur •Late Access: •L-14h
Progress
Soyuz
Launch – hatch opening time
L+60 to L+90h
•Launch Site: •KSC •Late Access: •L-12h?
Dragon
L+3d?
•Launch Site: •Kourou •Late Access: •L-weeks
ATV
>L+6d
>L+8d
•Launch Site: •Tanegnashima •Late Access: •L-weeks
HTV
>L+3d?
•Launch Site: •Wallops •Late Access: •L-weeks
Cygnus
Upload
Download
ISS Assembly Complete, 2010.
Experiment Transfer to vehicle to landing: ~36h
Experiment Transfer to vehicle to landing: 2d?
Soyuz
Dragon
Passive temperature control available
Landing to handover in Moscow ~12h
Landing to handover in JSC ~40h
Experiment return to scientists

Russian docking system (for Souyz, Progress, ATV): The ”Probe/Drougue Docking System”

Figure 7.6.2. Active Docking Assembly (ACA) and Passive Docking Assembly (ПСА)

Figure 7.6.3. ACA Location on the Soyuz

The active docking assembly (ACA) consists of the following major hardware and components:

- docking mechanism (CM);
- interface sealing mechanism (МГС);
- hatch sealing mechanism (МГК);
- electrical connectors (4 ea.);
- spring-loaded pushers (2 ea.);
- contact sensors

A view of the ACA is shown in Figure 7.6.4.

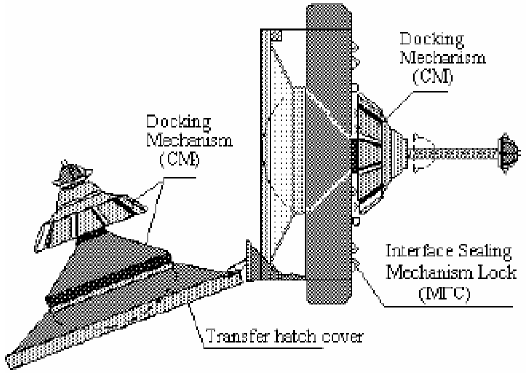


Figure 7.6.4 View of the ACA

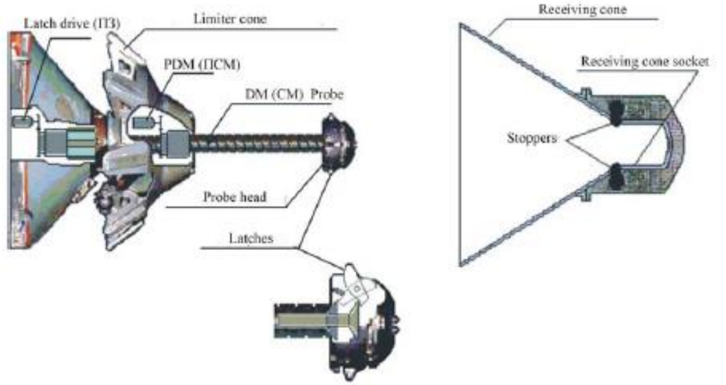


Figure 7.6.6 Docking Mechanism (CM) and Receiving Cone Design

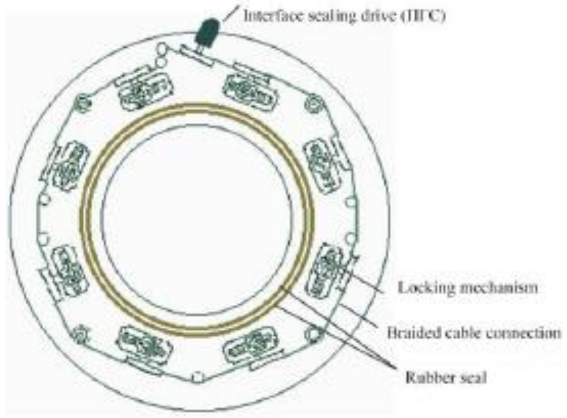
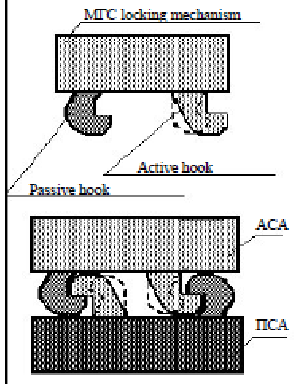


Figure 7.6.8 Interface Sealing Mechanism (МГС)



