Parabolic Flight Campaign with A300 ZERO-G
User's Manual

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Foreword

In addition to drop towers, sounding rockets, recoverable satellites and capsules, space shuttles, and space stations, parabolic flight has become a full-fledged means of accessing microgravity. Parabolic flight was first introduced for astronaut training; but today it is mainly used for testing of space technology and for short duration scientific experiments.

Novespace, subsidiary of the French Space Agency (CNES), was involved in the start-up of parabolic flight in Europe in 1988 with the Caravelle Zero-G. Novespace has since then organized more than 50 parabolic flight campaigns.

Novespace now operates and manages the biggest parabolic flight aircraft in the world, an Airbus A300 specially adapted for microgravity. Novespace was commissioned by CNES to manage the programme which is financed both by CNES (aircraft acquisition, overhaul and maintenance) and Novespace (aircraft microgravity adaptation). The A300 Zero-G is maintained by Sogerma and operated in flight by the Centre d'Essais en Vol (Flight Test Center), from Novespace facilities at Bordeaux-Mérignac International Airport.

This document contains the necessary technical information to:

- design an experiment complying with Novespace parabolic flight rules.
- prepare all technical documentation related to a parabolic flight campaign.

Inquiries concerning clarification or interpretation of this manual should be directed to :

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Introduction   Chapter 1

Parabolic flight is a useful tool for performing short duration scientific and technological experiments in reduced gravity due to its short turnaround time, low cost, flexible experiment approach, and direct on-board intervention possibilities.

Space agencies and industrial companies can benefit from a participation in a parabolic flight campaign on the Airbus Zero-G in the following ways :

- Testing as part of a quality approach to manufacturing space hardware. This is particularly true for mechanical parts (antenna and solar panel deployment, hydromechanical system, etc.).

- Acquiring a better understanding of gravity in physical or physiological phenomena for example.

- Gaining new insight into system’s safety and ergometric features facilitated by in-situ observation by project engineers and scientists.

- Using the prestige associated with Zero-G flying as part of a marketing strategy.

Novespace offers two different flight configurations:

- **Standard campaigns** which consist of three flights of thirty parabolas each on 3 consecutive days. Novespace can also accommodate several different customers who can share the experiment cabin and the cost of the campaign. The aircraft can accommodate more than a dozen different experiments and between thirty and forty experimenters.
- **Specialized campaigns** can be customized to the desires and needs of individual independent companies. These companies may decide on the number of flights, the duration, and the profile of each flight. These flights can depart either form Bordeaux or from any other airport in the world.

In collaboration with the Centre d'Essais en Vol and Sogerma, Novespace is willing to consider all demands of those interested in using parabolic flight services.

A300 Zero-G Parabolic Flight Technique

Chapter 2

2.1 Obtaining microgravity

A reduced gravity environment is obtained by flying a specially modified Airbus A300 Zero-G through a series of parabolic maneuvers which result in approx. twenty-two seconds periods of « 0g » acceleration (actually around 10^{-2} g). Each parabola is initiated with a 1.8 g pull up and terminated with a 1.8 g pull out.

A normal mission lasts two to three hours and consists of thirty parabolic maneuvers.

2.2 Description of the Parabolic Maneuver

Starting from a steady normal horizontal flight, the aircraft takes a 1.8 g load factor, nosing up to 45° and climbing to 23 000 Ft over an interval of about twenty seconds. This is the entry pull-up phase.

Then the engine thrust is considerably reduced, to the point where it just overcomes the aerodynamic drag, and the pilot kills the lift. This transitory phase of "injection" separating the 1.8 g pull-up from the zero g parabola lasts fewer than five seconds.

The aircraft is then in microgravity phase for some twenty-five seconds. A symmetrical 1.8g pullout phase is then executed on the down side of the parabola to bring the aircraft back to its steady horizontal flight in about 20 seconds. There is an interval of two minutes between two parabolas.

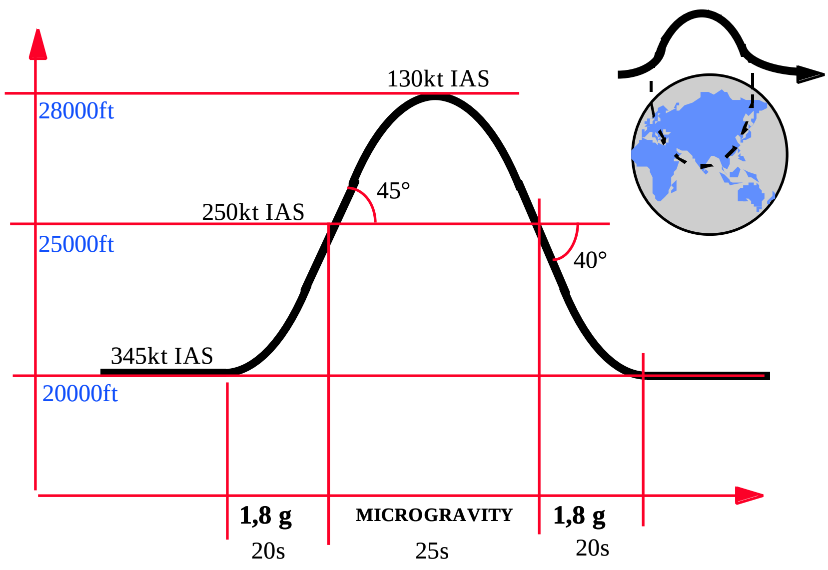

Fig. 1 - Parabolic Maneuver

2.3 Acceleration Levels and Piloting Techniques

During the 20 to 25 seconds of the parabolic maneuver, the residual gravity level for any apparatus attached to the aircraft structure oscillates between - $5*10^{-2}$ and + $5*10^{-2}$ g (z-axis) and between - 10^{-2} and + 10^{-2} g (x- and y-axis).

A small object free floating in the cabin may benefit from a higher quality of weightlessness (microgravity less than 10^{-4} g) for a period of five to ten seconds, i.e. until it touches the walls of the aircraft. This is called the free-float technique necessitating at least one person from the safety crew as additional assistance.

The piloting techniques may be, up to a technically realizable degree, adapted to the needs of the experimenters.

The different techniques are:

a) Standard technique where the crew is trying to obtain a level of microgravity as close to zero as possible (in average and in amplitude) and as long as possible.
b) The procedure to minimize negative microgravity values, called soft procedure.
c) The procedure to keep a residual gravity (of low or high value).
d) The free-float procedure where the piloting is done with respect to keeping an object free-floating in the middle of the cabin (visible for the pilots on a video screen).

The application of procedures which are not standard ones may result in parabolas of minor quality, i. e. of reduced duration. As these techniques might necessitate a special training or material (especially the last two ones, c and d) and therefore generate additional cost for the user, the interested experimenters are highly recommended to contact Novespace early before a campaign to express their needs.

Experimentation Area Description

Chapter 3

In this chapter we present the resources of the aircraft. These resources (room availability, electric power, venting...) are to be *shared* by different experiments. Although it seems obvious, we would like to emphasize the fact that unless the entire aircraft is commissioned by one single company, all experimenters are obliged to share the aircraft resources. Hence, the aircraft will not be entirely at one's disposal. In a standard campaign, 10 to 15 different experiments share global resources.

3.1 Cabin dimensions (See Figures 2, 3, and 4)

The testing cavity is 20 meters in length, 5 meters in width, and 2.3 meters in height (see figures 2, 3, and 4). The second front door, through which equipment is loaded, is 1.93 m high by 1.07 m wide. An experiment being larger than the door may be loaded by being taken apart.

The total volume of the cabin is 300 m^3.

