ABSTRACT
Initiated in 2012 by the Swedish National Space Board (SNSB), a new programme dedicated for Swedish scientists to gain access to space using balloons and sounding rockets was started. This programme promotes the possibility to ensure continuity in both the science and the technology used.

The sounding rocket part of this national programme started with three possible missions. SPIDER (Small Payloads for Investigation of Disturbances in Electrojet by Rockets) from the Space and Plasma physics department of KTH, O-STATES (Oxygen Species and Thermospheric Airglow in The Earth's Sky) from the Department of Meteorology Stockholm University (MISU) and LEEWAVES (Local Excitation and Effects of Waves on Atmospheric Vertical Structure) that is collaboration between KTH and MISU. These three missions were planned for launches in 2015 and 2016.

SSC has been contracted on a launch ticket basis to provide the launch and service to the scientific instrumentation.

This paper presents the SPIDER, O-STATES and LEEWAVES missions focussing on a mission related technical solutions perspective.

1. SOUNDING ROCKET MISSIONS
The Swedish National Space Board (SNSB) issued a call for ideas for rocket and balloon missions within the new programme and initially two rocket missions were chosen and funded:

SPIDER, Small Payloads for Investigation of Disturbances in Electrojet by Rockets
O-STATES, Oxygen Species and Thermospheric Airglow in The Earth's Sky

Additionally a third mission was chosen:

LEEWAVES, Local Excitation and Effects of Waves on Atmospheric Vertical Structure

1.1. O-STATES mission
O-STATES (Oxygen Species and Thermospheric Airglow in The Earth's Sky) is a mission with Professor Jörg Gumbel from the Department of Meteorology at Stockholm University (MISU) as principal investigator.

The scientific goal is to perform analysis of \( \text{O}_2 \) atmospheric band airglow to characterize remote sensing techniques. These techniques can for instance be used for weather predictions.

This analysis will be done by in-situ measurements in the thermosphere between 80 and 240 km with two launches into opposite conditions. The same payload will be refurbished and reflown during one single launch campaign.

SSC is contracted for the project and MISU and partners are providing the instrumentation.

The payload instrumentation consists of photometers and optical oxygen probes from Department of Metrology at Stockholm University (MISU), FIPEX electrical oxygen sensors from Institute of Space Systems at Stuttgart University (IRS) and from the Technical University Graz (TUG) ion-, electron probes and a faraday antenna system.

All instrumentation except the side looking oxygen probes are forward looking and covered by the nose cone during lift-off. The nose cone is then jettisoned to expose the instrumentation while hatches are released to expose the side looking instruments.

1.2. O-STATES 14-inch payload

Figure 1, Payload configuration

The front looking instrumentation is located in the optical module. The top deck works as means of mounting for the antennas, probes and electrical sensors as well as a seal to prevent gases from inside the payload to disturb the optical measurements. The middle deck is the mounting fixture for all of the photometers. It is also liquid cooled to work as an energy buffer for the electrical (PELTIER) cooling system integrated into the photometers. The cooling deck is cooled to approximately 2°C on ground before lift-off and then heat is transferred from inside the photometers and dumped into this cool mass for the duration of the flight to keep an even low temperature on the sensors. The lower deck holds all instrument electronics as well as the thermal control and electrical cooling control electronics. Also a remote set of data collection units for the service module is located here. The module is flushed by dry nitrogen on ground to prevent condensation when running the cooling system.

The side looking oxygen probes are located in the oxygen module. Hatches are released to expose the instruments at the region of interest. The instruments are purged with dry nitrogen on ground to keep optics clean and for test purposes in ambient pressure.

The service module (SM14) is the core of the O-STATES data system. Its main objectives are to provide:
- means for data collection from all payload units
- communication between payload and ground for transmitting scientific data
- attitude and position data for correlation with the scientific data
- data for vehicle tracking
- activation and timing of the pyro activators controlling the release of nose cone and hatches
- power to all payload units
- umbilical connections

The SM14 was developed initially for the PHOCUS mission in 2011. It was built to be the service system.
backbone of Swedish national 14-inch payloads. It also has the possibility to extend and add external systems and complies with CCSDS standards.

Some selected features of the SM14 system are:
- 8 x galvanically isolated full duplex RS422 for external users
- Multiple RS422/RS485 for internal use
- 8 bit parallel output
- 4 x SpaceWire interfaces
- GMSK cmd input
- GMSK bitsychronizer output
- OCXO input
- OCXO for slant range
- 2 x CCSDS telemetry interfaces (1.25 to 10 Mbit/s)
- 2.5 Mbit, 5W, S-band, FM downlink
- Internal H/K
- System power control
- 15 x 1A LCL power switches for external users
- 1 x 3.5A LCL power switch for external user
- Local H/K storage SD
- COCOM GPS receiver
- Time synchronizations
- 6 pyro control channels
- 3 x 3200 mAh, NiMh, redundant batteries
- 90 x Analog I/O, 16 bit (1 x 30 local / 2 x 30 remote)
- 3 x Digital I/O, 16 bit inputs / 8 bit output (1 x local / 2 x remote)
- 12 LVDS pulse counters (4 x local / 8 x remote)
- DMARS-R, Roll Gimbaled Inertial Navigation System

The O-STATES payload is ready for launch in August 2015 as the first rocket payload under the Swedish national balloon and rocket programme.