Second mechanical connection
Fig. 8

Learning the docking system in Russia ca 1994

Docking systems on the USOS: APAS (Shuttle) & CBM

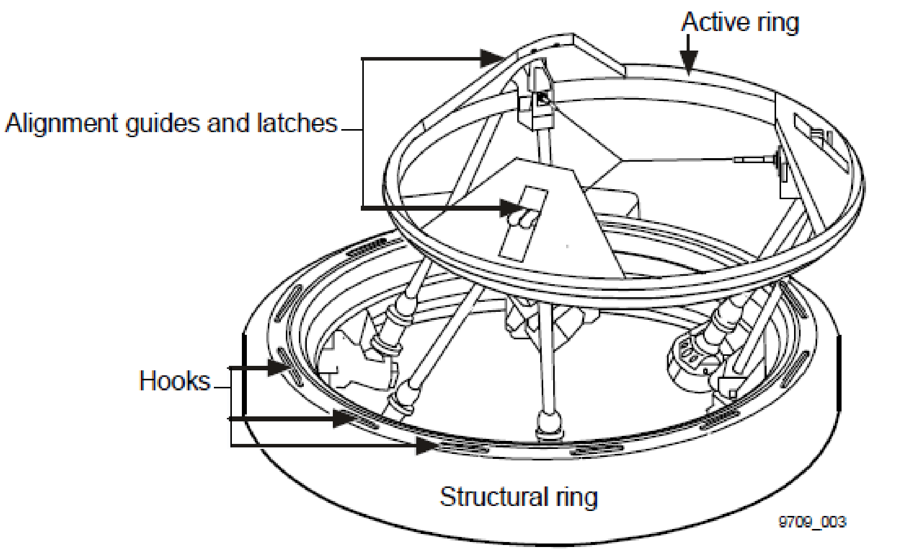
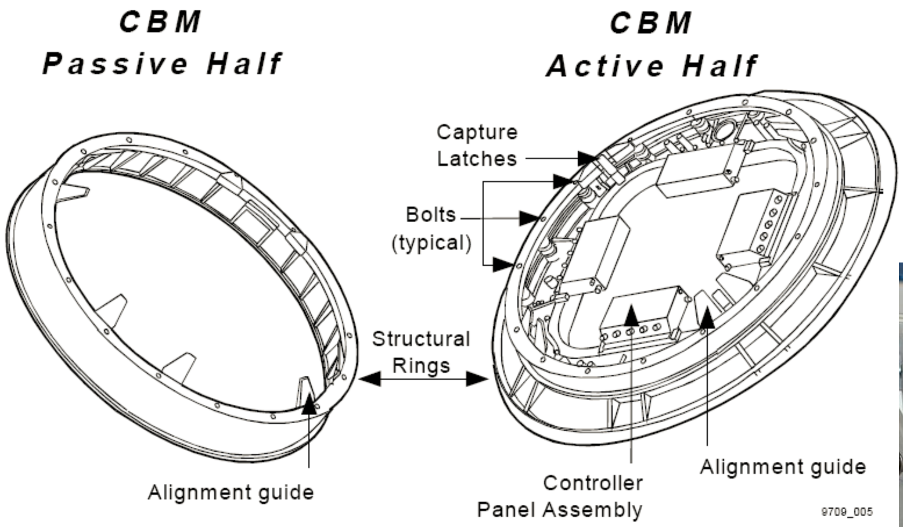
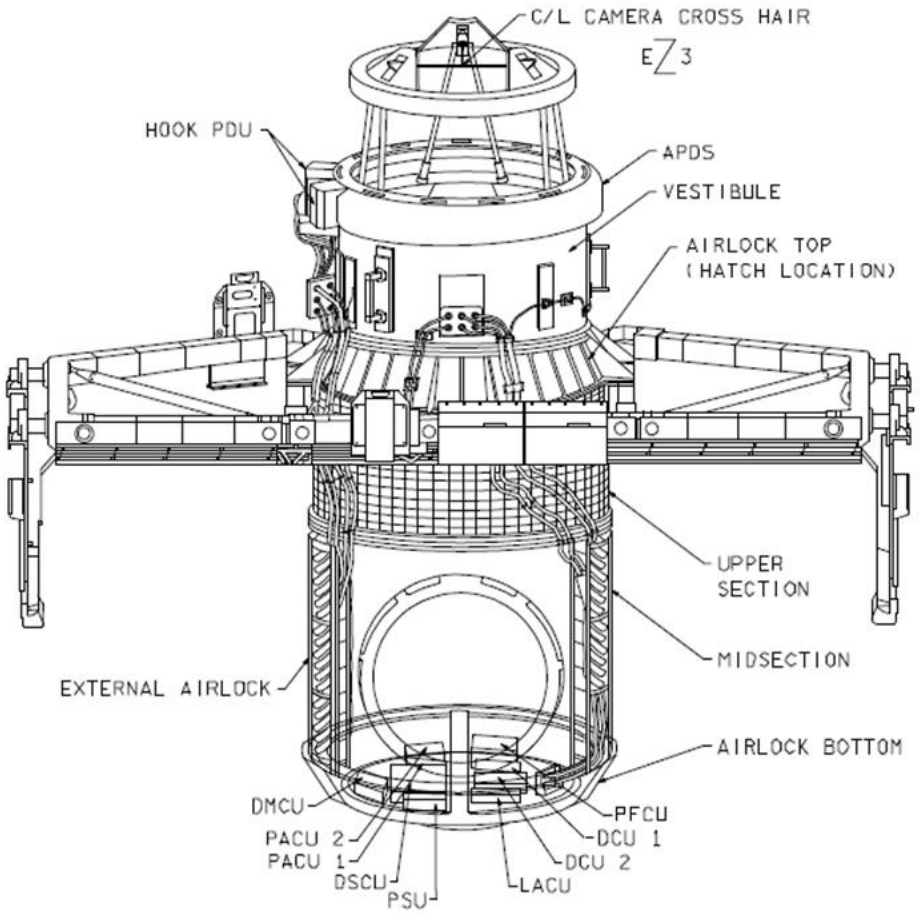