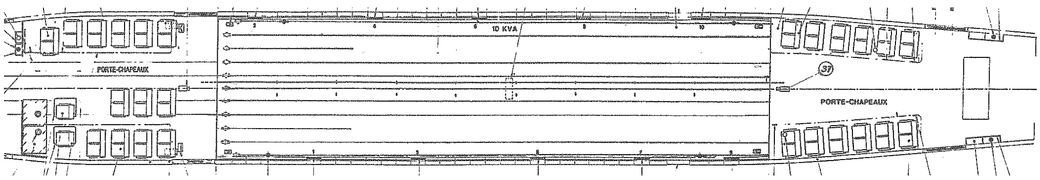

Fig.2 - Upper View of the Cabin

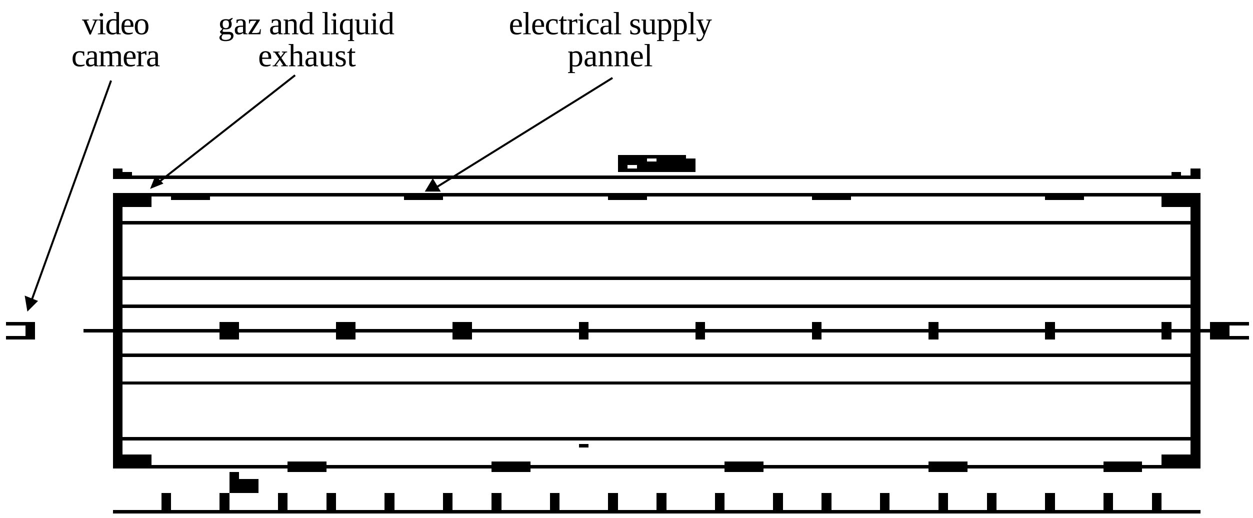

Fig. 3 - Bi-Section of Aircraft Cabin

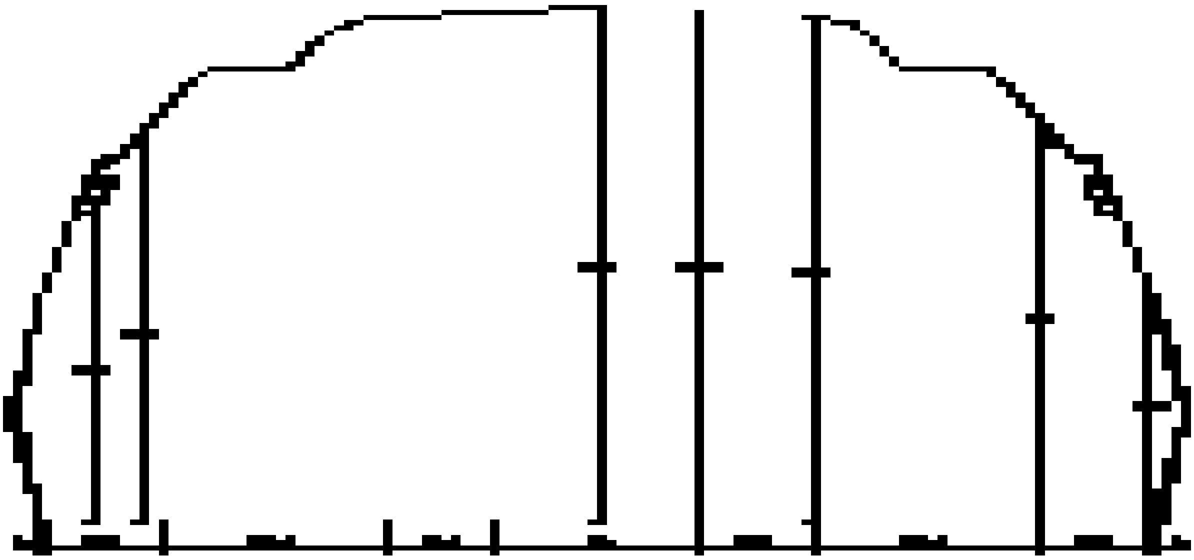

Fig. 4 - Cross Section of Aircraft Cabin - Position of attachment rails

3.2 Environment

Cabin pressure is maintained at approximately 800 mb during parabolic maneuvers. A further loss of cabin pressure must be considered in the design of the test equipment. Normally, cabin temperature varies from 18 to 25 degrees Celsius in flight. The temperature in the cabin is not controlled while the airplane is on the ground.

Lights are installed in the aircraft test section. These are sufficient to support photography of most open test equipment.

The interior walls of the cargo compartment are covered with foam padding for the protection of personnel and equipment.

3.3 Electrical Power and Interfaces

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

1.	220 volt AC, 50 Hz, single phase	2 kVA per electric panel x 10 (20 kVA total)
2.	28 volt DC	20 amps per electrical panel x 5 (100 amps total)
3.	115-200 volt AC, 400 Hz, three phase	on early request

The aircraft electrical test power is distributed to ten power distribution panels along the lower side walls of the test section. All power and ground leads from test equipment to the panels should be 6 meters long. The 50 Hz AC power leads require the standard French grounded plug. The 28V DC requires a Souriau 840-23-832 connector: terminal 1 = +28 V, terminal 2 = ground. All exposed power leads and electrical contacts should be covered to protect personnel and equipment.

In specific cases and if available, power exceeding 2kVA can be furnished. A Souriau 840-45-810 connector and a Souriau 840-40-004 rear connector are necessary in these cases.

On ground an external power supply is provided allowing to light up the aircraft inside and to supply electricity to the experiments. During the flight, power is generated by the internal airplane system. The switch-over from external to internal power supply is done before the airplane starts to roll and after experimenters have been seated and fastened seat belts. This means that the electrical supply will be interrupted for some minutes. The experimenters are not allowed to stay aside their experiments in this period, but may access their experiments some minutes after take-off, i. e. 5-10 minutes before the first parabola. At that time it is possible to reinitialize or restart their system. This time will be, if possible, maximised to allow for experiment preparation. If this hampers the experimental procedure experimenters are asked to inform Novespace before the security review.

Momentary interruptions of electrical power may occur during flight. Although infrequent, these interruptions may disrupt certain sensitive instruments, and test equipment should incorporate protection devices to prevent data loss. In case of sudden loss of electricity the experiment has automatically to pass into a safe status, e. g. gas lines to be closed, flames off, etc..

Each experiment has to be equipped with an red emergency push button to switch off the 220 V and the 28 V. The button has to be accessible from the experimenter's seat or position.

The experiments' electrical instruments must not interfere with the aircraft systems and instruments, and must meet the safety standards for electromagnetic compatibility of equipment on board.

3.4 Overboard Vent System

No gas, liquid or material, even known as not toxic, can be released from an experiment into the aircraft cabin. Four connections to outside atmosphere are located at the four extremities of the experimentation room and allow manual or automatic gas/liquid venting. The necessary connections must correspond to the Pneurop 6606/1981 and DIN 28403 with a connection diameter of DN 25 ISO-KF. The connections and tubes must be supplied by the experimenting parties themselves. If evacuation lines are to be used kind, pressure and temperature of the elements to be evacuated have to be made available to Novespace.

User Procedures   Chapter 4

4.1 Safety Policy

The A300 Zero-G parabolic flight programme is operated in accordance with stringent safety procedures established by the French "Centre d'Essais en Vol". The exploitation in microgravity 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 "Centre d'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. Approval from multiple authorities is required prior to flight.

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 flight. These items are described in the following chapters.

The degree of detail, rigor, and formality required in the development and conduct of a reduced gravity test depends on the complexity, hazards, and uniqueness of a test. Communications with Novespace are required early and often 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 organized, 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 deplaning.

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.

4.2 Documentation requested

Three months prior to flight, the test experimenter should forward to Novespace a document containing general information. This package should contain:

1. Test Objectives
2. Brief description of the test and associated test equipment (Please note if test is fixed or free-floating)
3. Dimensions of equipment
4. Total weight
5. Electrical consumption
6. Number of flights requested (1, 2 or 3)
7. Number of test personnel required for flight and detail of each person's function on board
8. Special support required (personnel, equipment, etc..) or special constraints (temperature, pressure, ground support, etc..)
9. Preliminary Hazard Analysis identifying hazards and controls (any format is acceptable)
10. Names, addresses, and phone number of points of contacts

Two months prior to flight, the test equipment data package must be submitted to Novespace, who will review the proposed test with CEV qualified experts, if need be. This package should contain the following :

1. Experiment title and Principal Investigators names and address
2. Test objectives
3. Test description
4. Equipment description (narrative, drawing, schematics, photographs, block diagrams, etc.)
5. Structural load analysis (please indicate the position of each structure)
6. Weight of each structure (measured, not estimated!)*
7. Electrical consumption (maximum and average) of each part of experiment (measured, not estimated!)*
8. Proof of mechanical resistance of each structure (see Appendix 2)
9. Pressure vessel certification (if applicable, see Appendix 3)
10. In flight test procedures (checklist form, please)
11. In the case of experiments on humans, detailed protocol in French and insurance certificate complying with French Huriet law (protecting persons in biomedical research).
12. Test support requirements (flight and ground) and constraints
13. Data acquisition system description
14. Test operation limits or restrictions, specific requirements
15. Hazard Analysis in accordance with Appendix 1 including Material Safety Data Sheet (MSDS) for Materials.**
16. Information and liability waiver forms for each flying individual, signed by each experimenter and his/her employer (see appendix 7 and 8), including assistant personnel on the ground.***

* It is really important that the weights and electrical consumptions are measured (the latter with a multimeter) and not estimated. Under- or over-estimation are both considered as not trustable and experiments in this case will not be allowed to fly.

