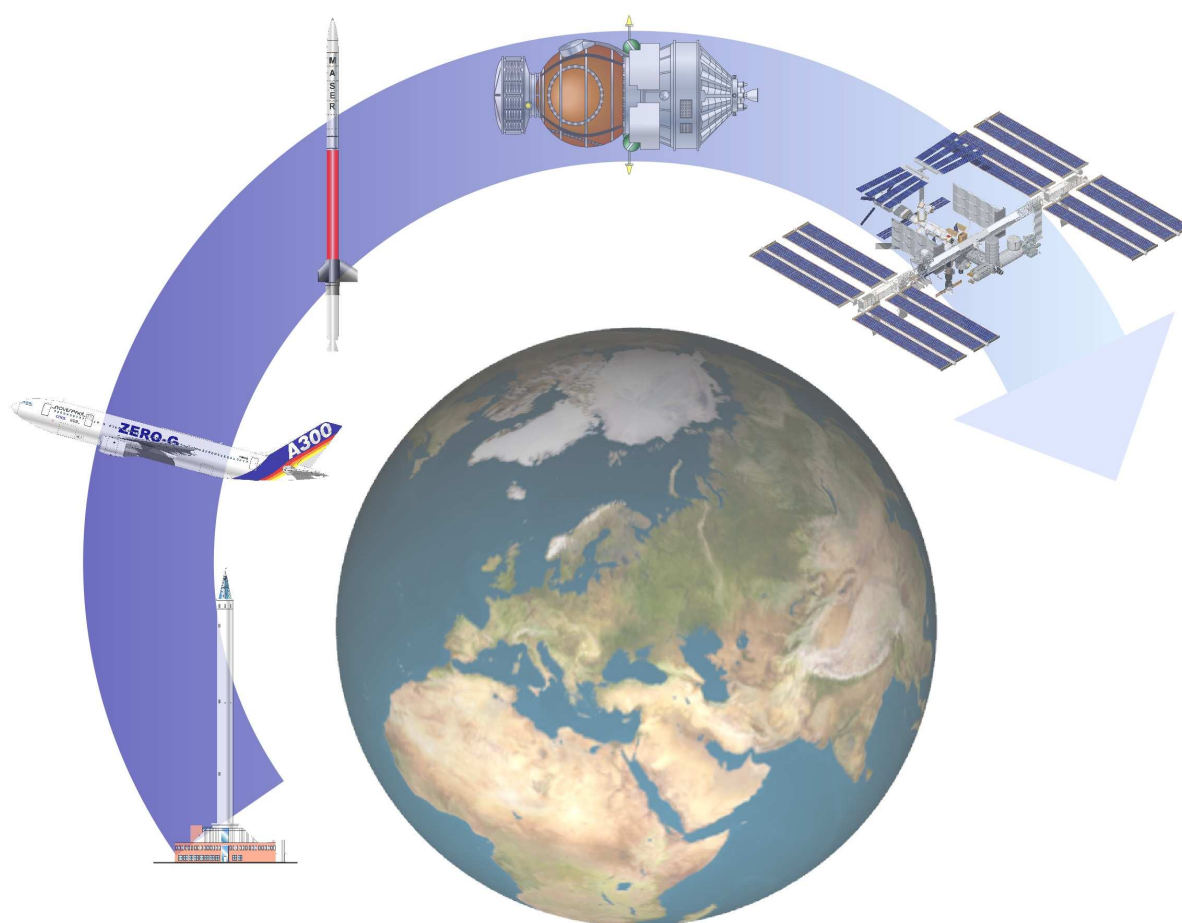


European Users Guide to Low Gravity Platforms



This document has been produced by the Erasmus User Centre and Communication Office of the Directorate of Human Spaceflight, Microgravity and Exploration Programmes of the European Space Agency.

Copyright © 2005 Erasmus User Centre and Communication Office (HME-HE), ESA.

For further information please refer to the contact details provided on the next page.

Title: European Users Guide to Low Gravity Platforms
Reference: UIC-ESA-UM-0001, Issue 2 Revision 0

Copyright © 2005 Erasmus User Centre and Communication Office, ESA
September 2005

Author: Enrico Ceglia (ESA)
Project Manager/Editor: William Carey (ESA)
Producer: Dieter Isakeit (ESA)

Fact Sheets: Jacqueline Myrrhe (ESA), William Carey (ESA)
Illustrations: Giuseppe De Chiara (MARS Center), David Ducros (Active Design)
Layout, Cover Design and Graphics Coordinator: Enrico Ceglia (ESA)

Erasmus User Centre and Communication Office
Directorate of Human Spaceflight, Microgravity and Exploration Programmes
European Space Agency (ESA)
Keplerlaan 1, 2201 AZ Noordwijk
The Netherlands
Tel: +31 (0) 71 565 6616
Fax: +31 (0) 71 565 8008

spaceflight.information@esa.int
<http://www.spaceflight.esa.int/users>

PURPOSE OF THE USERS GUIDE

The European Users Guide to Low Gravity Platforms is intended to provide an overview of what the five low gravity platforms sponsored by ESA are, and how they are made available to people wishing to use them for either scientific, educational or commercial purposes.

The five platforms covered by this Guide are the following:

- Drop Tower;
- Parabolic Flights;
- Sounding Rockets;
- Foton Retrievable Capsules;
- International Space Station (ISS).

The Guide does not seek to lay down rules, but as it suggests, simply offers guidance in understanding whether or not the capabilities and resources provided by each of the five platforms meet the requirements of the Users' needs. The Guide has been written with the intention of satisfying three classes of people:

- The general public;
- Potential users of ESA sponsored low gravity platforms;
- Current/experienced users of ESA sponsored low gravity platforms.

In order to understand all the details involved in accessing the platforms, a considerable amount of information has to be studied and understood. It would be impossible, within the scope of this Guide, to cover all this material, and it is for this reason that the major objective is to only present the most important basic information. Where more details are required, Users are given the appropriate document references, web links, or contact coordinates.

