4 PARABOLIC FLIGHTS

This section is aimed at providing new and experienced users with basic utilisation information regarding Parabolic Flights on the ESA-CNES Airbus A-300 Zero-G aircraft managed by Novespace. It begins with a brief description of parabolic flights.

4.1 Introduction to Parabolic Flights

4.1.1 What Are Parabolic Flights?

Parabolic flights are aircraft flights conducted with a specific mission profile using specially configured aeroplanes. These aircraft execute a series of manoeuvres, called parabolas, each providing up to 20 seconds of reduced gravity or weightlessness, during which scientists are able to perform experiments and obtain data that would otherwise not be possible on Earth. During a flight campaign there are typically 3 flights (usually carried out on separate days), with around 31 parabolas being executed per flight. For each parabola, there are also 2 periods of increased gravity (~ 1.5 to 1.8 g), which last for 20 seconds immediately prior to and following the 20 seconds of weightlessness. Parabolic flights are the only sub-orbital carriers that provide users with the opportunity to execute research on human subjects under conditions of weightlessness, complementing studies conducted in space, and on the ground under simulated weightless conditions.

4.1.2 What Do Parabolic Flights Offer?

Parabolic flights provide:

- 93 parabolas per campaign, each with approximately 20 seconds of weightlessness;
- A level of low gravity of the order of 10^{-2} g;
- An ideal opportunity for precursor research in preparation for long-duration missions;
- An ideal environment for new experiments;
- An ideal opportunity for carrying out tests of experiment-critical phases;
- An ideal situation to test safety aspects;
- A short time between experiment proposal and execution (of the order of months);
- A low cost research opportunity;
- The possibility of executing a series of experimental runs within 3 days;
- A flexible research approach, i.e. typical laboratory-type instrumentation is used;
- Possibility of direct intervention by the research team on their experiments during flight;
- The possibility to modify the experimental set-up by the research team between flights.

4.1.3 Why Use Parabolic Flights?

Parabolic flights are a low-cost research opportunity, which offer an ideal research platform for:

- Users who are new to microgravity experimentation;
- Users who want preliminary data before submitting a long duration mission proposal;
- Users who wish to test their hardware in preparation for a long duration mission;
- Research involving human subjects;
- Student experiments.

4.1.4 Principal Characteristics of the Airbus A-300 “Zero-G”

Since 1997, ESA has been using the Airbus A-300 “Zero-G” based at the Bordeaux-Mérignac airport. This aircraft is managed by the French company Novespace, contracted by ESA to provide support to all parabolic flight operations. The following is a list of the main characteristics and features of the A-300 “Zero-G” aircraft, the largest parabolic flight aircraft in the world:

- The aircraft is a two-engined modified Airbus A-300;
- It is based at the Aéroport International de Bordeaux–Mérignac;
- Aircraft mass – approximately 145 tonnes;
- Overall length – 54 metres;
- Wingspan – 44 metres;
- Fuselage diameter – 5. 64 metres;
- Total cabin volume – 300 m^3;
- Dimensions of testing volume inside cabin – 20 x 5 x 2.3 metres (L x W x H);
- Total testing volume – 230 m^3;
- The cabin walls, floor and ceiling are specially padded;
- The interior is continuously illuminated by neon lights;
- The aircraft can accommodate 40 passengers;
- There are 6 passenger doors, but only 2 are used;
- The door through which equipment is loaded has a height of 1.93 metres and a width of 1.07 metres. For experiments larger than this, the equipment must be designed to be taken apart.

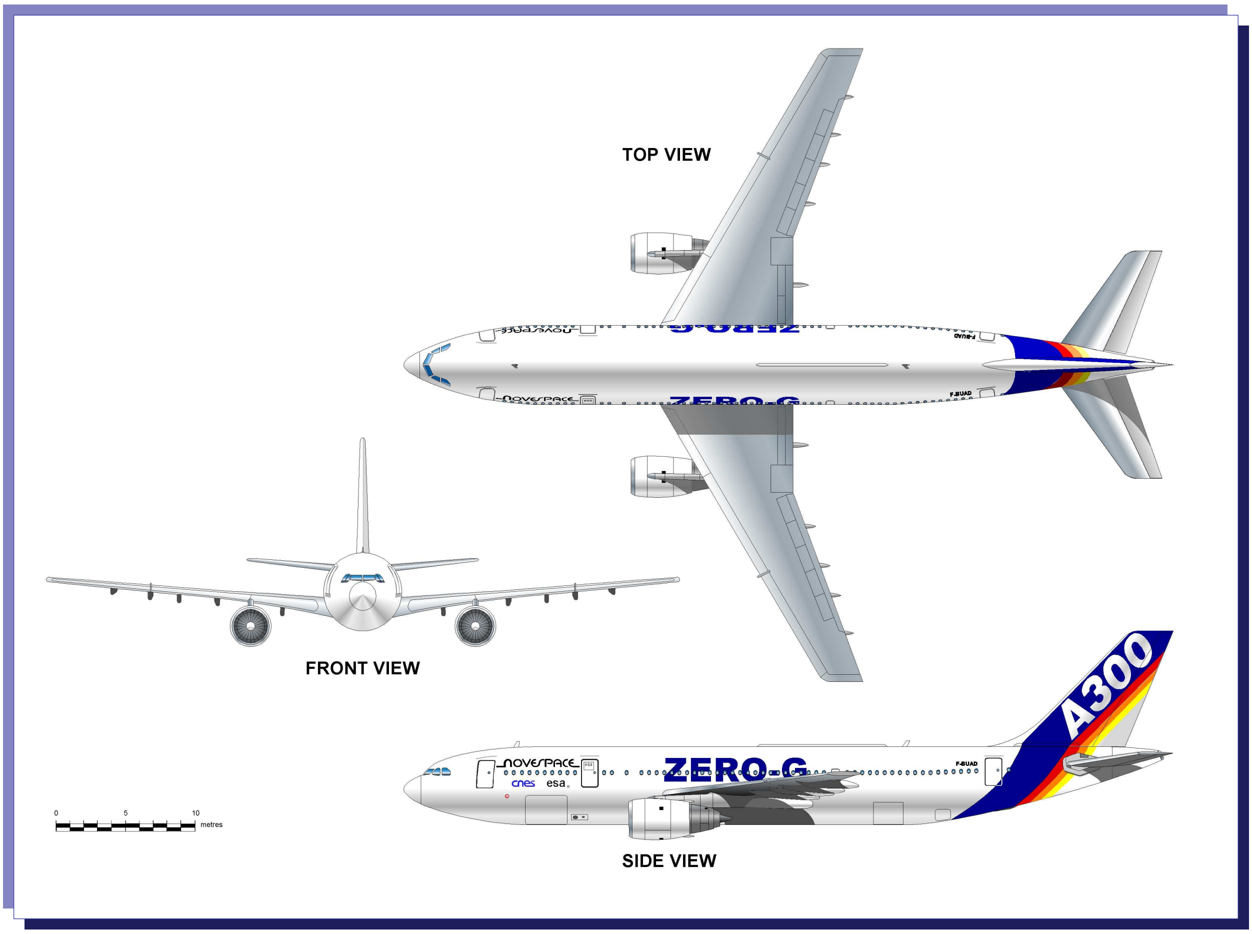

Figure 4-1: Airbus A300 "ZERO G"

