→ 5 PARABOLIC FLIGHTS

This chapter is aimed at providing new and experienced users with basic utilisation information regarding Parabolic Flights on the ESA-CNES Airbus A300 "ZERO-G" aircraft managed by Novespace. It begins with a brief description of parabolic flights.

5.1 Introduction to parabolic flights

Image 5-1: The Airbus A300 "ZERO-G" aircraft

5.1.1 What are parabolic flights?

Parabolic flights are aircraft flights conducted with specific mission profiles using specially converted aeroplanes. These aircraft execute a series of manoeuvres, called parabolas, each providing up to 22 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 campaign there are typically three flights (usually carried out on separate days), with around 31 parabolas being executed per flight. For each parabola, there are also two periods of increased gravity (~1.5 – 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 ground under simulated weightless conditions.

Parabolic Flights

22 s microgravity time
10^{-2} g low gravity environment
93 parabolas/campaign
15 experiments/campaign

5.1.2 What do parabolic flights offer?

Parabolic flights provide:

- 93 parabolas per campaign, each with approximately 20 seconds of weightlessness;
- a level of low gravity with an accuracy in 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;
- a short time between experiment proposal and execution (in the order of months);
- a low-cost research opportunity;
- the possibility of executing a series of experimental runs within three 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.

5.1.3 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.

5.1.4 Principal characteristics of the Airbus A300 "ZERO-G" aircraft

Since 1997, ESA has been using the Airbus A300 "ZERO-G" aircraft based at the Bordeaux-Mérignac airport in France. This aircraft was managed by the French company Novespace and contracted by ESA to provide support to all parabolic flight operations. After 17 years of service and 13 183 parabolas performed, the A300 "ZERO-G" aircraft retired in October 2014. It is planned to inaugurate the new Airbus A310 in April 2015.

Image 5-2: Bordeaux-Mérignac airport and the Novespace premises

The following is a list of the main characteristics and features of the Airbus A300 "ZERO-G" aircraft:

- the aircraft is a two-engine modified Airbus A300 "ZERO-G" aircraft;
- 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;
- the door through which equipment is loaded has a height limit of 1.80 metres based on the capabilities of the loading truck and a width of 1.07 metres. For experiments larger than this, the equipment must be designed to be taken apart.

