SCIENTIFIC BALLOON FLIGHTS FROM ESRANGE

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Stratospheric balloons are mainly used in supporting atmospheric research, validation of satellites and testing of space systems. Esrange Space Center in northern Sweden has frequently been used since 1974 for balloon flights. The geographical location, infrastructure, the dedicated balloon systems and the opportunity of confrontation with many scientific events in the arctic atmosphere makes Esrange to an ideal launch site for stratospheric balloons.
The French CNES has during decades performed a large number of scientific and technological balloon campaigns at Esrange. A number of American scientific balloon experiments supported by NASA like SOLVE and AURA validation has been performed at Esrange. NASA/CSBF and Esrange has since 2005 been performing a number of long duration balloon flights from Sweden to Northern Canada carrying heavy astronomical instruments. Flight durations up to 5 days are achieved with giant balloons (1.2 Million cubic metres) carrying payloads up to 3 – 4 tons.
Many scientific groups in US, Europe and Japan have indicated a need of semi-or circum polar long duration balloon flights.
We are also working on an agreement with Russia giving us the opportunity on circum polar stratospheric balloon flights around the North Pole. The agreement is planned to be signed in August 2009.

Key Words: Stratospheric Balloons

1. INTRODUCTION

The Swedish Space Corporation SSC, is internationally recognised as a flexible and successful partner in space operations. The space operations are performed at Esrange Space Center as the prime range located at 68°N and 21°E in northern Sweden.; an ideal site for launch of sounding rockets, balloons and for satellite operations. SSC/Esrange is together with DLR/Moraba within the framework of EuroLaunch capable of launching sounding rockets and balloons world wide. Stratospheric balloons are primarily used in supporting atmospheric and astronomical research and testing of space systems. Balloon operations have been carried out at Esrange since 1974. A large number of balloon flights are yearly launched in cooperation with CNES, France. Since 2005 NASA/CSBF and Esrange provide long duration semi circumpolar balloon flights to North America.

2. LAUNCH SITE

The Esrange facility was established by ESRO, the European Space Research Organisation in 1966. At the start the facility was using sounding rockets and ground-based scientific equipment to conduct research mainly in the field of auroral research and atmospheric physics. The location north of the Arctic Circle (68° N, 21° E) combined with a favourable sub-arctic climate made the site excellent for sounding rocket launchings into the aurora.

The first sounding rocket was launched from Esrange in November 1966. Nowadays five to ten rockets are launched yearly, most micro-gravity flights for ESA and Germany. Since the start of the range a total of 509 rockets have been launched from Esrange until end of 2008.

In 1973 the first stratospheric balloon launches were conducted from Esrange and around 20 flights are being made yearly. Most of these flights are aimed at atmospheric and astronomical research, but over the years a number of technical flights have been made

from Esrange. Up till the end of 2008 a total of 405 stratospheric balloons have been launched from Esrange.

3. LAUNCH WINDOW/TRAJECTORIES

3.1 Winter period

Balloon launchings during the winter period are mainly for atmospheric research where many of the balloons are launched into the polar vortex but some of the campaigns are also in the field of astronomical research. The predominating stratospheric winds are rather strong from W to NW which gives 2-5 hours of ceiling time and with recovery of the payloads either in Finland or Russia. Some of balloon projects in the winter period are carried out in cooperation with CNES, France. One example of a project during the

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winter period was the MIPAS-B/TELIS and TWIN project.

3.1.2 MIPAS-B/TELIS and TWIN

The Archeops, a French project with Dr Alain Benoit as the project scientist was performed in the period of 2000-2002.
The last flight in a series of 4 flights was launched on 7 February 2002 and turned out to be extremely successful. One hour after the launch, the main window on the cryostat opened and the gondola started to rotate. The experiment could then be tuned and the observations of the sky could start. Collection of scientific data began when the balloon reached its ceiling of an altitude of 34.9 km after an ascent of 2h50 in the Arctic night. 21 bolometers observed the sky at frequencies of 143, 217, 353 and 545 GHz, with 6 of them being polarisation sensitive. The detectors were at nominal temperature about 95 milliKelvin, i.e. 0.095 degree above absolute zero (-273 degrees Celsius) obtained with a dilution refrigerator. The analysis from the flight gave good performance for all the photometric pixels: direct detection of the Galactic Plane crossing and the Cosmic Microwave Background Doppler dipole effect.
The payload was taken down near Norilsk in Siberia after 21 hours of flight. The Archeops campaign proved that it is possible to make advanced measurements of the outer space from a balloon, and this means that more flights with the Archeops payload are possible.