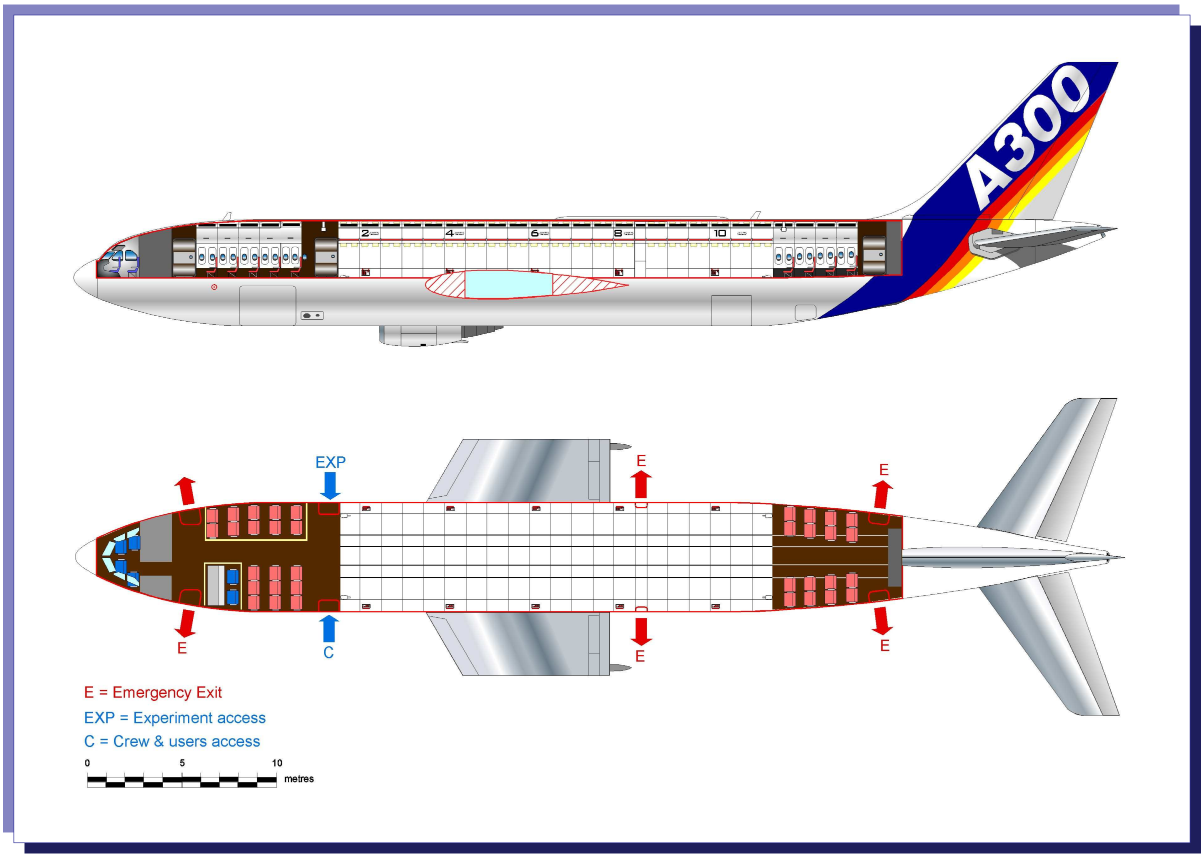

Figure 4-2: Airbus A300 "Zero G" internal side and upper views

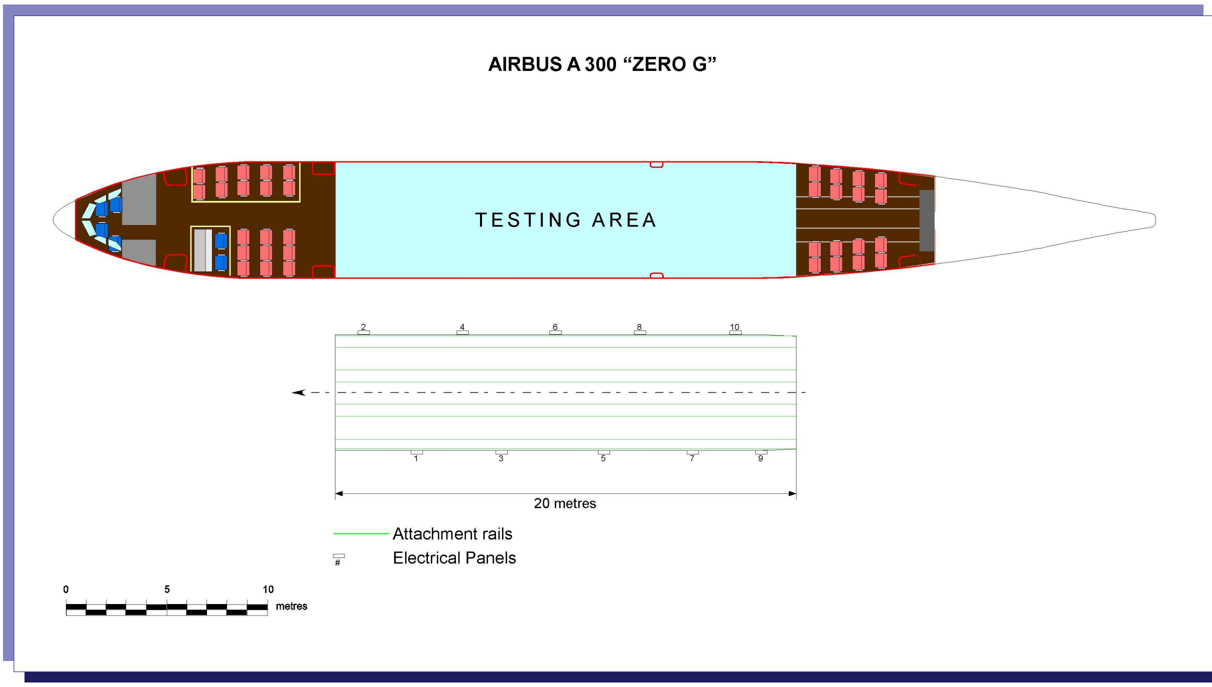

Figure 4-3: Airbus A300 "ZERO G" Testing area

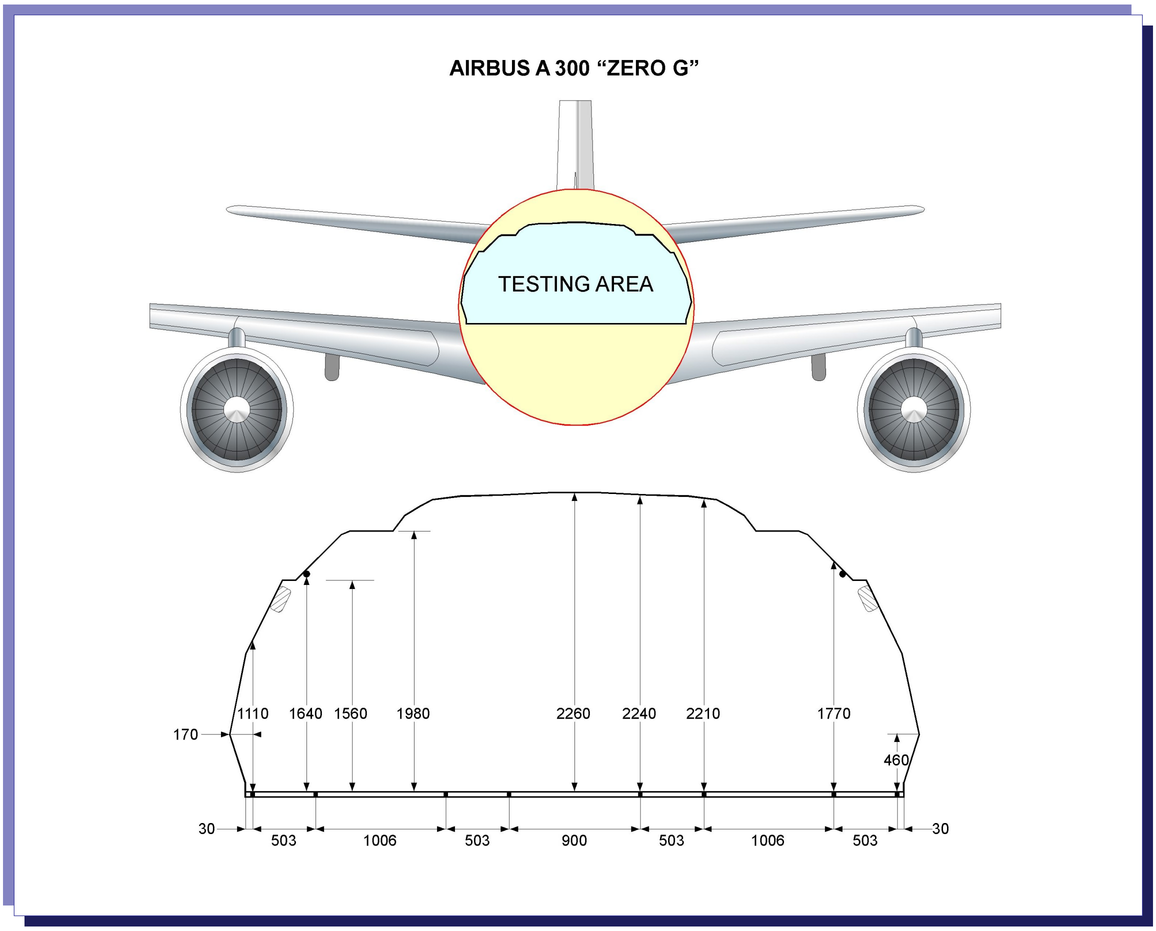

Figure 4-4: Cross-section of aircraft cabin with position of attachment rails

4.1.5 Parabolic Flight Manoeuvres

The Airbus A-300 Zero-G parabolic flight campaigns are based at the Bordeaux-Mérignac airfield in France. If unfavourable weather conditions, or other problems, are encountered during flight, several alternate airfields can be used by the aircraft for landing. These airfields, marked in red, can be seen in Figure 4-5. The figure also shows the zero-g and test area boundaries within which the aircraft must remain.

