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Asgard@SpacePole Programme

Documentation: Erik de Schrijver
Reference: ASGARD 2-08-2011
Edition: 1.14.1
Revision: 15
Date: 26/09/2024
Status: FINAL

User's Guide

REVISION HISTORY

Date	Status	Changes	Author
18/09/2011	Final	na	E. de Schrijver
19/10/2011	Final	Deadl. proposals	E. de Schrijver
4/11/2011	Final	Table3, spelling	E. de Schrijver
16/06/2012	Final	Deadlines, avionics	E. de Schrijver
16/07/2013	Final	Calendar, connections	E. de Schrijver
12/06/14	Final	Recovery, calendar, testing	E. de Schrijver
18/06/15	Final	Recovery, calendar, testing	E. de Schrijver
10/07/16	Final	Power, recovery, calendar	E. de Schrijver
14/07/17	Final	Batteries, calendar	E. de Schrijver
13-10-18	Final	Complete overhaul	E. de Schrijver
15-01-21	Final	Power supply & calendar	E. de Schrijver
15-10-22	Final	General revision, calendar	E. de Schrijver
12/02/23	Final	Calendar	E. de Schrijver
20/09/23	Final	General revision, calendar	E. de Schrijver
26/09/24	Final	Radio transmissions, calendar	E. de Schrijver

Table 1: Revision history

ABBREVIATIONS

%:	percent
A:	Ampère
Atm:	Atmosphere
BC:	Board Computer
CG:	Center of Gravity
EP:	Experiment Platform
ESA:	European Space Agency
ESERO:	European Space Education Resource Office
g:	Gravitational acceleration of the Earth (9,81 m/s²)
GMT	Greenwich Mean Time
H_2:	Hydrogen gas
He:	Helium gas
KMI:	Koninklijk Meteorologisch Instituut
LED	Light Emitting Diode
N:	North
NA:	Not Applicable
Pa:	Pascal
PPB	Payload Preparation Building
SPJ:	Sint-Pieterscollege Jette
SSC:	Swedish Space Corporation
TBC:	To Be Confirmed
TBD:	To Be Determined
TM:	Telemetry
V:	Volt
UG:	User's Guide

Table 2: Abbreviations

PREFACE

ASGARD

ASGARD is a hands-on space education programme realised by Sint-Pieterscollege from Jette (Brussels) in cooperation with Belgium's Royal Meteorological Institute (KMI) and other partners. The goal is to offer primary and secondary school pupils the opportunity to design, develop and build a scientific and/or technology experiment and fly it to the edge of space on a stratospheric balloon. These Asgard balloons are flown once a year (in the March-May timeframe) and reach a maximum altitude of about 33km. The Asgard-gondola was designed to carry a number of small educational payloads. Asgard is a unique educational instrument that combines low cost (no entry fee), a short turnaround time and great flexibility to do hands-on space education in near-space conditions.

The educational advantages of such hands-on projects include:

- coaching the students through all phases of a science/technology project (end-to-end): design, development, testing, flying, data-processing and reporting
- experiencing all aspects of a realistic space program (such balloons are being used by professional researchers all over the world for space research, including NASA)
- gaining a better understanding of the relevant parameters in the space environment (and hence on Earth)
- gaining a better understanding of the importance of thorough testing when developing new hard- and/or software

ACKNOWLEDGEMENTS

Mr. Dirk Frimout, President of the Euro Space Society and Belgium's first astronaut
Mr. Roeland Van Malderen, KMI
Mr. Erik de Schrijver, SPJ

for their contributions great or small, for information and time they devoted to this project.

TERMINOLOGY AND DEFINITIONS

1. Project proposal

In order to qualify for admission on board an Asgard balloon flight a formal project proposal has to be submitted. The form to fill in is found in Appendix 4. On the basis of these project proposals a selection is made by a jury headed by M. Dirk Frimout, Belgium's first astronaut.

2. Formal experiment description

Once an experiment is selected, the flight hardware can be developed by the submitting team. However, no payload can be integrated into the flight gondola unless the following documents are submitted to the organizers:

• Project proposal;
• Final design description (following the design and development phase);
• Test plan and Test report;

The organizers need this information no later than hardware delivery **(date due in the calendar)** in order to determine whether the hardware can be integrated in the gondola.

2. The payload

The payload is the ensemble of hard- and software that flies on the balloon, carrying out a specific task, for example performing a scientific or technological experiment. A payload can have several subsystems. Every subsystem has to satisfy the safety and technical prescriptions of this user's guide.

3. The 'client'

The client is the person responsible for the project meeting its stated goals, i.e. the project leader. The client takes care of the timely delivery of the flight hardware (at least two weeks prior to the flight campaign), and is the contact person between the organizers and the participating team.

4. Near-space

Near-space is that part of our atmosphere that can be reached on weather or stratospheric balloons. There is no internationally agreed-upon upper and lower limit for near-space, but the region between 25 and 50km is generally considered to suit the term. The name is derived from the physical conditions' similarity to the actual (orbital) space environment. It should be noted that the boundary of space is not a physical frontier, but depends on convention (The FAI - Fédération Aéronautique Internationale - defines space as the region above 100km). Air pressure in near-space is approximately 1% of sea level values. As a result, heat transfer is governed by radiative processes, not by contact or convection. Air humidity is essentially zero and solar radiation arrives pretty much unfiltered. If it wasn't for the value of the gravitational acceleration and the chemical composition of the (eariest remains of the) atmosphere, conditions would be similar to those on Mars.

LEARNING OPPORTUNITIES

• Information on the use of stratospheric balloons: Archimedes' Principle, balloon types (superpressure balloons, zero pressure balloons, MIR-Montgolfière à InfraRouge, ...), ascent velocity, parachute systems, lifting gases (Helium vs. Hydrogen), etc.
• Information on the atmosphere: temperature, pressure and density gradients, propagation of sound, air pollution, etc.
• Information on radiation: solar radiation (its nature, intensity, spectral properties), cosmic rays, etc.
• Experiments in teledetection: albedo (reflectivity of the Earth), photography, video, etc. Camera's at altitude hold the middle ground in scanned area and resolution between planes (small area but higher resolution) and satellites (larger areas but lower resolution).
• Experiments in biology.
• Landing systems.
• Localisation experiments (using accelerometers and/or gps).

Getting access to 'near-space' is quicker, easier, and far cheaper than launching a satellite. Near-space balloon flights are therefore often used to space-qualify parts and subsystems scheduled for use in actual spacecraft.

USEFUL DOCUMENTS (UD)

UD[1] National Scientific Balloon Facility recommendations for gondola design, NSBF, April 1986
UD[2] http://weather.uwyo.edu/upperair/sounding.html
UD[3] http://www.irf.se
UD[4] http://www.rymdbolaget.se
UD[5] http://www.ee.nmt.edu/~anders/courses/ee481lf08/book/NearSpace0.pdf

EXTRA INFORMATION

This document is revised periodically; comments and suggestions on all aspects of this UG are encouraged and appreciated. Inquiries concerning clarification or interpretation of this manual should be directed to:

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Extra information can also be obtained from:

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1. INTRODUCTION

This User's Guide (UG) describes the environmental conditions and the technical aspects of the Asgard programme for the benefit of the clients. These aspects and conditions need to be taken into account when designing an experiment. The technical aspects also determine boundary conditions to be met by an experiment to make it eligible for an Asgard mission.

1.1 PURPOSE OF THE MANUAL

In this manual you can find:

- **Chapter 1**: Introduction
  General information on the Asgard programme and its organisation;
- **Chapter 2**: Systems description
  Description of the balloon, the gondola and other subsystems;
- **Chapter 3**: Performance data and flight phases
- **Chapter 4**: Environmental conditions
  Environmental conditions and their consequences for experiment design and qualification;
- **Chapter 5**: Gondola and payload interfaces
  Description of interfaces between gondola and experiment;
- **Chapter 6**: Experiment design and verification
  Qualification tests and calendar management;
- **Chapter 7**: The launch campaign with calendar;
- **Chapter 8**: The lauch site
  Payload preparation and ground operations;
- **Appendix 1** adresses the possibilities for external experiments
- **Appendix 2** shows graphs with temperature and pressure data taken from the in- and oustides of the gondola on the maiden flight;
- **Appendix 3** gives additional information on environmental conditions, taken from other but similar balloon flights;

With this information, it should be feasible for the would-be client to determine whether the research question can be adressed with a balloon mission.

1.2 LAUNCH PREPARATIONS

Balloon preparations are taken care of by KMI personnel. Their team is in charge of the 3 flights a week KMI carries out for meteorological purposes. More information on the launch site can be found in Chapter 8.

1.3 LAUNCH SERVICES

Payload integration and verification operations are performed by the team from Sint-Pieterscollege.

Every client will make sure to

- provide the required technical information in due time;
- perform the necessary tests and report on the results;
- deliver the hardware in time;

This is in order to allow integration procedures to run smoothly and by the numbers.