Figure 9-10. Androgynous peripheral attach system

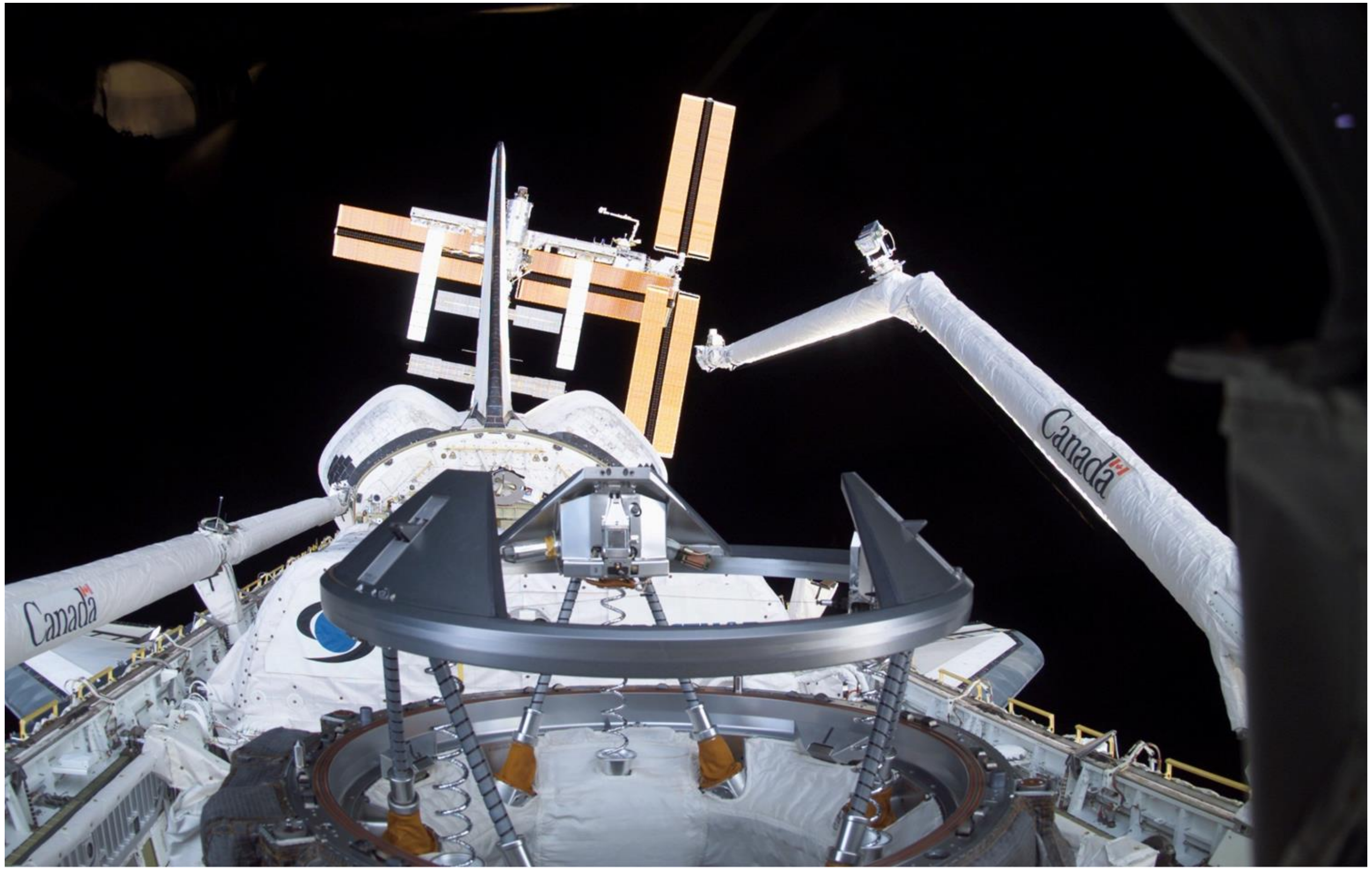
The APAS is a Russian design and is designed to mate with an exact copy of itself (hence the name androgynous). Each APAS half can act as either the passive half or the active half. However, the APAS sites used on the ISS are passive only and do not have the power and data connectivity to operate as an active half. The APAS was also used on the shuttle/Mir flights and was referred to as the Androgynous Peripheral Docking System (APDS).