The Airbus A-300 generally executes a series of 31 parabolic manoeuvres during a flight. Each manoeuvre (see Figure 4-6) begins with the aircraft flying in a steady horizontal attitude, with an approximate altitude and speed of 6000 metres and 810 km/h respectively. During this steady flight the gravity level is 1g.

At a set point, the pilot gradually pulls up the nose of the aircraft and it starts climbing at an angle. This phase lasts for about 20 seconds, during which the aircraft experiences an acceleration of between 1.5 and 1.8 times the gravity level at the surface of the Earth, i.e. 1.5 – 1.8 g.

At an altitude of 7500 metres, with an angle of around 47 degrees to the horizontal and with an air speed of 650 km/h, the engine thrust is reduced to the minimum required to compensate for air-drag. At this point the aircraft follows a free-fall ballistic trajectory, i.e. a parabola, lasting approximately 20 seconds, during which weightlessness is achieved. The peak of the parabola is achieved at around 8500 metres, at which point the speed has dropped to about 390 km/h.

At the end of the weightless period, i.e. again at 7500 m, the aircraft must pull out of the parabolic arc, a manoeuvre which gives rise to another 20-second period of approximately 1.8 g on the aircraft. At the end of these 20 seconds the aircraft again flies a steady horizontal path at 1g, maintaining an altitude of 6000m.

The period between the start of each parabola is 3 minutes, i.e. a 1-minute parabolic phase (20 seconds at 1.8g + 20 seconds of weightlessness + 20 seconds at 1.8g), followed by a 2-minute period at steady level 1g flight.

Parabolas are executed in sets of 5. At the end of each set, a longer time is allowed to elapse (4, 5 or 8 minutes – see Figure 4-7) to allow experimenters enough time to carry out modifications to their experiment set-up. During the flight, the pilot makes announcements through the cabin speakers regarding times, angles, pull-up, injection and pull-out.