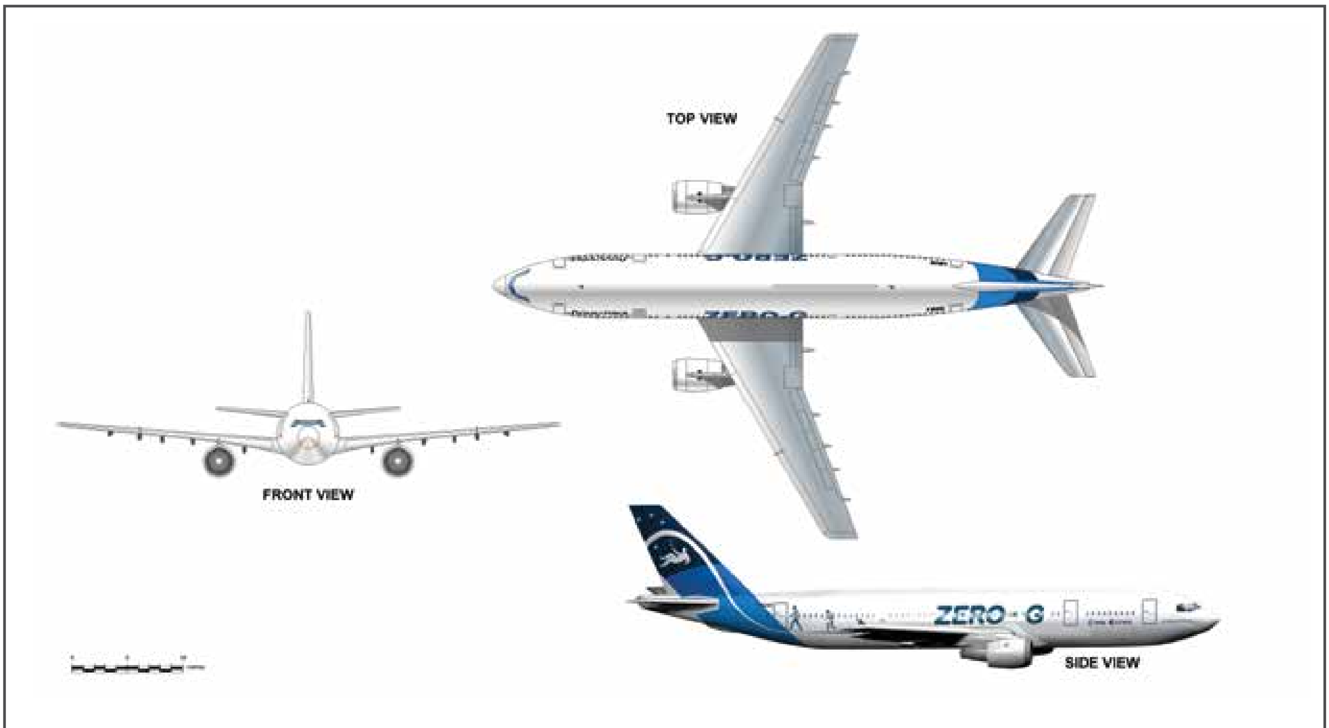

Figure 5-1: Airbus A-300 "ZERO-G" aircraft

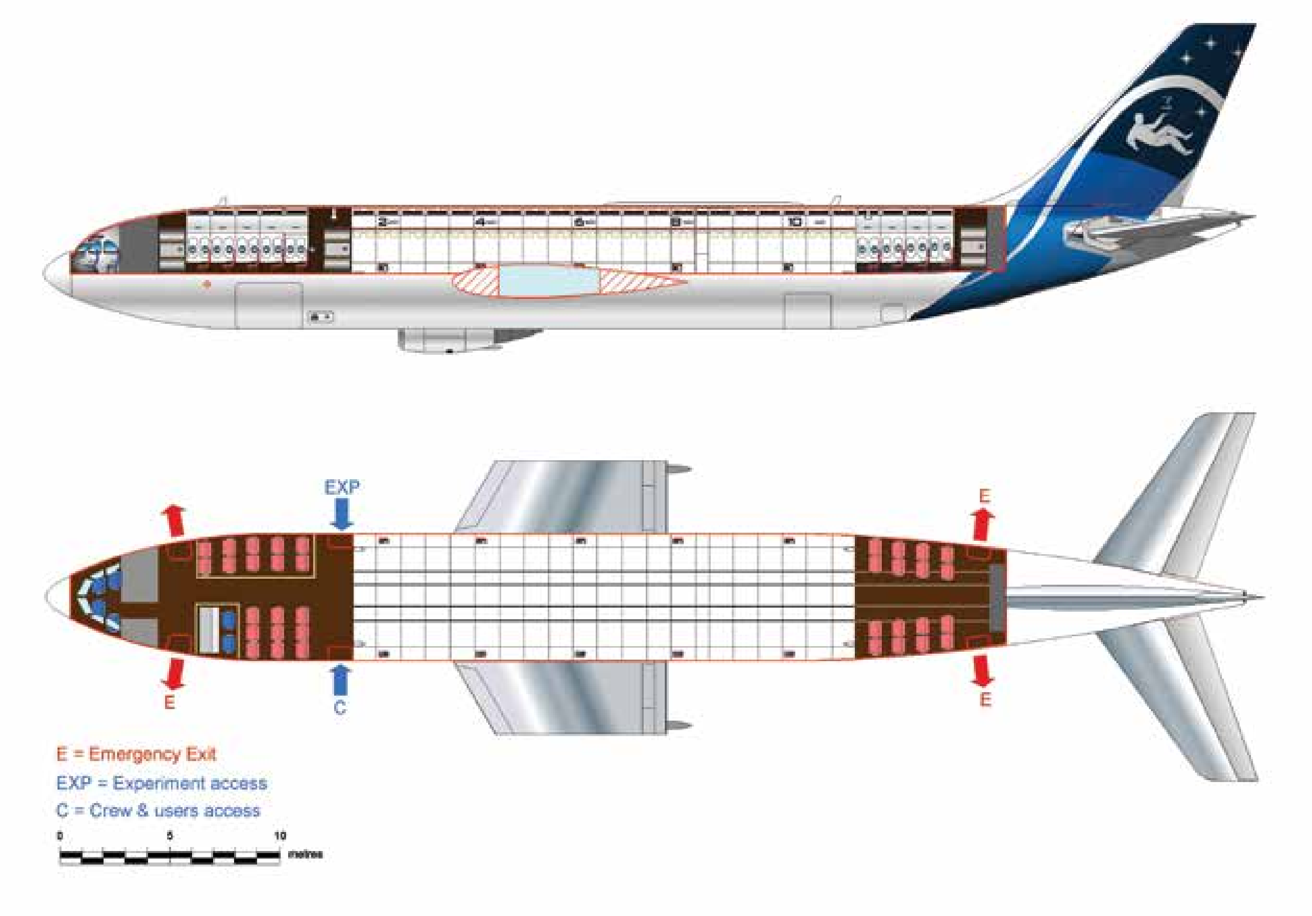

Figure 5-2: Airbus A300 "ZERO-G" aircraft internal side and upper views

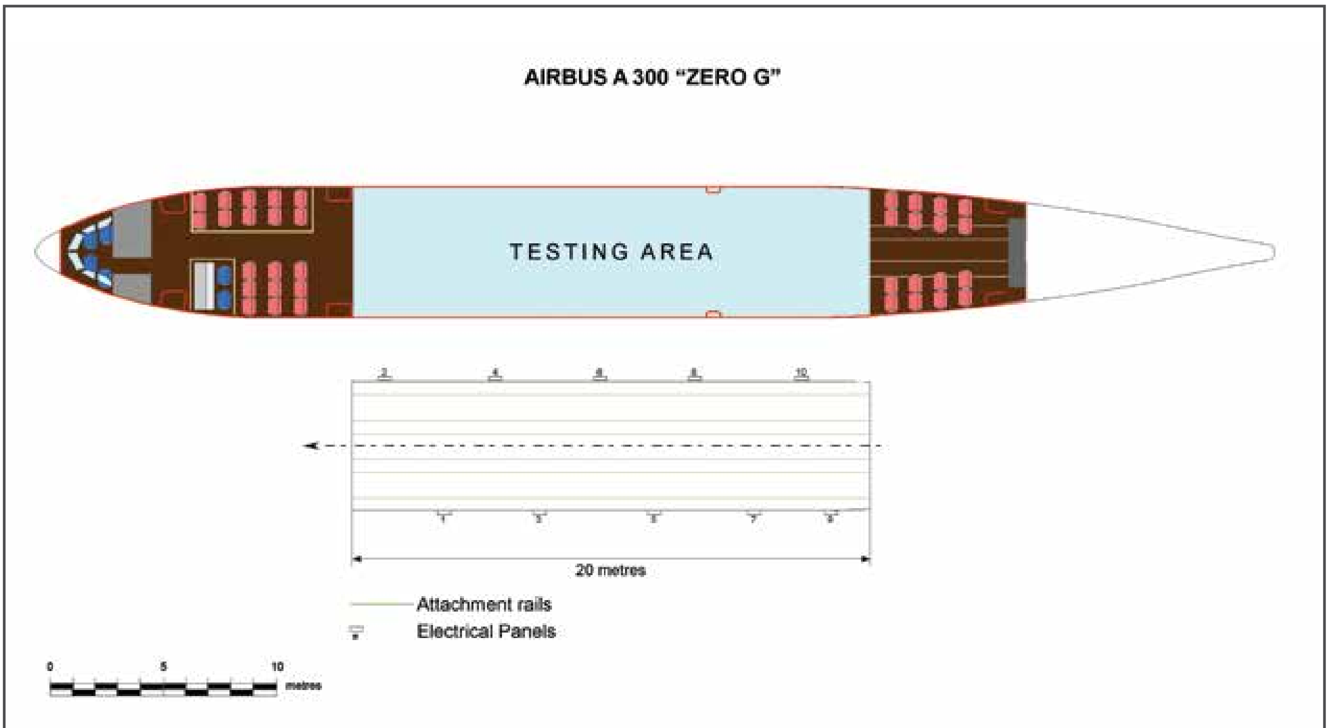

Figure 5-3: Airbus A300 "Zero-G" aircraft testing area

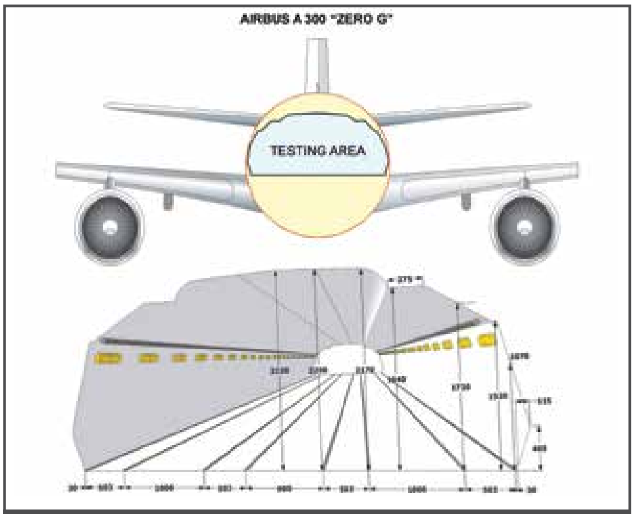

Figure 5-4: Cross-section of aircraft cabin with position of attachment rails

5.1.5 Parabolic flight manoeuvres

The Airbus A300 "ZERO-G" aircraft parabolic flight campaigns are based at the Bordeaux-Mérignac airport in France. If unfavourable weather conditions or other problems are encountered during a flight, several alternate airports can be used by the aircraft for landing. These airports, marked in red, can be seen in Figure 5-5. The figure also shows the ZERO-G flight test area usually used over the Bay of Biscay. Other flight test areas are available over the Mediterranean Sea and over land.

The Airbus A300 "ZERO-G" aircraft generally executes a series of 31 parabolic manoeuvres during a flight. Each manoeuvre (see Figure 5-6) begins with the aircraft flying a steady horizontal attitude, with an approximate altitude and speed of 6000 metres and 810 km/h respectively. During this steady phase, the gravity level is approximately 1 g.

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 acceleration 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 1 g, maintaining an altitude of 6000 m.

The period between the start of each parabola is three minutes, i.e. a 70 second parabolic phase (20 seconds at 1.8 g + 3 to 5 seconds of transition + 20 seconds of weightlessness + 3 to 5 seconds of transition + 20 seconds at 1.8 g), followed by a 110 second period at steady level 1 g flight. Parabolas are executed in sets of five. At the end of each set, a longer time is allowed to elapse (five or eight minutes – see Figure 5-7) 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.

