CENTRE NATIONAL D'ÉTUDES SPATIALES

ISRAEL AEROSPACE INDUSTRIES LTD

The VENµS mission operation concept

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Contents

- Introduction: the VENµS project and its 2 missions
- The VENµS ground segment
- The VENµS mission operation concept
  - Main common design drivers for the mission centers
  - The two operational modes for Mission operation
- Development guidelines for the 3 centers involved in the mission
- Conclusion: The VENµS mission centers design: a challenging task

Introduction : the VENµS project (1)

VENµS: Vegetation and **E**nvironment monitoring on a **N**ew **µS**atellite

- **Cooperation France / Israel**

- **Orbit:**
  - **Sun synchronous & Ground Locked**
  - **Revisit time: 2 days**

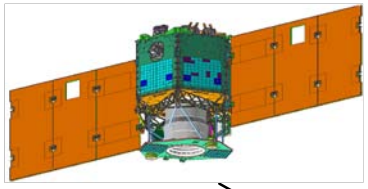
- **Three Mission Phases:**
  - **VM1 (Venus Mission 1): 2.5 years @ 720 Km**
  - **VM2: altitude decrease 720Km to 410 Km (up to 0.5 years)**
  - **VM3: 1 year @ 410 Km**

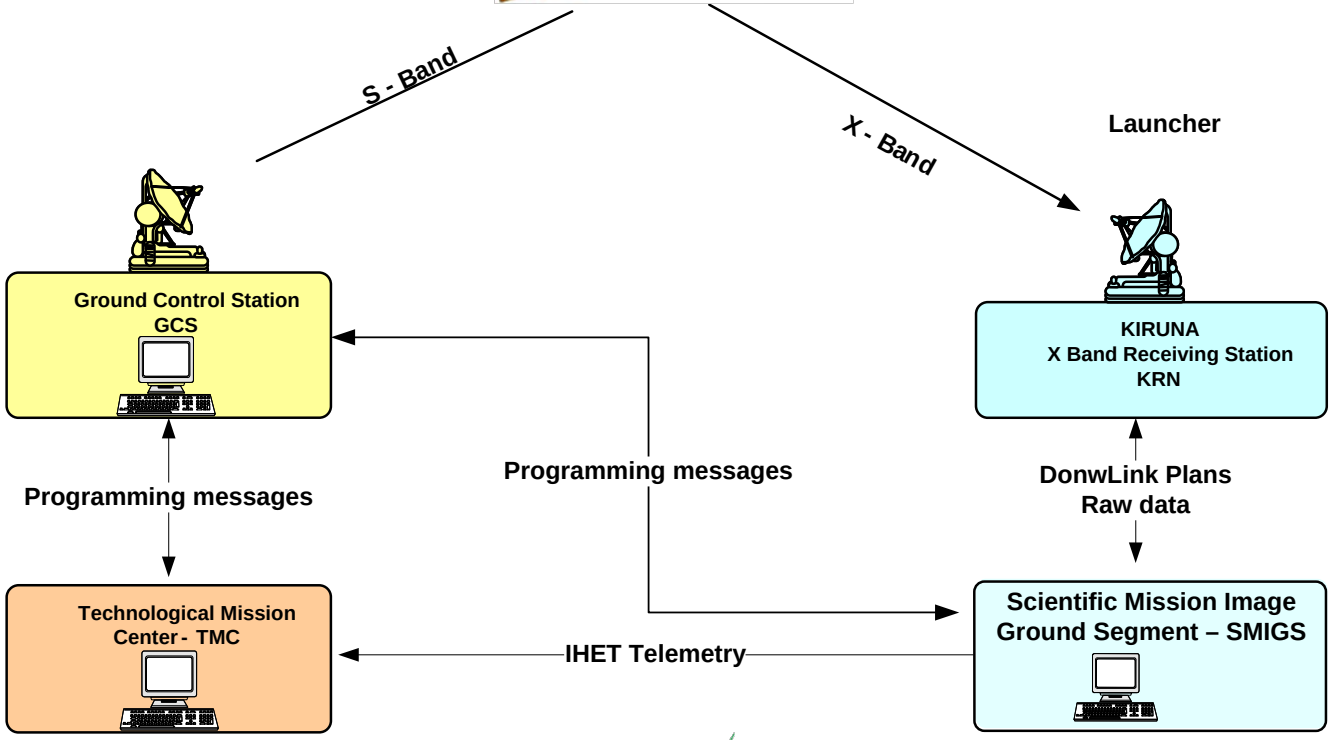
Introduction : the VENµS project (2)

Dual mission (two payloads):

- Scientific (remote sensing for vegetation monitoring)
  - The Scientific Payload: a 12 bands Multi-spectral camera in visible and Near infrared
  - 5m resolution
  - Identical acquisition conditions (same viewing angles)
- Technological (Hall thrusters for orbit control)
  - The Technological Payload: two Hall Effect Thrusters
    - ✓ A few days or a whole month in VM1
    - ✓“ Continuously” in VM2
    - ✓ A few orbits per cycle in VM3

Introduction : the VENµS project (3)





Introduction : the VENµS project (4)

- **Israel responsibility**
  - The Platform
  - The satellite Ground Control Station (GCS)
  - The technological payload : IHET (Israeli Hall Effect Thruster)
  - The Technological Mission Ground Center (TMC)
- **France responsibility**
  - The scientific payload; VSSC (VENµS Super Spectral Camera)
  - The Scientific Mission Image Ground Segment (SMIGS)
  - The X-Band receiving station