REVISION RECORD

Issue.Revision	Date	Pages affected	Description of change/s
2.0	09/09/2005	All	

TABLE OF CONTENTS

1	INTRODUCTION.....	1-1
1.1	Background.....	1-1
1.2	Relation to Ground Based Facilities.....	1-1
1.3	Structure of the Guide.....	1-1
1.4	Overview.....	1-2
1.5	General Information and Advice.....	1-6
1.5.1	Erasmus Experiment Archive (EEA).....	1-6
1.5.2	User Documentation Access System (UDAS).....	1-7
1.5.3	Erasmus User Centre High Bay.....	1-7
1.5.4	Contacts.....	1-8
2	THE ACCESS PROCESSES.....	2-1
2.1	Overview.....	2-1
2.2	European Space Agency Access Routes.....	2-1
2.2.1	Periodic Announcements of Opportunity.....	2-1
2.2.1.1	Contents of a Proposal.....	2-1
2.2.1.1.1	Cover Page.....	2-1
2.2.1.1.2	Proposal Abstract.....	2-2
2.2.1.1.3	Project Description.....	2-2
2.2.1.1.4	Work Package Breakdown and Financial Form.....	2-2
2.2.1.1.5	Biographical Sketches.....	2-2
2.2.1.1.6	Facilities and Equipment.....	2-2
2.2.1.2	Proposal Evaluation.....	2-2
2.2.1.3	Evaluation Criteria.....	2-3
2.2.1.4	Contacts.....	2-3
2.2.2	Continuously Open Research Announcement.....	2-5
2.2.2.1.1	Evaluation Criteria.....	2-5
2.2.2.2	Contacts.....	2-6
2.2.3	Coordinated Research.....	2-7
2.2.4	Topical Teams.....	2-7
2.2.5	Fundamental and Applied Research Programmes.....	2-7
2.2.6	Commercial Access.....	2-8
2.2.6.1	The Open Call for Commercial Proposals.....	2-8
2.2.6.2	The Commercial Proposal – Structure and Contents.....	2-8
2.2.6.3	Evaluation Procedure.....	2-9
2.2.6.4	Contract Negotiation – Intellectual Property Rights (IPR) and Marketing Rights.....	2-9
2.2.6.4.1	Intellectual Property Rights.....	2-9
2.2.6.4.2	Marketing Rights.....	2-9
2.2.6.5	Commercial Project Implementation.....	2-10
2.2.6.6	Pricing.....	2-10
2.2.6.7	Contacts.....	2-10
2.2.7	Student Access.....	2-11
2.2.7.1	International Space Station.....	2-11
2.2.7.2	Parabolic Flights.....	2-11
2.2.7.2.1	Phase 1.....	2-11
2.2.7.2.2	Phase 2.....	2-12
2.2.7.2.3	Phase 3.....	2-12
2.2.7.2.4	Outreach Programme.....	2-12
2.2.7.2.5	Contacts.....	2-12
2.2.7.3	Other Platforms.....	2-13

2.3	Complementary Access Routes.....	2-13
2.3.1	Drop Towers.....	2-13
2.3.1.1	Funding Via National Agencies.....	2-13
2.3.1.2	ZARM Funding.....	2-13
2.3.1.2.1	Conditions.....	2-13
2.3.1.2.2	Support and Services.....	2-13
2.3.1.2.3	Applications.....	2-14
2.3.1.3	Co-Funding Through DLR.....	2-14
2.3.2	Parabolic Flights.....	2-14
2.3.2.1	Funding Via National Agencies.....	2-14
2.3.3	Sounding Rockets.....	2-14
2.3.3.1	Funding Via National Agencies.....	2-14
3	DROP TOWER.....	3-1
3.1	Introduction.....	3-1
3.1.1	What Are Drop Tubes and Drop Towers?.....	3-1
3.1.2	What Do Drop Tubes and Drop Towers Offer?.....	3-1
3.1.3	Why Use Drop Tubes and Drop Towers?.....	3-1
3.1.4	Principal Characteristics of the ZARM Drop Tower.....	3-2
3.2	Physical Environment.....	3-4
3.2.1	Pressure Environment.....	3-4
3.2.2	Thermal Environment.....	3-4
3.2.3	Accelerations.....	3-5
3.2.3.1	Transition From 1g to 0g.....	3-5
3.2.3.2	Residual Accelerations.....	3-5
3.2.3.3	Deceleration Forces.....	3-7
3.3	Scientific Research Suitable to the ZARM Drop Tower.....	3-8
3.4	Payload Accommodation.....	3-9
3.4.1	Mechanical Aspects of the Drop Capsule.....	3-9
3.4.1.1	Experiment Platforms.....	3-11
3.4.2	Electrical Aspects of the Drop Capsule.....	3-12
3.4.2.1	Experiment Power Control Unit (EPC).....	3-12
3.4.2.2	Electromagnetic Compatibility.....	3-13
3.4.3	Electronic Aspects of the Drop Capsule.....	3-13
3.4.3.1	Experiment Control.....	3-13
3.4.3.2	Capsule Control System (CCS).....	3-13
3.4.3.3	Virtual Serial Interface.....	3-13
3.4.4	Safety Requirements.....	3-13
3.5	Available Facilities and Resources.....	3-15
3.5.1	Laboratories, Workshops and Workplace.....	3-15
3.5.2	Accommodation.....	3-15
3.5.3	CCD-cameras, VCRs, Lenses.....	3-15
3.5.4	Digital High speed CCD systems.....	3-15
3.5.4.1	Camera Specifications.....	3-15
3.5.4.2	Recorder Specifications.....	3-15
3.5.5	Non-standard Voltage/Current supply.....	3-16
3.5.6	Vent-Line.....	3-16
3.5.7	Pressurised Air Reservoirs.....	3-16
3.5.8	Micro-g Centrifuge.....	3-16
3.5.9	Free-Flyer.....	3-16
3.5.10	Combustion Research Laser Diagnostics.....	3-16
3.6	Payload Life Cycle and Major Milestones.....	3-18
3.7	Utilisation/Operational Cycle of the ZARM Drop Tower.....	3-20
3.8	References.....	3-22
4	PARABOLIC FLIGHTS.....	4-1