3.2 Summer period

During the summer period from mid May to mid July the stratospheric winds are very stable from the east, which makes that period very suitable for medium to Long Duration Balloon (LDB) flights. These LDB flights are very suitable for astronomical and cosmic ray payloads where a long measuring time is needed. During this period the latitude excursions are not expected to exceed +/-3°. The payloads are equipped with redundant flight proven systems for line-of-sight and over-the-horizon telemetry and commanding. Total flight duration would be in the order of 5-7 days. This new capability is a joint effort between the Swedish Space Corporation (SSC) Esrange and the National Aeronautics and Space Administration (NASA). The inauguration flight named BLAST was performed on 11 June 2005.

3.2.1 MEAP/P-BACE

MEAP/P-BACE was a long duration balloon flight aiming to demonstrate the capability of SSC to perform a safe balloon flight controlled by satellite communication beyond the horizon. The newly designed gondola was equipped with a new power system based on solar panels and a new Iridium satellite TM/TC system.
University of Bern, Switzerland in cooperation with IRF in Kiruna was offered the possibility to fly an atmospheric composition experiment (mass spectrometer MEAP / P-Bace). An amateur radio experiment delivering position data (APRS) was also included. This system will be improved and used on future mission as back-up The flight was launched on 28 June 2008 and was terminated in Canada ~200km south Cambridge Bay.
The Swiss/Swedish scientific mission and the experiment had three objectives: (1) to study variation of the stratospheric composition during the flight, (2) to verify P-BACE instrument design for planetary mission applications (future ExoMars).
The conditions at an altitude of 34-36 km in the stratosphere on Earth are similar to the Mars atmosphere. (3) to establish solid working relations with the ESRANGE balloon program and learn the specifics of the balloon platforms for the future potential experiments. The flight was both technically and scientifically a success and experiences will be implemented in future circumpolar balloon missions.

3.3 Turn-around periods

During the turn-around periods in late April and early May and second half of August the stratospheric winds are very low and irregular which means that the payloads can be in the line-of-sight TM up to 2-3 days. These types of flights are performed in the following areas: astrophysics, atmospheric research, drop tests from high altitudes and testing of space systems. A typical project for this period was the CAPANINA campaign performed during the period 5 August – 5 September 2005.

3.3.1 CAPANINA

The aim of the campaign was to test a new airborne wide band communication system. The project, which was an EU project, was managed by Carlo Gavazzi Space Italy together with DLR, Germany and University of York, England.
The purpose of the balloon launch was to test a new technique of delivering wireless broadband to users in remote, rural areas or – for example – fast moving trains.
The payload was launched on August 30 and reached a ceiling of 24.2 km which was the operating altitude. The technical goal was to keep the payload inside a circle of 60 km in radius from Esrange at least for 6 hours and it was taken down by command and recovered by helicopter. The campaign was a complete success.

4. INFRASTRUCTURE

The infrastructure for balloon launchings are up-to-date and consists of two payload assembly halls, one assembly hall for flight train preparation and a very large launch area for both auxiliary and dynamic launch techniques (250 000m^2). To be able to launch payloads up to 4 tons a launch vehicle has been built last year by a local company in Kiruna. To control the balloon and for flight termination a new TM service system (EBASS) was built in 1998 together with our partner in EuroLaunch, DLR. In 2006 a modern TM system for payload purposes has been qualified and become operational. The system which is called E-Link is a 2 Mbps duplex data link with Ethernet interface.

3.1 Payload assembly halls

For payload preparation two assembly halls are available.