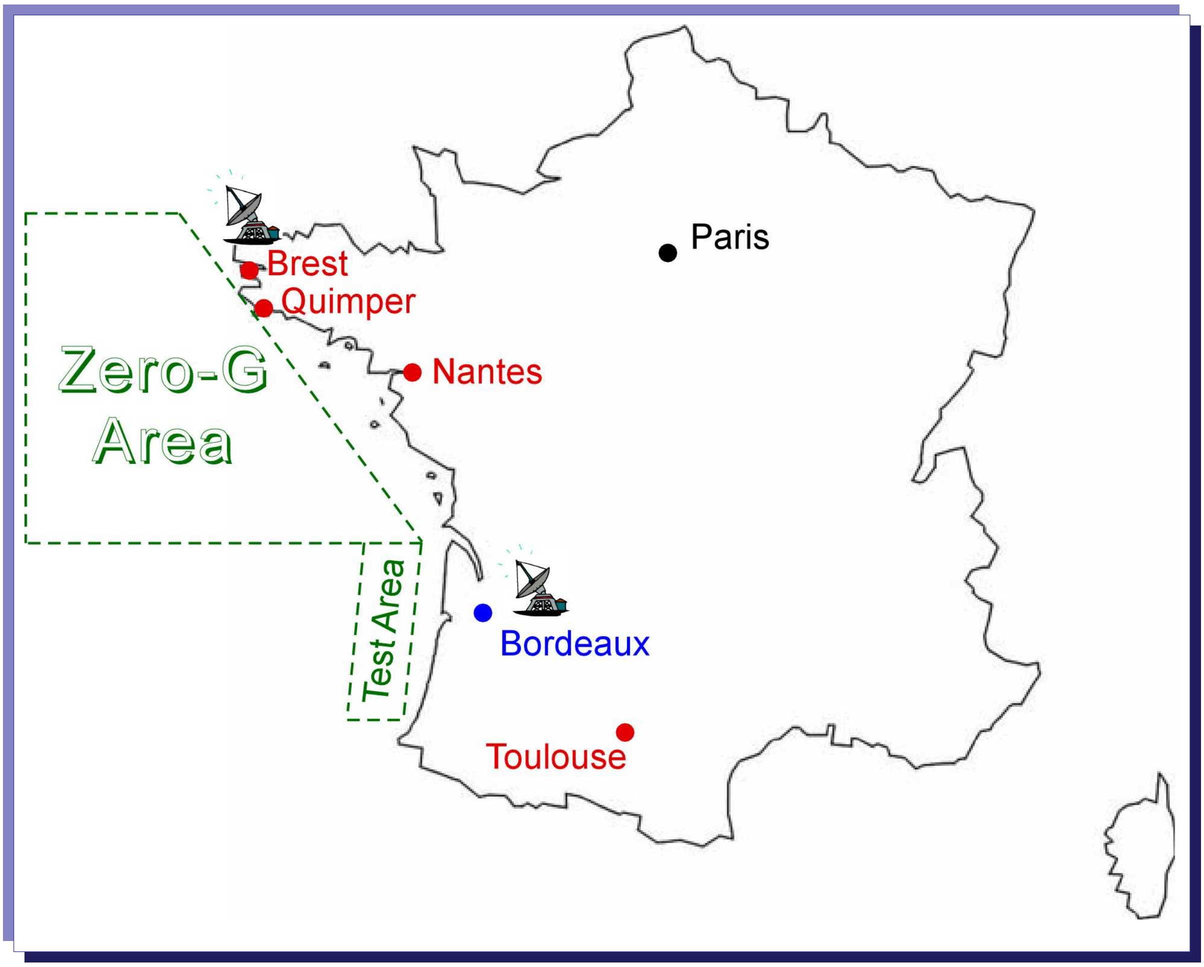

Figure 4-5: Airbus A-300 Zero-G flight area and alternate landing airports

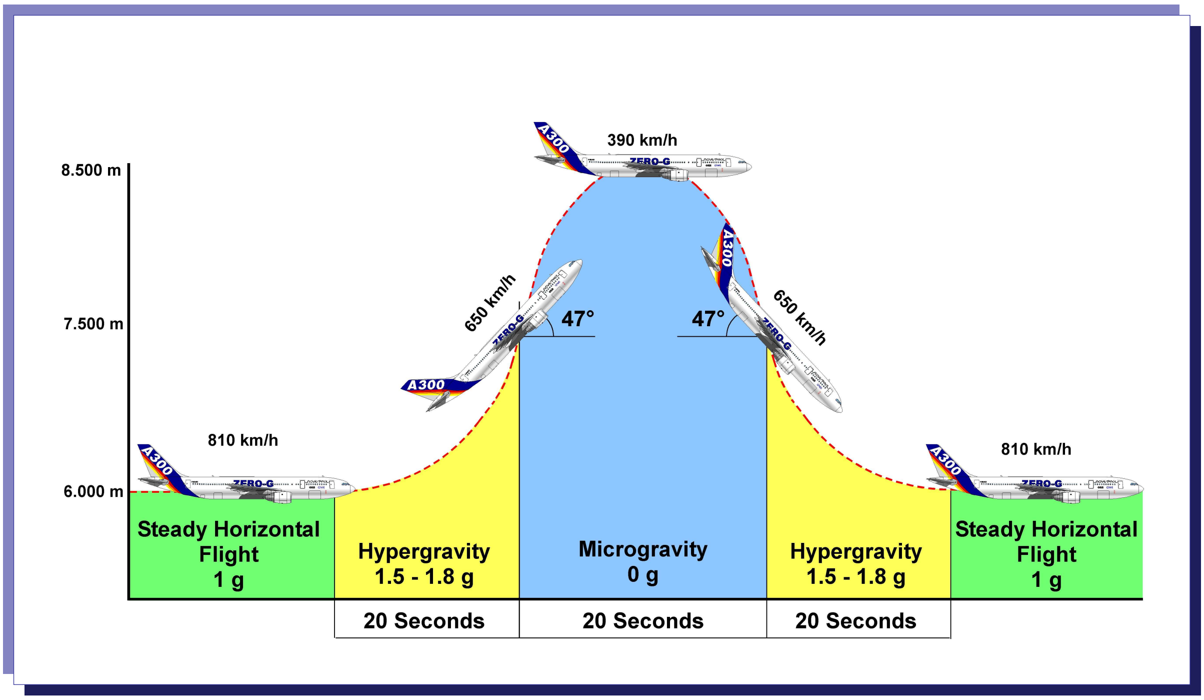

Figure 4-6: Parabolic flight manoeuvre profile

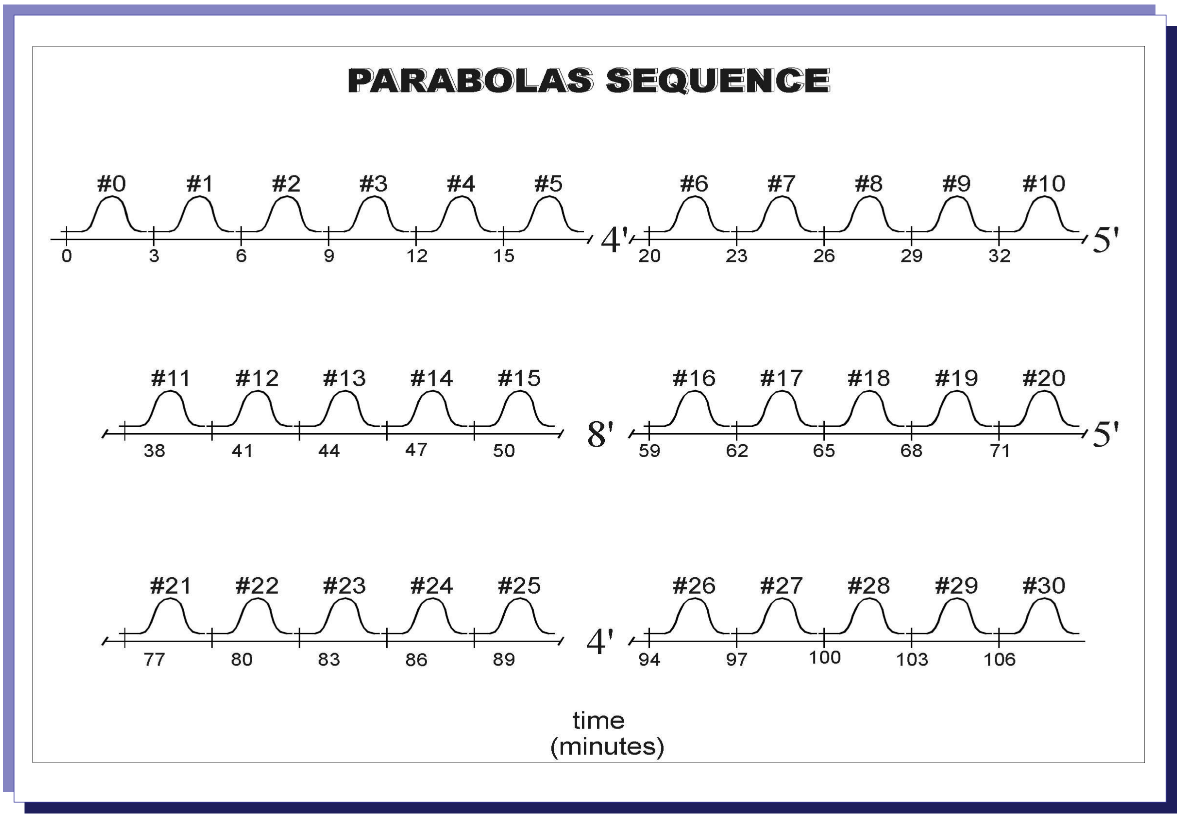

Figure 4-7: Parabolas sequence

4.2 Physical Environment

4.2.1 Cabin Pressure

The cabin pressure is maintained at around 800mbar (i.e. 0.79 atmospheres or 79 % of the pressure at sea level) during parabolic manoeuvres. Users should however design their test equipment for operation in a lower pressure environment due to possible loss of cabin pressure.

4.2.2 Cabin Temperature

During flight the cabin temperature is controlled and maintained between 18 and 25 °C. Users should note, however, that while the plane is on the ground, the cabin temperature is not controlled.

4.2.3 Illumination

Neon lights illuminate the test section, and are usually sufficient for photographic and video equipment.

4.2.4 Acceleration Levels

During the approximately 20 seconds of weightlessness experienced in a parabolic manoeuvre, the residual gravity level for any equipment attached to the interior of the aircraft cabin varies between -5×10^{-2} g and $+5 \times 10^{-2}$ g along the z-axis (see Figure 4-8) and between -10^{-2}g and $+10^{-2}$g along x and y.

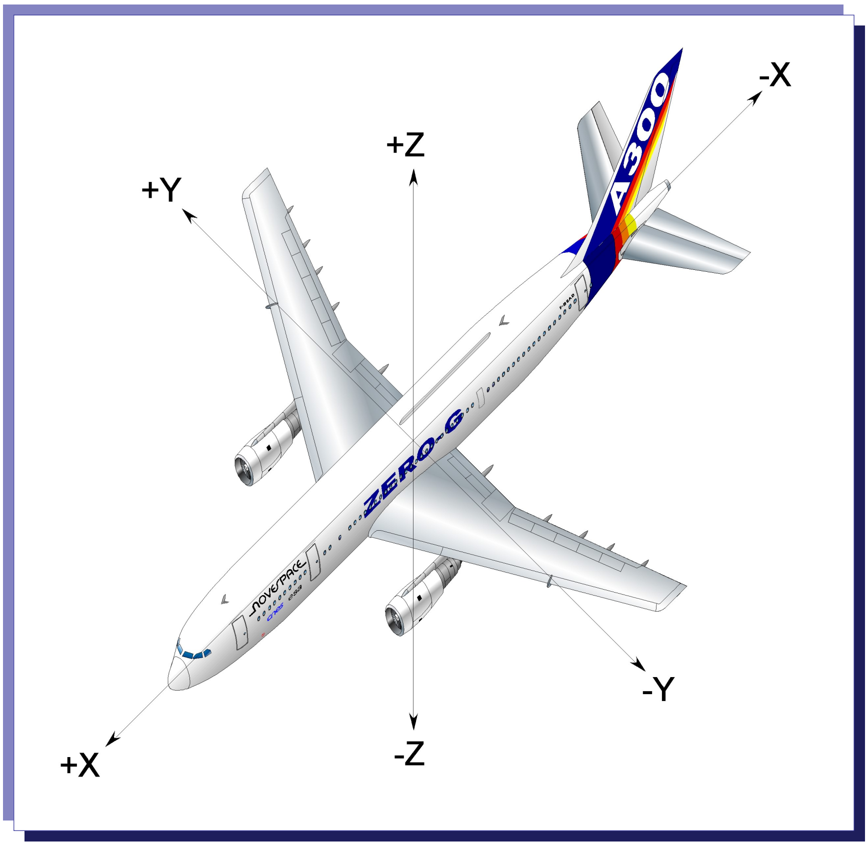

Figure 4-8: Aircraft coordinate reference system

Free-floating objects within the cabin may experience a higher quality of microgravity (approximately 10^{-3}g) for periods of up to 5-10 seconds, until they come into contact with the cabin walls. This free-float technique requires the support of at least one member of the safety crew.

In some cases upon special request, and only if technically possible, non-standard piloting techniques can be implemented to obtain specific types of gravity, e.g. minimising negative gravity values. Users who require non-standard techniques should contact ESA and Novespace as early as possible, since these may require extra costs on-behalf of the user as well as special training and material. Users should however note that these techniques might result in parabolas with a shorter duration.

4.3 Scientific and Technological Research Suitable to Parabolic Flights

The following blocks (Figure 4-9) highlight the various scientific fields, which are suitable for research on parabolic flights. It is important to note, however, that these fields are based on the data from current and past research carried out on parabolic flights, and should therefore NOT be considered exhaustive by the user. Scientists should view the fields presented below as a guide, but are encouraged to propose new research areas, as long as their experiments can be executed within parabolic flight limitations.

FUNDAMENTAL PHYSICS

Complex plasmas and dust particle physics
- Aerosol particle motion
- Frictional interaction of dust and gas
- Plasma physics
- Aggregation phenomena

FLUID AND COMBUSTION PHYSICS

Combustion
- Droplet and spray combustion
- Soot concentration
- Combustion synthesis
- Laminar diffusion flames
- Fuel droplet evaporation
- Ignition behaviour

Structure and dynamics of fluids & multiphase systems
- Pool boiling
- Heat and mass transfer
- Dynamics of drops and bubbles
- Thermophysical properties
- Interfacial phenomena
- Dynamics and stability of fluids
- Evaporation
- Complex dynamic systems
- Diffusion
- Foams
- Chemo-hydrodynamic pattern formation

MATERIALS SCIENCE

Thermophysical properties
- Thermophysical properties of melts

New materials, products and processes
- Morphological stability and microstructures
- Physical chemistry
- Aggregation phenomena
- Granular matter

BIOLOGY

Plant Physiology
- Statolith movement
- Gravitropism
- Gravireceptors

Cell and developmental biology
- Animal physiology
- Ageing processes
- Electrophysiological and morphological properties of human cells
- Osteoblast cells

PHYSIOLOGY

Integrated physiology
- Cardiovascular function
- Respiratory function
- Body fluid shift
- Central venous pressure system
- Digestive system

Muscle and bone physiology
- Skeletal system
- Blood lactate studies
- Body mass tests
- Human locomotion
- Posture
- Bone models

Neuroscience
- Neurobiology
- Vestibular functions
- Spatial orientation
- Motion sickness
- Motor skills

TECHNOLOGY
- ISS Experiment validation
- Phase separation technologies – biological fluids
- Metal halide lamps
- Crew in-flight syringes
- Crew foot restraint
- Crew exercise devices
- Urine monitoring system

Figure 4-9: Research fields carried out on Parabolic Flights, based on past experiments

4.4 Payload Accommodation

Once users have completed the design phase of their experiment, they will be contacted by Novespace who will provide support regarding the equipment configuration design. Only then should users begin the development phase.