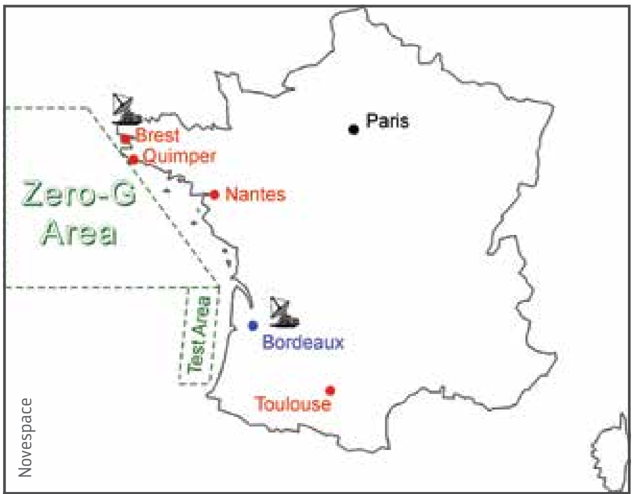

Figure 5-5: Airbus A-300 "Zero G" flight area and alternative landing airports

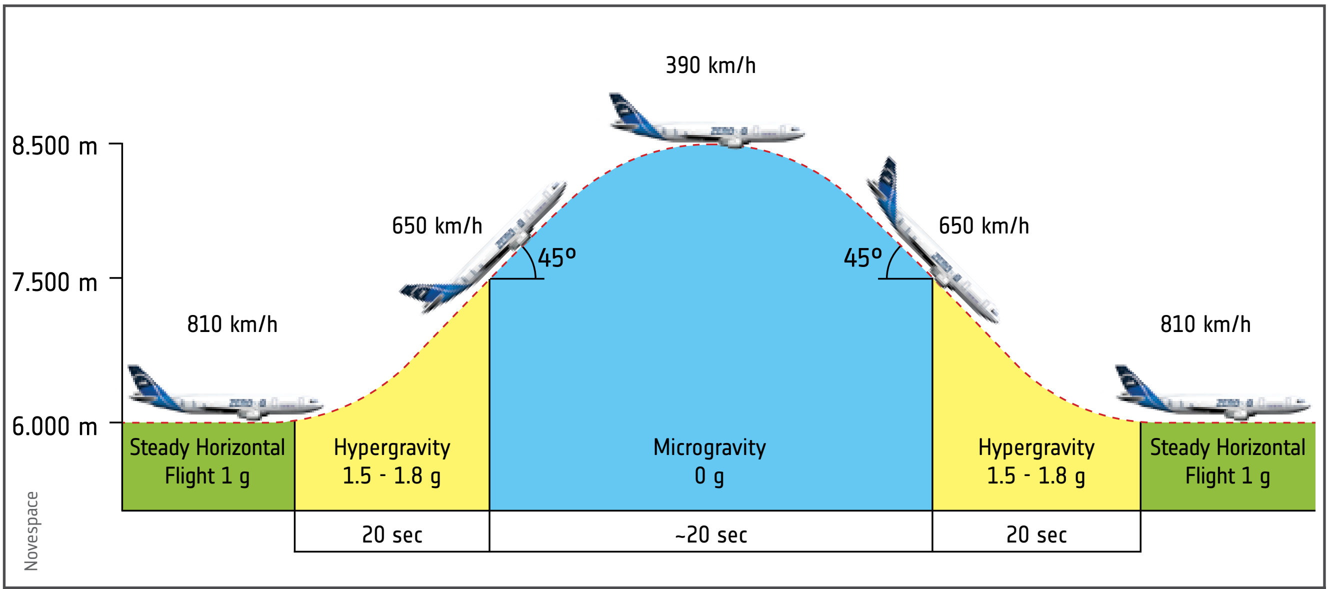

Figure 5-6: Parabolic flight manoeuvre profile

5.1.6 Partial gravity levels

The Airbus A300 "ZERO-G" aircraft has been certified for flight manoeuvres that provide, in addition to microgravity, reduced gravity levels of 0.16 g for approximately 25 s and 0.38 g for approximately 32 s. These gravity levels correspond to lunar and martian gravity levels.

5.1.7 Public access to parabolic flights

In May 2012, Novespace introduced zero gravity 'discovery flights' with the Airbus A300 "ZERO-G" aircraft for the general public. The first discovery flight took place in March 2013. For more information please visit **www.airzerog.com**

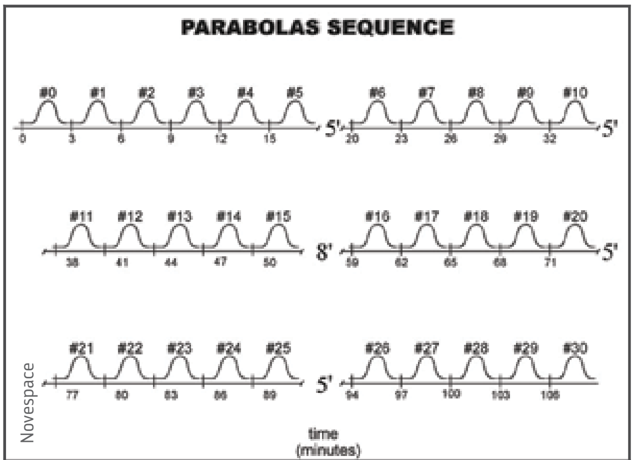

Figure 5-7: Parabolas sequence

5.2 Physical environment

5.2.1 Cabin pressure

The cabin pressure is maintained at around 825 mbar (i.e. 0.8 atmospheres or 80% 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.

5.2.2 Cabin temperature

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

5.2.3 Illumination

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

5.2.4 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 fluctuates between -2×10^{-2} g and $+2 \times 10^{-2}$ g (with possible temporary excursions between -5×10^{-2} g and $+5 \times 10^{-2}$ g) along the z-axis (see Figure 5-8) and between -10^{-2} g and $+10^{-2}$ g along x- and y-axes.