Failure to comply may result in the organizers' decision not to integrate and fly the experiment.

2. SYSTEMS DESCRIPTION

2.1 THE BALLOON SYSTEM

A balloon sytems consists of more than just the balloon. There is a so-called 'flight train', which encompasses:

- A gondola containing the experiments, power system, avionics and other vital subsystems:
  - the Avionics platform (with on-board computer and the power system);
  - one or more experiment platforms;
- A parachute system;
- A radiosonde;
- The balloon;

The Asgard configuration and corresponding figures can be found in Table 3.

Balloon system

BALLOON	
Lift-off volume	3,5 m^3
Lifting gas	H_2
Balloon dry weight	1,2 kg
Pressure at lift-off	1atm
Balloon material	Latex
PARACHUTE	
Cutdown mechanism	none
Pressure at balloon burst	7 -10hPa
Parachute area	~0,7 m^2
Parachute mass	0,140 kg
Vertical tension	+1/-2.5 g
Horizontal tension	+/-0.5 g
GONDOLA	**(S = Small gondola / L = Large gondola)**
Dry weight	S: 0,3 kg / L: 0,5 kg
Maximum payload mass	S: 2 kg / L: 1,5 kg
Available power	**Approx. 6W@5VDC(*) / gondola**
Shape	Hexagonal prism (dimensions in App.1&2)
Structure	30 mm Polystyrene
Thermal insulation	Polystyrene and Mylar

Table 3: Asgard balloon system properties

(*) Experiments can carry their own batteries if for example higher voltages or currents are required.

2.2 THE BALLOON

The weather balloons used are manufactured by TOTEX, http://www.totex.jp.

2.3 AT BURST ALTITUDE

As the balloon rises the decreasing atmospheric pressure causes the lifting gas inside the balloon to expand, creating increasing tension in the balloon fabric. At an atmospheric pressure of about 7 - 10 hPa (an altitude of approximately 30km) the balloon bursts and the gondola falls back to the ground. A parachute suspended in the flight train catches the very thin high-altitude air and starts to open, gradually decelerating the gondola as air density increases until it reaches a terminal velocity of about 12 - 14 m/s. More information on balloons and parachutes can be found in UD [1].

2.4 THE PARACHUTE-SYSTEM

KMI takes care of the balloon and the parachute system. For better visibility, it's color is red. The parachute is a circular piece of plastic of sufficient strenght to safely bring back a <2,5kg gondola at velocities of about 14m/s.

The parachute is suspended in the flight train (just underneath the balloon). Between the parachute and the gondola is an anti-torch ring. This ring ensures that even in the very thin upper atmosphere, the parachute quickly gathers enough air to open without the cords getting entangled. (Deploying a parachute at 30km is not as straightforward as it is at sea level).

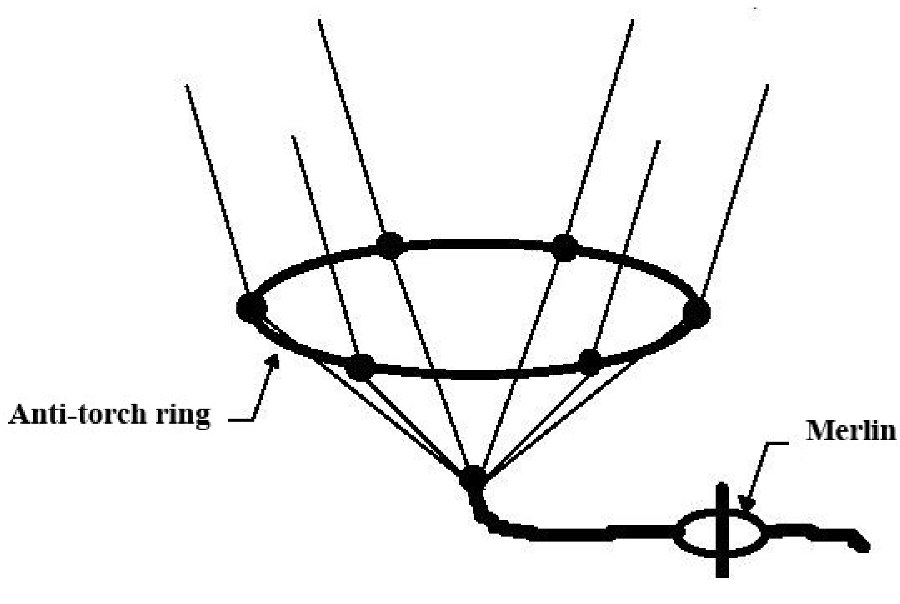

Figure 1: The Anti torch ring facilitating parachute deployment

This 'anti-torch ring' has a diameter of about 20cm and is attached to both parachute and gondola with 6 cords.

3. FLIGHT PHASES

3.1 INTRODUCTION

With the information in this chapter, would-be clients should be able to determine whether a balloon flight is suitable platform for the experiment envisioned.

3.2 FLIGHT FIGURES

The gondola descends underneath the parachute after balloon burst. This occurs between approximately 28 and 35km, some 60 to 90 minutes after lift-off. Ascent velocities are close to 5-6m/s. Gondola mass is approximately 2kg. Maximum mass per experiment is set at 200 grams.

Descent velocities are typically twice ascent values, bringing total flight times to about 100 to 150 minutes. Horizontal displacement obviously depends on wind speeds. At values of about 60km/h, the gondola may land over 150km from the launch site. Of course, wind speeds can differ substantially at altitude from ground level values, but recovery may still take several hours. Clients requiring rapid examination of their hardware (biology samples for example) should take this into account, and consider being part of the recovery team.

3.3 FLIGHT PROFILE

The 3 phases of an Asgard balloon flight:

- Phase I: Ascent;
- Phase II: Descent;
- Fase III: Gondola recovery;

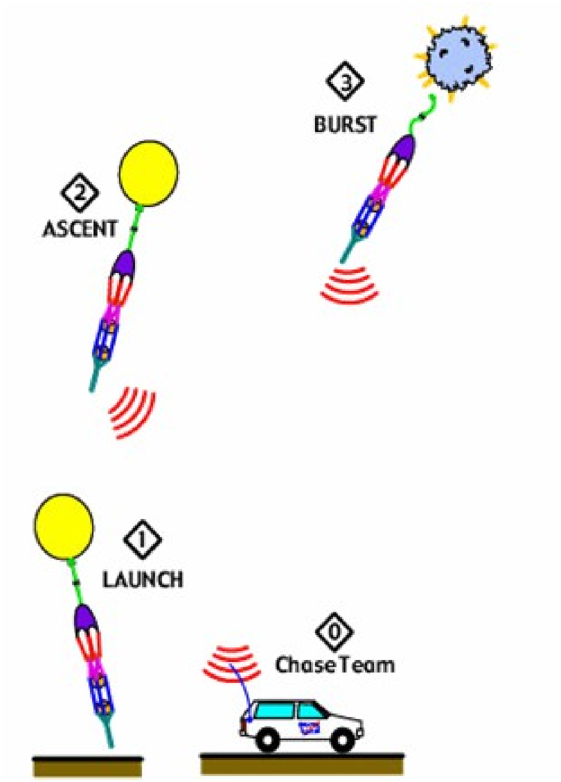

Figure 2: Flight phases

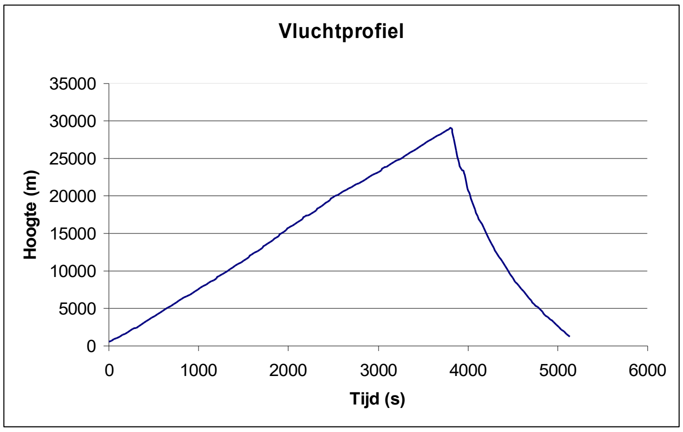

Figure 3: Flight profile

Phase I: Ascent

The ascent phase from the time of lift-off till the time of balloon burst. The duration of this phase depends on the mass of the gondola, the quantity of lifting gas and atmospheric conditions. At an altitude between 11 and 25 km the temperature goes through a minimum of about -60°C. Frozen condensate will usually sublime before the altitude of 25 km is reached. The ascent phase takes about 90 minutes. Average ascent velocity is therefore usually close to 6 m/s. During this phase, 3D postioning of the gondola is assured by the organizers. 3D positioning throughout the flight is on the organizers wish list for future flights. The gondola can not alter its orientation in the horizontal plane. Experiments requiring this capability need to be equipped with their own (external) steerable platform.