The contact details of Novespace are:

Thierry Gharib
Parabolic Flight Manager
NOVESPACE
Rue Marcel Issartier
33700 Mérignac
France
Tel: +33 (0) 5 56 34 05 99
Fax: +33 (0) 5 56 34 06 09
E-mail: t.gharib@novespace.fr

4.4.1 Structural Requirements

Users must design their equipment to withstand the following loads during the take-off and landing phases (refer to Figure 4-8):

- X-axis: 9g forward;
- X-axis: 1.5g aft;
- Y-axis: 3g port;
- Y-axis: 3g starboard;
- Z-axis: 4.2g up;
- Z-axis: 7.3g down.

Structural calculations for the take-off and landing configurations must be based on the yield strength of the materials used for developing the hardware. The in-flight test configuration must be designed for a possible 2.5g load at the parabolic manoeuvre entry and exit points. Free-floating equipment must be designed for a possible 2.5g load from any direction after a manoeuvre.

Each structural analysis must include at least the following:

- Structural drawings or diagrams;
- Results of stress calculations, with at least one sample calculation;
- Component masses and positions;
- Material properties.

Structural calculations must be submitted with the description of the experiments.
The experiment must also be designed to withstand vibrations and compression/decompression cycles corresponding to normal operation of the cabin pressure system, as well as sudden decompression resulting from a pressure system failure. Where necessary, it is recommended to test all equipment in an altitude chamber. Novespace will provide support to users for all of the above calculations.

4.4.2 Aircraft Rail Loading

Experiments are fastened to the aircraft rails on the floor by means of specially designed interfaces. A general rule is that the load on a rail should not be higher than 100 kg per metre. If one or more of the following statements are true for the experiment being built, then the users must contact Novespace in advance:

- The experiment mass exceeds 200 kg;

- The centre of gravity is higher than 670 mm (with respect to the floor of the aircraft);
- The distance between two fastening points on one rail is less than 508 mm;
- The experiment is longer than 3 m.

The maximum allowable loads for each fixation point are (refer to Figure 4-8):

- X-axis: 22500 N;
- Y-axis: 9000 N;
- Z-axis: 13300 N (positive direction);
- Z-axis: 17500 N (negative direction).

4.4.3 Equipment Attachment

The base of all equipment must be drilled with 12 mm holes so that they can be fastened to the attachment interfaces by means of H-head M10 screws (provided by Novespace). The distance between two holes on the same rail (i.e. along the x-axis) must be a multiple of 25.4 mm (1 inch). The distance between two directly opposing holes on separate rails (i.e. along the y-axis) must be either 503 mm or 1006 mm.

4.4.4 Free-Float Packages

As was mentioned previously, experiments can be of a free-floating type to obtain g-levels as close to zero as possible. These experiments should be as compact as possible, and should not have a mass of more than 10 kg. If a tether is used between the free-floating experiment and the floor-attached support equipment, this should be at least 2 metres in length. Users should contact Novespace for further details regarding free-floating experiments.

4.4.5 Pressure Vessels

If pressure vessels and pressurised systems are used, these must be certified as safe before operation and re-certified periodically if re-used. The certification or re-certification of all pressurised systems (including bottles) should not be more than 5 years old. Each pressure vessel and pressurised system must be designed to 2 times the maximum allowable working pressure (MAWP) and must be certified to 1.5 MAWP in accordance with applicable national consensus codes.

4.4.6 Electrical Systems

On a 220 V AC line, an 8 amps (maximum) rapid fuse on the experiment general electrical input must protect the aircraft power supply from electrical shorts originating from the experiments. On a 28 V DC line, a 20 amps (maximum) fuse should be implemented. Also, users must make sure that all test equipment is correctly grounded. Normal aircraft vibration, high humidity, handling and loads of more than 1g must be taken into account when selecting connectors and wiring. Unless specifically requested and properly monitored, all equipment is to remain switched off in the aircraft or in the ground laboratory outside of working hours. Users must make sure that during this period all batteries are disconnected. The 220V circuit should also be protected with a ground fault interrupter adjusted at 30 mA.

4.4.7 Hazardous Materials

Users should try to avoid using hazardous liquids and gases, including high pressure, toxic, corrosive, explosive and flammable materials. If such materials are necessary, in-flight dumping and purging may be required, therefore it is imperative that users contact Novespace as early as possible for support.

4.4.8 Emergency Shutdown

Users must include an emergency button in their experiment designs, which is able to cut off all experiment activities with only the flip of a switch or the push of a button. Furthermore, all equipment must be designed to remain unattended after an emergency shutdown, without causing any risks.

4.4.9 Safety

The parabolic flight programme is operated in accordance with stringent safety procedures established by the French "Centre d'Essais en Vol" (CEV). The exploitation in weightlessness is done under an exceptional "Laisser-Passer" signed by the General Direction of Civil Aviation in France. The flights are regarded as test flights and as such fall under the rules for test flights, under the authority of the CEV. Due to the critical nature of this programme, a multi-stage review and approval procedure has been developed to ensure flight safety.
In particular, the test experimenter must submit to Novespace relevant documents at different stages of the project (including experiment description and hazard analysis). In addition, all test personnel must follow Novespace requirements and attend a final safety review and safety visit prior to the flights.
It is necessary to contact Novespace as early as possible to eliminate any last minute surprises, which might cause delays. Relevant personnel will review and comment on preliminary drawings and plans at all stages of development. It should be noted that a flight will be conducted only after Novespace and CEV have been assured that a safe, well organised, and productive flight can be achieved.
During the flights, all personnel on board the aircraft will be under the direction of the aircraft flight crew and test directors for the entire duration of a campaign. The aircraft commander is the final authority for all operations from boarding to exiting. Strict adherence to the authority of test personnel will be rigidly enforced. Any deviation from the flight-test plan must be discussed with Novespace before its implementation.

4.4.9.1 Safety Visit

The Safety Visit is the final review prior to the start of the flight campaign. It includes a complete review of supporting analyses and documentation, an inspection of the test equipment, and a final verification of flight readiness. A safety visit is required for all new and modified test articles. A list of modifications to already-flown equipment and changes to any test procedures must be provided.
During the safety visit the test equipment will be either approved, or approved after pending corrections have been implemented, or denied for flight. A unanimous decision is required for flight approval. Test equipment, which has not been approved due to lacking conformity with any rules subject to the flight, may be scheduled for a subsequent review when deficient areas have been corrected.

4.4.10 Other General Guidelines

The following is a list of general guidelines to be kept in mind by users when designing and developing their equipment:

- All exposed edges and corners, whether sharp or not, must be protected by padding;
- Use of liquid electrolyte batteries is strictly prohibited. Use of Lithium batteries will be reviewed by Novespace on a case-by-case basis;
- Avoid use of flammable materials;
- Consider equipment or procedural failures. Provide safety arrangements or spare items to prevent such failures from becoming hazardous to personnel or the aircraft;
- Plan in-flight activities so as to minimise movement during the high gravity phases of the parabolic manoeuvres;
- Consider the need for handles for the weightless phase of the parabolas;
- Cover any glass monitors with Lexan or non-flammable Plexiglas.

4.4.11 Biomedical Experiments with Human Subjects

For all ESA campaigns, experiment protocols intending to use human subjects must be submitted at the latest 3 months before a campaign to the ESA Medical Board, who will review and eventually approve (or disapprove) the protocol.