4.1	Introduction to Parabolic Flights.....	4-1
4.1.1	What Are Parabolic Flights?.....	4-1
4.1.2	What Do Parabolic Flights Offer?.....	4-1
4.1.3	Why Use Parabolic Flights?.....	4-1
4.1.4	Principal Characteristics of the Airbus A-300 “Zero-G”.....	4-2
4.1.5	Parabolic Flight Manoeuvres.....	4-4
4.2	Physical Environment.....	4-7
4.2.1	Cabin Pressure.....	4-7
4.2.2	Cabin Temperature.....	4-7
4.2.3	Illumination.....	4-7
4.2.4	Acceleration Levels.....	4-7
4.3	Scientific and Technological Research Suitable to Parabolic Flights.....	4-9
4.4	Payload Accommodation.....	4-10
4.4.1	Structural Requirements.....	4-10
4.4.2	Aircraft Rail Loading.....	4-10
4.4.3	Equipment Attachment.....	4-11
4.4.4	Free-Float Packages.....	4-11
4.4.5	Pressure Vessels.....	4-11
4.4.6	Electrical Systems.....	4-11
4.4.7	Hazardous Materials.....	4-11
4.4.8	Emergency Shutdown.....	4-11
4.4.9	Safety.....	4-12
4.4.9.1	Safety Visit.....	4-12
4.4.10	Other General Guidelines.....	4-12
4.4.11	Biomedical Experiments with Human Subjects.....	4-12
4.5	Available Flight Facilities and Resources.....	4-14
4.5.1	Electrical Power and Interfaces.....	4-14
4.5.2	Overboard Vent System.....	4-14
4.5.3	Data Recording and Accelerometers.....	4-14
4.5.4	Safety and Emergency Procedures.....	4-14
4.6	Ground Support Facilities.....	4-15
4.7	Legal Aspects.....	4-16
4.7.1	Confidentiality.....	4-16
4.7.2	Liability and Insurance.....	4-16
4.8	Human Aspects.....	4-18
4.8.1	Medical Aspects.....	4-18
4.8.2	Pre-flight Briefing.....	4-18
4.9	Payload Life-Cycle and Major Milestones.....	4-19
4.10	Payload Documentation Development.....	4-21
4.10.1	Experiment Form.....	4-21
4.10.1.1	Title of the Experiment and Team Coordinator Name.....	4-21
4.10.1.2	Experiment Objectives.....	4-21
4.10.1.3	Experiment Description.....	4-21
4.10.1.4	Technical Description of the Experiment Set-Up.....	4-21
4.10.1.5	Electrical Consumption.....	4-21
4.10.1.6	Mechanical Resistance Analysis.....	4-21
4.10.1.7	In-Flight Procedures and In-Flight Personnel.....	4-22
4.10.1.8	Pressure Vessel Certification (if applicable).....	4-22
4.10.1.9	Vent Line Connection and Other Requests.....	4-22
4.10.1.10	Certification for Use of Human Subjects (if applicable).....	4-22
4.10.1.11	Liability Waiver.....	4-22
4.10.1.12	Hazard Analysis.....	4-22
4.10.1.12.1	Experiment Hazard Evaluation.....	4-22
4.10.1.12.2	Hazard List.....	4-22
4.10.1.12.3	Hazard Report Preparation.....	4-22
4.11	Operational Cycle of a Parabolic Flight Campaign.....	4-23
4.12	References.....	4-25

5	SOUNDING ROCKETS.....	5-1
5.1	Introduction to Sounding Rockets.....	5-1
5.1.1	What Are Sounding Rockets?	5-1
5.1.2	What Do Sounding Rockets Offer?	5-1
5.1.3	Why Use Sounding Rockets?	5-1
5.1.4	Principal Characteristics of Sounding Rockets Used by ESA	5-2
5.1.4.1	MiniTEXUS.....	5-2
5.1.4.2	TEXUS	5-4
5.1.4.3	MASER.....	5-6
5.1.4.4	MAXUS.....	5-8
5.1.5	Sounding Rocket Mission Profiles	5-10
5.1.5.1	MiniTEXUS.....	5-12
5.1.5.2	TEXUS and MASER.....	5-14
5.1.5.3	MAXUS.....	5-16
5.1.6	Launch and Landing Site.....	5-18
5.2	Physical Environment	5-19
5.2.1	Acceleration Levels.....	5-19
5.2.2	Thermal Environment.....	5-20
5.3	Scientific Research Suitable for Sounding Rockets	5-21
5.4	Payload Accommodation	5-22
5.4.1	ESA Experiment Modules.....	5-23
5.4.1.1	Materials Sciences	5-23
5.4.1.2	Fluid Sciences.....	5-25
5.4.1.3	Life Sciences.....	5-29
5.4.1.4	Combustion.....	5-31
5.4.1.5	Fundamental Physics	5-31
5.5	Available Flight Resources	5-32
5.5.1	Service Module	5-32
5.5.1.1	Telemetry System.....	5-32
5.5.1.2	Telecommand System.....	5-32
5.5.1.3	Rate Control System (RCS).....	5-32
5.5.1.4	Acceleration Measurement	5-32
5.5.2	TV Module.....	5-32
5.5.3	MAXUS Rocket Systems.....	5-33
5.5.3.1	Interstage Adapter (INA).....	5-33
5.5.3.2	Telemetry and Tracking Unit (TTU)	5-33
5.5.3.3	Guidance Control System (GCS).....	5-33
5.5.4	Recovery System.....	5-33
5.5.5	External Temperature Control.....	5-33
5.6	Ground Support Facilities	5-34
5.6.1	Main Building	5-34
5.6.2	Launching Area.....	5-34
5.6.2.1	Offices.....	5-34
5.6.2.2	Payload Assembly Hall.....	5-34
5.6.2.3	Laboratories	5-34
5.6.2.4	Workshop.....	5-35
5.6.2.5	User's Blockhouse	5-35
5.6.2.6	Storage	5-36
5.6.3	Scientific Centre.....	5-36
5.6.3.1	Telemetry.....	5-36
5.6.4	Telescience.....	5-36
5.6.5	TV Centre.....	5-38
5.6.6	Late Access/Early Retrieval	5-38
5.6.7	Recovery of Payloads.....	5-38
5.6.8	Accommodation at Estrange.....	5-38
5.7	Legal Aspects.....	5-39
5.8	Safety	5-40
5.8.1	Safety Organisation	5-40

5.8.2	Operations and Scientific Centre.....	5-40
5.8.3	Dangerous Material	5-40
5.8.4	Experiment Module Safety.....	5-40
5.9	Payload Life-Cycle and Major Milestones.....	5-41
5.10	Payload Assembly, Integration and Test (AIT).....	5-43
5.10.1	Experiment Module Status at Delivery.....	5-43
5.10.2	Module Incoming Inspection.....	5-43
5.10.3	Payload Assembly and Interface Tests	5-43
5.10.3.1	Mechanical Interface Test.....	5-43
5.10.3.2	Electrical Interface Test	5-43
5.10.4	Payload System Tests	5-43
5.10.4.1	Module Checkout.....	5-43
5.10.4.2	Mass Properties and Balancing.....	5-44
5.10.4.3	Spin Test	5-44
5.10.4.4	System Electrical Test 1 and EMI-Check	5-44
5.10.4.5	Vibration Test	5-44
5.10.4.6	System Electrical Test 2.....	5-44
5.10.4.7	Flight Simulation Test	5-44
5.11	Operational Cycle of a Sounding Rocket Campaign.....	5-45
5.12	References.....	5-47