** The Hazard Analysis is compulsory, in the form of appendix 1 of the manual.

*** The list of personnel including ground personnel must be known at least four weeks before the first flight. No personnel will be allowed to enter the airport area unless he or she is on the list.

4.3 Safety visit

The Safety Visit is the final review prior to flight. 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. An 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 Medical Certificates

In order to obtain clearance to fly, personnel must obtain a Federal Aviation Administration (FAA) Class III physical test and pass a hypobaric chamber test. The medical visit is not a routine visit, and personnel can be denied clearance should they be found unfit for flight. This test can be performed by any qualified medical services affiliated with Aeronautic Medicine. Please contact Novespace if you would like the physical exam and altitude test to be conducted in a registered centre in France.

A medical visit is valid for a year and the hypobaric chamber is valid for five.

A copy of the physical exam results (NOT just the medical certificate) and the physiological training record for each person must be received at Novespace at least three weeks prior to the flight date.

4.5 Pre-Flight Briefing

A precise schedule for the week before and the week of flights will be delivered by Novespace one month before flight.

A security briefing will take place the day before or the morning of the first flight. This briefing is mandatory for all experimenters. A schedule of the flight, advice concerning the flight, and a security procedure and rescue exposé will be presented.

Novespace will verify, if each experimenter has passed the necessary tests (medical and hypobaric chamber test) and has been present at the security briefing.

4.6 Biomedical experiments with human subject

All investigations involving test on human subjects must include a specific protocol in French, complying with Huriet law (protecting subjects of biomedical experiments). This protocol shall be submitted to CCPPRBB (biomedical research "ethic" commission, composed of eighteen members including medical doctors, psychiatrists, social workers, etc..), which will review each protocol (they charge a fee for it). The "promotor" of experiment (usually the PI) should provide a insurance certificate, complying with French law (exact wording and minimum guarantee can be asked to Novespace), covering his liability in case of injury linked to the experiment. Special procedures apply to the experiment subjects (forms to be signed, listing in a national subjects file, etc...). Novespace can assist the PI's in complying with these requirements if necessary, PI's must contact Novespace as early as possible.

Test Equipment Fabrication Requirements — Chapter 5

Before manufacturing an experiment, designers should contact Novespace to get first approval on the design. Thereby experimenters can implement necessary changes, if required, already before start of construction.

5.1 Structural Requirements

All equipment must be designed and manufactured to withstand the following loads during take off and landing.

X axis	9 g forward
	1.5 g backward
Y axis	3 g left or right
Z axis	4.2 g upward
	7.3 g downward

The X, Y and Z directions are referenced to the main aircraft reference system.

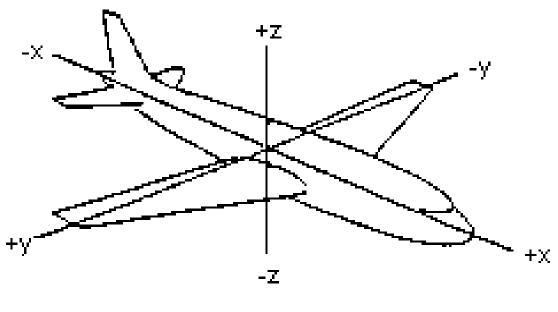

Fig 5 - Aircraft Reference Axes

Structural calculations for the take off and landing configuration should be based on the yield strength of the hardware. The in-flight test configuration should be designed for a possible 2.5-g force at maneuver entry and exit. Free-float test articles should be designed for a possible 2.5-g force from any direction due to possible recovery on an end or side of the airplane after a maneuver.

Each structural analysis must at least include :

1. Structural drawing or diagram
2. Stress calculations results (if in table form, at least one sample calculation must be given)
3. Component weights and positions
4. Material properties

Structural calculations must be delivered with the description of the experiments.

The equipment must also be designed to withstand vibrations and compression/de-compression cycles corresponding to normal operation of the cabin pressure system, as well as a sudden decompression resulting from a pressure system failure. In case of doubt, it is recommended that the equipment be tested in an altitude chamber.

The simple model calculation in Appendix 2 can be used to demonstrate the strength of the structures. In case the safety coefficients resulting from this simple calculation do not exceed 1, the experiment is not accepted unless the strength of the structures are demonstrated with a complete structural calculation. If this calculation still leads to a safety coefficient of less than 1, the structure has to be strengthened.

5.2 Aircraft Rail Loading

The position of the experiments in the airplane is determined by Novespace and agreed by the "Centre d'Essais en Vol". Aircraft rails, in other aircraft used to fasten seats to aircraft floor, are used in A300 ZERO-G to fasten experiments to the floor by means of specially designed interfaces. As the complete specifications may not be described here, a basic rule is: The load on a rail should not be higher than 100 kg per linear meter. As an example, if an experiment with four attachment points is heavier than 200 kg, two attachment points on the same rail are to be located more than one meter one from the other.

It is recommended to consult Novespace in advance if an experiment is to be build-up. In most cases the experiments comply with rail loading specification. But, if one or several of the items below are fulfilled it is mandatory to contact Novespace in advance:

- experiment weighs more than 200 kg
- the center of gravity of experiment is higher than 670 mm
- the distance between two fastening points on one rail is less than 508 mm (20 inches)
- the experiment is longer than three meters.

Maximal loads for each fixation point in the different directions are:
In x 2250 daN, in y 900 daN, in +z 1330 daN (direction to the ceiling), in -z 1750 daN (direction to the ground).

5.3 Equipment Attachment

The base of any experimental equipment must be drilled with 12 mm holes so that it can be fastened to the attachment interfaces by means of H-head M10 screws provided by Novespace. The screw holes should be in positions easily accessible so that the screws may be fastened by Sogerma personal having the skills to tighten the screws.

The distance between two holes on the same rail (X axis) must be a multiple of one inch (25.4 mm).

Two holes in line on two different rails (Y axis) must be 503 mm or 1006 mm apart (when checking the distance between holes, be sure to check also the diagonals). The actual distance will be confirmed by Novespace.

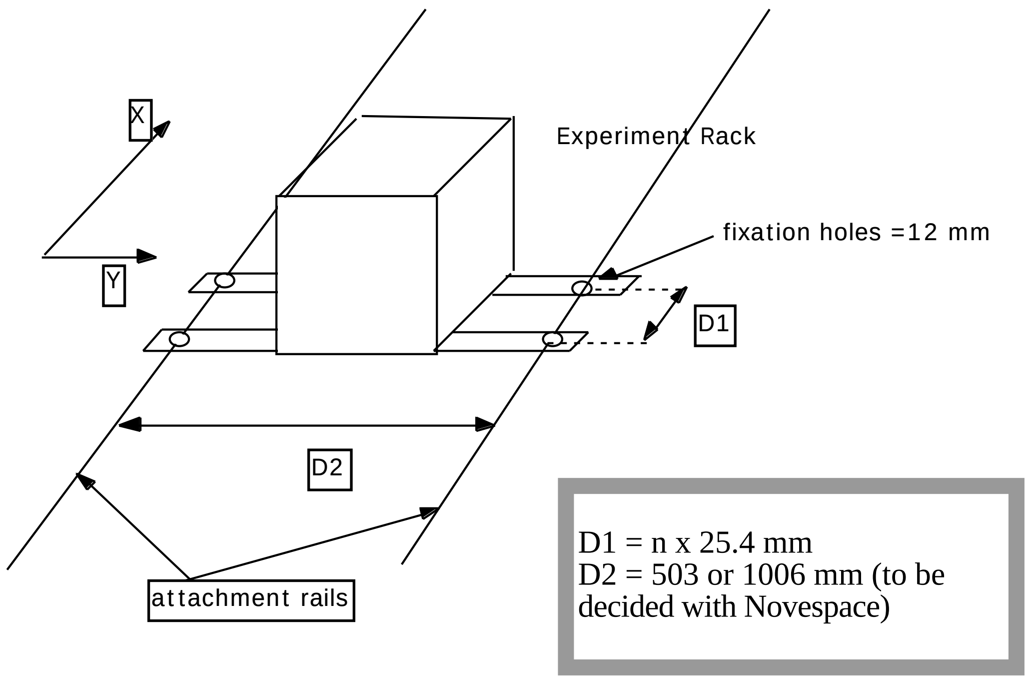

Fig. 6 - Equipment Attachment

5.4 Free-Float Packages

Perturbations of the airplane can cause small "g" forces during a zero-g maneuver. If a precise zero-g is required, the test package can be free-floated inside the cabin, preventing contact with the walls, ceiling, or floor of the aircraft. To provide the maximum free-float time, the package to be floated should be as compact as possible. It should not weigh more than 25 kg. If a tether is used between the floating package and tied-down support equipment, it should be at least 2 meter long to allow the floating package to freely drift. For large (higher than 0,5 m) and heavy free-floating equipment , handles should be mounted in the middle of the experiment using 2 cm tubing.

Free-float packages normally require one extra Flight Test Center safety personnel which is counted on the experiment’s quota and for whom additional costs will occur.

5.5 Pressure Vessel

All pressure vessels and pressurized systems shall be certified as safe to operate before use and shall be re-certified periodically if re-used.