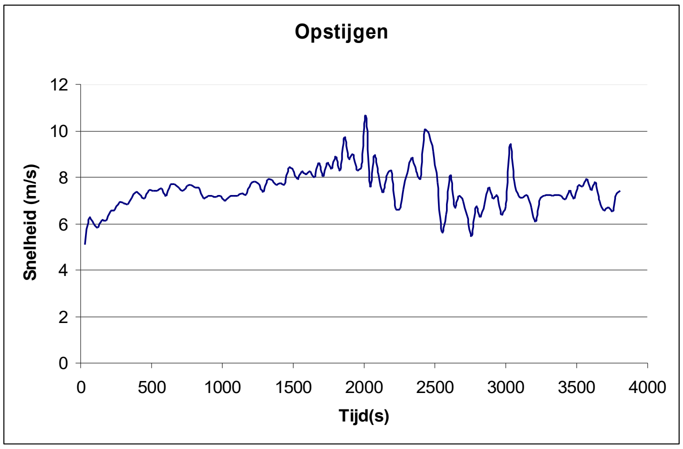

Figure 4: Vertical velocity (m/s) vs time (s) during ascent

Phase II: Descent

Descent can be subdivided in:

- the time from balloon burst till full parachute deployment
- parachute descent

The duration of each subphase can vary with atmospheric conditions, gondola mass and the quantity of lifting gas. During descent the gondola encounters the same environmental conditions as during ascent. Parts and subsystems on the gondola outside can suffer detrimental effects from condensation, freezing and/or corrosion. Most problems usually don't occur until the gondola drops below 12 km altitude, because above 12 km, air humidity is essentially zero. Clients fearing damage through moisture, condensation or freezing take appropriate countermeasures themselves. Internal experiments or subsystems usually do not suffer from moisture or condensation problems because the conditions inside the gondola are far more benign than those out in the open (see Appendix 3).

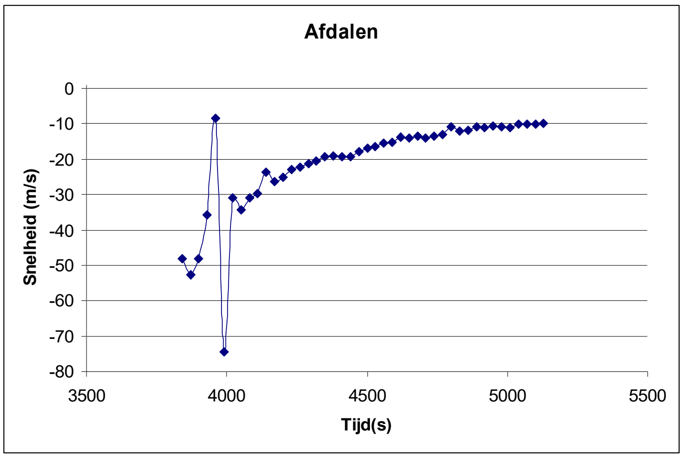

Figure 5: Vertical velocity (m/s) vs time (s) during descent

Phase III:Gondola recovery

Gondola recovery is an adventure at times fraught with problems. Often the recovery team has to negotiate with land owners to get permission to access private property or to reach an isolated patch of land. This can cause delays of hours, sometimes days. The organizers will do whatever is possible to recover the gondola quickly, but can not be held accountable for any delays. Typical landing areas are fields, meadows, ponds, lakes, private gardens and woods. In the latter case the gondola may be stuck in a tree. As there is no possibility to steer a descending gondola, one can only hope for the best.

Additional information can be found under 3.5.

3.4 LAUNCH WINDOW AND FLIGHT FREQUENCY

An Asgard balloon could in principle be launched any day of the week, regardless of weather conditions (exceptional storm conditions notwithstanding). In practice however, only tuesdays and thursdays are possible launch days, as the KMI has no meteorological balloon soundings on these days, giving the launch team more leeway.

3.5 GONDOLA RECOVERY

To enable smooth recovery, the gondola carries a gps-tracking device. Once on the ground, an sms sent by the recovery team triggers the module into texting back its coordinates, which can then be imported in Google maps on a smartphone. Hence the recovery team knows the landing position of the gondola (with an accuracy better the about 10m). Furthermore, the KMI radiosonde aboard gives information on altitude, direction and speed throughout ascent, so the recovery team can be on its way even before balloon burst. This can easily speed up recovery by several hours, especially on windy days when the gondola may drift a good distance.

4. ENVIRONMENTAL CONDITIONS

A safety margin of 10% above the specifications in this UG is recommended for all parts and subsystems. If this is not achievable, the organizers recommend thorough testing under relevant conditions be performed prior to flight in order to verify proper behaviour.

4.1 GENERAL

The environmental conditions to which the gondola is exposed during payload integration, flight preparations and actual flight are very different. This applies to mechanical, thermal and electromagnetic conditions alike. Possible extremes are treated in this chapter.

4.2 MECHANICAL ASPECTS

A balloon flight is a very smooth operation, not characterized by intense accelerations, vibrations or noise, as is the case for a rocket flight. Landing can cause a severe shock though, and for delicate equipment a vertical acceleration of 9 g's and a horizontal acceleration of 6 g's should be taken as design constraints.

4.2.1 Other design constraints

Given the shock and vibration free flight conditions no special design constraints apply. One should bear in mind the possibility of sudden wind gusts though.

4.2.2 Other shocks

The parachute is hanging beneath the balloon and its filling with air after balloon burst is a gradual process occuring as the gondola falls into ever denser atmospheric layers. No shocks are expected (wind gusts notwithstanding) except for landing.

4.2.3 Static pressure in the gondola

The gondola is not airtight. As a result, air pressure inside always equals outside pressure. More information on pressure as a function of altitude can be found in Appendix 3.

4.3 THERMAL ASPECTS

No measures are taken to provide the gondola with a particular thermal environment, either before lift-off or during flight. The gondola insulates its contents though, through its make-up (polystyrene) and its insulating layer (Mylar). Prior to flight, the experiments are therefore exposed to normal weather conditions (March/May in Belgium). Some heating inside the gondola may occur prior to lift-off because the heat produced by the experiments is not evacuated efficiently. This also applies to the period between landing and gondola opening. Typical temperatures inside the gondola and outside as a function of altitude can be found in Appendix 3.

4.4 CLEANLINESS AND CONTAMINATION

Payload integration is not performed in clean room. Normal temperatures, air humidities and atmospheric conditions apply.

Under no circumstances can an experiment release substances, either in the atmosphere or in the gondola, without prior permission of the organizers. This also applies to substances considered harmless, and it applies to solids, liquids and gases alike. All use of corrosive, flammable, explosive or toxic substances is explicitly forbidden. In case of doubt, a Materials Safety Data Sheet (MSDS) shall be submitted to the organizers. The use of gases under high pressure is not recommended.

4.5 ELECTROMAGNETIC ASPECTS

The only downlink during the flight is KMI's radiosonde. Since they operate in the meteorological frequency band, amateur radio regulations do not apply to such radio sondes. The organizers will strive to provide a downlink capability with basic information (position, physical conditions in the gondola, battery status).

Experiments generating intense electric or magnetic fields could perturb other experiments. It is therefore **required** to characterize such fields (or voltages) and to **include this information in the experiment documentation**. If necessary, the organizers will require the experiment to be properly shielded in order to safeguard the electromagnetic environment in the gondola for the other experiments.

5. GONDOLA AND PAYLOAD INTERFACES

The functionalities of the flight computer & power supply fall outside the scope of this manual. The structure and configuration of the experiment platforms, and how to connect to the central battery will be discussed.

5.1 INTRODUCTION

In this Chapter the gondola shapes and dimensions are given, as are the interfaces used to integrate the experiments into the payload adapter.