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

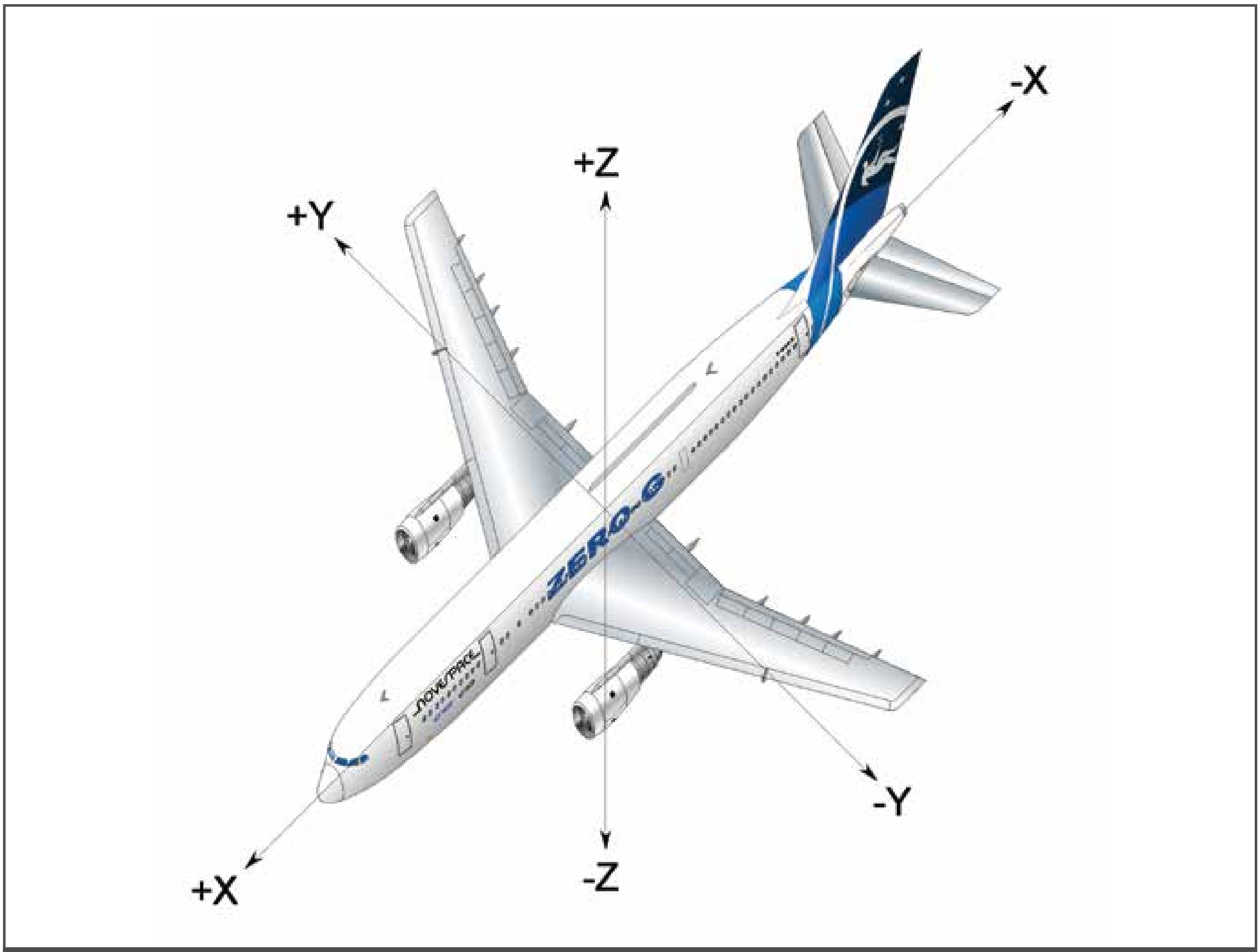

Figure 5-8: Aircraft coordinate reference system

5.3 Scientific and technological research topics suitable to parabolic flights

Figure 5-9 highlights the various scientific disciplines, 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.

For more information on flown parabolic flight experiments visit the Erasmus Experiment Archive at the following web address:
eea.spaceflight.esa.int

Image 5-3: Experiments on board the Airbus A300 "ZERO-G" aircraft

FUNDAMENTAL PHYSICS

Complex plasmas and dust particle physics

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

MATERIALS SCIENCE

Thermophysical properties

- Thermophysical properties of melts

New materials, products and processes

- Morphological stability and Microstructures
- Physical chemistry
- Aggregation phenomena
- Granular matter

FLUID AND COMBUSTION PHYSICS

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

Combustion

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

HUMAN RESEARCH

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

BIOLOGY

Plant physiology

- Statolith movement
- Gravitropism
- Gravireceptors

Cell and developmental biology

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

TECHNOLOGY

- ISS Experiment validation
- Phase separation technologies – biological fluids
- Metal halide lamps
- Thermophysical properties of melts
- Crew foot restraint
- Crew exercise devices
- Urine monitoring system

Figure 5-9: Research fields carried out on parabolic flights, based on past experiments

5.4 Payload accommodation

During the design phase of their experiment, users will be contacted by Novespace who will provide support regarding the equipment confirmation design. Only then should users begin the development phase.

Technical requirements for payload design, accommodation and safety analysis can be found in Novespace's Requirements, Guidelines and Interfaces documents:

- RQ-2014-6_Requirements_EN
- GDL-2014-6_Guidelines_EN
- ITF-2014-5-Interfaces_EN

These documents are available on a permanent server:
documentation.novespace.com/externe/last_applicable_rq/

ID: exp
Password: doc71_u3

The following sections summarise the main requirements.

5.4.1 Structural requirements

Full requirements can be found via the same URL, login and password shown above in section 5.4.

5.4.2 Safety

The parabolic flight programme is operated in accordance with stringent safety procedures established by the French Direction Générale de l'Armement (DGA) Essais en Vol. The exploitation in weightlessness is carried out under an exceptional "Laissez-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 these, under the authority of the DGA Essais en Vol. 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 relevant documents to Novespace 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 advisable 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 DGA Essais en Vol have been assured that a safe, well-organised, and productive flight can be achieved. In addition to the safety review with the DGA Essais en Vol, ESA will have an additional assessment to verify that the proposed experiments are inherently safe.

During an ESA campaign, all experimenters invited by ESA will be under the authority of the ESA Campaign Coordinator. 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 flight captain 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.