The certification or re-certification for all pressurized systems (including bottles) must not be older than 5 years. The utilization pressure must be less than 2/3 of the pressure certified.

5.6 Electrical

A 10 amps (max) rapid fuse, on the experiment general electrical input, must protect aircraft power supply against electrical short on experiments. Each piece of test equipment must be adequately grounded. Normal aircraft vibration, high humidity, handling, and loads of more than 1-g should be considered in connector and wiring selection. See also 3.3 for voltages, connections and requirements.

No equipment should be left «power on» in the aircraft or in the experiment laboratory outside working hours. All batteries should be disconnected. If necessary and on request, manpower can be made available to monitor a specific equipment which absolutely needs to stay «power on». In this case additional costs will occur.

5.7 Hazardous Materials

If possible, avoid hazardous liquids and gases, including high pressure, toxic, corrosive, explosive, and flammable materials. If such materials are required for a test, proper containment must be provided. Early contact with Novespace for discussions on proper use and containment of hazardous materials may prevent delays in getting approval for the use of such materials. If such materials are necessary, provisions for dumping and purging in flight may be required. A current Material Safety Data Sheet must be supplied for each hazardous material.

5.8 Emergency Shut-Down

Investigators have to equip their experiment with an emergency button to quickly cut off all experimental activities with only one action. The experiment shall be designed in such a way that the equipment can be left unattended after shut off without any risk.

5.9 Miscellaneous Guidelines

1. Avoid sharp edges and corners on all test equipment. All exposed edges and corners, sharp or not, must be padded.
2. **Do not use** liquid electrolyte batteries of any type (battery circuits may require analysis by battery experts to avoid shock, shorts, or overheating). Use of Lithium batteries will be reviewed on a case-by-case basis by the test directors and Novespace.
3. Avoid flammable materials in test article construction.
4. Consider equipment or procedural failures. Provide safety arrangements or exchange items to prevent such failures from becoming hazardous to personnel or aircraft.
5. Consider the activities to be performed during the 2-g and 0-g portions of the parabolic maneuvers. Structure activities so as to minimize movement during the high-g portions. Consider the need for handholds during the 0-g portions.
6. Experiments involving radioactive materials will be handled on an individual basis.

7. Cover any glass monitor screens with Lexan or non-flammable Plexiglas.

Flight Campaign Organization

Chapter 6

6.1 Campaign Order

It is best to plan a parabolic flight campaign at least six months in advance to ensure free choice of flight date and location. At the very latest, an order must be submitted 12 weeks before the requested flight date.

6.2 On-Board Support

Well-trained safety personnel will be on-board the aircraft to support experimenters. When flying an experiment requiring extra support from Novespace safety personnel, this personnel will be included in the customer's totally available personnel seat count. The necessity of Novespace safety personnel will be decided upon during the safety review (one month before the flight) by attending safety experts.

Please Note: a normal strapped-down experiment does not require extra safety personnel, but a free-floating experiment usually does.

6.3 Data Recording and Accelerometers

After the campaign, Novespace provides a set of data recorded during the flight which includes acceleration levels. On request, and if available, Novespace can also provide accelerometers which can be directly connected to the experiment equipment.

6.4 Flight Suits

Novespace provides Nomexâ flight suits to experimenters. A security deposit (check or passport) is required in exchange for each suit. Experimenters can wear their own suit provided it is also made of Nomexâ.

6.5 Delivery

All equipment should be delivered to :

NOVESPACE
rue Marcel Issartier
33700 Mérignac
Tel: +33 (0) 5 56 34 05 99
Fax +33 (0) 5 56 34 06 09

6.6 Ground Facilities and Duty Hours

A laboratory is available for test equipment build-up and check. Access hereto is permitted from 8 a.m. to 5 p.m., access to the aircraft is permitted from 9 am to 4 p.m., except in case of aircraft maintenance.

6.7 Aircraft Integrity

No work on experiment can be made inside the aircraft, especially drilling or any work that results in dust or light debris. This kind of work shall be completed before boarding, or the specific equipment shall be taken off the aircraft to be worked on.

To protect the aircraft padding from deterioration, it is also forbidden to use adhesive tape or stickers on the walls of the cabin.

6.8 Confidentiality

Users should not divulge any information concerning an experiment other than their own, nor should they take any photographs or videos without express authorization from the agency responsible for questions related to such photos/videos.

NOVESPACE reserves the right to communicate the names of customers, their theme of research, photos, and video reports.

6.9 Journalists

Journalists who wish to participate in campaigns must contact the NOVESPACE press service at least one month before the first flight of the campaign. NOVESPACE will forward them a registration form and specific information file, along with pertinent rules and protocol.

6.10 Liability

Any damage suffered by the equipment or the aircraft during the test series shall be at the expense of their respective owners.

Damage of whatsoever nature suffered by CEV, CNES, NOVESPACE and/or organizations taking part in the test series shall be at their respective expense, even if responsibility lies with one of the other parties, except in the event of gross negligence by anther party.

Every experimenter's organization and/or experimenter must fill out and sign a liability waiver form which will be returned to Novespace. The waiver form is found in Appendix 7.

6.11 Insurance

NOVESPACE has contracted in-flight individual insurance and civil liability insurance for all A300 Zero-G experimenters.

The ceiling per experimenter is 500,000 French Francs.

6.12 Experiment Timeline

- Two months prior to flight:
    - Provision of detailed documentation (hardware and procedures)
    - Provision of description, hazard analysis

- Six weeks prior to flight:
    - Security review

- One week prior to flight:
    - Hardware reception at Bordeaux
    - Hardware mounting and assembly
    - Experimental ground testing

- One week to one day prior to flight:
    - Loading, bolting, and electrical connecting

- One day prior to flight:
    - Security visit

- **FLIGHT DAY(S)**

- Last flight day (afternoon) - unloading

6.13 Test Personnel Timeline

- Five years to three weeks prior to flight:
  - Hypobaric chamber test training

- One year to three weeks prior to flight:
  - Medical aptitude exam

- One month prior to flight:
  - Detailed information on each person flying

- One week prior to flight:
  - Parental authorization for personnel (if applicable)
  - Waiver of liability signed by company and personnel

- One day prior to flight :
  - Pre-flight briefing

- **FLIGHT DAY(S)**

Novespace will deliver, one month prior to flight, a precise schedule for the week before and the week of flights.

Hazard Analysis — Appendix 1

The following hazard analysis guidelines were adapted from NASA Hazard Analysis Guidelines. These guidelines are intended to help the test developer to perform the **hazard analysis**, to identify hazards in the test equipment and procedures, and to prepare the hazard analysis required for the test equipment data package (see Section 4.2 of this document).

A. Experiment Hazard Evaluation

This portion of the data package should contain a brief summary of the results of an intensive review of the experiment hardware and planned test operations. These data should identify potential hazard sources inherent in either the experiment equipment or test operations. In attempting to identify these hazards, the evaluator should keep in mind "Murphy's Law" which states, "If anything can go wrong, it most likely will." During the evaluation process, the evaluator should take a devil's advocate position while reviewing the experiment design, performance configuration, and planned operations. All hazards which could cause injury to flight test personnel or adversely affect the flight worthiness of the A300 Zero-G aircraft should be carefully assessed in this process, no matter how far away the possibility of such an occurrence may seem to be. To aid in this process, a **Hazard Source Checklist** has been included in the following sections.

The evaluator should note that no potential hazard should be ignored and left unidentified just because stringent precautions have been taken to prevent the hazard from occurring.

Such precautions are called **Hazard Controls**. The proper approach to such a situation is to identify both the hazard and the controls utilized to prevent its occurrence. Another common error in hazard identification frequently occurs when the evaluator determines that a condition or situation normally considered a hazard should not be included in the hazard evaluation because it is not considered to be a *credible* hazard. An example illustrating this point is the use of a very small amount of a toxic substance in an experiment such as mercury which, for photographic purposes, must be placed in a glass container. Because the quantity of mercury used is so small, the evaluator reasons that, even if the glass container breaks, there is no need to identify the mercury as a hazard source. *This is not correct*! The proper approach is to place the mercury on the hazard list and then demonstrate, by analytical means, that if all the available mercury were dispersed in the immediate environment, the maximum concentration possible would still be within acceptable industrial hygiene limits. Only after such an evaluation can the mercury be considered to constitute a *non-credible* hazard.

In summation, the evaluator should identify those hazard sources which are considered most critical from a safety standpoint and those which require special or unique controls to ensure that a hazardous condition or accident will not occur. If the evaluation indicates that no significant hazards exist in the experiment or in planned experiment operations, the evaluator should clarify this, as well.

B. Hazard List

Based on the evaluation discussed in Section A, the experimenter shall prepare a Hazard List which lists all potential hazards identified during the evaluation. Each hazard should be roughly categorized under the following **Generic Hazard** listings :

1. Radiation (ionizing, electromagnetic, laser)
2. Toxic Materials/Contamination
3. Explosion/Implosion
4. Fire
5. Collision/Impact
6. Loss of Habitable Environment
7. Electrical Shock/Static Discharge
8. Injury and/or Illness
9. Temperature Extremes
10. Structural Failure
11. Corrosion
12. Any others which may not fall into any of the above categories.