These protocols should be sent to:

Dr. Volker Damann
Secretary of the ESA Medical Board
HME-AM
European Astronaut Centre (EAC)
Linder Hoehe
51147 Cologne
Germany
Tel: +49 2203 6001 400/1
Fax: +49 2203 6001 402
E-mail: volker.damann@esa.int

Once an experiment protocol has been approved, and if it is to be carried out during a flight that takes place over France (which is the case for the majority of ESA parabolic flight campaigns), it must include a specific protocol in French, which complies with the Huriet law (a law which protects subjects of biomedical experiments). This protocol must be submitted to the “Comité Consultatif pour la Protection des Personnes impliquées dans la Recherche Biomédicale” – CCPPRB (“Consultative Committee for the Protection of Persons involved in Biomedical Research”, a biomedical research "ethics" commission, composed of eighteen members including medical doctors, psychiatrists, social workers, etc.), which will review each protocol. Protocols in French are prepared by MEDES, a subsidiary of CNES, with whom ESA has a contractual agreement. The experiment coordinator will be asked to provide an insurance certificate, complying with French law, covering his liability in case of injury linked to the experiment. Users can request the assistance of MEDES to help them with the required procedures.

4.5 Available Flight Facilities and Resources

4.5.1 Electrical Power and Interfaces

The following electrical power is available to users in the test section of the aircraft cabin:

Table 4-1: Electrical power available to users in test section

TYPE	QUANTITY
220 volt AC, 50 Hz, single phase	2 kVA per electrical panel x 10 (20 kVA total)
28 volt DC	20 amps per electrical panel x 5 (100 amps total)
115-200 volt AC, 400 Hz, three phase	On early request only

The electrical test power is distributed to ten power distribution panels along the lower sidewalls of the cabin. All power and ground leads from the test equipment to the panels must be 6 m long. The 50 Hz AC power leads require the standard French grounded plug. The 28 V DC requires a Souriau 840-23-832 connector: terminal 1 = +28 V, terminal 2 = ground. For safety, all exposed power leads and electrical contacts must be covered. In specific cases and if available, power exceeding 2 kVA can be supplied. For this case a Souriau 840-45-810 connector and a Souriau 840-40-004 rear connector are necessary.
Momentary interruptions of power may occur during flight. Test equipment must include protection devices to avoid loss of data and to automatically place the experiment in a safe status.
Users must make sure that electrical instruments do not interfere with any of the aircraft's systems, and that they meet the safety standards for electromagnetic compatibility with on board equipment.

4.5.2 Overboard Vent System

It is prohibited for experiments to release gas, liquids or materials (even non-toxic), into the aircraft cabin. There are four connections located at the extremities of the test area, which allow for manual or automatic venting to the outer atmosphere. Connectors for venting purposes must correspond to the Pneurop 6606/1981 and DIN 28403, with diameters of DN 25 ISO-KF. Users must procure their own connectors and tubes. Novespace must be informed as early as possible of the elements that will be evacuated from the aircraft, as well as at what pressure and temperature they will be vented.

4.5.3 Data Recording and Accelerometers

During the campaign, Novespace records various sets of flight data including the acceleration levels. Also, users can, if available, request accelerometers from Novespace to connect to their experiments.

4.5.4 Safety and Emergency Procedures

During take-off and landing, users must be seated with their seat belts securely fastened. They can only unfasten their belts and leave their seats when authorised to do so and must return to their seats when asked by on-board personnel. Each user is assigned a seat at take-off and should, if possible, always return to the same seat. In an emergency evacuation situation, the crew will ask passengers to exit the aircraft through the two rear doors or the two front doors, which are equipped with escape slides. There are smoke hoods located under each seat, which must be donned when asked to do so by the crew. If cabin pressure is lost, oxygen masks will automatically drop from the ceiling and must be worn by users. In case of an emergency situation over water, life jackets are also available to the passengers onboard the aircraft.

4.6 Ground Support Facilities

A laboratory is made available to users for carrying out modifications to, and set-up of, their experimental equipment. Access to this laboratory is restricted to the hours between 08:00 and 17:00. Each team will be assigned its own workbench. There are only 220 V AC outlets available next to each bench. It is mandatory for at least one team member to be present when an experiment is powered up.

4.7 Legal Aspects

4.7.1 Confidentiality

Users must not divulge any information concerning any experiment other than their own, unless they are authorised to do so. ESA, through its contractor Novespace, reserves the right to communicate the names, research themes, photos and videos of their customers. Photos and videos can be taken inside the Novespace facilities and inside the aircraft. However, it is strictly forbidden to take photos or videos of the aircraft parking area, which is ruled by airport authorities.

4.7.2 Liability and Insurance

Every user and/or the organisation to which he/she belongs must fill out, agree and sign a liability release form, which will state the following:

"1. The Parabolic Campaign Participant consents to release ESA and its parties from any liability, which may arise from the participation in the Parabolic Flights, their preparatory activities and their post-flight activities.
2. The Parabolic Campaign Participant shall not make any claim against ESA and/or its parties for damage to or loss of his or his parties' property or for injury to him or his parties' personnel involved in the Parabolic Flights activities, which is caused by ESA and/or its parties, whether such damage or injury arises through negligence or otherwise.
3. ESA shall not make any claim against the Participant and/or its parties for damages to or loss of his or his parties' property or for injury to him or his parties' personnel involved in the Parabolic Flights activities, which is caused by the Parabolic Campaign Participant and/or its parties, whether such damage or injury arises through negligence or otherwise.
4. Damage shall not only mean bodily injuries to or death of any person, damage to loss or loss of any property, but also loss of revenue or profits or other direct, or indirect consequential damages arising thereof.
5. "ESA and its parties" shall mean the European Space Agency (ESA), Novespace, other Parabolic Campaign Participants, other parabolic Flights users, all contractors and/or sub-Contractor at every tier of all of the aforementioned, as well as all the employees of all of the aforementioned.
6. "The Parabolic Campaign Participant and its parties" shall mean the Parabolic Campaign Participant, all contractors and/or sub-Contractor at every tier of all of the aforementioned, as well as all the employees of all of the aforementioned.
7.a-** In addition, I declare by signing this form that I have verified with my employer insurance policy or/my private (life) insurance policy, that I, the social security and my heirs, are adequately covered against risk of injury or death which may be caused by my participation to the Parabolic Flights, and that I have obtained from the above insurer his waiver of subrogation rights against the Agency and/or its parties and the Contractor and/or his parties.
Reference of insurance policy: ____

7.b-** I declare that neither my employer nor myself have currently an insurance to cover the risk of injury or death and to provide adequate indemnification to me, my heirs and social security. Therefore, I take note of the insurance subscribed by Novespace for my own and my heirs' and my social security's benefit with a Limit of Coverage of EURO'S 150.000, - and of the possibility to subscribe a complementary coverage at my own cost.
8.a-** I declare that I have subscribed a complementary coverage.
8.b-** I declare that I have not subscribed a complementary coverage.
9. In the case where I have subscribed a complementary insurance coverage, I declare by signing this form, that I have obtained from the insurer his waiver of subrogation rights against the Agency and/or its parties and the Contractor and/or his parties.

In addition, regarding Image Rights,

10. The Parabolic Flight Campaign Participant declares having been informed that the French law related to the "droit à l'image" (image rights or right of publicity) is applicable to the Parabolic Flights Activities, and agrees that he has been fully informed at the flight briefing of the purpose, coverage, his/her related responsibility. Hence, the Parabolic Campaign Participant agrees to indemnify and hold ESA and its parties harmless from any action, claims of any nature whatsoever arising out of or on any way relating to the photographs or videos he/she made.
11. The Parabolic Campaign Participant hereby give his consent to ESA and its Parties, to use, without any prior authorisation or compensation, any photographs and/or videos, where he would appear, as far as they remain for the purposes and in the context of the Parabolic Flight Activities.
12. The Parabolic Campaign Participant consent to keep ESA and its Parties, harmless from any claim arising out of or in any way related to the photographs and/or videos, where he would appear, as far as they remain for the purposes and in the context of the Parabolic Flight Activities.
13. ESA shall endeavour to keep the Parabolic Campaign Participant and/or his parties harmless from any claim arising out of or in any way related to the photographs and/or videos, where ESA personnel would appear, as far as they remain for the purposes and in the context of the Parabolic Flights Activities. The application of this provision does not extend however to photographs and/or videos of property items, persons, situations as have been outlined at the Flight Briefing.
14. It is agreed that all the provisions of the present ESA Liability Release and Image Right Form shall be given the widest application permissible under national law."

(**) Delete what is not applicable

4.8 Human Aspects

4.8.1 Medical Aspects

Novespace and CEV request that each participant of a parabolic flight campaign undergoes a medical examination. A CEV physician has the authority to declare a person unfit for parabolic flight, even if that person has a valid aptitude certificate and the corresponding examination report.
The examination consists of a standard aviation medical exam for pilots applying for a private pilot's licence, and is based on Federal Aviation Administration (FAA) Class III, JAR FCL3 class II or French Class 2 standards. Only these documents will be accepted, and must be completed in either French or English. Usually, the validity of the certificates is 2 years for people under 40 and 1 year for people over 40, unless the medical examiner states otherwise.