6 FOTON RETRIEVABLE CAPSULES.....6-1

6.1	Introduction to Foton Capsules	6-1
6.1.1	What Are Foton Capsules?.....	6-1
6.1.2	What Do Foton Capsules Offer?	6-1
6.1.3	Why Use Foton Capsules?	6-1
6.1.4	Principal Characteristics of a Foton Spacecraft.....	6-3
6.1.4.1	The Service Module.....	6-3
6.1.4.2	The Battery Module	6-4
6.1.4.3	The Re-Entry module.....	6-5
6.1.4.4	The Launch Vehicle.....	6-5
6.1.5	Foton Mission Profile.....	6-7
6.1.5.1	Launch Phase	6-7
6.1.5.2	Orbital Phase.....	6-8
6.1.5.3	Re-Entry and Landing Phases.....	6-8
6.1.6	Launch and Landing Site.....	6-10
6.1.6.1	Baikonur Location and Map	6-10
6.1.6.2	Map of Landing Area.....	6-11
6.2	Physical Environment	6-13
6.2.1	Internal Environment.....	6-13
6.2.1.1	Gravity Levels	6-13
6.2.1.2	Pressure.....	6-13
6.2.1.3	Radiation.....	6-13
6.2.1.4	Air Composition	6-13
6.2.1.5	Humidity.....	6-13
6.2.1.6	Temperature.....	6-13
6.2.2	External Environment.....	6-14
6.2.2.1	External Vacuum	6-14
6.2.2.2	External Temperature	6-14
6.2.2.3	Atomic Oxygen.....	6-14
6.2.2.4	Cosmic Radiation.....	6-14
6.2.2.5	Solar Light	6-14
6.3	Scientific Research Suitable to Foton Capsules	6-15
6.4	Payload Accommodation	6-16
6.4.1	Total Scientific Payload Envelope	6-16
6.4.2	Size and Mass of a Single Experiment	6-17
6.4.3	Mechanical Compatibility	6-19

6.4.4	Vibration and Shock Test Levels	6-19
6.4.4.1	Linear Accelerations	6-19
6.4.4.1.1	For Launch	6-19
6.4.4.1.2	For Re-Entry	6-19
6.4.4.2	Sinusoidal Vibrations (Resonance Survey).....	6-19
6.4.4.3	Random Vibrations	6-19
6.4.4.4	Landing Shock Levels	6-20
6.4.5	Inspection Criteria	6-21
6.4.6	Import/Export Requirements	6-21
6.5	Available Flight Resources	6-22
6.5.1	Flight Facilities.....	6-22
6.5.1.1	Biobox.....	6-22
6.5.1.2	Biopan.....	6-23
6.5.1.2.1	Experiment Design Requirements.....	6-25
6.5.1.3	Stone	6-26
6.5.1.4	FluidPac	6-27
6.5.1.5	TeleSupport Unit (TSU) and Telescience	6-28
6.6	Ground Support Facilities	6-32
6.6.1	Transport Containers	6-32
6.6.2	Travel and Accommodation	6-32
6.7	Safety	6-33
6.7.1	Materials, Mechanical Parts and Processes	6-33
6.7.1.1	Stress Corrosion.....	6-33
6.7.1.2	Flammability.....	6-34
6.7.1.3	Offgassing and Toxic Analysis.....	6-34
6.7.1.4	Supplementary Tests.....	6-34
6.7.1.5	Forbidden Materials	6-34
6.7.2	Electrical, Electronic, Electromechanical (EEE) Parts.....	6-34
6.7.3	Pressure Vessels/Sealed Containers	6-34
6.7.4	Batteries.....	6-35
6.8	Payload Life-Cycle and Major Milestones.....	6-36
6.8.1	Phase I: Design.....	6-36
6.8.2	Phase II: Qualification.....	6-36
6.8.3	Phase III: Fine-Tuning.....	6-36
6.9	Payload Documentation Development.....	6-38
6.10	Operational Cycle of a Foton Campaign.....	6-39
6.11	References.....	6-41

7 INTERNATIONAL SPACE STATION – ISS..... 7-1

7.1	Introduction to the ISS	7-1
7.1.1	What Is the ISS?.....	7-1
7.1.2	What Does the ISS Offer?	7-3
7.1.3	Why Use the ISS?.....	7-4
7.1.4	Principal Parameters and Characteristics of the ISS.....	7-4
7.1.5	Major Elements and Launch Dates.....	7-7
7.1.6	Launch and Transfer Vehicles.....	7-13
7.1.6.1	Automated Transfer Vehicle (ATV).....	7-15
7.2	Operational Environment	7-18
7.2.1	Altitude.....	7-18
7.2.2	Inclination.....	7-18
7.2.3	Attitude.....	7-19
7.2.3.1	Coordinate Systems	7-19
7.2.3.1.1	ISS Body Coordinate System.....	7-19
7.2.3.1.2	Local Vertical/Local Horizontal (LVLH) Coordinate System.....	7-20
7.2.3.1.3	X-Perpendicular Out of Plane (XPOP) Coordinate System	7-21
7.2.3.2	X-axis in the Velocity Vector (XVV) Attitude	7-21
7.2.3.3	XPOP Attitude	7-23

7.2.3.4	Y-axis in the Velocity Vector (YVV) Attitude	7-23
7.2.4	Operational Cycle of the ISS	7-25
7.2.4.1	Example Operational Modes Timeline	7-27
7.3	Physical Environment	7-29
7.3.1	Gravity Levels	7-29
7.3.1.1	Quasi-Steady State Accelerations	7-29
7.3.1.2	Vibratory Accelerations	7-30
7.3.1.2.1	Rack Level Isolation Systems	7-31
7.3.1.2.2	Sub-Rack Isolation Systems	7-32
7.3.1.3	Measuring the ISS Microgravity Environment & Accessing Data	7-32
7.3.2	Internal Environment	7-36
7.3.2.1	Cabin Atmosphere	7-36
7.3.2.2	Illumination	7-36
7.3.2.3	Interior Colour	7-37
7.3.2.4	Internal Contamination	7-37
7.3.2.5	Noise	7-38
7.3.2.6	Touch Temperatures	7-38
7.3.3	External Environment	7-39
7.3.3.1	Induced External Environment	7-39
7.3.3.1.1	Quiescent Periods	7-39
7.3.3.1.2	Non-Quiescent Periods	7-40
7.3.3.2	Natural External Environment	7-40
7.3.3.2.1	Pressure	7-40
7.3.3.2.2	Thermal Environment	7-40
7.3.3.2.3	Humidity	7-40
7.3.3.2.4	Atomic Oxygen	7-40
7.3.3.2.5	Electromagnetic Radiation	7-41
7.3.3.2.6	Plasma	7-41
7.3.3.2.7	Ionising Radiation	7-41
7.3.3.2.8	Plume Impingement	7-42
7.3.3.2.9	Meteoroids and Orbital Debris	7-42
7.4	Utilisation Fields Applicable to the ISS	7-43
7.4.1	Life and Physical Sciences	7-43
7.4.1.1	Life and Physical Sciences Research Cornerstones (2002-2006)	7-43
7.4.2	Space Science	7-49
7.4.2.1	Solar Physics	7-49
7.4.2.2	Astrophysics	7-49
7.4.3	Earth Observation	7-49
7.4.4	Technology	7-49
7.4.5	Commercialisation	7-50
7.4.5.1	The Commercial Promotion Office	7-50
7.4.5.2	The Commercial Agents Network	7-50
7.4.5.3	The Co-Operation Agreement	7-50
7.4.6	Education	7-51
7.5	ISS Resources and Partner Utilisation Rights	7-52
7.5.1	ESA Utilisation Rights and Resources	7-53
7.5.2	ESA Barter Agreements	7-54
7.5.2.1	ESA/NASA Early Utilisation Opportunities of the ISS (18 March 1997)	7-55
7.5.2.2	ESA/NASA Super Guppy Transporter Barter Contract (15 August 1997)	7-55
7.5.2.3	ESA/NASA Columbus Orbital Facility Launch Barter (8 October 1997)	7-56
7.5.2.4	ESA/NASA MOU for Cooperation in the X-38 Project (8 July 1999)	7-56
7.5.2.5	ESA/NASA Cupola Barter Agreement (3 August 2000)	7-56
7.5.2.6	ESA/Roscosmos Service Module DMS Agreement (1 March 1996)	7-57
7.5.2.7	ESA/NASDA MOU on Hardware Exchange for ISS Utilisation (5 November 1997)	7-57
7.5.2.8	ESA/CSA FSL and MVIS Cooperation (6 February 2001)	7-57
7.5.2.9	ESA/ASI MPLM and Columbus Common Features Exploitation Arrangement (17 April 1997)	7-57
7.5.3	ESA Additional Flight Opportunities	7-58