It should be noted that there is some overlap in the above hazard categories and, in some cases, it may not be readily obvious into which category a particular hazard has to be grouped. The categorization of the hazards is not, in itself, critical, and, when the correct category is unclear, the analyst should use his or her best judgement.

In addition to grouping the hazards into categories, each hazard should be identified by a descriptive and concise hazard title which includes the hazard category (e.g., "Fire Resulting From LO2 Leakage", "Toxic Material Release into Cabin", etc.…).

C. Hazard Report Preparation

The experimenter must prepare a Hazard Report for each of the hazards identified in the above Hazard List. The format used for the Hazard Report is left to the discretion of the experimenter. However, it may be convenient to use a format similar or identical to the one shown in this appendix page A1.11. It should be noted that, whatever format is used, the report must contain those topics identified in the shown format and include supporting data.

The basic purpose of a Hazard Report is to document the safety analysis to assure that all potential hazard causes have been addressed and adequate controls have been implemented. The report should be of sufficient depth and detail so that technical management personnel can determine if adequate hazard elimination or control has been accomplished or if additional hazard resolution analysis is required. The preparation of Hazard Reports should begin during the conceptual phase of the experiment as hazards are identified and should continue throughout the experiment life cycle. Hazard reports must be updated whenever changes to experiment design or operations affect the hazard condition addressed in the report.

A description of the required contents of a Hazard Report follows :

1. Hazard title -
As stated in the last paragraph of Section B above, the title should be concise and descriptive, and should include the applicable hazard category (per Section B).

2. **Description of Hazard** -
This section should briefly describe the potential hazard in terms of the risk to flight test personnel and to the flight worthiness of the A300 Zero-G aircraft structure and flight systems. The experimenter should take care to identify the actual hazard as opposed to the hazard cause. For example, the over-pressurization of a tank is a hazard cause, whereas the possible explosion of the tank (with the potential for catastrophic consequences) is the actual hazard. In the same vein, a pressure relief valve (PRV) attached to the tank would constitute a hazard control. A test showing that the valve actually opened at the required pressure would provide verification that the control was adequate.

3. **Hazard Causes** -
This section of the hazard report should identify and itemize all potential events or factors which could induce a specific hazard. Again, it is very important that *all possible causes* be identified and analyzed. Referring to the example in Section C2 above, the cause of the tank explosion could conceivably be any of the following factors :

a. Tank inadvertently under-designed for maximum operating pressure
b. One or more tank weldings are defective
c. Tank not equipped with a PRV
d. The PRV fails to open at the correct pressure
e. Tank pressure gauge reading incorrectly
f. Tank failing because of error in operating procedure and/or software
g. Human error
h. Other possible factors not identified above

Each of the hazard causes identified above must be countered by one or more specific Hazard Controls. These controls are discussed in the following section.

4. Hazard Controls -

Particular emphasis must be placed on thorough development of the contents of this section of the Hazard Report. Hazard control statements must be :

- **Specific**
  Do not generalize

- **Complete**
  Identify all controls applicable to the specific hazard

- **Definitive**
  Please provide adequate details to fully describe each control. This section must specifically identify the precise Hazard Control(s) utilized (such as redundancy or other design features, safety devices, warning devices, materials selection, and/or special operation procedures) that will eliminate, reduce, counter, or otherwise control the hazard(s) resulting from each Hazard Cause previously identified. Each Hazard Control must also be backed up by supporting data such as "as-built" drawings, quality assurance inspection or certification procedures, schematics, materials lists, approved test procedures, etc. Referring again to the pressurized tank example on the previous pages, examples of acceptable Hazard Control statements for two of the Hazard Causes listed on the previous page might be :

a. For Hazard Cause **A**, a statement that "the pressure vessel has been designed to sustain maximum expected operating pressure with a safety factor of 2" would normally be acceptable.

b. For Hazard Cause **B**, an appropriate statement might be "Redundant PRV's with proper relief pressure settings will be used on the pressurized tank." Specify relief pressure setting numbers (e.g., relief valve setting).

If the experimenter determines that he has a potential hazard for which no suitable Hazard Control is available, the deficiency must be documented and brought forward as an uncontrolled hazard. This hazard will then be made visible to appropriate authority for a decision regarding risk acceptance.

5. Verification Method/Status

This portion of the Hazard Report should identify the verification method(s) used to demonstrate the effectiveness of each Hazard Control, the data/documentation/certification which will be provided to demonstrate that verification has been satisfactorily accomplished, and the status of each verification data item.

Basically, there are three verification methods which may be used by the experimenter in satisfying the verification requirements. These are :

a. Test
b. Inspection
c. Analysis (both mathematical and data evaluation, such as review of design drawings, schematics, test results, etc.).

Test results will normally be documented by approved or certified test reports. Inspection results will be validated by Quality Control Inspection Reports, Receiving Inspection Reports, Acceptance Reports, etc. Analytical results will be validated by detailed structural stress analyses of the experiment, fracture mechanics analyses, thermal analyses, etc. When concerning data such as design drawings, schematics, test results, etc., the term "analysis" should be interpreted as a detailed, critical review of the drawing and test results that determine if they substantiate the claims made in the Hazard Control sections.

Referring to the example Hazard Control statements above, the Verification Method/Status statement for examples **A** and might be worded as follows :

(1) Hazard Cause A

Verification Method/Status - Test & Analysis

(a) Test Procedure, TP-011-Complete. In Data Pack

(b) Test Report, TR-011-Complete. In Data Pack.

(c) Fracture Mechanics Analysis-Complete. In Data Pack.

(2) Hazard Cause B

Verification Method/Status - Test & Analysis

(a) Acceptance Test Report, ATR-007-Complete. In Data Pack.

(b) Analysis of Plumbing Schematic, SC-P-001-Complete. In Data Pack.

D. Mandatory Verification Data for all Experiments

Certain verification documentation requirements are mandatory for all flown experiments. These are :

1. A structural loads/stress analysis which demonstrates that the experiment can safely withstand the loads specified in Section 3.1 of this document.

2. A Pressure Vessel Certification document (if applicable) which meets the criteria specified in Appendix 3 of this document.

Hazard source Checklist

Flammable/combustible material, fluid (liquid, vapor, or gas)
Toxic/noxious/corrosive/hot/cold material, fluid (liquid, vapor, or gas)
High pressure system (static or dynamic)
Evacuated container (implosion)
Frangible material
Material susceptible to stress corrosion
Inadequate structural design (e.g. low safety factor)
High intensity light source (including laser)
Ionizing/electromagnetic radiation
Rotating device
Extendible/deployable/articulating experiment element (collision)
Stowage restraint failure
Stored energy device (e.g. mechanical spring under compression)
Vacuum vent failure (i.e. loss of pressure/gas)
Heat transfer (habitable area over-temperature)
Over-temperature explosive rupture (including electrical battery)
High/Low touch temperature
Hardware cooling/heating loss (i.e. loss of thermal control)
Pyrotechnic/explosive device
Propulsion system (pressurized gas or liquid/solid propellant)
High acoustic noise level
Toxic off-gassing material
Mercury/mercury compound
Organic/microbiological (pathogenic) contamination source
Sharp corner/edge/protrusion/protuberance
Flammable/combustible material, fluid ignition source (i.e. short circuit, under-sized wiring/fuse/circuit breaker)
High voltage (electrical shock)
High static electrical discharge producer
Software error
Carcinogenic material

EXPERIMENT/TEST EQUIPMENT HAZARD REPORT

Name ....……..

Organization..

Phone number :...Date :…………………............

Equipment name : ....

…………………………………………………………………………………......................

Hazard title : ....

…………………………………………………………………………………......................

Hazard Description : ....

…………………………………………………………………………………......................

Hazard evaluation :

1. Evaluation of cause n°1

a. Hazard cause :

b. Hazard control(s) :

c. Verification method(s)/status :

2. Evaluation of cause n°2

a. Hazard cause :

b. Hazard control(s) :

c. Verification method(s)/status :

(Note : Continue as above until all Hazard Causes applicable to the Hazard Title have been addressed. The experimenter should again note that a separate Hazard report is required for each hazard identified in the Hazard List of this appendix.)

Demonstration of the mechanical strength of structures supporting airborne experiments

Appendix 2

The structures should be made of aluminum or steel sections. The most commonly used sections are square tubes or L brackets with equal or unequal flanges and rounded corners. The main framework should in no case be made from perforated sections.

The parts used should be assembled by bolts or rivets with gussets, rather than by welding or friction systems. The minimum gusset thickness is 5 mm (or same thickness as the section if greater than 5 mm).

The following pages give a simplified calculation example (sufficient in many cases) used to demonstrate the strength of a structure. This calculation involves three steps:

1. Determination of the centre of gravity and total weight of the installed equipment and the structure

2. Determination of the crash resistance of the bay attachments to the aircraft floor.

3. Demonstration of bending strength of the uprights: the bend calculation is performed on an upright alone, ignoring the shelves and any other stiffening element. The most unfavorable case is considered, which is 9 g forwards.

Applying this simplified type of calculation the safety coefficients are underestimated. Furthermore, it does not replace a thorough investigation of all single components meaning that the resistance of each instrument on its shelf must also be checked.