APAS on the shuttle: The orbiter docking system

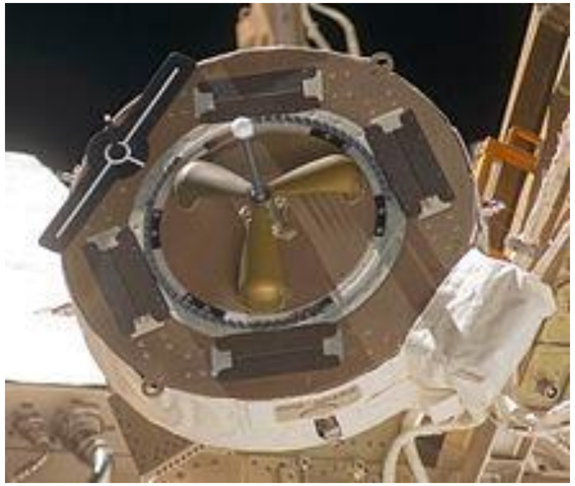


Orbiter Docking System View Looking Aft

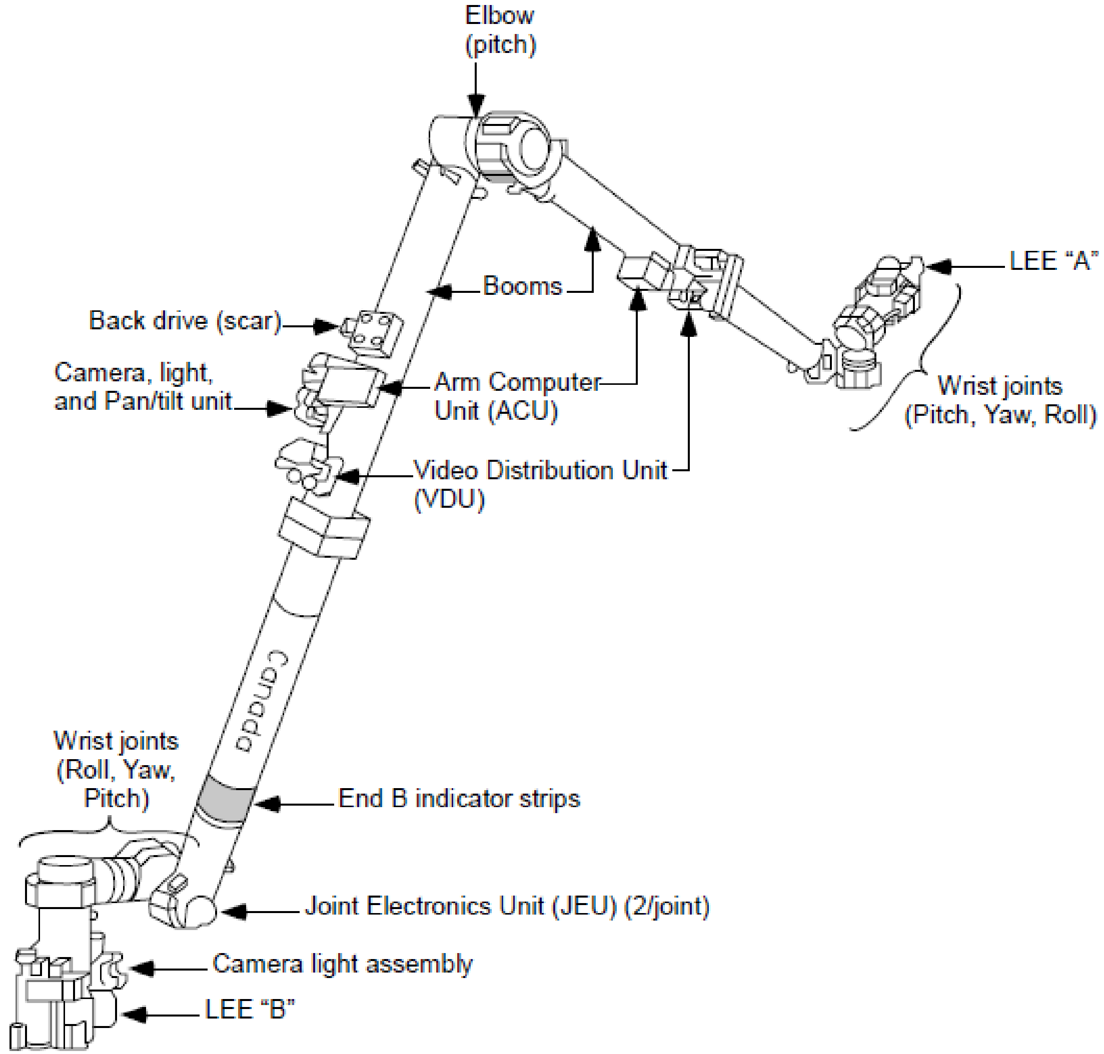


SSRMS (Space Station Remote Manipulator System); ”*Canadarm2*”