1.3. SPIDER mission

SPIDER (Small Payloads for Investigation of Disturbances in Electrojet by Rockets) is a mission with Associate Professor Nickolay Ivchenko from the Space and Plasma physics department of KTH as principal investigator. The scientific goal is to study turbulence in the auroral electrojet. This analysis will be done by in-situ multi point measurements in the atmosphere e-region between 95 and 115 km. Ten (10) free flying units with Langmuir and e-field probes will be released simultaneously from the main payload to perform these measurements.

SSC is contracted for the project while KTH is providing the free flying units and ejection mechanisms.

1.4. SPIDER 14-inch payload

The FFU’s are release simultaneously at an altitude of approximately 60 km to 65 km and use the residual spin rate (vehicle final spin rate is 3 to 4 Hz) to deploy their eight (8) individual wire booms, four (4) Langmuir and four (4) E-field probes each. All scientific data is stored locally in the FFU’s and then their internal tracking and parachute recovery system will be used for location after landing providing position data for helicopter recovery and scientific data extraction.

The service module used for SPIDER, SM14 light, is a simplified version of the SM14 module from PHOCUS and O-STATES. Its main objectives are to provide:
- communication between payload and ground for transmitting tracking and recovery system data.
- safety/activation/timing of pyro activators controlling the release of FFU’s.
- power internally and to the SPIDER modules
- umbilical communication before liftoff
- a complementary system to be run in parallel projects to the SM14 where the requirements from the service system are less
Some selected features of the SM14 light system are:
- 8 x galvanically isolated full duplex RS422 for external users
- Multiple RS422/RS485 for internal use
- 8 bit parallel output
- 4 x SpaceWire interfaces
- GMSK cmd input
- GMSK bitsychronizer output
- OCXO input
- OCXO for slant range
- 3 x CCSDS telemetry interfaces (1.25 to 10 Mbit/s)
- 1.25 Mbit, 5W, S-band, FM downlink
- Internal H/K
- System power control
- 8 x 1A LCL power switches
- 5 x power switches (isolated DC/DC converted power (+51V/+12V/+28V))
- Local H/K and data storage SD/USB
- CAN bus
- Ethernet i/f
- COCOM GPS receiver
- Time synchronizations
- Battery charging
- 6 pyro control channels
- 6800 mAh Li-Ion battery
- 4 x analog I/O, 16 bit
- 1 digital I/O, 20 bit (4 frequency counters)

SPIDER is currently planned to be launched in a combination payload with LEEWAVES in early 2016

1.5. LEEWAVES mission

LEEWAVES, (Local Excitation and Effects of Waves on Atmospheric VErtical Structure), is a mission with Professor Jörg Gumbel from the Department of Meteorology at Stockholm University (MISU) as principal investigator.

The scientific goal is to study gravity waves in the atmosphere.

This is done by measuring vertical profiles of horizontal winds from 70 km to 100 km or preferably more. Initially this was planned to be done by launching three (3) identical payloads with four (4) falling spheres each during one campaign and in coordination with the airborne DLR campaign GW-LCYCLE in the beginning of 2016.

SSC is contracted for the project while KTH is to provide the falling spheres and their ejection mechanisms.

1.6. LEEWAVES 14-inch payload

The falling spheres are released simultaneously at an altitude of approximately 60 km to 65 km and during ascent and descent record these vertical wind structures with internal sensors.

All scientific data is stored locally in the falling spheres and then their internal tracking and parachute recovery system will be used for location after landing providing position data for helicopter recovery and scientific data extraction.

The service module (SITT) used for LEEWAVES is an even more simplified version of the SM14 and SM14 light modules used on PHOCUS, O-STATES and SPIDER.
Its main objectives are to provide cheap disposable technology with:
- Communication between payload and ground for transmitting tracking data
- Safety/activation/timing of pyro activator controlling the release of falling spheres
- Internal power
- Umbilical communication before lift-off

**Figure 8, Service module (SITT)**

Some selected features of the SITT system are:
- 20 Kbit, 1W, S-band, FM downlink
- Internal H/K
- System power control
- 8 x 1A LCL power switches
- 5 x power switches (isolated DC/DC converted power (+5.1V/+12V/+28V)
- Local H/K and data storage USB
- CAN bus
- Ethernet i/f
- COCOM GPS receiver
- Time synchronization
- Battery charging
- 6 pyro control channels
- Up to 6800 mAh Li-Ion battery
- 4 x analog I/O, 16 bit
- 1 digital I/O, 20 bit (4 frequency counters)

LEEWAVES is currently planned to be launched in a combination payload with SPIDER in early 2016

**1.7. SPIDER/LEEWAVES combination**

SPIDER was initially planned to be launched in late 2014. When the dedicated NIKE booster failed inspection the only viable option was to move the payload to a single stage S30. This, in combination with the cancellation of the LEEWAVES mission, their similar apogee requirements and similar launch date requirements, provided the foundation for the decision to combine the two. The S30 motor provides more than enough capacity for this combination.

**1.8. SPIDER/LEEWAVES payload**

The SPIDER modules are under preparation for payload AIT while the LEEWAVES module is under development. All service system, service module, recovery system etc. are ready for payload AIT and the launch planned for early 2016.

**2. CONCLUSIONS**

Currently the Swedish National Space Board is funding a running programme dedicated for Swedish scientist to gain access to space. This promotes the possibilities for continuity in science and technology. It also by that promotes the means to, in a longer perspective, do science in a more cost efficient way, thus giving the scientist more science for the budget.