The CEV will only recognise medical examinations carried out by the following:

- An Aeronautical Medical Centre or Authorised Medical Examiner (AME) authorised by the French Civil Aviation Authorities (DGAC) for French Class 2 examinations;
- An active air force aeronautical medical examiner specialised in aeronautical medicine;
- A medical examiner or aeronautical medical centre authorised by a national civil aviation authority.

At the end of the examination the user must have 2 documents:

- "Physical and Mental health compliance certificate", completed and signed by the doctor. This is not a standard document, and can be requested from Novespace;
- "Medical examination forms: FAA Class III, JAR FCL3 class II standards or French Class 2". This is divided into 2 parts:
    - Part 1: Application form – summarises all medical information provided by the applicant to the examiner;
    - Part 2: Medical report – presents medical results of applicant.

Copies of these documents must be submitted to Novespace at least 6 weeks before the start of the flight campaign. The medical exam forms must be enclosed in an envelope labelled "Medical – Private and Confidential". This envelope together with the "Physical and Mental health compliance certificate" must be enclosed in another envelope and mailed to the following address:

NOVESPACE
Rue Marcel Issartier
33700 Mérignac
France

N.B. No documents sent via fax will be reviewed by the CEV.

Users should have copies of all medical documentation with them when arriving at Novespace before the flight campaign.

4.8.2 Pre-flight Briefing

It is mandatory for all users participating in the flights during a campaign to attend the safety briefing that takes place the day before the first flight. During the briefing the flight safety procedures and medical aspects will be discussed. Users will be informed about the emergency equipment on the aircraft and will be given advice and suggestions on how to avoid or minimise motion sickness in flight.

4.9 Payload Life-Cycle and Major Milestones

The payload life cycle varies from experiment to experiment, and depends strongly on the complexity of the hardware as well as the channel through which access has been obtained to fly during a parabolic flight campaign. Based on the data relative to campaigns carried out in the past, the period that elapses from the moment that an experiment is selected for a specific campaign to the start of the campaign flight week, is approximately 3-6 months. Also, experiments, which are not being carried out for the first time, will have a reduced integration time.

Figure 4-10 represents a typical timeline with major milestones of an experiment for a parabolic flight campaign. The user must keep in mind that, although the tasks displayed in the timeline are standard, the periods are based on a generic case, and will differ, as described above, from experiment to experiment. The timeline is given in terms of weeks with respect to the start of the flight week (L).

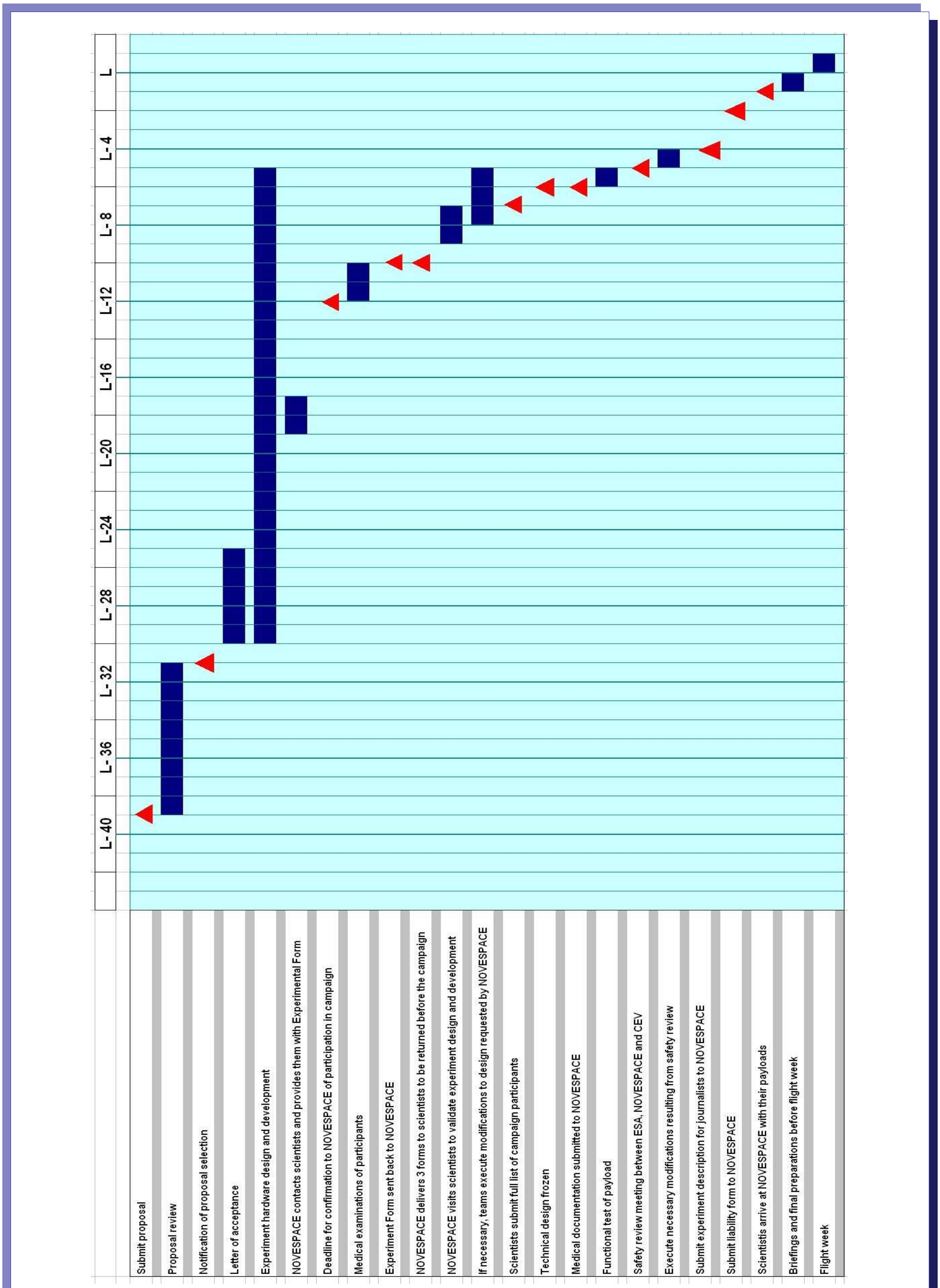

Figure 4-10: Typical timeline for an experiment on a parabolic flight campaign

4.10 Payload Documentation Development

The most important documentation requested by NOVESPACE consists of the Experiment Form, which is sent to the scientists about 4 months prior to the flight campaign, and which must be subsequently completed and returned at the latest 2 months before flight week.

4.10.1 Experiment Form

The information contained in the experiment form includes the following:

4.10.1.1 Title of the Experiment and Team Coordinator Name

4.10.1.2 Experiment Objectives

This section must present the scientific problem, the assumptions made, the research paths chosen to solve it and the results expected. If possible, the experiment objectives can be supported by potential industrial applications.

4.10.1.3 Experiment Description

This part acts as the link between the scientific objectives and the experiment itself. The users should explain how they are going to fulfil the scientific goals.

4.10.1.4 Technical Description of the Experiment Set-Up

This section must include:

- A brief description of each system;
- A table per each experiment rack, containing the following data for every single element:
  - Designation and function;
  - Mass (measured, NOT estimated);
  - Dimensions;
  - Electrical consumption (if applicable);
- General schematics or drawings of the experiment;
- Detailed schematic of each rack;
- Synopsis of the circuits (electrical, hydraulic, etc.) and/or block diagrams;
- List of products including name, state (liquids, gas, solid), quantity, concentration and containment;
- Photographs;
- Present the team's approach for designing, building and testing the experiment.

4.10.1.5 Electrical Consumption

Users must provide maximum and average values of electrical consumption. These values must be measured values, and NOT estimates!

4.10.1.6 Mechanical Resistance Analysis

A complete mechanical resistance analysis of the experiment structure must be carried out. The computations must also include:

- Determination of shear stress on the attachment screws;
- Determination of traction force on the attachment screws;
- Determination of bending strength of uprights.

4.10.1.7 In-Flight Procedures and In-Flight Personnel

This section should contain a table with the major tasks to be performed by each experimenter during each phase of the flight (after take-off, before first parabola, at each parabola, in 0g, 1.8g, between two parabolas, after the last parabola). Also, the table should indicate the function of each team member on board.

4.10.1.8 Pressure Vessel Certification (if applicable)

See paragraph 4.4.5.

4.10.1.9 Vent Line Connection and Other Requests

See paragraph 4.5.2.

4.10.1.10 Certification for Use of Human Subjects (if applicable)

See paragraph 4.4.11.

4.10.1.11 Liability Waiver

See paragraph 4.7.2.