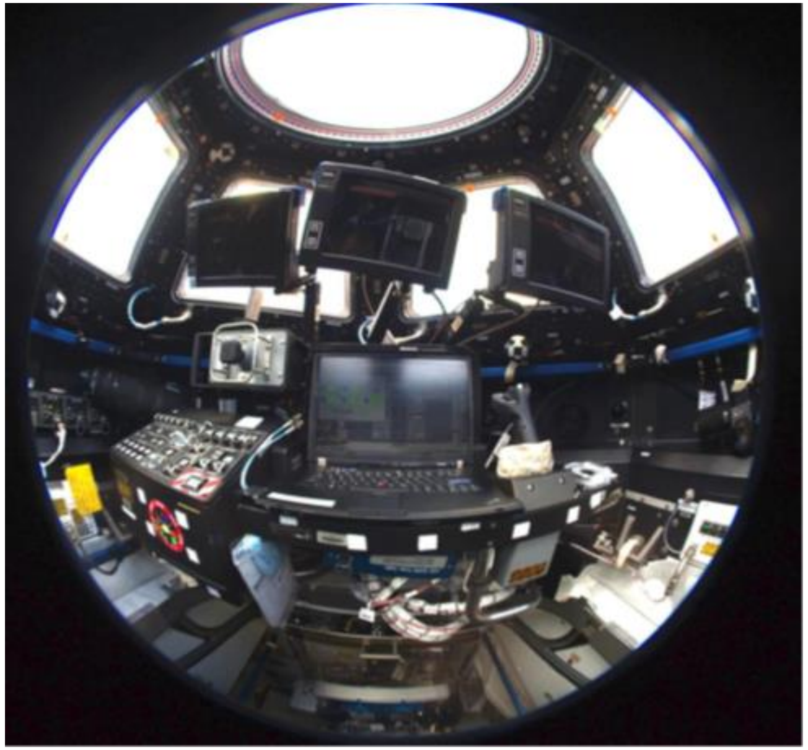
17.6 m long;
35 cm diameter
1.800 kg
7 degrees of freedom
Max mass can handle: 116 t
Can „jump“ between powers sites (PDGF)



Power and Data **Grapple Fixture** (PDGF)



SSRMS can be operated from inside ISS or from MCC-H

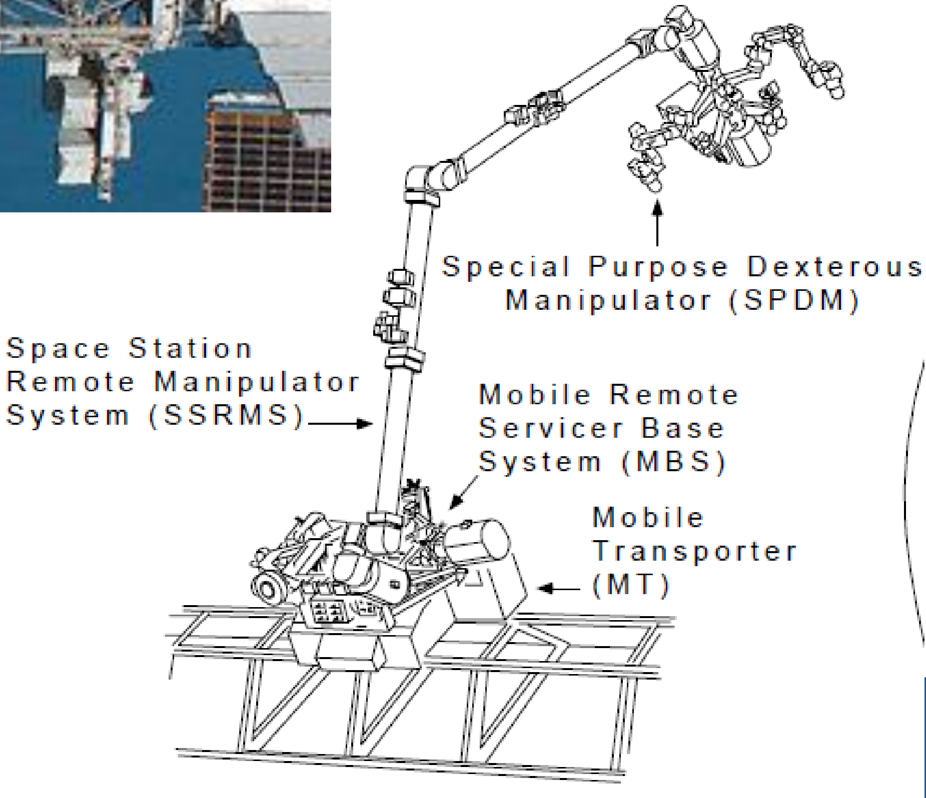


RWS, Robotic Workstation
in the Cupola

SSRMS with MT on MBS and the SPDM make up the MSS

MSS = Mobile Servicing System
MT = Mobile Transporter
MBS = Mobile Remote Servicer Base System
SPDM = Special Purpose Dexterous Manipulator (”*Dextre*”)