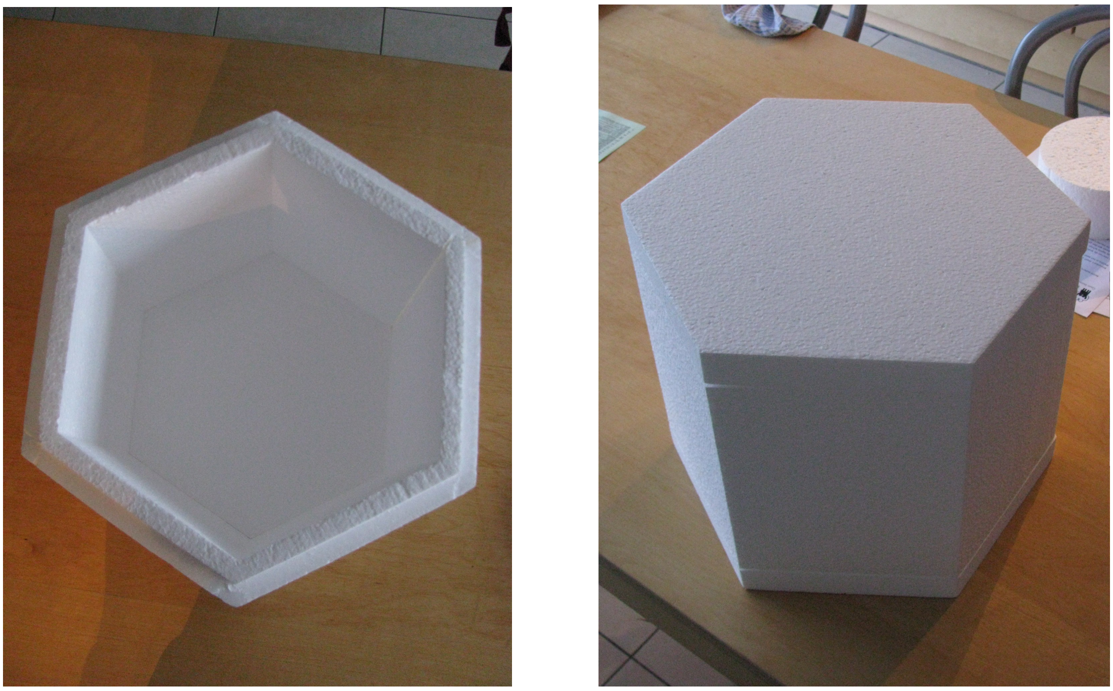

Figure 6: Gondola in- and outside

The payload is inserted into the gondola by means of a custom-made payload adapter. This allows late access to verify the proper functioning of all subsystems and experiments until shortly before launch. It should be noted the payload's proper functioning is checked at payload integration. Late access is only intended for experiments that need to have some last-minute operation performed on them. The adapter provides structural support and stiffness, as well as connection to the gondola's power supply.

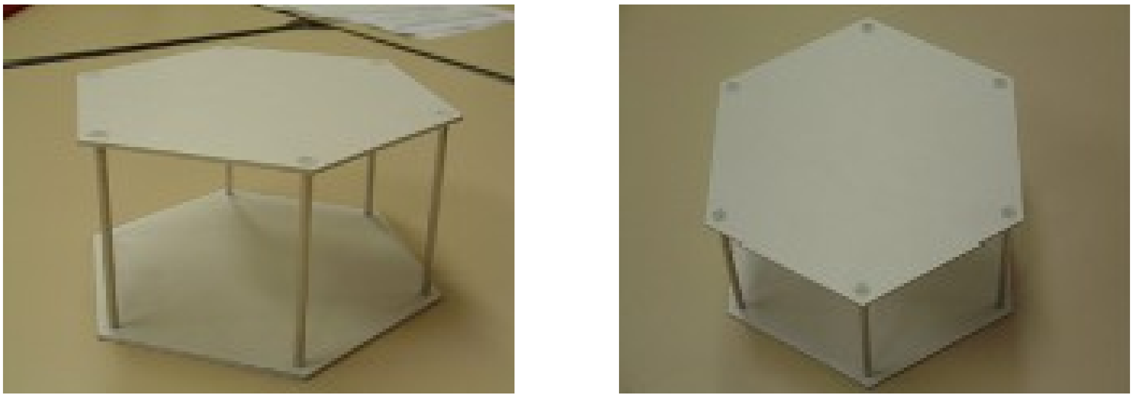

Figure 7: Payload adapter

(The # of platforms and the distance separating them are adjustable per Asgard mission.)

5.2 REFERENCE AXES

In order to facilitate communication between client and organizers, the following reference axes are defined.

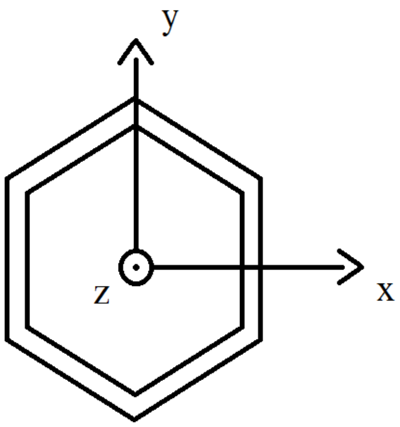

Figure 8: Asgard coordinate system

5.3 THE GONDOLA

5.3.1 Payload volume

A distinction is made between internal and external experiments. An internal experiment has all parts and subsytems inside the gondola. An external experiment has at least part of the hardware attached to the gondola's outside. Examples of the latter are passive biology experiments where plant seeds are attached to the outside of the gondola for exposure to near-space conditions. Or it could be a datalogger where the sensor is on the outside of the gondola but the microcontroller and the memory device are inside.

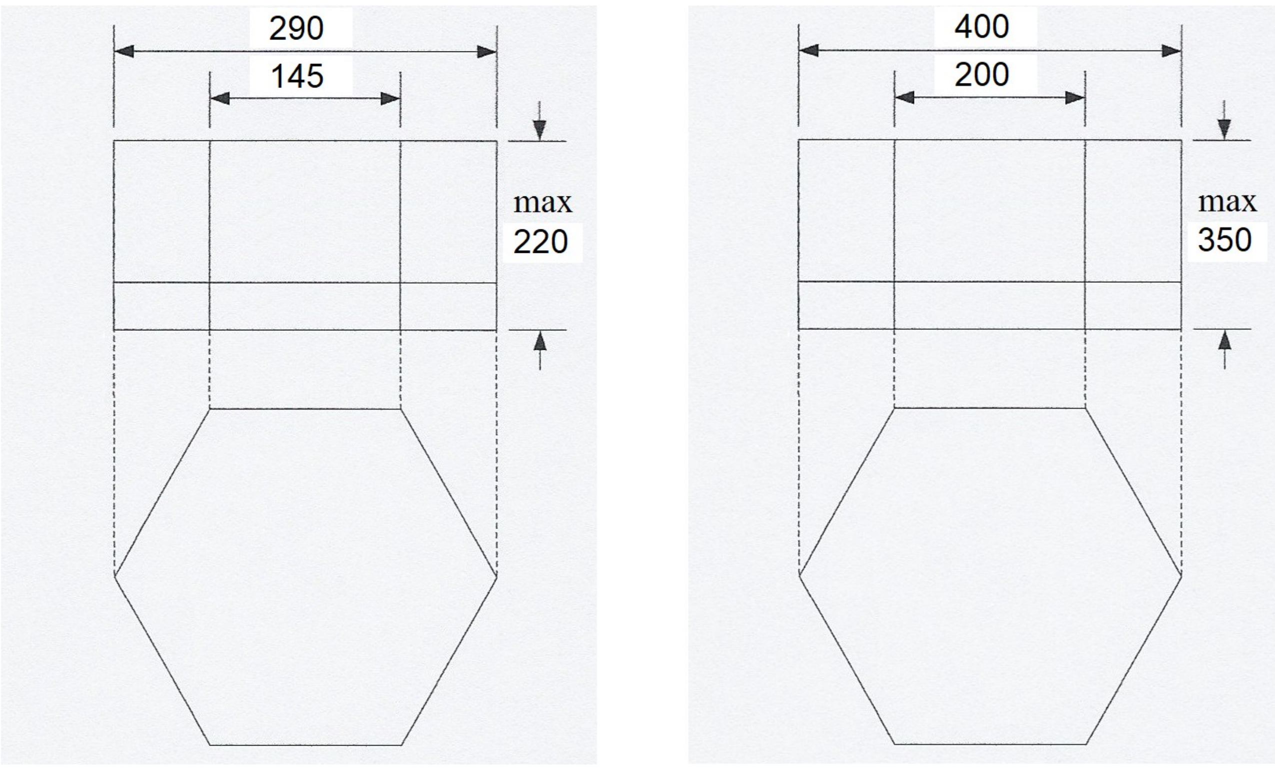

Figure 9: Payload adapter dimensions (in mm). Left = Small gondola, Right = Large gondola

Payload volume is considered to mean available volume in the payload adapter. Hence its meaning is limited to internal experiments or internal parts of external experiments. Under no circumstances can any internal part protrude from the payload adapter as this would hinder sliding the payload adapter into the gondola. Maximum payload adapter dimensions can be read from Figure 9. The height of each instrument compartment (that is the distance between the experiment platforms) can be adjusted to the flight's needs (see Figure 8).

5.3.2 Payload accessibility

Integration of the experiments into the paylod adapter is done by the team from SPJ approximately two weeks prior to launch. Integration activities end with an integration test consisting of powering up the power-board, thereby powering up all experiments. The clients then verify the proper functioning of their experiment and eventual problems are adressed in concert with SPJ. Thus: clients should besign their experiments so as to allow multiple power ON/OFF cycles prior to flight

Integration is concluded one or two weeks PRIOR to launch! Last minute access is ONLY for experiments needing it: f.e. to insert biology samples, freshly annealed dosimeters, internal batteries, etc), NOT to finish work on an experiment that is not flight-ready!