7.6	Columbus Payload Accommodation.....	7-60
7.6.1	Class 1 Payloads.....	7-60
7.6.1.1	The International Standard Payload Rack (ISPR).....	7-61
7.6.1.2	Centre Aisle Payloads.....	7-64
7.6.1.3	Assembly Complete Rack Topology.....	7-65
7.6.2	Class 2 Payloads.....	7-67
7.6.2.1	Middeck Locker (MDL).....	7-67
7.6.2.2	International Subrack Interface Standard (ISIS) Drawer.....	7-68
7.6.3	Columbus External Payload Facility (CEPF).....	7-69
7.6.3.1	Columbus External Payload Adapter (CEPA).....	7-73
7.6.3.2	CEPF Integrated External Payload Configuration, Interfaces and Resources.....	7-74
7.6.4	Other Partner External Accommodations.....	7-76
7.7	ESA Facilities and Payloads.....	7-78
7.8	Other ISS Partners Facilities.....	7-80
7.8.1	NASA Facilities.....	7-80
7.8.1.1	Human Research Facility (HRF).....	7-80
7.8.1.2	Microgravity Sciences Glovebox (MSG).....	7-81
7.8.1.3	Window Observational Research Facility (WORF).....	7-81
7.8.1.4	Space Station Fundamental Biology Research Facility (SSFBRF).....	7-81
7.8.1.5	Materials Science Research Facility (MSRF).....	7-81
7.8.1.6	Fluids and Combustion Facility (FCF).....	7-82
7.8.1.7	Biotechnology Research Facility (BTF).....	7-82
7.8.1.8	X-Ray Crystallography Facility (XCF).....	7-82
7.8.1.9	Low-Temperature Microgravity Physics Facility (LTMPF).....	7-82
7.8.2	JAXA Facilities.....	7-83
7.8.2.1	Gradient Heating Furnace (GHF).....	7-83
7.8.2.2	Fluid Physics Experiment Facility (FPEF).....	7-83
7.8.2.3	Solution/Protein Crystal Growth Facility (SPCF).....	7-83
7.8.2.4	Cell Biology Equipment Facility (CBEF).....	7-83
7.8.2.5	Clean Bench (CB).....	7-84
7.8.2.6	Image Processing Unit (IPU).....	7-84
7.8.2.7	Aquatic Habitat (AQH).....	7-84
7.8.2.8	Space Environment Data Acquisition Equipment/Attached Payload (SEDA/AP).....	7-84
7.8.2.9	Monitor of All-sky X-ray Image (MAXI).....	7-84
7.8.2.10	Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES).....	7-85
7.9	User Support and Operations Centres (USOCs).....	7-86
7.9.1	USOC Assignments.....	7-87
7.9.2	USOC Tasks and Responsibilities.....	7-88
7.10	Legal Aspects.....	7-90
7.10.1	Legal Framework.....	7-90
7.10.1.1	General Principles.....	7-90
7.10.1.2	Space Station Agreements.....	7-90
7.10.1.3	Extension of National Jurisdiction to the Space Station.....	7-91
7.10.2	Intellectual Property.....	7-91
7.10.2.1	Protection.....	7-91
7.10.2.2	Ownership and Exploitation.....	7-92
7.10.2.3	Liability.....	7-93
7.11	Safety And Product Assurance.....	7-94
7.11.1	Safety.....	7-94
7.11.1.1	Safety Reviews.....	7-95
7.11.2	Materials.....	7-96
7.11.3	Reliability and Maintainability.....	7-96
7.12	Payload Planning.....	7-98
7.12.1	Multi-Increment Planning.....	7-98
7.12.2	Tactical Planning.....	7-99
7.12.3	Pre-Increment Planning.....	7-99
7.12.4	Increment Execution Planning.....	7-99
7.12.4.1	Short-Term Planning.....	7-99