4.10.1.12 Hazard Analysis

Safety is probably the most important issue during a parabolic flight campaign, and consequently the hazard analysis is likely to be one of the most crucial aspects in preparing an experiment for flight. Users will be supported by Novespace in preparing the necessary hazard analysis documentation. For ESA parabolic flights, the execution of a hazard analysis is based on the "NASA Hazard Analysis Guidelines".

4.10.1.12.1 Experiment Hazard Evaluation

The hazard analysis process begins with the experiment hazard evaluation, which is a brief summary of the results of an intensive review of the experiment hardware and planned test operations. The emphasis should be on identifying potential hazard sources inherent in either the experiment equipment or test operations. All hazards which could cause injury to passengers and flight personnel and which could in any way damage the aircraft, must be assessed, no matter how remote such hazards may seem. This evaluation must also identify those potential hazards for which stringent precautions (called "hazard controls") have been taken to prevent the hazard from occurring. In these cases both the hazard and the controls implemented to prevent its occurrence must be highlighted.

4.10.1.12.2 Hazard List

Based on the evaluation discussed in the previous paragraph, users (with the support of Novespace) must prepare a Hazard List, which lists all potential hazards identified during the evaluation.

4.10.1.12.3 Hazard Report Preparation

Novespace, with the aid of the user, will prepare a Hazard Report for each hazard reported in the hazard list. The basic purpose of such a report is to document the safety analysis, which assures that all potential hazard causes have been addressed and adequate controls have been implemented. The preparation of Hazard Reports should already be begun during the conceptual phase of the experiment as hazards are identified and should continue throughout the life cycle of the experiment.

4.11 Operational Cycle of a Parabolic Flight Campaign

The following provides a general step-by-step outline of the utilisation/operational cycle of a parabolic flight campaign ("TO1" refers to take-off on the first flight day):

Table 4-2: Major events in a parabolic flight campaign operational cycle

TIME	EVENT
TO1 – 7 days	Team members arrive at Novespace facility; Review by Novespace team.
TO1 – 6 days	Begin experiment preparation in Novespace workshop.
TO1 – 5 days	Loading of experiments into the aircraft. Experiment preparation continues in aircraft.
TO1 – 4 days	Complete experiment preparation in aircraft. Experiments must be in flight configuration by 17:00.
TO1 – 1 day	10:00 – 11:30 Specialists of the CEV Flight Test Centre carry out a safety review of the experiments in flight configuration. They are accompanied by ONLY one team representative to answer any questions. After this, the flight suits are distributed.
TO1 – 1 day	14:00 A mandatory safety briefing is carried out, which includes a 2-minute presentation of each experiment by the respective team coordinators.
TO1 – 2 hours	Teams meet at the Novespace facility.
TO1 – 1 hour	Optional medication is submitted to team members.
TO1 – 35 min	Team members board aircraft and experiments are switched-off.
TO1 – 30 min	Aircraft doors are closed, passengers are requested to be seated and aircraft electrical panel is switched-off.
TO1 – 15 min	Aircraft begins taxiing.
TO1 – 10 min	Aircraft electrical panel powered up.
TO1	Aircraft takes off.
TO1 + ~10 min	Passengers may leave their seats and experiments can be switched on.
TO1 + ~20 min	A demonstration parabola (Parabola #0) is carried out.
TO1 + ~25 min	Begin sequence of parabolas with Parabola #1.
TO1 + ~145 min	End sequence of 31 parabolas; Team members switch off experiments and set-up landing configuration.
TO1 + ~155 min	Aircraft electrical panel switched off and passengers take their seats.
TO1 + ~180 min	Aircraft lands, taxis and parks.
TO1 + ~185 min	Electrical panel switched on; On request, experiments can be switched on, but the presence of one team member is mandatory.
TO1 + 240 min	Debriefing.
TO1 + 270 min	Modifications and preparation of experiments for next flight day. There are a total of 3 flight days with one backup day. At the end of the last day of the campaign all experiments are unloaded from the aircraft and the flight suits are returned. For flight days 2 and 3 the cycle follows the same steps given above, starting from L – 2 hours.

The following figure (Figure 4-11) summarises the sequence of events during a parabolic flight campaign.

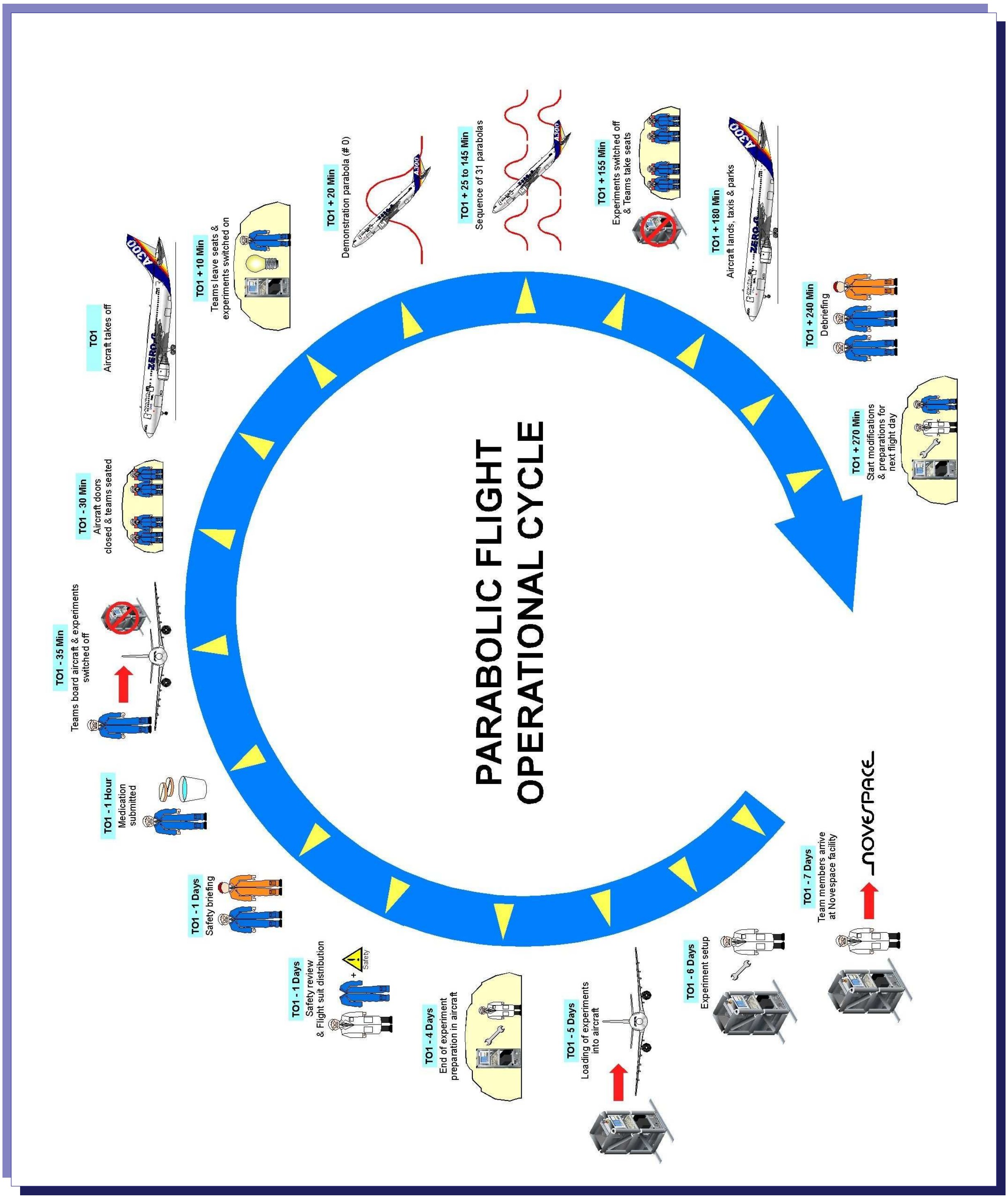

Figure 4-11: Parabolic flight operational cycle

4.12 References

1. "Parabolic Flight with A300 Zero-g: User's Manual", Edition 5.2, Novespace, France, 1999.
2. Novespace Parabolic Flight Web site: http://www.novespace.fr/VEnglish/Microgravity_a/microgravity.htm
3. ESA Parabolic Flight web site: http://spaceflight.esa.int/users/file.cfm?filename=paraf
4. ESA Student Parabolic Flights web site: http://www.estec.esa.nl/outreach/parabolic/
5. Erasmus Experiment Archive (EEA) Internet address: http://www.spaceflight.esa.int/eea
6. Erasmus User Information Centre Internet Home Page: http://www.spaceflight.esa.int/users/
7. "Facilities for Microgravity Investigations in Physical Sciences supported by ESA", ESA SP-1116, March 1995.