Competences - Overview

SSC has the following main areas of competence:

- **Spacecraft System**
  - Overall system and mission prime for In house development of compact platforms

- **AOCS/GNC**
  - Provider of AOCS system to all SSC spacecraft to date. Now also to SGEO and follow-ons

- **Propulsion**

- **Payload**
Facilities

Space system division has the following facilities

• 200 m² Clean room (ISO Class 8)
• Chemical Clean room (ISO Class 7)
• Lab for electronics testing etc,
• Testing (vacuum chamber)
• Mechanical workshop
• Complete spacecraft test environment
  – MGSE
  – EGSE, including
Personnel resources

- Summary of staff and competences
Tools and methods

• Lista på mjukvaruverktyg osv som vi använder
Spacecraft system

- System engineering competences and
- A wide range of tools (DOORS, STK, ...)
- In house development of all sub systems
  - Electronics
  - Software:
  - Structure
  - Thermal
Business Profile

- Experience in definition and delivery of small satellite systems, also covering ground and launch segments, and including the mission operations phase.

- Capability to lead space projects from mission definition and analysis, through system engineering and development, to integration, test and delivery in-orbit.

- Skills to engage in overall system engineering, AOCS and the detailed design of software, electronics and mechanical structures, including related product assurance tasks.

- Capacity to build, test and operate small satellites on site.

Our Heritage
Propulsion

- Considerable overall strength with current daughter companies ECAPS and Nanospace
- Experience and routines for a wide range of different propulsion systems
  - Hydrazine (SMART-1, PRISMA)
  - HPGP Green Propellant (PRISMA)
  - Cold gas (PRISMA, PROBA-3)
  - Xenon EP (SMART-1, Small GEO)
  - Solid propulsion (Freja, Astrid)
- Facilities for manufacturing and testing
  - Welding
  - Xray inspection
  - ...

Swedish Space Corporation
Propulsion

- Extensive activities in the propulsion area
  - Electrical propulsion subsystems
  - Procurement and implementation of Hydrazine systems
  - Green propellant systems and components through the ECAPS subsidiary
  - Micro propulsion cold gas systems & MEMS Propulsion components through the Nanospace subsidiary
  - In-house facilities for propulsion development, manufacturing & testing
  - Propulsion drive and interface electronics
AOCS: Experience and resources

- Development of AOCS for all types of missions
  - Formation flying/RVD (PRISMA)
  - Interplanetary (SMART-1)
  - LEO (PRISMA, ODIN)
  - GEO (Small GEO)
  - Scientific Spinners (Freja, Astrid)
**Heritage: SSC has provided AOCS/GNC Subsystems & Onboard software systems to all our spacecraft**

<table>
<thead>
<tr>
<th>Freja:</th>
<th>Odin: High precision 3-axis control with several modes, Separate AOCS computer</th>
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<tbody>
<tr>
<td>Astrid 1:</td>
<td></td>
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<td>Astrid 2:</td>
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<tr>
<td>Spin control</td>
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<table>
<thead>
<tr>
<th>SMART-1: 3-axis control with several modes, earth and moon orbit, integrated system</th>
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<tr>
<th>PRISMA: Integrated AOCS/GNC&amp;OBSW, rendezvous and formation flying, two satellites</th>
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<tr>
<th>Small GEO: AOCS partner to OHB</th>
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<tr>
<th>Ongoing software and AOCS development for future projects</th>
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<tr>
<th>Small Geo 2012</th>
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<tr>
<th>Prisma 2010</th>
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</table>
AOCS Development at SSC

*Full Subsystem Responsibility in all Development Phases*

- Development of flight-ready AOCS software
  - *Basic attitude control*
  - *Advanced orbit control for formation flying*
- Specification and Procurement of Sensors and Actuators
- Mission Analysis
- System Level Simulator Development
- Software/Spacecraft System Level Testing
- Flight Dynamics
- Operations
AOCS Design Capabilities

- **Attitude Control**
  - High-precision 3-axis stabilized Attitude Control
  - 3-axis stabilized solar magnetic control
  - Robust Sun Acquisition and Safe Mode Control
  - Thruster and Magnetic based Rate and Momentum Control
  - Active SADM and EP thrust vector Mechanism Control

- **Formation Flying and Orbit Control**
  - Advanced Model Predictive Control framework for Formation Flying
  - Passive Autonomous Formation Flying
  - Forced Motion Proximity Operations and Final Approach/Recede Maneuvers
  - Integration of GPS and Vision Based Sensor Navigation
  - Autonomous Rendezvous based on Vision Based Sensor only
  - Low-thrust Station Keeping
Model Based Software Development

- Automatic Flight Code Generation from Matlab/Simulink

- SMART-1 Heritage
  - First Matlab-based auto coding accepted for flight by ESA
  - Included auto coded modules for AOCS, Thermal, Power, FDIR