Examples of assembly, along with the screw and section characteristics are given at the end of the appendix.

1. General notations

- Re : yield strength of the material
- Rm : tensile strength of the material subject to traction forces
- Rc : tensile strength of the material subject to shear forces

$$Rc = 0.6\ Re$$

- Mfmax : maximum bend moment

2. The test table

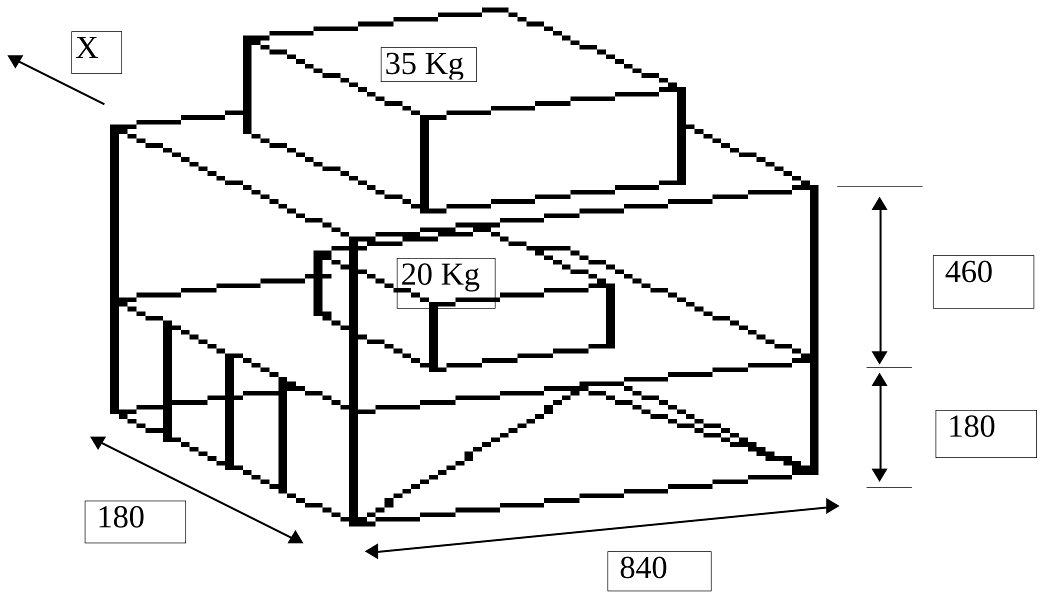

Figure 7: Structure Resistance Calculation

2.1 Weights of the example equipment

	Weight	Height of centre of gravity
Test table	m1 = 10 kg	h1 = 370 mm
Box No. 1	m2 = 20 kg	h2 = 230 mm
Box No. 2	m3 = 35 kg	h3 = 720 mm

2. Technical data

	Material	Rm (MPa)	Re (MPa)	Rc (MPa)
Bay uprights	A33	330		
Attaching screws	35 NC 6	900	740	444

The bay is secured to the aircraft floor by 4 M10 screws.

3. Calculation of weight and centre of gravity

$M = m1 + m2 + m3$

$\underline{M = 65\ kg}$

$$H = \frac{h1.m1 + h2.m2 + h3.m3}{M}$$

$\underline{H = 515.4\ mm}$

4. Crash performance

4.1. Shear stress on the attachment screws:

- the standard sets a 9 g forward acceleration in the event of a crash,
- the force experienced by the bay is thus : F = 9 M g

Hence a shear force on the attachment screws of : $Fc = \frac{F}{n}$

Where :	M	=	Total mass capacity for cargo bay = 65 kg
	g	=	9.81 m/s
	n	=	number of screws = 4

$$Fc = \frac{9.M.g}{n} = \frac{9 \text{ x } 65 \text{ x } 9.81}{4} \text{ N}$$

$\Leftrightarrow$ Fc = 1435 N

Safety coefficient = $C = \frac{Fcmax}{Fc} = \frac{16250}{1435}$ (see “Screw characteristics” table)

C = 11.3

4.2 Traction force on the attachment screws:

Assuming a crash landing, we consider that the bay rotates around the front attachments (in the x-z plane, see section 5.1) and thus only the rear attachments take up the force. Then, the horizontal acceleration creates the following moments:

F x H	=	X x d
F	=	9 M x g
H	=	height of assembly's centre of gravity = 515.4 mm
X	=	force on rear attachments
d	=	distance between forward and rear attachments = 800 mm

$$X = \frac{9.MgH}{d} = \frac{9 \text{ x } 65 \text{ x } 9.81 \text{ x } 515.4}{800}$$

$\Leftrightarrow$ X = 3697N

X represents the force experienced by two M10 screws, thus a traction force on the screws of:

$$X' = X/2 = 1850 \text{ N}$$

The pre-stressing of the screws by the 2 mkg tightening torque imposes an additional traction force of 14000 N. The traction force on the rear screws is thus:

F = X' + 14000 = 15850 N

Safety coefficient : : $C = \frac{Ftmax}{Ft} = \frac{32940}{15850} = 2{,}07$

(see "Screw characteristics" table, page A2.7)

4.3 Bending strength of uprights

The bay consists of four uprights made from 60 x 40 x 5 L sections:

Mfmax = 1,402,500 Nmm (see table concerning unequal flange brackets)

Bending moment on an upright

$$Mf = \frac{9MgH}{n}$$

M	=	Total weight of equipped bay = 65 kg
g	=	9.81 m/s
H	=	Height of centre of gravity calculated in paragraph 3
n	=	number of uprights = 4

$$Mf = \frac{9x65x9.81x515.4}{4}$$

Mf = 739 451 Nmm

Safety coefficient :

$$C = \frac{Mfmax}{Mf} = \frac{1\ 402\ 500}{739\ 451}$$

C = 1.9

Characteristics of screw quality class 8.8

Nominal diameter (mm)	Pitch (mm)	Maximum traction force (N)	Maximum shear force (N)
5	0.8	12780	6304
6	1	18090	8924
8	1.25	32940	16250
10	1.5	52200	25572
12	1.75	75870	37429

Characteristics of square tubes with rounded angles

Material : A33 (Rm = 330 MPa)		
Width (mm	Thickness (mm)	Mfmax (N.mm)
35	2.5	966240
	4	1226940
40	2.5	1320000
	3	1486980
	4	1735800
45	2.5	1727880
	3	1963830
50	3	2505360
	4	3018840

Material : 5086 H 111 (Rm = 250 MPa)		
Width (mm)	Thickness (mm)	Mfmax (N.mm)
35	2.5	73200
	4	929571
40	2.5	999875
	3	1126500
	4	1315000
45	2.5	1308889
	3	1487778
50	3	1898000
	4	2287000

Characteristics of unequal flange brackets with rounded corners

Material: A 33 (Rm = 330 MPa)			
a (mm)	b (mm)	e (mm)	Mfmax (N.mm)
45	30	4	630300
		5	775500
50	30	4	768900
		5	943800
		6	1105500
	40	5	990000
		6	1161600
60	40	5	1402500
		6	1659900
		7	1910700
65	50	5	1706100
		6	2013000
		7	2306700
		8	2590500
70	50	6	2323200
		7	2666400

Material : 5086 H 111 (Rm = 250 MPa)			
a (mm)	b (mm)	e (mm)	Mfmax (N.mm)
45	30	4	477500
		5	587500
50	30	4	582500
		5	715000
		6	837500
	40	5	750000
		6	880000
60	40	5	1062500
		6	1257500
		7	1447500
65	50	5	1292500
		6	1525000
		7	1747500
		8	1962500
70	50	6	1760000
		7	2020000

Characteristics of equal flange brackets with rounded corners

Material: A 33 (Rm = 330 MPa)		
a (mm)	e (mm)	Nfmax (N.mm)
35	3.2	320100
	3.5	349800
	4	389400
	5	478500
37.5	3.2	372900
40	3	396000
	3,5	458700
	4	511500
	5	630300
	6	745800
45	3	504900
	4	666600
	4,5	762000
	5	801900
	6	950400
50	3	630300
	4	831600
	5	1006500
	6	1191300
	7	1372800
	8	1534500
60	4	1214400
	5	1491600
	6	1745700
	7	2013000
	8	2286900
	10	2745600
65	5	1752300
	6	2065800
	7	2385900
70	5	2013000
	6	2399100
	7	2775300
	9	3498000

Material : 5086 H 111 (Rm = 250 MPa)		
a (mm)	e (mm)	Nfmax (N.mm)
35	3.2	242500
	3.5	265000
	4	295000
	5	362500
37.5	3.2	282500
40	3	300000
	3,5	347500
	4	387500
	5	477500
	6	565000
45	3	382500
	4	505000
	4,5	550000
	5	607500
	6	720000
50	3	477500
	4	630000
	5	762500
	6	902500
	7	1040000
	8	1162500
60	4	920000
	5	1130000
	6	1322500
	7	1525000
	8	1732500
	10	2080000
65	5	1327500
	6	1565000
	7	1807500
70	5	1525000
	6	1817500
	7	2102500
	9	2650000

Use of sections not specified in previous tables

In a case such as this, the section's bend constant must be found in the manufacturer's documentation. The bend constant is defined by the term I/v (mm^3), where:

I : Moment of bend inertia (mm^4). This value is only linked to the geometry of the cross-section.

v : Distance of the plane furthest from the neutral plane (mm).