At this time there are no windows in the gondola walls, but the organizers are considering the possibility for future flights.

5.3.3 Logo's, stickers, etc.

Logos or insignia from schools or partners can be placed on the gondola walls (or spin-inhibiting winglets) **IF** they are smaller than 10 by 10 cm **and are delivered to the organizers at the same time as the experiment hardware.**

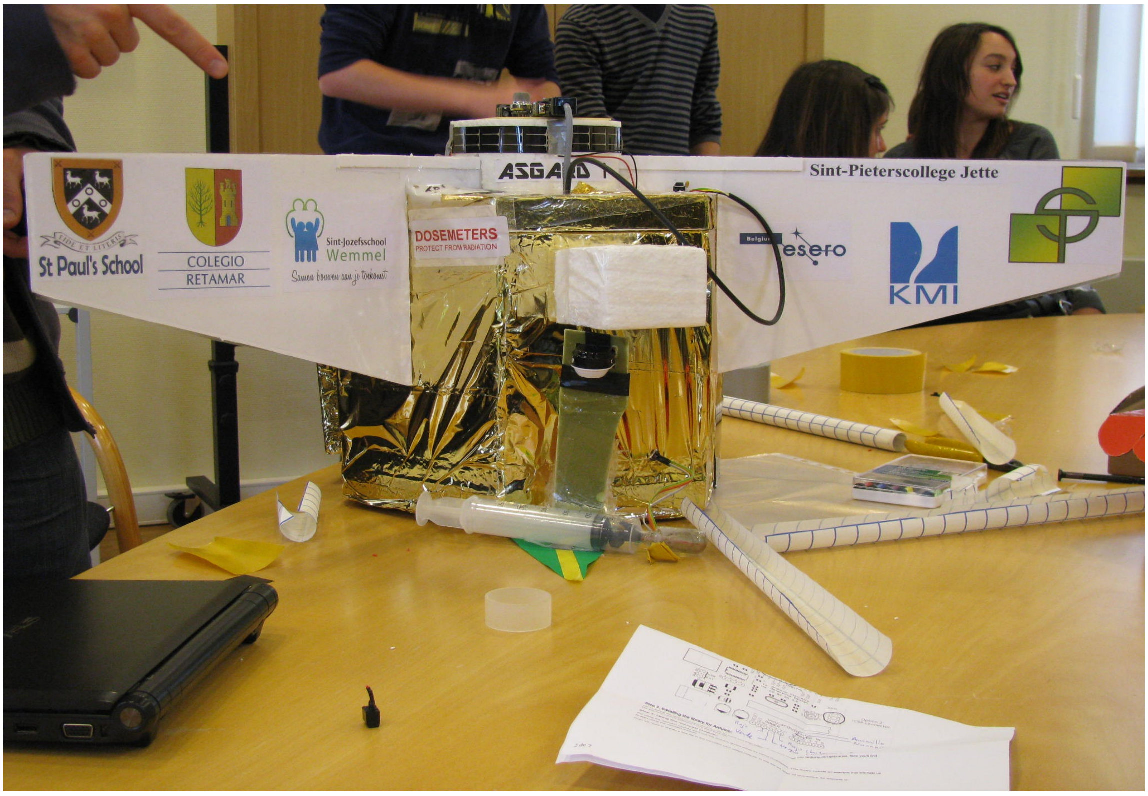

Figure 10: Logos of schools and partners on Asgard-1's gondola

5.4 MECHANICAL INTERFACE

5.4.1 Gondola structure description

The gondola shape is a hexagonal prism, thus combining the structural advantages of flat surfaces (for easy attachment of external samples, sensors, ...) with the goal of maximizing internal volume.

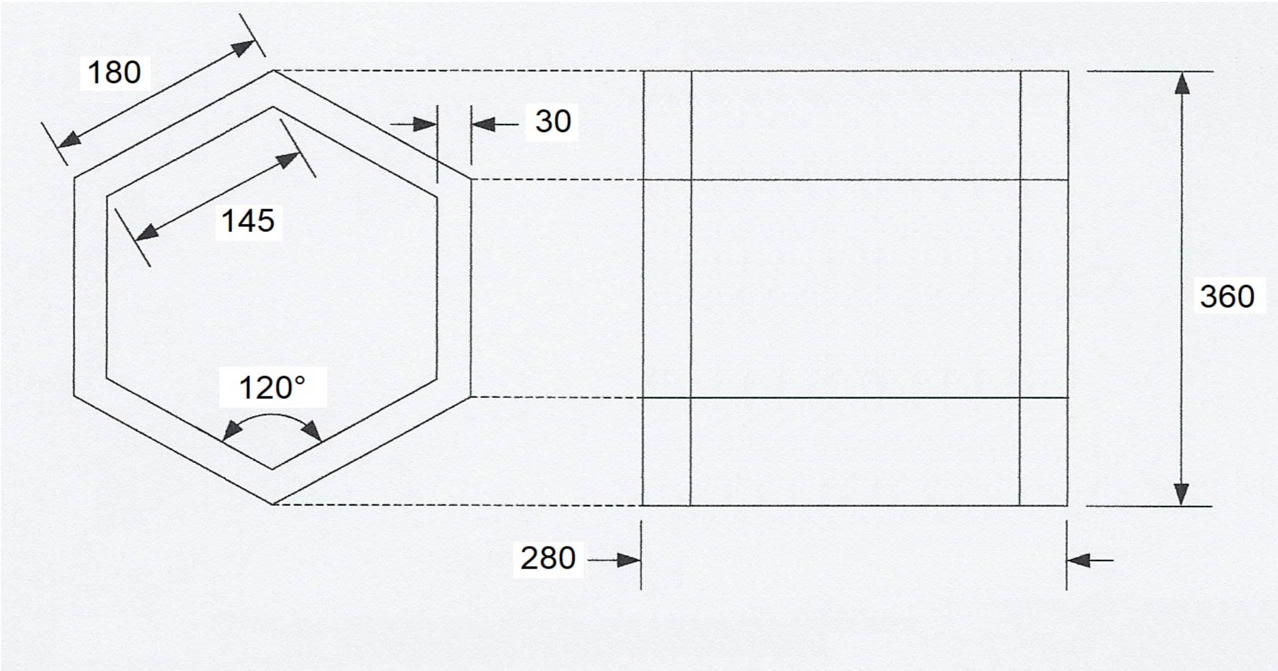

Figure 11: Small gondola dimensions (in mm)

The small gondola is made from 30 mm thick polystyrene which makes for good insulation against the adverse cold of the tropopause at an acceptable mass penalty of 300grams. For even better insulation, the gondola is covered with a Mylar foil (sold as thermal blanket).

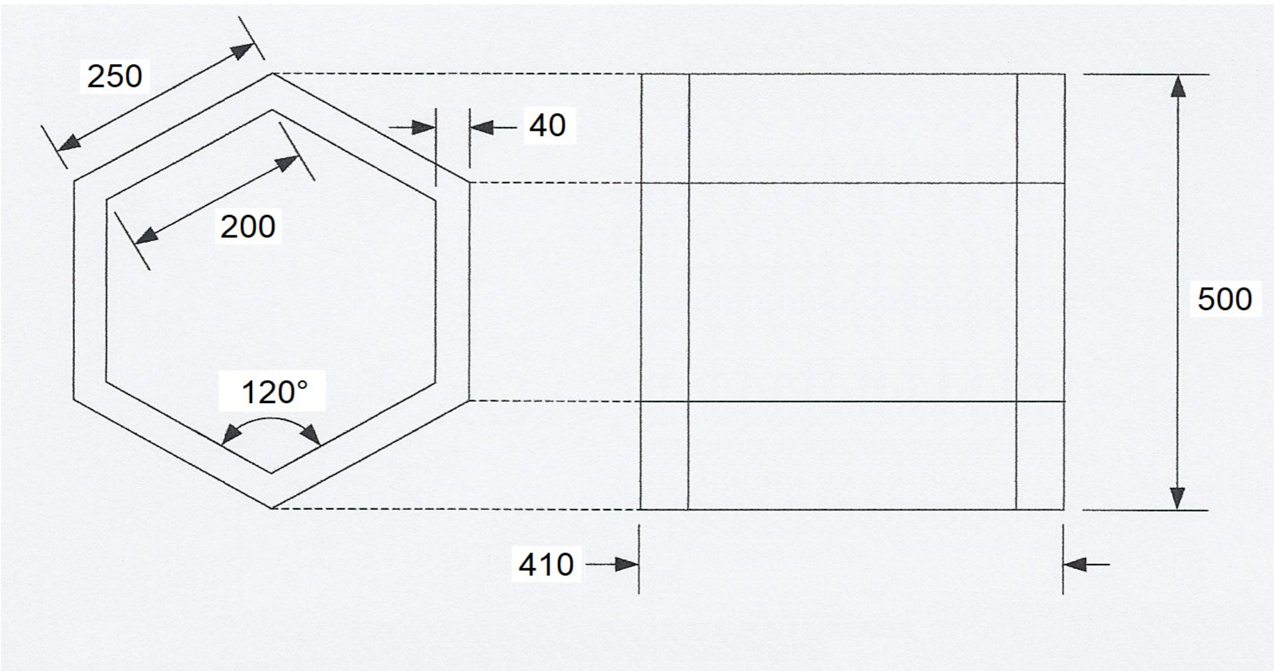

Figure 12: Large gondola dimensions (in mm)

The large gondola is made from 40 mm thick polystyrene which makes for good insulation against the adverse cold of the tropopause at an acceptable mass penalty of 500grams. For even better insulation, the gondola is covered with a Mylar foil (sold as thermal blanket).