- Present AOCS/OBSW Designs
  - Automatic Code Generation of complete PUS compliant OBSW
  - Inclusion of 3rd party traditional software (binary or source code)
  - Development of System Level Real-Time Simulator
Model Based Software Development Concept

Early Analysis Models

- Test Development
- Test Results Analysis
- Trouble shooting
- Operational Procedure Development
- Flight Performance Analysis

Development

MATLAB Closed Loop Model
- Spacecraft Model
- AOC Software

System Level Spacecraft Simulator
- Thrusters
- Flexible Dynamics
- Reaction Wheels
- Kinematics
- Rate Sensors
- Star Tracker
- Sun Sensors

Auto Coding

Complete On-Board Software

Real-Time OS

- Power System Application
- Thermal Control Application
- Attitude Control Application
- Failure Detection, Isolation and Recovery Application
- Payload
- TM/TC
- System Manager
- etc...

Swedish Space Corporation

Real-Time Closed Loop

SATLAB
SATLAB Software System Test Environment

- Real-Time Simulation Environment
- EM Computers in-the-loop
- CAN Bus in-the-loop
- Other H/W Simulated towards CAN I/F
- Additional H/W can be included for H/W in-the-loop testing
- Commanded with real operational software through RAMSES Mission Control System
- Expandable for S/C system test with FM H/W
# Datahandling systems

<table>
<thead>
<tr>
<th>Mission type</th>
<th>Key Feature</th>
<th>Launched</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S-DHS</strong></td>
<td>Interplanetary and HEO missions</td>
<td>2003 on ARIANE-5</td>
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<tr>
<td>2003: SMART-1</td>
<td>ERC32 20 MHz 2Mbyte EEPROM 3Mbyte SRAM 512Mbyte MM CCSDS telemetry</td>
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<tr>
<td><strong>P-DHS</strong></td>
<td>LEO mission</td>
<td>Launch on PRISMA 2010 Qualified for Dnepr</td>
</tr>
<tr>
<td>2009: PRISMA</td>
<td>Leon3-FT 24 MHz 4Mbyte EEPROM 32Mbyte SRAM 1Gbyte MM CCSDS telemetry</td>
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The P-DHS

Key features of the P-DHS

- Modular design
- Backplane less architecture
- Flexible redundancy handling
- Single frame redundancy
- Designed for testability
- Low power

Prisma main satellite DHS during EMC test
P-DHS Core Unit

Capacity
LEON3-FT 24MHz
32 MByte SRAM
4 MByte EEPROM
1000 Mbyte SDRAM

Features
CCSDS TM&TC
SCET with GPS sync
SpaceWire
5W@24MHz / 28V
750g / board
The P-DHS Interface Units

Key elements of the P-DHS RIU

- Propulsion systems
  - HPGP
  - Hydrazine
  - NanoSpace u-prop

- Thermal control
  - Thermistors
  - Heaters

- AOCS sensors
  - Star tracker
  - Sun sensors
  - Rate sensors
  - Gyros
  - Integrated GPS board
  - Magnetic meters
  - Magnetic torquers
P-DHS Interface Units

- CAN bus
- Nominal and redundant unit on same board
- 28V, 3W

Thermal control & Pyro control Unit

Propulsion Unit For Hydrazine & HPGP
PROBA-3 Interface electronics
**RAMSES** is a combined EGSE and Mission Control System developed for all current SSC projects.

- Sub system Testing – Software Validation – EGSE For Spacecraft AIV – Mission Control System
- **Multiple Satellites/Rockets**

CCSDS
ECSS PUS

Mission Database
Functionality in RAMSES

- Monitoring
- Commanding
- Control Procedure Execution
- Performance Evaluation
- Time Synchronization
- Data Archiving
- System Supervision
- Data Distribution
- 3D Visualization
- Operational Database
- Flight Dynamics
- Flight Dynamics
Use of RAMSES

RAMSES used by SSC for all type of space systems

- Satellites
- Satellite Subsystems
- Experiment Equipment
- Sounding Rockets

Development Test & EGSE & Mission Control System

Swedish Space Corporation
Example view: Monitoring

- Functionality to process, extract, calibrate, limit check, verify, and display any data
- Provides alphanumeric, graphic, out-of-limits, and mimic displays
- Supports synthetic/derived parameters
  - ECSS SPEL language
- Performs quality and completeness checks
Key Features

Flexible
- Easy integration with cooperating subsystems and COTS applications.

Open
- Open network interface with loosely coupled modules. All levels of data available for authorized users.

Cost Effective
- Runs on ordinary office PC’s. No recurrent hardware costs. Used during the entire project life time, from development to operations.

Easy to deploy
- One installation file to install the complete system.

Scalable
- Distributed network architecture. Distributed processing.