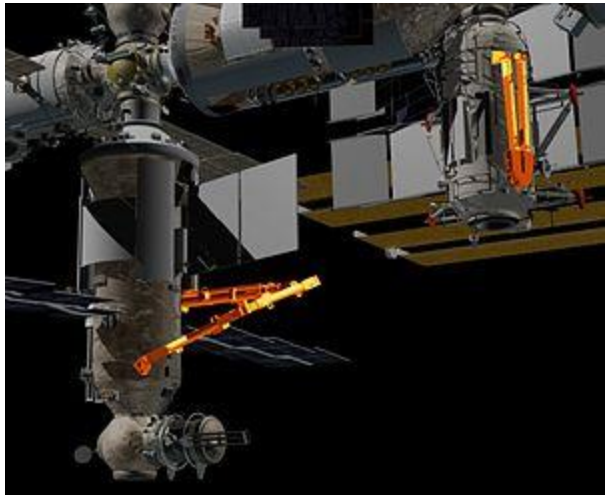
The MT can travel along the whole truss on a rail



MSS External Components

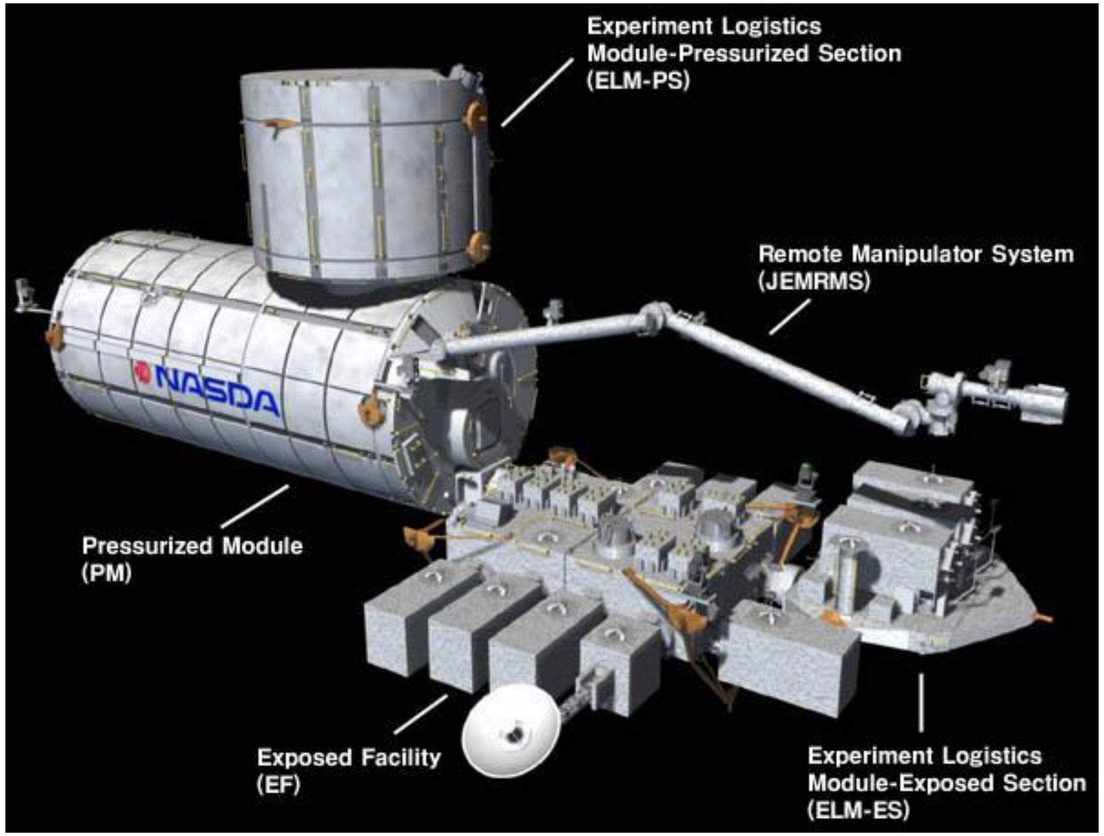
More robotic arms: ERA and JEMRMS

ERA (European Robotic Arm) on the Russian MLM (Multipurpose Laboratory Module; ”*Nauka*”)