Novespace organises a dedicated workshop at their premises in Bordeaux for those in the experiment teams flying for the first time or without recent experience. The goal of this workshop is to introduce the general campaign preparatory work (filling the Experiment Safety Data Package or ESDP [see section 5.9]), preparing the experiment hardware before and during the campaign, the various safety aspects) and to present and visit the Novespace ground installations along with the Airbus A300 "ZERO-G" aircraft. The attendance of new experiment team members is strongly advised. It is emphasized that attending this workshop for newcomers is useful in understanding how parabolic flight campaigns are run. It also simplifies the interactions between Novespace and the experiment teams for the campaign preparatory work and as such, it is seen as a necessary first step in preparation of the campaign.

5.4.2.1 Safety visit

The safety visit is the final review prior to the start of the flight campaign. It includes an inspection of the test equipment and a last verification of flight readiness. The safety visit is mandatory for all experiments. During the week prior to the flight week, Novespace engineers use the whole preparation time to ensure that the experiment hardware and documentation are following the procedures set out by the ESDP document specified in section 5.9 below. Both documentation and complete experiment hardware are thoroughly tested. 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.

5.4.3 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;
- all sources of energy are reviewed by Novespace (electrical, pressurised, mechanical systems);
- avoid use of flammable materials;
- all liquids must be double contained, except (cold) water if less than half a litre;
- 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 polycarbonate.

5.4.4 Biomedical experiments with human subjects

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

These protocols should be sent to the ESA Campaign Coordinator who will forward them to the ESA Medical Board Secretary.

In parallel, a specific protocol must be prepared, to comply with the French law dealing with protection of test subjects of biomedical experiments. Novespace with the University of Caen will provide help in finalising the protocol and collecting all necessary documents. The protocol will be submitted to the Comité pour la Protection des Personnes (CPP). The CPP is a biomedical research 'ethics' commission, composed of medical doctors, psychiatrists, social workers, etc.), which will review each protocol.

French regulations require that all human subjects must have either a French health card (for French subjects) or a European Health Insurance Card (EHIC) (for non-French subjects).

Image 5-4: Experiment with human subjects

5.5 Available flight facilities and resources

5.5.1 Electrical power and interfaces

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

Table 5-1: 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 A per electrical panel x 5 (100 A 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 side walls of the cabin. A standard electrical multiplug is provided by Novespace and cable length is adjusted on a case by case basis. The 50 Hz AC power leads require 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.

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.

Image 5-5: Interior of Airbus A300 "ZERO-G" aircraft

5.5.2 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 corners 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 vented from the aircraft, as well as at what pressure and temperature they will be vented.

5.5.3 Data recording and accelerometers

During the campaign, Novespace records various sets of flight data including the acceleration levels. These acceleration levels are available and sent to the experimenters after each flight.

5.5.4 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 to by on-board personnel. 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.

5.6 Ground support facilities

Two workshops and one laboratory are made available at Novespace's facility (see images 5-6 and 5-7) to users for carrying out the set-up and check-out of their experiment equipment. If needed, also minor modifications can be applied in the workshop. Access to these facilities is restricted to the hours between 08:00 and 18:00. 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.

Image 5-6: Novespace premises

Image 5-7: Novespace workshops

5.7 Legal aspects

5.7.1 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, due to a regulation by the airport authorities.

5.7.2 Liability and insurance

All participants to an ESA campaign must abide by the terms of the document “Terms and Conditions for Participation in ESA Parabolic Flight Campaigns” (ref. PF-ESA-TN-001, iss. 1, rev. 1) that will be made available at the beginning of the campaign preparation process or under request. It is important to carefully read this document and verify that all participants are authorised to sign this document which includes legal and insurance issues.

5.8 Human aspects

5.8.1 Medical Aspects

ESA and Novespace request that each participant to an ESA parabolic flight campaign undergoes a medical examination. A physician appointed by ESA and Novespace 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 for parabolic flight aptitude is similar to a standard aviation medical examination for private pilot aptitude like Federal Aviation Administration (FAA) Class III, JAR FCL3 class II or French Class 2 standards. Only a specific medical certificate will be accepted, and must be completed in either French or English. Usually, the validity of the certificates is two years for people under 40 and one year for people over 40, unless the medical examiner states otherwise.

ESA and Novespace will only recognise medical examinations carried out via the following three options:

Option 1

You choose to have your medical examination with your treating physician or with a physician that has followed you as a patient for at least one year, and has access to your complete medical record.

Type of medical exam: Similar to the one to obtain a medical certificate of no contraindication in a sport practice.

Validity period: 1 year

Mandatory test:

- for all: an electrocardiogram less than a year old at the date of the examination;
- for people aged 65 and over: an exercise ECG done less than two years before the flight.

Option 2

You choose to have your medical examination with an authorised aviation medical examiner.

Type of medical exam: Identical as the one for a private pilot.

Validity period:

- two years for people aged under 40 at the date of the medical examination;
- one year for people aged 40 and over at the date of the medical examination.

Mandatory test:

- the authorized aviation medical examiner decides if the parabolic flight candidate needs to do an ECG;
- for people aged 65 and over: an exercise ECG done less than two years before the flight.

Option 3

You are a pilot (private pilot or professional); both your airplane pilot license and your medical certificate are valid. Please provide a copy of your valid airplane pilot license (PPL, CPL, MPL, and ATPL) and of your medical certificate.

A copy of the "Parabolic Flight Medical Certificate", received when passing one of the above mentioned medical examinations, must be submitted to Novespace at least six weeks before the start of the flight campaign and mailed to the following address:

NOVESPACE
29, rue Marcel Issartier
33700 Merignac
France

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


Image 5-8: Safety briefing

5.8.2 Pre-flight briefing

It is mandatory for all users participating in the flights during a campaign to attend the flight 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.