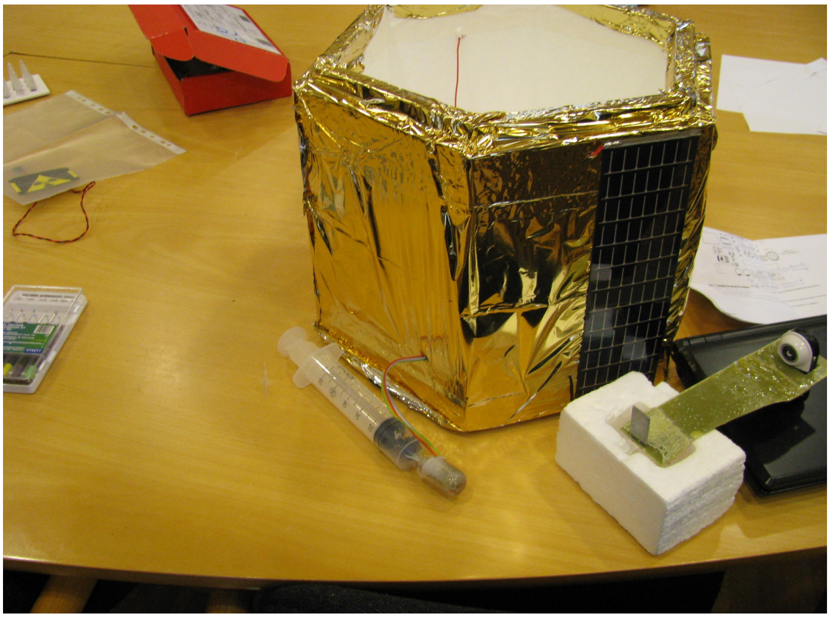

Figure 13: Asgard gondola with Mylar insulation

5.4.2 Description of the experiment platforms

Depending on the number of experiments and their respective heights, the payload adapter can be made up of different compartments. There is always at least one compartment. The height of each compartment can be adjusted between 30 and the maximum total height. The lower compartment contains the on-board computer and batteries, the other compartments contain the experiments. The uppermost compartment contains those experiments requiring a connection to outside subsytems. This enables those connections to be made before the payload adapter is inserted in the gondola, which allows the proper functioning of these experiments to be verified together with all other experiments.

When fastening experiments to the experiment platforms the following considerations will apply:
• the payload adapter should slide smoothly into the gondola
• the experiments should be easily accessible so adjustments can be made if something turned out to be wrong during integration testing

5.5 ELECTRICAL AND RADIO INTERFACE

Asgard organisers do not provide downlinking of data during the flight. **TEAMS wishing to use radio to transmit data to the ground need to obtain the proper permits themselves AND obtain permission from Asgard organisers to use particular frequencies and power levels. Failure to obtain the proper permits from the relevant authorities exposes the team to legal consequences as the organisers decline all responsibility. Failure to obtain permission FROM the organisers WILL result in a NO-FLY decision.**

Experiments that do not provide their own power can connect to the power supply available on the gondola. The supplied voltage is 5VDC and the current must be limited to a maximum of 200mA, or a special waiver must be obtained from the organisers. The connector will be provided by the organisers.

5.5.1 Electrical functions

The lower platform containing the on-board computer also holds the batteries powering the experiments (except for those providing their own power). The characteristics of the nominal power supply (variations are possible) are given in Table 4.

Battery type	AA LithiumUltralife
Number	as needed
Nominal voltage	Buck convertor output is 5VDC
Operating temperature	-40°C to +60°C
Mass	Typically 150-200g
Max current	2,0A (continuous)
Max reverse current	2μA
Internal resistance	100-250mΩ
Capacity	2000mAh/battery

Table 4: Properties of the nominal power supply

Every experiment using the on-board power supply must be characterized in terms of its power consumption. Every connection to this power supply is fuse- protected by the organizers, so other experiments do not face battery exhaustion should one experiment short out. It is up to the teams to make sure their current consumption is properly determined and the experiment is reverse current protected!

Remark1: Experiments can carry their own power supply (total mass limitations stay valid!). In this case the battery should be able to provide at least 4 hours worth of continuous power!
Remark2: Safety rules require all wires and connections to be insulated.

6. EXPERIMENT DESIGN AND VERIFICATION

6.1 INTRODUCTION

This chapter deals with the constraints and directives to be taken into account when designing an experiment, in order for the experiment to be eligible.

The environmental conditions in the gondola (pressure, temperature, humidity, etc.) are monitored but not controlled. Every internal experiment (or internal subsystem of an external experiment) is subject to more or less the same conditions.

Every experiment proposal is welcomed (all scientific and/or technological disciplines) if it satisfies the requirements mentioned in this UG.

Safety rules:

• An experiment has to be designed in such a way as not to be of influence on the balloon flight, even in case of catastrophic failure. Every client shall be liable for any damage caused by his equipment to the equipment of other clients or the organizers.
• The organizers can not be held accountable for loss of the gondola or damage to gondola contents.
•If an experiments requires modifications to the payload adapter, the experiment proposal should mention that and provide a detailed description of the requested modification. The organizers decide on whether or not to grant the modification.
• Prior to the flight, all experiments are powered OFF. Power ON is done once during integration testing and one more time in the PPB before the gondola is sealed. In both cases, power ON is performed by the SPJ team.
• Should an experiment contain parts that need to be removed prior to flight, then these parts shall be readily accessible and be painted in red.

6.2 QUALITY ASSURANCE

A smooth flight campaign and proper functioning of experiments require the clients and organizers to communicate frequently and to the point. Some topics need to be covered in this two-way communication, which is why these topics are mentioned in the 'Formal experiment description' p4.

• Project proposal (see Appendix 4);
• Final design description (following the design- and development phase);
• Test plan and Test report;
• Description of flight sequences;

Under certain conditions, additional information may be required: Materials Safety Data Sheets for potentially dangerous substances, 'data sheets' for components of which proper functioning is uncertain, ...

The documents requested by the organizers shall be provided to and approved by the organizers before integration in the payload adapter can be considered.

6.3 INTERFACE VERIFICATION

6.3.1 Prior to the launch campaign

The launch campaign at the KMI campus is very short, barely two hours. Payload integration and integration tests are performed approximately two weeks prior to transfer to the KMI campus.

These tests include (among other things):

Mechanical integration: All experiments are fitted physically into the payload adapter to verify everything fits. This includes verification of external dimensions, presence of the required fastening points. LED visibility will also be checked as will accessibility of parts to be removed (if there are any).

Electrical aspects: Connectibility to the power supply will be verified, as will compliance of power consumption with the information in the experiment documentation.

6.4 DATA SHARING

After the flight, the organizers will make all data on pressure, temperature, position, etc. available to the clients. In return, clients are requested to make their data available to the organizers, should they so desire. Obviously publication rights remain with the parties concerned (clients and organizers) and credit will be given where due. Should participation in Asgard result in the publication of 'papers', then M. Roeland Van Malderen (KMI-IRM) and M. Erik de Schrijver (Sint-Pieterscollege Jette) will be added as co-authors.

6.5 QUALIFICATION

Experiments will only be delivered after proper testing.

6.5.1 Design philosophy

It is recommended that a benchtop model of the hardware be built as an integral part of the design and development work, and to perform the relevant testing on the benchtop model before beginning the assembly of what is to become the actual flight hardware.

Before delivery to the organizers the actual flight hardware shall be subjected to the relevant tests as well. This approach makes for a thorough understanding of the hardware and allows a rapid fix of any problems that might occur during payload integration and/or integration tests.