ERA can be controlled from inside and outside by an astroanut in space suit

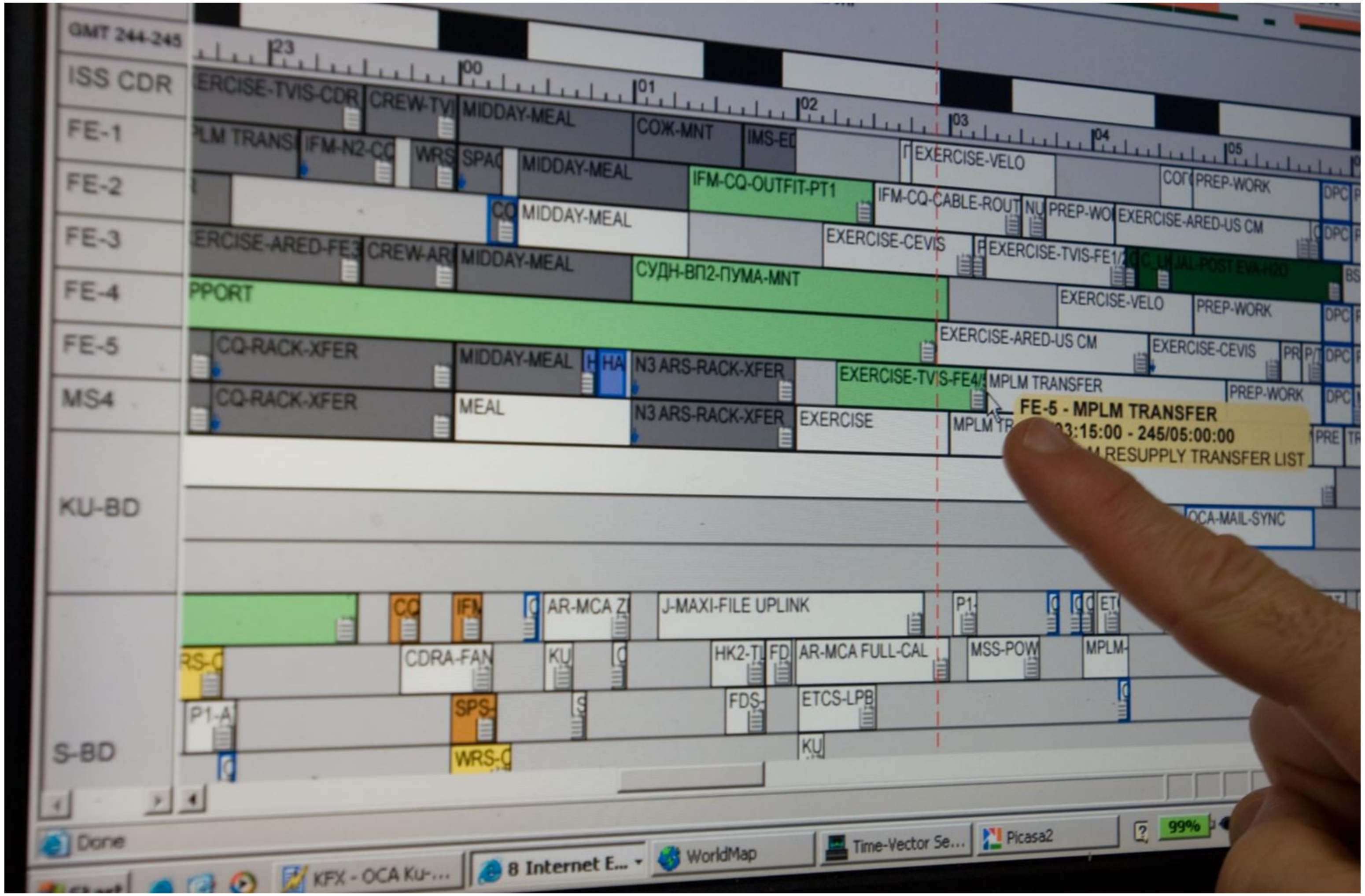
JEMRMS + Small Fine Arm



In addition Russia has a manually operated crane: ”*Strela*”

Crew work in typical space environment

Electronic schedules gives a lot of details, including links to procedures (Checklist)



In principle 8 h daily work

Only a few checklists are on paper (also), but Emergencies are one

Checklists and laptops!

The crew's main purpose is to perform experiments and other "utilization"

Utilizisation = work not devoted to take care of ISS ("systems work") or to take care of themselves (like 2 h physical traingin per day)

Utilization limited by crew time, up-& down mass, data links (rate), power

Research Resources

Resources for the ISS are often described as upmass (mass of material brought to the ISS), downmass (mass of material returned from ISS) and crewtime (amount of time crew dedicates to an activity).

Research Resources	ISS Expeditions 31/32 Apr 2012 – Sept 2012	ISS Expeditions 33/34 Sept 2012 – Mar 2013	ISS Expeditions 0-34 Dec 1998 – Mar 2013
Upmass	1642.5 kg	805.5 kg	48835.3 kg
Downmass	124.9 kg	399.1 kg	11320.0 kg
Crew time	1176.7 hrs	1614.2 hrs	19623.2 hrs

62 h util. per week for the whole crew!

Number of Investigations Performed on the International Space Station

The information below provides an overview of ISS utilization up to the end of **March 2013**. An expedition refers to the nominal 6-month period that a single crew is on ISS. The utilization reflects activities of all of the ISS International Partners: CSA, ESA, JAXA, NASA, and Roscosmos. An investigation is defined as a set of activities and measurements (observations) designed to test a scientific hypothesis, related set of hypotheses, or set of technology validation objectives. Investigators include the principle investigator(s) and co-investigator(s) that are working to achieve the objective of the investigation.