5.9 Payload documentation development

The most important documentation requested by NOVESPACE consists of the Experiment Safety Data Package (ESDP), which is sent to the users about six months prior to the flight campaign and which must be subsequently returned/updated regularly to show the experiment progress.

5.9.1 ESDP form

The information contained in the experiment form includes the following:

5.9.1.1 Title of the experiment and team coordinator name

5.9.1.2 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.

5.9.1.3 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 fulfill the scientific goals.

5.9.1.4 Technical description of the experiment set-up

This section must include:

- a brief description of each system;
- a table for each experiment rack, containing the following data for every single element:
  - designation and function;
  - mass (measured, not estimated) and centre of gravity;
  - dimensions;
  - electrical consumption.
- 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.

5.9.1.5 Electrical consumption

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

5.9.1.6 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.

Novespace submits tools to easily assess the mechanical resistance and adjust the rack design accordingly.

5.9.1.7 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 zero g, 1.8 g, between two parabolas, after the last parabola). Also, the table should indicate the function of each team member on board.

5.9.1.8 Pressure vessel certification (if applicable)

Full requirements can be found via the following link:
http://documentation.novespace.com/externe/last_applicable_rq/

Login: exp
Password: doc71_u3

5.9.1.9 Vent line connection and other requests

See paragraph 5.5.2.

5.9.1.10 Certification for use of human subjects (if applicable)

See paragraph 5.4.4.

5.9.1.11 Hazard analysis

Safety is probably the most important point to manage 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.

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 put 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.

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.

Hazard Report preparation

Novespace, with the aid of the user, will prepare a hazard report for each hazard identified 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 started during the conceptual phase of the experiment as hazards are identified and should continue throughout the life cycle of the experiment.

5.10 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 three to six months. Experiments, which are not being carried out for the first time, will have a reduced integration time.

Figure 5-10 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).

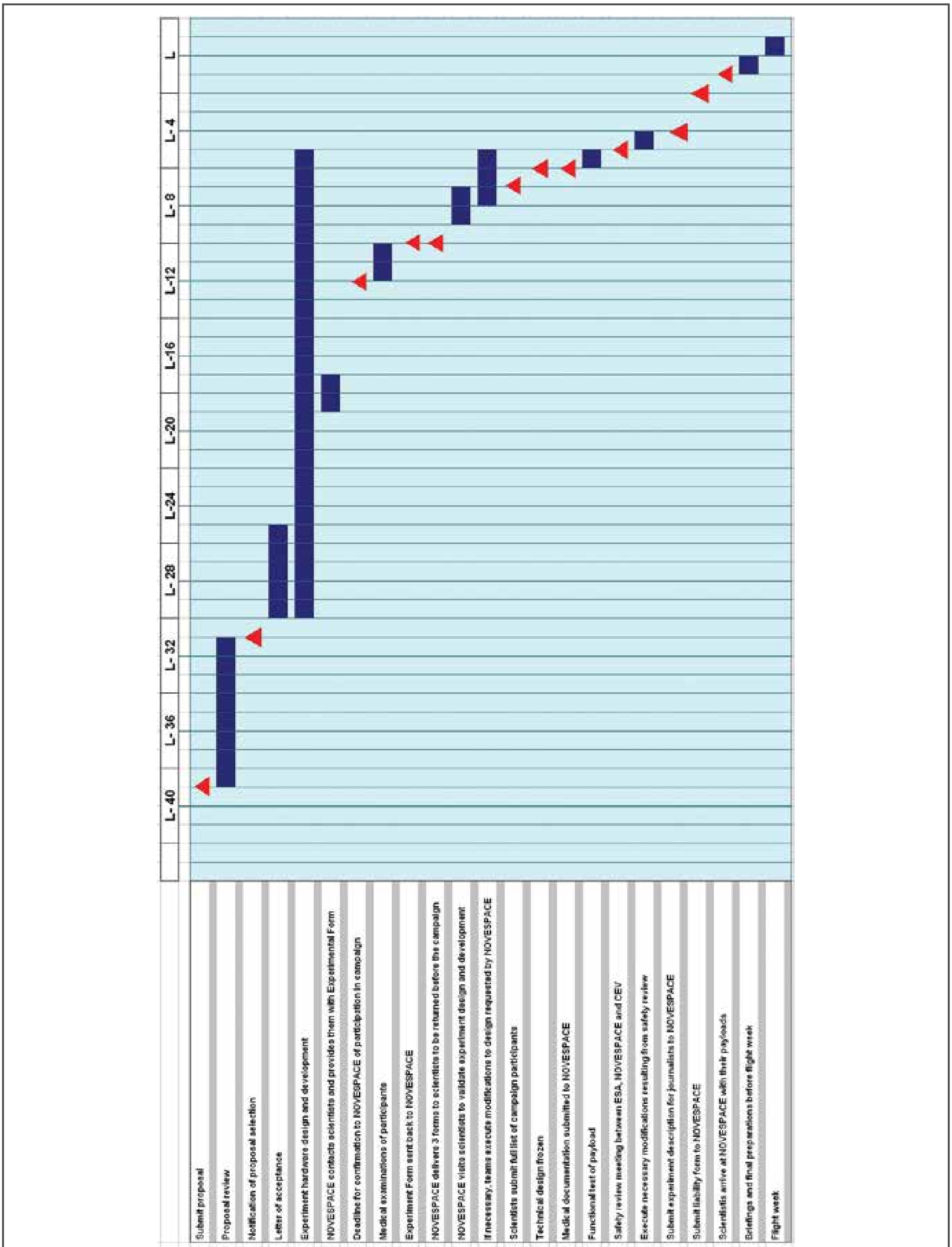

Figure 5-10: Typical timeline for an experiment on a parabolic flight campaign

5.11 Operational cycle of a parabolic flight campaign

Table 5.2 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):

Figure 5-11 summarises the sequence of events during a parabolic flight campaign.