The maximum allowable bend moment on the section is thus defined as follows:

$$Mfmax = Rm \frac{I}{v}$$

Rm: Material tensile strength (MPa)

Pressure Vessel Certification

Appendix 3

All pressure vessels and pressurized systems used in the A300 Zero-G shall be certified as safe to operate before use and shall be re-certified periodically if re-used. This certification verifies that the pressure vessel/system has been inspected by a pressure system engineer, relief valves in the system are at appropriate locations, relief valves are certified, all pressure gauges are calibrated, appropriate proof tests were performed, etc.

Each pressure vessel and pressurized system shall be designed to 2 times the Maximum Allowable Working Pressure (MAWP) and certified to 1.5 MAWP in accordance with applicable national consensus codes. Furthermore, these certificates must not be older than five years at the flight days.

It is the responsibility of the test developer to provide the documentation necessary to prove the certification of the pressure vessels and pressurized systems. This documentation will be reviewed by Novespace and other relevant experts.

The following is a recommended outline for pressure vessel certification as required in the test equipment data package.

1. System drawing or sketch, dated and initialled by designing engineer.

2. Component identification data :

a. Relief Devices - Set pressure, manufacturer, model number, and system component number of all relief devices. Each valve should be tagged to indicate its set pressure.

b. Components (valves, filters, regulators, check valves, etc.) - Manufacturer, model number, pressure rating, and system component number. Regulators should be tagged with a certification, and all pressure gauges should be calibrated and labeled as such.

c. Flex hoses - Pressure rating, size, and system component number.

d. Pipe and Tubing - Material, size, and schedule or thickness.

e. Pressure Vessels :

(1) Drawings or specifications that as a minimum specify :

(a) MAWP
(b) Material thickness'
(c) Material specifications
(d) Head and shell geometry
(e) Weld joint geometry

(2) Serial number or unique identifying number.

(3) Certification Tests

(a) Pressure Vessels :

All pressure vessels require proof-pressure testing. Hydrostatic testing at 1.5 MAWP is the preferred method. Pneumostatic testing at 1.25 MAWP may be performed, except on DOT vessels, which must be hydrostatically tested.

(b) Relief Valves :

All relief valves require set-pressure testing. In no case should the set pressure of the relief valve exceed the MAWP of the system.

(c) Flex Hoses :

All flex hoses require proof-pressure testing. The only acceptable method of testing flex hoses is a hydrostatic test at 1.5 MAWP.

(d) System Piping :

All system piping requires proof-pressure testing. Hydrostatic testing at 1.5 MAWP is the preferred method of accomplishing this test. Pneumostatic testing at 1.25 MAWP may be performed.

Note : Certification tests must be witnessed by an independent quality assurance representative and adequate documentation must be provided.

Pre-Shipment Checklist

Appendix 4

This checklist is intended as a final, pre-shipment equipment checklist. However, this checklist, although useful during packing preparations, does not replace the safety requirements outlined in this document.

A. General

Has the flight equipment been identified ? Has the ground equipment been identified ? Have the flight procedures been prepared ?

Have the contingency flight procedures been prepared (power failure, computer failure, need for spare batteries, etc.) ?

Have the operational limits been defined ?

Has the detailed structural analysis been performed (take off and landing configuration, free-floating test article configuration) ?

Has the electrical load analysis been performed ?

Is the general workmanship satisfactory (screws and bolts secure, wiring secure, cable routing convenient and safe, components secure on baseplates) ?

B. Human Factors

Have all of the corners, edges, and protrusions been padded ?

Are all surface temperatures below 113° F or 40° C?

Are all rotating components contained ?

Are all electrical connections covered ?

Are there adequate handholds ?

C. Electrical system

Are all the cables and connections labeled ?

Are all cables adequately restrained or clamped ?

Are the cables of adequate length ?

Do the cables have adequate strain relief ?

Are protection devices (circuit breakers and fuses) provided for each piece of equipment ?

Are all components labeled ?

Are the high voltage sources protected and marked with warning labels ?

Is the equipment properly grounded ?

Are the batteries of the proper type (dry or gel cell only - no liquid electrolyte or Lithium) ?

Is all insulation properly protected against abrasion ?

D. Lasers

Are the type, manufacturer, peak power, pulse length, voltage requirement, and mode of operation documented ?

Are interlocks provided ?

Are they marked with warning labels ?

E. RF Systems

Has an EMC test been conducted ?

F. Pressure Systems

Are the design pressure and MAWP specified ?

Is the system guarded against any component inadvertently increasing MAWP ?

Does the system have over-pressure protection (automatic controls, relief valves) ?

Is the certification still valid ? Is the following relief device information included :

set pressure ?
manufacturer ?
model number ?
component number ?

Are the relief devices tagged with the set pressure ?

Is the following information included for other components such as valves, regulators, filters, etc.

manufacturer ?
model number ?
pressure rating ?
component number ?

Have the regulator gauges been certified and tagged or labeled ?

Have the pressure gauges been certified and tagged or labeled ?

Has proof testing been performed for the following components :

pressure vessels ?
flex hoses ?
piping system ?
relief valves ?

Has proof testing been performed for the fully configured system ?

G. Vacuum system

Are the drawings included ?

Is the system equipped with relief devices (positive or negative relief valves) ?

H. Hazardous Materials

(If possible, avoid high pressure, toxic, corrosive, explosive, radioactive, and flammable materials !)

Is the absolute minimum quantity used for the experiment ?

Are the materials properly contained ?

I. Breakable Items

Are glass monitor screens covered with ≥ 1/16 inch Lexan ?

Is all glass tubing wrapped or contained properly ?

Are any high-temperature viewing ports made of tempered glass ?

Are any other viewing ports made of Lexan or Plexiglas ?

J. Cleanliness

Is the test equipment free from drilling debris, rests of tape, dust, and loose items (tools, pencils, pens, paperclips, etc.) which would free-float in zero-g?

K. Transportation

Are the manuals included ?

Is the test apparatus properly secured, padded, and ready for transportation ?

Are storage bottles, if any, empty (at zero pressure) for transport ?

If not, do they meet transportation regulations ?

Suggestions for Flight

Appendix 5

A. PREPARING YOUR EXPERIMENT

Things to bring

Be conscious that you are responsible for everything required to perform your experiment. You should bring all the ground support equipment, test samples, tools, spare parts, consumables, test equipment, etc., that your experiment requires. Unless you have checked first, don't assume that anything will be available on the aircraft base.

Preparing your experiment

One of the best features of parabolic flight is that it can be used very much like any other laboratory, albeit a rather crowded one. Many experiment packages look very much like they would in any laboratory except for greater compactness and some judicious padding. There are some exceptions to this :

- If hard disk readers are to operate during pull in or pull out phases of the parabola, it is advised to set them upright to avoid any read or write errors occurring under high load factor (close to 2g).

- Since the experiment package will be compact and the aircraft crowded, be sure to have every item you need to access on one single side of your experiment, in front of which you will be most likely lying or sitting.

- Take care to avoid interference between your own pieces of equipment. Due to the compactness of the experiment, it is likely that you will experience some electro-magnetic interference between your electrical and measurement components. You must test the equipment in a lab in exactly the same physical configuration it will have in the aircraft. You will also have to carefully connect the ground of each electric or electronic equipment to the common ground. The sensitive parts of your experiment (measurement, teledetection...) could also receive interference from other experiments or from the aircraft. Be sure that the sensitive parts have a special electromagnetic shelter.

- Verify that the cooling openings of your equipment are not obstructed by padding or by other equipment.

- For some experiments, high electrostatic loads in the aircraft could be a problem (dust or small particles behaviors...)

To pass the safety review, build or modify your apparatus with common sense in mind. Use sensible labeling on switches and indicators. Have interlocks on critical controls. Have a "panic button" to shut off your system in case of a serious problem. It is imperative that critical items are properly documented and tagged. Double-check that your structural elements can handle the specified loads.

The importance of proper documentation, certification and tagging of critical items cannot be overemphasized. Most experimenters have equipment that is intrinsically safe, but in the past, some have not properly demonstrated and documented these facts to the Safety Visit committee's satisfaction.

If your apparatus is heavy, bolt on handles on strategic locations. If it is very heavy, bolt on removable wheels or bring a small dolly. Keep fragile components and wiring well away from lifting locations.

Many people will be walking or floating close to your experiment. Thus, protect exposed switches on your apparatus, use plenty of foam padding, particularly on sharp corners and edges. Bolt a sheet of LEXAN or non-flammable Plexiglas over your video monitor.

Experimental Procedures

The number of operations that can be carried out in twenty seconds is of course limited. Only essential operations should be executed during this time, to make the best use of the period of microgravity.

Consequently, the experimental procedures must be determined precisely before the flight, and you and your associates should know these procedures perfectly.

The interruptions between the parabolas - the sequence of normal gravity, hypergravity and microgravity - should also be taken into account in the procedures. Build your apparatus and define your procedures in such a way that you are not bound by one type of flight profile, as the profile can be changed.