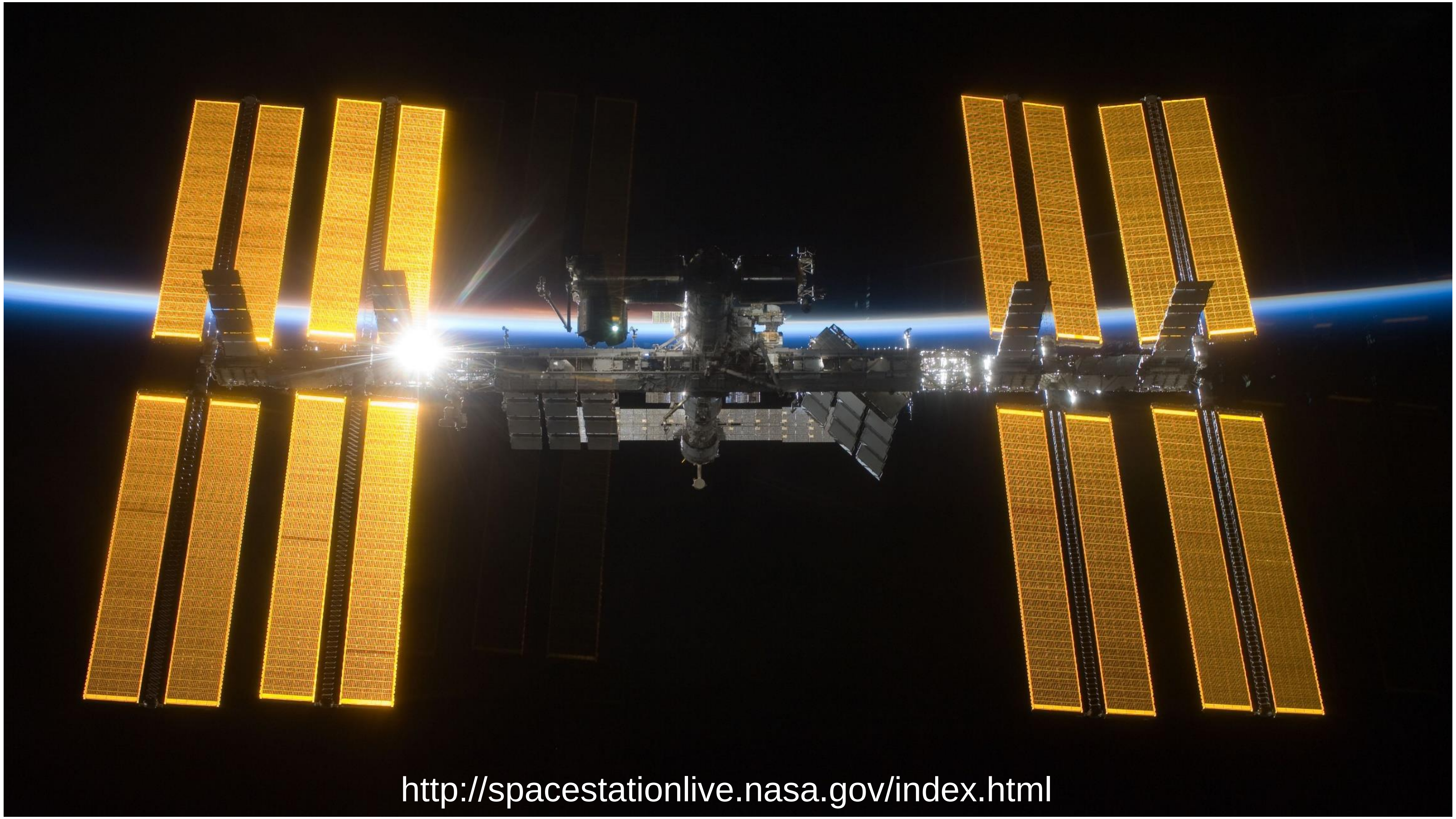
	ISS Expeditions 31/32 Apr 2012 – Sept 2012	ISS Expeditions 33/34 Sept 2012 – Mar 2013	ISS Expeditions 0-34 Dec 1998 – Mar 2013
Number of Investigations	189	220	1502*
New Investigations	29	47	-
Completed/Permanent Investigations	34	39	1068
Number of Investigators with Research on the ISS	484	523	1667
Countries with ISS Investigations	34	46	69

How do you measure your mass in *weightlessness?*

Basically use
F = ma

The frequency of vibration measures the mass of the subject to 0.5% accuracy.

ISS Live!



What ”Utilization” is ISS used for?

- Science
  - Weigtlessness
  - Space view
  - Earth view
  - Space environment (radiation, vacuum, human isolation)
- Technology demonstrations / development
- Exploration preparation
- Education / outreach / inspiration

The International Space Station is a fantastic, unique lab, with <u>views up to space</u>, <u>down on Earth</u> and <u>WEIGHTLESSNESS</u>