6.5.2 Testing philosophy

The following tests and measurements are considered a basic minimum set:
- Physical properties (dimensions, mass, CG);
- Mechanical interface (including the emplacement of the fastening holes);
- Electrical properties (emplacement of the connector and LED, current draw);
- Vacuum test: have your experiment operate in partial vacuum (P<100hPa) during at least 1 h. **Vacuum tests can be offered free of charge by Sint-Pietercollege. Shipping costs either way are not covered by Sint-Pieterscollege or Asgard organisers.**
- Thermal Vacuum tests and cycled heating/cooling (only for heat-sensitive and/or delicate equipment);

6.6 THE CALENDAR

Project proposal submitted	**November 11th , 2024**
Proposals evaluated+ selection	**December 2024**
FIRST PROGRESS REPORT	**January 30th , 2025**
FINAL DESIGN DESCRIPTION submitted	**April 3rd , 2025**
Building phase for the flight hardware	**<April 15th , 2025**
Testing flight hardware	**<April 15th , 2025**
TEST PLAN AND REPORT submitted	**<April 15th, 2025**
HARDWARE delivered	**<May 1st , 2025**
Launch campaign	**May 14-16th , 2025**
Asgard-XI balloon flight	**May 15th , 2025**

Table 5: The calendar

6.7 DELIVERY AND ACCEPTANCE OF EXPERIMENT HARDWARE

Hardware acceptance follows the following procedure:

- Flight hardware is delivered to the organizers;
- Compliance of the flight hardware to the final building plan is checked by the organizers;
- Emplacement of the connector(s), LED, on/OFF switch and contact point is verified;
- General inspection of the experiment;
- If everything is OK, the experiment is formally accepted;

7. THE LAUNCH CAMPAIGN

Payload integration and testing at the Planetarium	**TBD**
Participating teams arrive in Brussels. Check-in at the hotel. Hotel Meininger Brussels City Center is recommended.	**Tuesday 13/5/2025**
Get-together	**Tuesday evening 13/5/2025**
PPT-Presentation by the teams at the Planetarium	**Wednesday morning 14/5/2025**
Power-up verification/Last minute access	**Thursday morning 15/5/2025**
Launch	**Thursday morning 15/5/2025**
Gondola recovery/ Guided tours&lectures	**Thursday afternoon 15/5/2025**
PPT-Presentation 'first results'	**Friday morning 16/5/2025**
Visit to Sint-Pieterscollege	**Friday afternoon 16/5/2025**

Table 6. The launch campaign calendar

Transfer hotel- KMI campus	**8am**
Arrival at the KMI campus, welcome address	**< 9am**
Payload preparation	**10am**
Launch	**11:30-12:00am**
Balloon burst	**~1:30pm**
Gondola landing	**~2:30pm**
Gondola recovery	**???**
At the hotel: disassembling the payload adapter, returning hardware to the teams	**???**
Data readout and 'first results' ppt preparation	**Evening/night**

Table 7. Launch day (May 15th, 2025) sequence of events

8. THE LAUNCH SITE

KMI has full authority on all aspects of the launch. The on-board computer is started up in the PPB and experiments are started up. All clients get a final chance to visually verify their experiment is up and running. The gondola is then sealed and handed over to KMI personnel for final preparation of the launch train and the actual balloon launch.

8.1 UKKEL

8.1.1 Introduction

Proper operation of each experiment is verified the day before the launch. At the launch site only emergency operations on the payload adapter will be allowed.

Figure 15: The campus of the KMI with the launch site (x) and the 'PPB-Payload Preparation Building' (o)

8.1.2 Payload preparation

Experiment hardware is being delivered 'ready-to-go' with a 2 pin header power connection in compliance will specifications (see also Fig. 14) and an ON/OFF switch used to activate the experiment on the launch site prior to gondola sealing. A LED that is lit or that blinks if the experiment operates properly is highly recommended.

Final preparations take place at the launch site in a room in the PPB where tables and power outlets are available (EU-standards apply).

8.1.3 Geographical location of the launch site

Launches take place from the KMI campus in Ukkel-Uccle (Brussels).

Launch site characteristics

Site's name	Ukkel, Brussels
Latitude	50° 47' 53"N
Longitude	4° 21' 27" E

Table 8: Location of the launch site

Local time is GMT(Greenwich Mean Time) +1h. From the last sunday of March till October local time is CEST (Central European Summer Time), i.e. GMT +2h.

Weather conditions

• Air temperature will vary between 5 and 30°C (March/May);
• Air humidity will vary between 20 and 100%.

Communication

There is wireless internet at the launch site, but access has to be requested prior to the launch campaign.

Power

Electrical power outlets are available during payload integration: 230V/400V - 50 Hz.

8.1.4 The launch campaign

All customers will get the chance to verify proper functioning of their experiment - provided it is equipped with the LED's recommended for this purpose - before the gondola is sealed. If a client cannot be present at the launch, the organizers can take over the final verification if properly briefed.

8.1.5 Flight operations policy

All persons present at the launch site will follow launch personnel instructions to the letter.

• There will be NO SMOKING on the campus of the KMI;
• The gondola will be sealed before being secured to the flight train (= balloon-parachute- gondola). Once sealed, the gondola will not be reopened until after recovery;
• The balloon is filled, taken care of and launched by KMI personnel;

Every activity that might cause a risk or liability of whatever nature should be brought to the organizers' attention at least two weeks prior to launch, in order to allow proper countermeasures to be taken.

Appendix 1

External experiments can be fixed to the sides, top or bottom surfaces of the gondola, depending on the experiments requirements.

Connecting external and internal subsystems requires puncturing the gondola walls. It is recommended to use two pin headers for the connections.

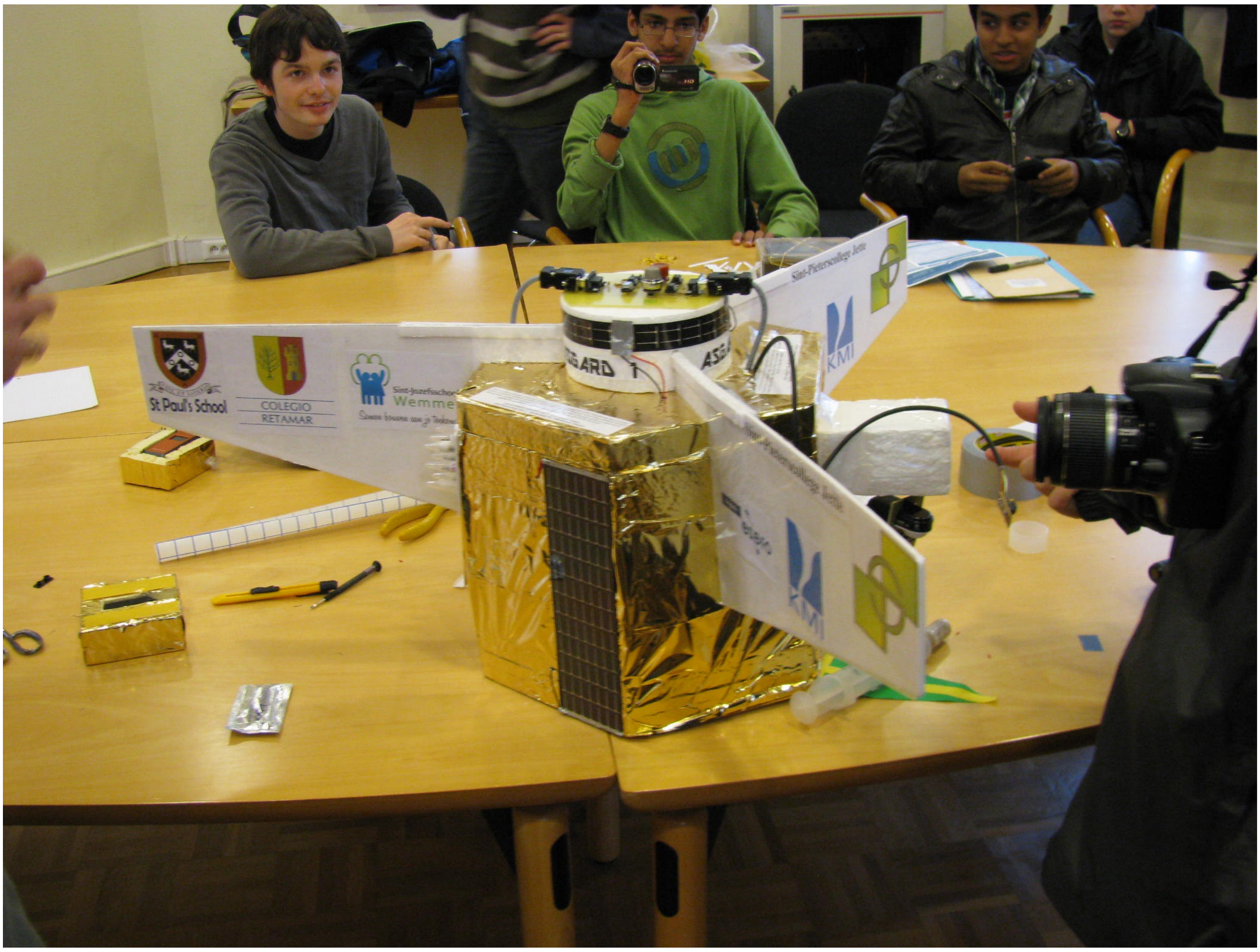

Figure 16: The Asgard-1 gondola

Appendix 2

This appendix gives data gathered from both inside and outside the Asgard-1 gondola on the programme's maiden flight on April 21st, 2011. Launched from the KMI campus in Ukkel (Uccle), Brussels, the gondola landed near Valenciennes, France. Burst altitude was 32200m.