It is often useful to visualize the quality of the ambient microgravity in the cabin in real time. Particularly for experiments that involve properties of flames, droplets, in weightlessness. A very simple **microgravity indicator** can be made for this. By connecting a dense, compact weight by a simple thread to the experiment structure, one can observe the free float. Usually the best microgravity environment is reached at the middle of the parabola.

When immediate results are needed, video and photo equipment is highly recommended. The best results are achieved using carefully focused cameras fastened to experiment racks. Be sure to bring spare batteries on board the aircraft, as well.

B. PERSONAL PREPARATION

Pre-flight preparation

Eat normally before the flights, one or two hours before take off, if possible. Eating nothing simply increases the risk of airsickness.

It is important to fly **in good physical condition** to limit fatigue during the flight. A good night's sleep is a favorable factor.

No toilets are available in the aircraft; participants must take this into account.

All experimenters wear a Nomex suit during the flights. The cabin temperature is set to allow light clothing, especially for subjects of medical experiments. So it is recommended to avoid wearing sweatshirts or sweaters, and to **limit underwear to a minimum**.

Only **sports shoes** are authorized, preferably with light-colored soles to avoid streaks and marks on cabin interior.

All **small objects** like pencils, cassettes, etc., fly away very easily during the parabolas and disturb the operation of experiments and of the aircraft. These objects should be secured to a person or to experimental equipment with string or Velcro or they should be stowed in suit pockets (make sure the pockets are closed) or in a bag attached to the experiment.

Hints for the Flight

Airsickness bags are distributed to each experimenter. If used, it is very important **to close them again before the next parabola**. The safety personnel on board will replace used bags as soon as possible. Used bags are stowed in one of the big plastic bags in the front and back of the cabin.

Strong odors accentuate the risk of nausea. The use of perfumes should be avoided. Very ill persons should go to the rear of the aircraft.

Smoking is prohibited in the aircraft.

The most comfortable attitude for experimenters during the **pull-in and -out phases (2g) is flat on their backs** or seated with the back against the side wall of the cabin.

Please be conscious of your own body during flight and try to avoid interfering with your neighbors and their experiments. Experimenters should **keep their legs in the restraining straps** (bring a strap for this purpose, and ask for a few O rings to attach it to the floor).

For experimenters who are flying for the first time, it is advised that they **remain seated for the first one or two parabolas** to get used to the new sensations specific to this maneuver.

As the cabin is often very crowded with equipment and people, **any unnecessary movement should be avoided** so as not to disturb the pursuit of the experiments; and **any experimenter who has finished his job should return to his seat** until the end of the flight.

Equipment and Safety Procedures

Appendix 6

The aircraft is fitted with 50 seats for the experimenters and supervisory personnel, 26 in the forward section and 24 in the rear section (fig. 1). Two-seat benches were removed to permit rapid access and evacuation.

During take off and landing, the experimenters are seated with seat-belts attached. They can only unfasten their belts and leave their seats when authorized to do so by the crew and must immediately return to their seats when ordered to do so. Each experimenter is assigned a seat for take off and must return to the same seat if necessary. Emergency evacuation from the aircraft will also be ordered by the crew. At this time, those in the aircraft will be asked to exit through the two rear doors or the two front doors, which are all equipped with escape slides.

Smoke hoods are on board, owing to the variety of experiments performed in the aircraft. The experimenters must don them when ordered by the crew. These hoods are located under each experimenter seat so that they are also accessible during take off and landing (the experiments are generally started up before take off and are active throughout all phases of the flight).

Furthermore, if cabin pressure is lost, oxygen masks fall down automatically from the ceiling within reach of the experimenters.

Life jackets are also available to the experimenters.

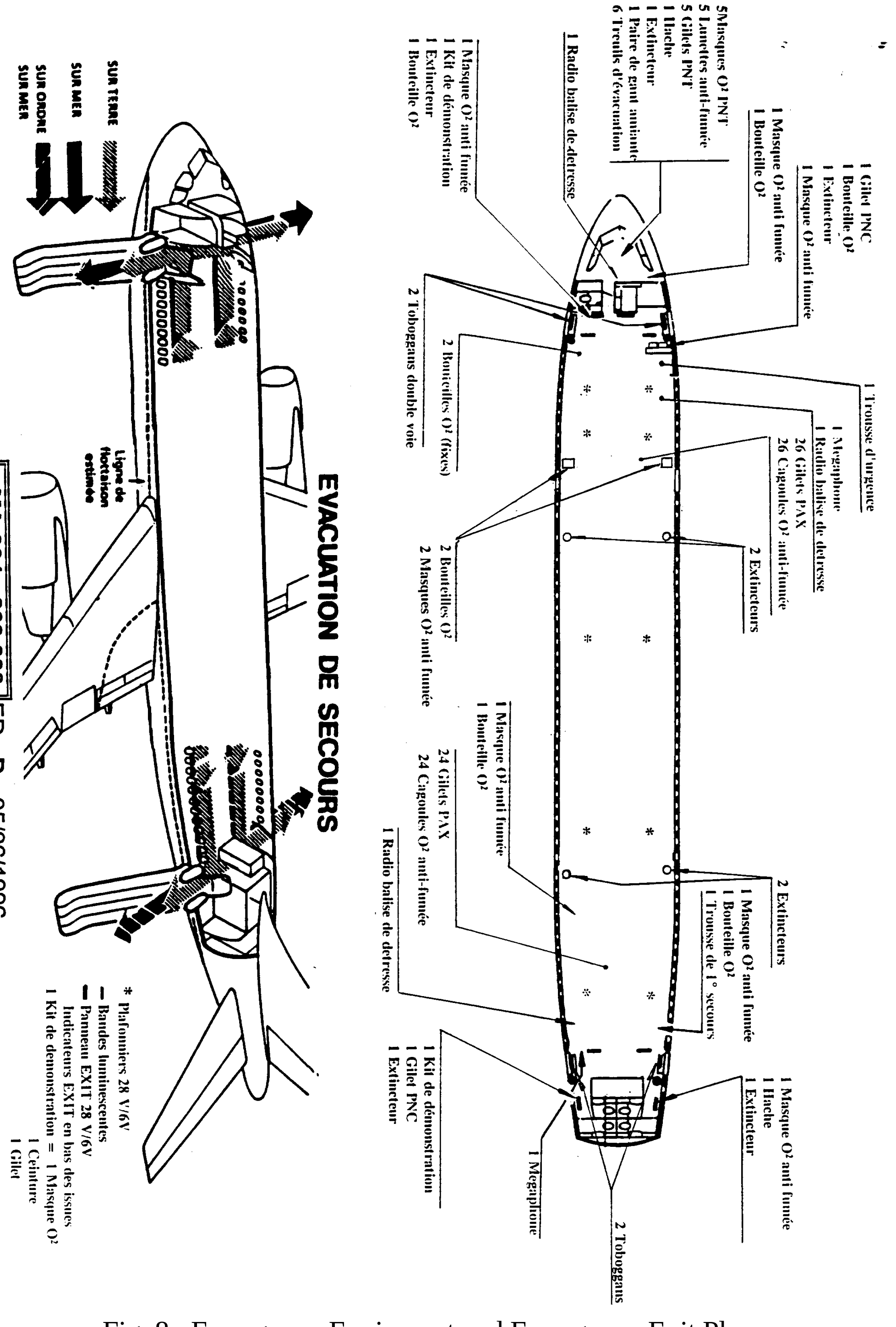

Fig. 8 : Emergency Equipment and Emergency Exit Plans

Claim waiver Appendix 7

Concerning

Mr :
Function:
Employer:

Campaign N° , from to 199

1 Any damage suffered by the equipment or the aircraft during the test series shall be at the expense of their respective owners.
Damage of whatsoever nature caused to the personnel from CEV, CNES, NOVESPACE and/or organizations taking part in the test series shall be at their respective expense, even if responsibility lies with one of the other parties, except in the event of a serious fault by said party.
These stipulations are limited to the relations between the parties and in particular do not prejudice any of the rights of accident victims and the social security organizations.

2 NOVESPACE confirms that it has taken out aircraft accident civil liability insurance for each experimenter with regard to persons not transported and the occupants, and individual insurance against bodily injury related to use of the A300 Zero-G.

3 The head of the CEV test section responsible for the test is alone qualified to decide on the ability of this person to be a experimenter on the flights.

4 The experimenters may in no case take part in the operation and running of the flight.

Name of organization's qualified representative

Function

Date

Signature and stamp Signature of the Experimenter

Individual Information Worksheet*

Appendix 8

Name and telephone of Experiment Coordinator:

Person Participating in the Experiment and Flight:

Name (Last):
Name(First):
Nationality:
Passport #:
Date of Birth:
Place of Birth:
Profession:
Telephone:
Telefax:
e-mail:

Employer:

Name:
Address
Postal Code: Country:

<u>Function during the campaign:</u>

ˇ On-board personnel ˇ Ground support ˇ Journalist ˇ Other (specify)...................

Date of Medical Certificate (or expected date):...
Date of Hypobaric Chamber Test (or expected date):..

* *Please complete for ALL PERSONNEL expected at the Novespace site in Bordeaux. Return information sheets to Novespace before the flight.*