7.12.4.2	Real-Time Planning	7-100
7.12.4.3	Real-Time Re-planning.....	7-100
7.13	Payload Life-Cycle and Major Milestones.....	7-101
7.13.1	Russian Segment Payloads	7-101
7.13.1.1	Project Reviews	7-103
7.13.1.1.1	Mission Feasibility Review	7-103
7.13.1.1.2	Mission Integration Review.....	7-103
7.13.1.1.3	Mission Verification Reviews	7-103
7.13.1.1.4	Final Project Review	7-104
7.13.1.2	Equipment Qualification, Testing and Acceptance Processes	7-104
7.13.1.2.1	Qualification Tests.....	7-104
7.13.1.2.2	Acceptance Tests.....	7-104
7.13.1.2.3	Incoming Inspection and Final Preparation	7-105
7.13.1.2.4	Pre-Launch Preparation and Final Operations.....	7-105
7.13.1.3	Operations Preparation	7-105
7.13.1.4	On-orbit Operations	7-105
7.13.1.5	Post-Flight Handover of Experiment Samples.....	7-105
7.13.2	USOS Payloads	7-106
7.13.2.1	Payload Integration	7-108
7.13.2.1.1	Payload Development.....	7-108
7.13.2.1.2	Major Reviews	7-108
7.13.2.1.3	Analytical Integration.....	7-109
7.13.2.1.4	Physical Checkout	7-109
7.13.2.2	Payload Training.....	7-110
7.13.2.3	Operations Preparation and Integration	7-110
7.13.2.4	Certification of Flight Readiness	7-110
7.13.2.5	Ground Processing.....	7-111
7.13.2.6	On-Orbit Operations	7-111
7.13.2.7	Post-Flight Processing	7-111
7.14	Payload Documentation	7-112
7.14.1	Russian Segment Payload Documentation	7-112
7.14.1.1	Technical Specification for the Experiment: TS-EX (xxx-yyy-100)	7-112
7.14.1.2	Technical Specification for the Equipment: TS-EQ (xxx-yyy-200)	7-113
7.14.1.3	Technical Description: TD (xxx-yyy-201)	7-113
7.14.1.4	Operations and Maintenance Manual: OM (xxx-yyy-202).....	7-114
7.14.1.5	Acceptance Test Programme: ATP (xxx-yyy-203).....	7-114
7.14.1.6	Equipment Incoming Inspection Manual (xxx-yyy-204).....	7-115
7.14.1.7	Qualification Test Programme (xxx-yyy-205).....	7-115
7.14.1.8	Qualification Test Report (xxx-yyy-206)	7-115
7.14.1.9	Safety Assessment Reports and Certificates (xxx-yyy-207).....	7-116
7.14.1.10	Crew Training Documentation and Inputs to Crew Procedures (xxx-yyy-208).....	7-116
7.14.1.11	Ground Test Equipment/Checkout Equipment (xxx-yyy-209).....	7-117
7.14.1.12	Passport (Logbook) for the Equipment (xxx-yyy-200PS).....	7-117
7.14.1.13	Requirements to the Contents of Electrical Circuit Diagrams (xxx-yyy-210-Annex 1 & 2) 7-118	
7.14.1.14	Requirements to the Contents of Outline Installation Drawings (xxx-yyy-211).....	7-118
7.14.2	USOS Payload Documentation.....	7-118
7.14.2.1	Payload Integration Agreement (PIA)	7-119
7.14.2.2	Payload Data Sets	7-119
7.14.2.2.1	Payload Training Data Set.....	7-119
7.14.2.2.2	Ground Data Services (GDS) Data Set.....	7-119
7.14.2.2.3	Payload Operations Data Set	7-119
7.14.2.2.4	Launch/Landing Site Support, Integration and Technical Requirements Data Set.....	7-120
7.14.2.2.5	Payload Configuration (Drawing) Data Set.....	7-120
7.14.2.2.6	Payload Planning Data Set	7-120
7.14.2.2.7	Payload Procedures and Displays Data Set	7-120
7.14.2.2.8	Command and Data Handling Data Set.....	7-121
7.14.2.3	Interface Control Documents	7-121



7.14.2.3.1	Payload Hardware Interface Control Document.....	7-121
7.14.2.3.2	Payload Software Interface Control Document.....	7-121
7.14.2.4	Payload Verification Plans.....	7-121
7.14.2.5	Safety Data Packages.....	7-122
7.14.2.5.1	Flight Safety Data Packages.....	7-122
7.14.2.5.2	Ground Safety Data Packages.....	7-122
7.15	Operational Cycle of an ISS Payload.....	7-123
7.15.1	Russian Segment Payload Operational Cycle.....	7-123
7.15.2	USOS Payload Utilisation/Operational Cycle.....	7-125
7.16	References.....	7-126
8	ACRONYMS	8-1
9	FACT SHEETS	9-1

LIST OF FIGURES

Figure 1-1: Low gravity magnitude and duration for the 5 ESA-sponsored platforms	1-3
Figure 1-2: Fields of research applicable to the 5 ESA-sponsored platforms	1-4
Figure 1-3: Payload development & integration times for the five ESA-sponsored low gravity platforms	1-5
Figure 1-4: Erasmus Experiment Archive (EEA) home page	1-7
Figure 1-5: Erasmus User Centre Drop Tower demonstrator	1-8
Figure 3-1: ZARM Drop Tower External View	3-2
Figure 3-2: ZARM drop tower interior layout	3-3
Figure 3-3: Typical accelerations immediately after release of capsule (Image: ZARM)	3-5
Figure 3-4: Residual accelerations during the drop (Image: ZARM)	3-6
Figure 3-5: Fourier spectrum of accelerations (after end of release transition) (Image: ZARM)	3-6
Figure 3-6: Typical deceleration plot (Image: ZARM)	3-7
Figure 3-7: Research fields carried out in the Drop Tower, based on past experiments	3-8
Figure 3-8: Standard drop capsule – Long version (with and without pressurising cover)	3-10
Figure 3-9: Dimensions of the Short and Long drop capsules	3-11
Figure 3-10: Experiment platform	3-12
Figure 3-11: Laser diagnostic capsule. Payload area limited to a height of 1300mm	3-17
Figure 3-12: Typical timeline for an experiment in a drop tower campaign	3-19
Figure 3-13: Drop Tower utilisation/operational cycle	3-21
Figure 4-1: Airbus A300 "ZERO G"	4-2
Figure 4-2: Airbus A300 "Zero G" internal side and upper views	4-3
Figure 4-3: Airbus A300 "ZERO G" Testing area	4-3
Figure 4-4: Cross-section of aircraft cabin with position of attachment rails	4-4
Figure 4-5: Airbus A-300 Zero-G flight area and alternate landing airports	4-5
Figure 4-6: Parabolic flight manoeuvre profile	4-6
Figure 4-7: Parabolas sequence	4-6
Figure 4-8: Aircraft coordinate reference system	4-7
Figure 4-9: Research fields carried out on Parabolic Flights, based on past experiments	4-9
Figure 4-10: Typical timeline for an experiment on a parabolic flight campaign	4-20
Figure 4-11: Parabolic flight operational cycle	4-24
Figure 5-1: MiniTEXUS sounding rocket	5-4
Figure 5-2: TEXUS sounding rocket	5-6
Figure 5-3: MASER rocket	5-8
Figure 5-4: MAXUS Sounding Rocket	5-10
Figure 5-5: ESA sponsored sounding rocket maximum altitudes compared to Shuttle and ISS	5-11
Figure 5-6: MiniTEXUS Flight Profile and major events	5-13
Figure 5-7: TEXUS and MASER Flight Profile and major events	5-15
Figure 5-8: MAXUS Flight Profile and major events	5-17
Figure 5-9: Impact areas for rockets launched from Esrange (Image: SSC)	5-18
Figure 5-10: Acceleration (g levels) measured along the flight-path axis during the ascent phase of the MAXUS 5 mission	5-19
Figure 5-11: Acceleration (milli g) measured along the flight-path axis during the microgravity phase of the MAXUS 3 mission	5-20
Figure 5-12: Research fields carried out on Sounding Rockets, based on past experiments	5-21
Figure 5-13: Generic Sounding Rocket campaign ground segment layout	5-37
Figure 5-14: Typical timeline for an experiment on a sounding rocket flight campaign	5-42
Figure 5-15: Sounding rocket campaign operational cycle	5-46
Figure 6-1: Schematic of Foton capsule (without protective covers and blanketing)	6-2
Figure 6-2: In-flight schematic of Foton spacecraft (with protective covers and blanketing)	6-2
Figure 6-3: Foton spacecraft structural layout	6-3
Figure 6-4: The service module of the Foton capsule (top part is a cutaway view)	6-4
Figure 6-5: The battery module of the Foton capsule (top part is a cutaway view)	6-4
Figure 6-6: The re-entry module of the Foton capsule (top part is a cutaway view)	6-5
Figure 6-7: Soyuz U (11A511U) launch vehicle	6-6