For more information on parabolic flights please visit the following web pages:

www.esa.int/Our_Activities/Human_Spaceflight/Research/Parabolic_Flights

Table 5-2: Major events in a parabolic flight campaign operational cycle

TIME	EVENT
TO1 – 8 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 from the DGA Essais en Vol carry out a safety visit of the experiments in flight configuration. After this, the flight suits are distributed.
TO1 – 1 day	14:00: A mandatory safety briefing is carried out, which includes a two-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 offered 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 the 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	Debrief.

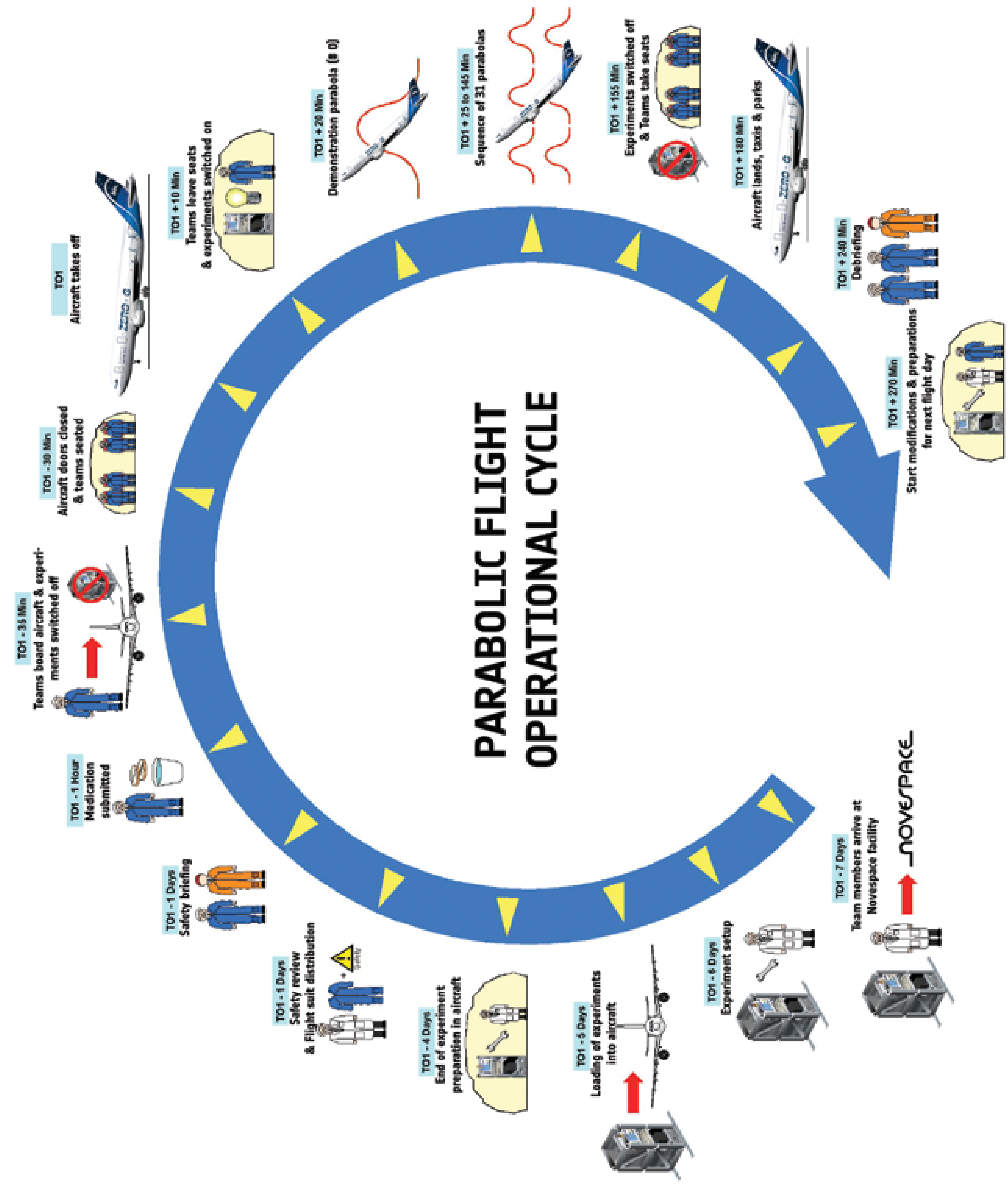

Figure 5-11: Parabolic flight operational cycle

5.12 References

1. " A300 ZERO-G Rules and Guidelines", ref. RG- 2009-2, Novespace, France, 7 April 2009.

2. Erasmus Experiment Archive (EEA) internet address: **eea.spaceflight.esa.int**

3. ESA Parabolic Flights web pages:
www.esa.int/Our_Activities/Human_Spaceflight/Research/Parabolic_Flights

4. "Facilities for Microgravity Investigations in Physical Sciences supported by ESA", ESA SP-1116, March 1995.

5. Novespace website: **www.novespace.fr**