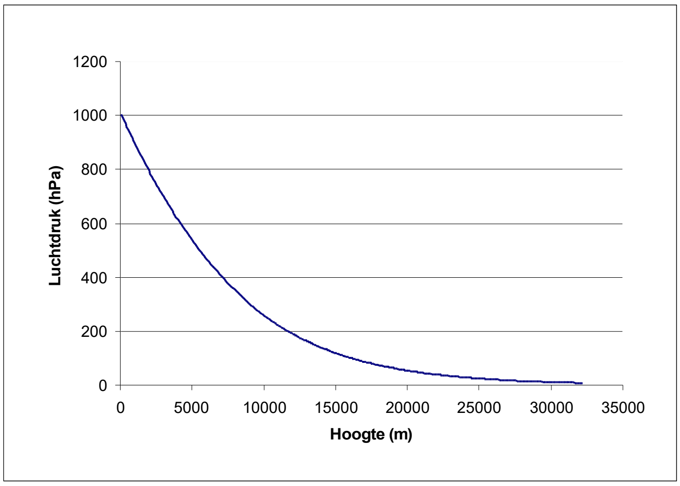

Figure 17: Pressure (hPa) (inside=outside the gondola) vs altitude (m asl.)

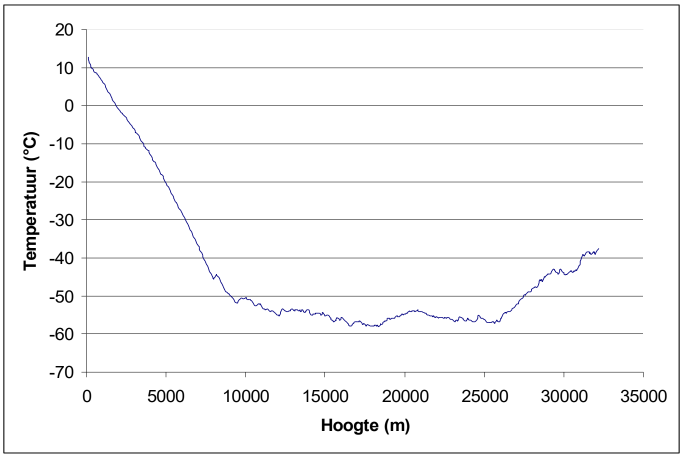

Figure 18: Temperature (°C) outside the gondola vs altitude (m asl.)

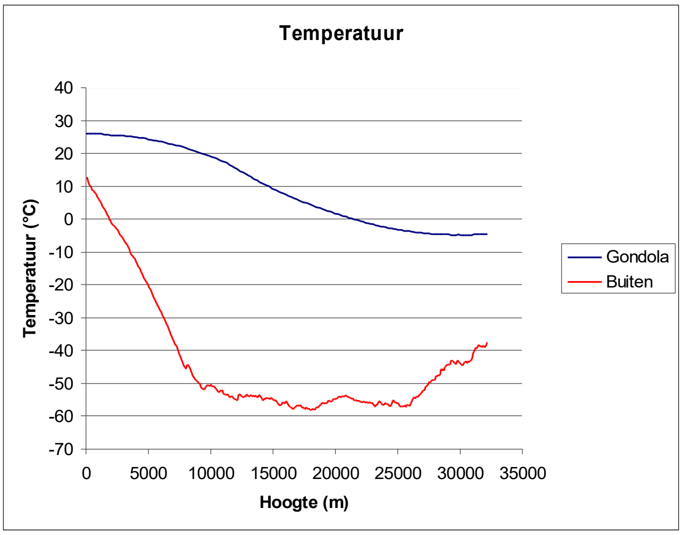

Figure 19: Temperature (°C) comparison inside (blue) and outside (red) the gondola vs altitude (m asl.)

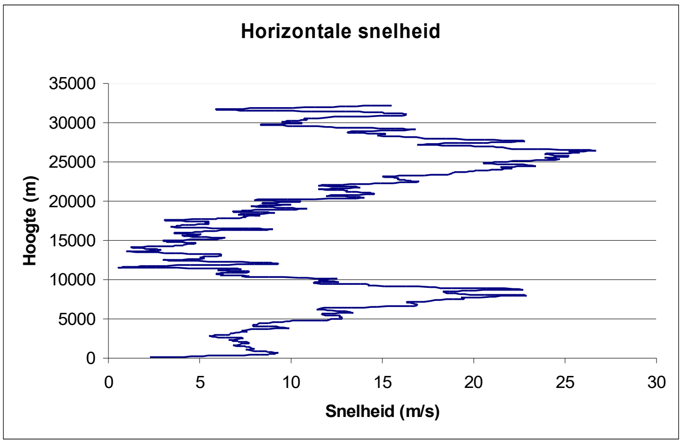

Figure 20: Horizontal velocity (m/s) altitude (m asl.) profile

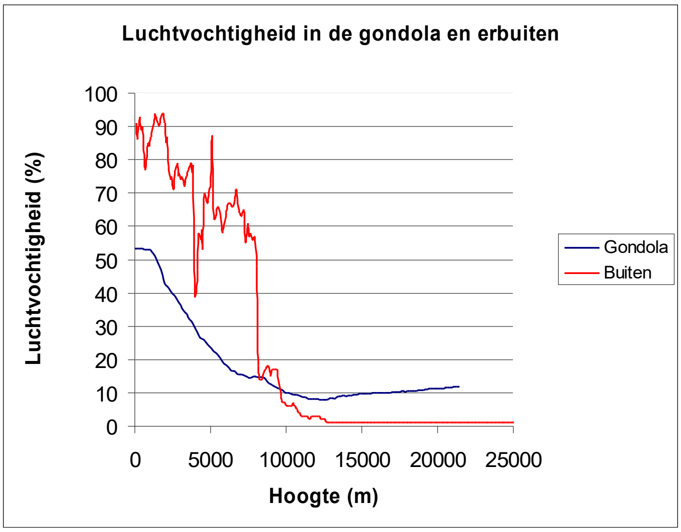

Figure 21: Air humidity (%) inside (blue) and outside (red) the gondola vs altitude (m asl.)

Appendix 3

This appendix contains data gathered on other but similar balloon flights, or theoretical data.

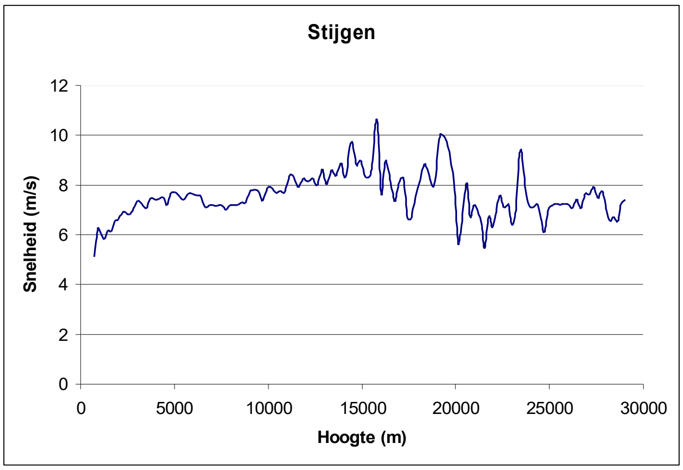

Figure 22: Ascent velocity vs altitude (m asl.)

Figure 23 : Descent velocity vs altitude (m asl.)

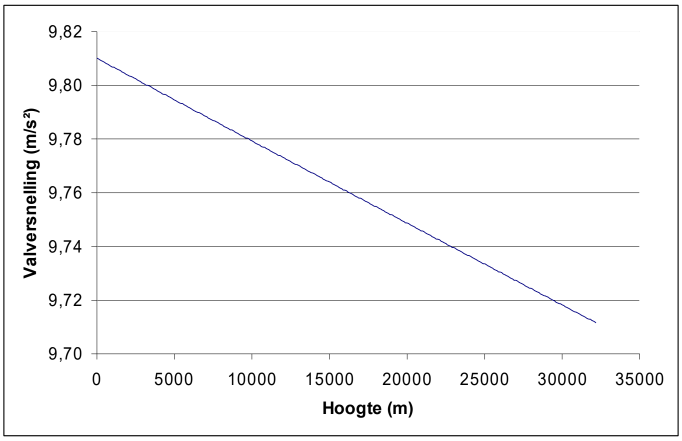

Figure 24: Gravitational acceleration (theoretical values in m/s²) vs altitude (m asl.)