Configurable
- Easy to adapt to any kind of mission.

Standards
- Following CCSDS and ECSS

User Friendly
- Windows applications designed with a consistent and familiar look and feel.

"Cradle to grave"
- Can be used from first circuit board ready to mission accomplished
Structure, Thermal and Mechanisms
S/C Structures

- Analysis, design, manufacturing and testing of S/C structures
- Full subsystem management:
  - Requirements development & validation
  - Budgeting & scheduling
  - Procurements
  - Assembly, integration and testing
- Software tools available:
  - Pro/Engineer
  - IDEAS
  - Pro/Mechanica
  - ANSYS
- Flight heritage from missions Odin, ESA Smart-1, Astrid 1,2, Prisma
Mechanisms

• Full development, manufacturing and testing
  – Solar panel deployment mechanisms (Odin, launched 2001; PRISMA launch 2010)
  – S/C separation systems (Astrid 1,2, launched 1995,1998; PRISMA, launch 2010)
  – Boom deployment mechanisms Astrid 2, launched 1998

• Subsystem management of complex mechanisms
  – Smart-1 thruster orientation mechanism
  – Smart-1 solar panel deployment and orientation mechanisms
  – Smart-OLEV mechanisms
Instruments & payload

• Mechanical development of instruments and payload
  – Radiometer design including wave path calculations (Odin, STEAM-R)
  – Experience in high accuracy pointing structures (optical benches etc.)
• Software tool for optical development and wave path analysis: Zemax
• Close cooperation with SSC sounding rocket payload group
Thermal Capabilities

- Full unit to spacecraft level thermal analysis, design, build, testing and flight operation.
- Full subsystem management:
  - Requirements dev’t & validation
  - Budgeting & scheduling
  - Procurements (heaters, MLI, coatings, cryosystems, heatpipes, thermostats, etc.)
  - Assembly, integration and testing
- Analysis tools available:
  - THERMICA + THERMISOL
  - IDEAS (12 & NX6) TMG
  - NX 7 Space Systems Thermal
- Heritage from 7 missions (including Odin, Smart-1, Prisma, Smart-OLEV), ECAPS thruster designs, rocket programs, and balloon platforms.
Full “analysis-to-flight operations” involvement and capabilities
Payload instruments
Odin Radiometer

- Compact
- SSB filtering
- Tuneable
- Cooled
- AOS
- Autocorrelators
- 119 GHZ HEMT
5 receivers

- Position or “Dicke” switched
- Frequency coverage 118.75, 486-504, 541-581 GHz
- Typical Tsys: 119 GHz at 600K and 3300K at 550 GHz
- Resolution 125 to 1000 kHz
- Bandwidth 100 to 1000 MHz
Odin Submm telescope

- Dual reflector offset Gregorian telescope
- Shaped surfaces in order to combine both low sidelobes and high gain.
- Reflectors made of CFRP honeycomb +facesheet
- Coated with vacuum deposited aluminium
- Surface accuracy 8 µ for primary and 5 µ for secondary
- Support structure single structure in CFRP
- Integrates the star tracker optical heads.
- Tested both with an optical collimator and a novel hologram method.
STEAMR instrument to PREMIER

- Radiometer for 300 GHz wavelength
- Currently pre-development in parallel with ESA PREMIER Phase A studies
- Swedish contribution to PREMIER mission
- SSC Payload Instrument Prime with overall responsible for project management, system design & analyses, integration, test
Synergies -- OHB

- Consolidates the AOCS and Propulsion for SGEO into the OHB group
- SSC can become “The Smallsat Expert” in the OHB family
- Project managers and System engineering to strengthen and off load OHB projects (Galileo, MTG etc)
- Co-operation with Kayser-Threde on Payloads (MTG, Sentinel-4, Post-EPS)
Synergies -- RUAG

- Adding the Mission/System Prime capability to the RUAG group
- Adding the two major sub systems, AOCS and Propulsion where the RUAG group currently has limited capability
- RUAG/SSC together covers all spacecraft subsystems
- Forms a strong partner to OHB in small GEO with several of the important subsystems: AOCS, EP, DHS, Structure, Thermal
- Complete control of the Swedish ESA georeturn
Synergies -- QinetiQ

- Together with current QinetiQ Space (former Verhaert) the most important independent Satellite prime in Europe besides “the three big”
- Similar Smallsat culture
- Adds missing capabilities AOCS and Propulsion to current QinetiQ Space
- Strengthen the DHS/electronics development capability (two small groups forms one larger)
- Synergies in PROBA-3 with propulsion and electronics
Synergies -- SENER

- Strengthening SENER capability as Mission/System prime
- PRISMA/PROBA-3 heritage will strengthen SENER as PROBA-3 prime
- Creating a very strong AOCS/GNC actor in Europe
- Provides openings for SENER into Small GEO business
Synergies TBD