3.1.1 The Chapel:

- Floor space -80 m^2
- Hoist hook height -5.2 m
- Hoist capacity – 1000 kg
- 2 offices

3.1.2 The Cathedral:

- Floor space -293 m^2
- Hoist hook height – 7.0 m
- Hoist capacity – 3,200 kg
- Kitchen and office on ground floor.
- 4 offices on 2nd floor

3.1.3 Flight train assembly hall

The Basilica:

- Floor space – 323 m2
- Hoist hook height – 3.35 m
- Hoist capacity – 1,000 kg
- 2 offices on ground floor
- Operation office on 2nd floor

3.3 Telemetry and command

3.3.1 EBASS

In January 1998 it was decided that SSC Esrange and DLR Moraba together should develop a TM/TC service system for stratospheric balloons based on the DLR MFB (Multi Function Board). The MFB has been used on both the Maser sounding rocket and on the Express satellite. The use of the MFB has significantly reduced the non-recurring cost for the system.
The system has been flown in totally 48 missions and has been working without any problems.

Specification

Transmitting:

- Transmitting frequency: 402.2 MHz (nominal)
- Modulation: FM
- Nominal data bandwidth: 38.4 kbps
- Output power: 2.5W

Receiving:

- Receiving frequency: 449.95 MHz
- Modulation: FM

Serial (user) parameters are:

- Type: Asynchronous
- Electrical levels: RS-232 or RS-422
- Bit rate: Up to 9600

Other:

- Operation time: 60 hours
- Mass (light version): ~17 kg
- Maximum load (light): 150 kg static load and 10 g shock load

- Mass (heavy version): ~30 kg
- Maximum load (heavy): 1000 kg static load and 10 g shock load.

3.3.2 E-Link

This year a modern TM system for payload purposes has been qualified and become operational. The system is a 2 Mbps data link with Ethernet interface and consists of 4 airborne units and 2 mobile ground stations.

Specification
- User interface Ethernet 10/100 Base-T
- Operating frequency: S-Band (nom. 2484.5 MHz)
- Modulation: DQPSK over spread spectrum
- Channel bandwidth: ± 11 MHz
- Data bandwidth: 2 Mbps duplex nominal
- Max output power: 10 Watt
- Maximum range at LOS: 500 km at 30 km altitude
- Antenna on ground: 1.8 meter parabolic dish
- Airborne antenna: Vertical polarized omni
- Airborne operating time: > 11 hours (standard battery conf.)
- Airborne unit weight: 20 kg including batteries
- Airborne unit size: 320x250x250 mm

3.3.3 Support instrumentation Package (SIP)

NASA's Long Duration Balloon (LDB) Support Instrumentation Package (SIP) will be utilised to offer a common interface for science and operational telemetry and commanding. The SIP has two independent over the horizon communication links with associated subsystems. Both sides of the SIP offer global uplink and downlink capability to the scientist. One link will consist of NASA's Tracking Data and Relay Satellite System (TDRSS). The other will utilise the IRIDIUM-system. In addition, a high-speed line of site uplink and downlink will be available for the first 12-14 hours of flight while the balloon is still in range of the launch site telemetry ground station.

TDRSS is NASA's communication system for the Space Shuttle and satellite programs. Nominal TDRSS support for balloon missions offers 100 Kbps return telemetry continuously. The SIP records all science data onto flight hard drives for up to 21 days. Command uplink requires advance scheduling. Scheduling commands is not normally a problem and can be done on very short notice when necessary. The Payload Operations Control Center (POCC) located in Palestine, Texas USA is the only location where TDRSS science data is accessible. Scientists can opt to either station personnel in Texas to analyse data and send commands, or locate computers in Texas to transfer data back to their home institutions via the internet.

4. CONCLUSION

The geographic location of Esrange, at 67 deg 56 min N and 21 deg 04 min E, offers several unique advantages for launching of stratospheric balloons:

- a vast area covering the northern parts of Finland, Norway, Russia, Canada, Alaska and Sweden is available for land recovery of experiments,
- long duration balloon flights up to 5-7 days can be performed during the favourable wind conditions in late May early July with an impact in Canada or Alaska
- during the turn-around periods in April/May and August/September medium duration balloon flights up to 48 hours can be performed with a safe land recovery in northern Scandinavia,
- testing of space systems including drop tests of free falling objects can be performed in the Esrange impact area for sounding rockets,
- validation of polar orbiting satellite experiment,
- the location is excellent from a scientific point of view, for experiments related to auroral research, astrophysics and other high latitude phenomena as the ozone depletion in the atmosphere.