Figure 6-8: The locations of the Plesetsk and Baikonur cosmodromes.....	6-7
Figure 6-9: FOTON launch and orbit insertion.....	6-8
Figure 6-10: Re-entry sequence of the Foton capsule.....	6-9
Figure 6-11: Landing sequence of the Foton re-entry capsule.....	6-9
Figure 6-12: Map of Kazakhstan Region.....	6-10
Figure 6-13: Baikonur Cosmodrome layout and main infrastructure.....	6-11
Figure 6-14: Landing area for Baikonur launches (Image: R. Demets).....	6-12
Figure 6-15: Research fields carried out on Foton capsules, based on past experiments.....	6-15
Figure 6-16: Foton payload envelope and orientation (Image: A. Verga).....	6-16
Figure 6-17: Type III container.....	6-18
Figure 6-18: Landing shock (Image: A. Verga).....	6-20
Figure 6-19: Open Biopan facility before installation on Foton (Image: R. Demets).....	6-23
Figure 6-20: Biopan location.....	6-24
Figure 6-21: Biopan cross-section and dimensions.....	6-25
Figure 6-22: Exploded schematic of Fluidpac facility.....	6-28
Figure 6-23: Foton M2 telemetry distribution architecture.....	6-31
Figure 6-24: Typical timeline for the concept, design and development of an experiment for a Foton mission.....	6-37
Figure 6-25: Schematic of the FOTON operational cycle.....	6-40
Figure 7-1: Space Station concept – January 1984 (Image: NASA).....	7-1
Figure 7-2: Space Station "Freedom" concept – 1988 (Image: NASA).....	7-2
Figure 7-3: Space Station "Fred" Concept – 1991 (Image: NASA).....	7-2
Figure 7-4: International Space Station Configuration at 1998 IGA signing. (Image: NASA).....	7-3
Figure 7-5: ISS at Assembly Complete and at May 2005.....	7-6
Figure 7-6: Exploded view of ISS Assembly Complete Configuration.....	7-12
Figure 7-7: ISS Programme Launch Vehicles (Image: ESA Ducros).....	7-14
Figure 7-8: ISS Transfer Vehicles (Image: ESA Ducros).....	7-17
Figure 7-9: ISS altitude history November 1998 - May 2005 (Image: NASA).....	7-18
Figure 7-10: Example of ISS ground tracks (shaded area refers to night time areas) (Image: NASA).....	7-19
Figure 7-11: ISS Body Coordinate System.....	7-20
Figure 7-12: LVLH reference system.....	7-20
Figure 7-13: XPOP Reference Coordinate System.....	7-21
Figure 7-14: XVV attitude.....	7-22
Figure 7-15: XPOP Attitude.....	7-23
Figure 7-16: YVV Attitude of the ISS.....	7-24
Figure 7-17: Example Operational Modes Timeline.....	7-28
Figure 7-18: ISS "iso-g" contours - XZ plane.....	7-30
Figure 7-19: ISS "iso-g" contours - YZ plane.....	7-30
Figure 7-20: Payloads + Vehicle Vibratory Acceleration limits.....	7-31
Figure 7-21: Accelerometer locations for stage 11A of the assembly sequence (Image: NASA).....	7-33
Figure 7-22: NASA MAC demo page for ISS UF5 configuration (Image: NASA).....	7-35
Figure 7-23: ISS Interior Noise Criteria Curves.....	7-38
Figure 7-24: Internal layout of Columbus racks.....	7-61
Figure 7-25: International Standard Payload Rack (ISPR): 6-post configuration.....	7-63
Figure 7-26: ISPR 6-post configuration dimensions – Front and Side View.....	7-63
Figure 7-27: Centre Aisle Payload Attachment and Standard Utility Panel (SUP) Locations.....	7-64
Figure 7-28: SUP panel layout.....	7-65
Figure 7-29: Rack configuration at Assembly Complete.....	7-66
Figure 7-30: Middeck Locker (MDL) Dimensions and Layout.....	7-67
Figure 7-31: International Subrack Interface Standard (ISIS) drawer.....	7-68
Figure 7-32: Exploded view of Columbus External Payload Facility (CEPF) on the Columbus starboard end cone.....	7-69
Figure 7-33: Columbus overall envelope with integrated external payloads.....	7-70
Figure 7-34: CEPF accommodation structure.....	7-71
Figure 7-35: Detailed view of CEPF accommodation with passive FRAM and MSP.....	7-71
Figure 7-36: External payload/Columbus module interface plane definition.....	7-72
Figure 7-37: Columbus External Payload Adapter (CEPA) Assembly.....	7-73
Figure 7-38: CEPA assembly envelope.....	7-74
Figure 7-39: CEPF integrated external payload envelope.....	7-76

Figure 7-40: External sites configuration on the Japanese Exposed Facility (JEF)	7-77
Figure 7-41: External sites configuration on the Starboard Truss (S3) (Image: ESA Ducros)	7-77
Figure 7-42: Geographical distribution of European USOCs.....	7-86
Figure 7-43: Russian Segment Payloads milestones and documentation.....	7-102
Figure 7-44: USOS Payloads Milestones and Documentation.....	7-107
Figure 7-45: Schematic of the operational cycle for a Soyuz-transported ISS payload	7-124
Figure 7-46: Schematic of a generic USOS ISS payload utilisation/operational cycle.....	7-125

LIST OF TABLES

Table 3-1: Drop tower environment pressure parameters	3-4
Table 3-2: Technical data of the thermostat	3-4
Table 3-3: Masses and dimensions of drop capsule	3-9
Table 4-1: Electrical power available to users in test section.....	4-14
Table 4-2: Major events in a parabolic flight campaign operational cycle.....	4-23
Table 5-1: Main characteristics of sounding rockets used by ESA	5-2
Table 5-2: MiniTEXUS sounding rocket characteristics	5-3
Table 5-3: TEXUS sounding rocket characteristics	5-5
Table 5-4: MASER sounding rocket characteristics	5-7
Table 5-5: MAXUS sounding rocket characteristics.....	5-9
Table 5-6: MiniTEXUS principal mission events	5-12
Table 5-7: TEXUS and MASER principal mission events	5-14
Table 5-8: MAXUS principal mission events	5-16
Table 5-9: Materials Sciences Experiment Modules	5-23
Table 5-10: Fluid Sciences Experiment Modules	5-25
Table 5-11: Life Sciences Experiment Modules	5-29
Table 5-12: Combustion Experiment Modules	5-31
Table 5-13: Fundamental Physics Experiment Modules.....	5-31
Table 5-14: Major events in a sounding rocket campaign operational cycle	5-45
Table 6-1: Soyuz U principal characteristics.....	6-6
Table 6-2: Daily Solar Constant Hour (SCh) recordings on past missions	6-14
Table 6-3: Dimensions of Type III container	6-17
Table 6-4: Sinusoidal testing vibrations.....	6-19
Table 6-5: Random testing vibrations	6-20
Table 6-6: Landing shock test levels.....	6-20
Table 6-7: Biopan experiment envelope and mass.....	6-25
Table 6-8: Major events in the Foton operational cycle	6-39
Table 7-1: Principal ISS parameters at Assembly Complete and as of May 2005	7-5
Table 7-2: ISS Pressurised Laboratory Modules.....	7-7
Table 7-3: Elements dedicated to exposed payloads.....	7-8
Table 7-4: Structural and Logistic elements/modules.....	7-9
Table 7-5: ISS Programme Launch Vehicles	7-13
Table 7-6: ISS Programme Transfer Vehicles.....	7-15
Table 7-7: ISS Operational Modes.....	7-26
Table 7-8: PIMS acceleration data analysis techniques	7-34
Table 7-9: Characteristics of internal cabin atmosphere	7-36
Table 7-10: Payload required illumination levels.....	7-37
Table 7-11: Interior hardware colours and finishes.....	7-37
Table 7-12: Hot and Cold Natural Thermal Environments	7-40
Table 7-13: Fundamental Physics Research Cornerstones (2002-2006).....	7-44
Table 7-14: Fluid and Combustion Physics Research Cornerstones (2002-2006)	7-44
Table 7-15: Materials Sciences Research Cornerstones (2002-2006).....	7-45
Table 7-16: Biology Research Cornerstones (2002-2006).....	7-46
Table 7-17: Physiology Research Cornerstones (2002-2006).....	7-47
Table 7-18: Astro/Exobiology, Planetary Exploration Research Cornerstones (2002-2006).....	7-48
Table 7-19: Baseline International Partner utilisation allocations (excluding Russia).....	7-52
Table 7-20: Global ISS utilisation capabilities.....	7-53
Table 7-21: European Research and Accommodation Facilities.....	7-54
Table 7-22: ESA Russian flight opportunities deriving from ESA/Roscosmos Framework Agreement (May 2001)	7-59
Table 7-23: Characteristics of JAXA International Standard Payload Rack (ISPR).....	7-62
Table 7-24: Standard Utility Panel connector allocation and function.....	7-65
Table 7-25: Middeck Locker Characteristics	7-68

Table 7-26: ISIS Drawer Characteristics.....	7-69
Table 7-27: Columbus to external payload system interfaces.....	7-75
Table 7-28: ESA Sponsored pressurised (internal) facilities for the ISS Utilisation programme	7-78
Table 7-29: ESA Sponsored unpressurised (external) facilities for the ISS Utilisation programme.....	7-79
Table 7-30: ESA Sponsored infrastructural support equipment for the ISS Utilisation programme.....	7-79
Table 7-31: Assignment of USOCs to Payloads	7-88
Table 7-32: Major events in the operational cycle of an ISS Russian Segment payload	7-123

ACKNOWLEDGEMENTS

We would like to thank the following people for their support and contribution to the production of the European Users Guide to Low Gravity Platforms:

(in alphabetical order)

M. Belingheri	(HME-EC, ESA Noordwijk, The Netherlands)
G. Bertoli	(HME-EC, ESA Noordwijk, The Netherlands)
R. Binot	(HME-GA, ESA Noordwijk, The Netherlands)
D. Castagnolo	(MARS Center, Naples, Italy)
R. Demets	(HME-GM, ESA Noordwijk, The Netherlands)
C. Eigenbrod	(ZARM, Bremen, Germany)
F. Gai	(NOVESPACE, Paris, France)
T. Gharib	(NOVESPACE, Paris, France)
J-C. Grenouilleau	(HME-EOI, ESA Noordwijk, The Netherlands)
T. Heimann	(HME-GQ, ESA Noordwijk, The Netherlands)
W. Herfs	(HME-GE, ESA Noordwijk, The Netherlands)
U. Kaczmarczik	(ZARM, Bremen, Germany)
K. MacDonell	(HME-A, ESA Cologne, Germany)
C. Mirra	(HME-EPI, ESA Noordwijk, The Netherlands)
C. Mora	(NOVESPACE, Paris, France)
S. Peppin	(HME-EP, ESA Noordwijk, The Netherlands)
V. Pletser	(HME-GML, ESA Noordwijk, The Netherlands)
A. Verga	(HME-GMS, ESA Noordwijk, The Netherlands)
J. Winter	(HME-GM, ESA Noordwijk, The Netherlands)
M. Zell	(HME-G, ESA Noordwijk, The Netherlands)






A special thank you to:

G. De Chiara (*MARS Center, Naples, Italy*) for his valuable contribution of graphical images included in this guide;

J. Myrrhe and W. Carey (*HME-HE, ESA Noordwijk, The Netherlands*) for preparing the Fact Sheets accompanying this document;

D. Ducros (*Active Design, Toulouse, France*) for his illustrations, which are an integral part of the Fact Sheets.

A P P R O V A L

	Name	Signature
Compiled/Authoried by:	Enrico Ceglia (HME-HE)	
Compiled/Edited by:	William Carey (HME-HE)	
Approved by:	Dieter Isakeit (HME-HE)	
Approved by:	Martin Zell (HME-G)	
Approved by:	Manuel Valls (HME-H)	
Approved by:	Daniel Sacotte (D/HME)	