VENµS ground segment (1)

GCS tasks

- Includes SCC (Satellite Control & Command) & TCC (Tracking & Communication Center)
- Regular GCS operations:
  - S/C command & control
  - Orbit correction by Hydrazine
- Venus GCS unique operations:
  - Manage payloads operation plans (originated by TMC & SMIGS)
  - Check Plans feasibility
  - Interleave different plans (scientific & technological) & resolve conflicts
  - Create, validate & upload command files
  - Create and send downlink plans to Kiruna
  - Create and send status reports to SMIGS & TMC

VENµS ground segment (2)

SMIGS tasks

- Mission Plans Elaboration and plans follow up, for the Scientific Mission
- Image processing
  - Level 1 (geo-referenced reflectance), Level 2 (Top of canopy reflectance), Level 3 (weekly cloud free synthesis of level 2)
- In-flight instrument calibration and processing parameters computation (radiometric, geometric)

VENµS ground segment (3)

TMC tasks

- Mission Plans Elaboration and monitoring, for the Technological Mission
- Technological mission telemetry processing
- In-flight payload calibration

VENμS ground segment (4)

- **To Summarize:**
  - There are three operational ground centers :
  - Two Mission Planning Centers (MPCs),
    - one per mission
  - One Ground Control Station (GCS).

- **The 3 entities are in different locations.**

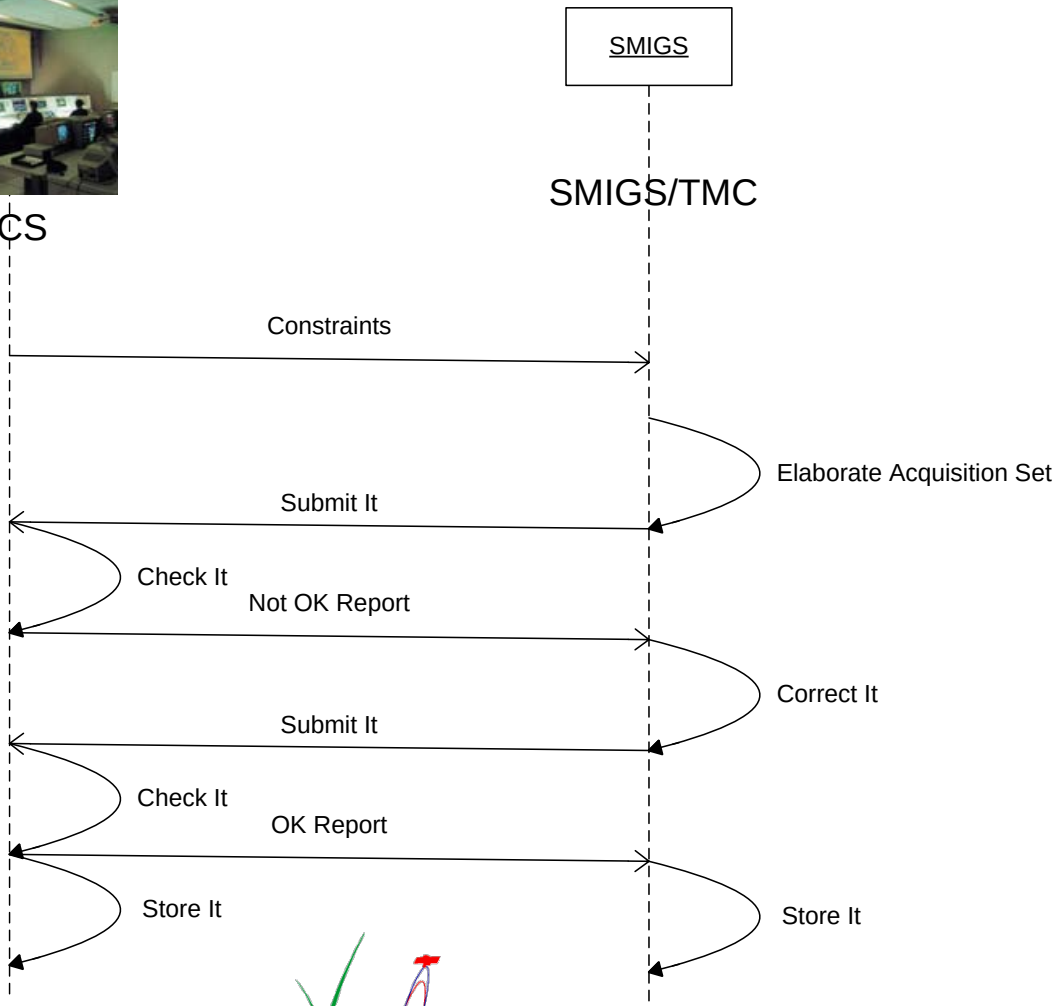
VENµS mission operation concept (1)

Two Operational Modes for mission Operation

- **Feasibility check mode (offline)**
  - **Payloads plans are created & checked using**
    - Nominal orbit
    - Nominal S/C initial conditions
    - For the scientific mission, 6 plans are also prepared for specific on-board failure cases
  - **May be operated before/after launch**
- **Operational mode (online)**
    - Actual orbit
    - Actual S/C initial conditions
  - **Fully operational only after launch**

VENµS mission operation concept (2)

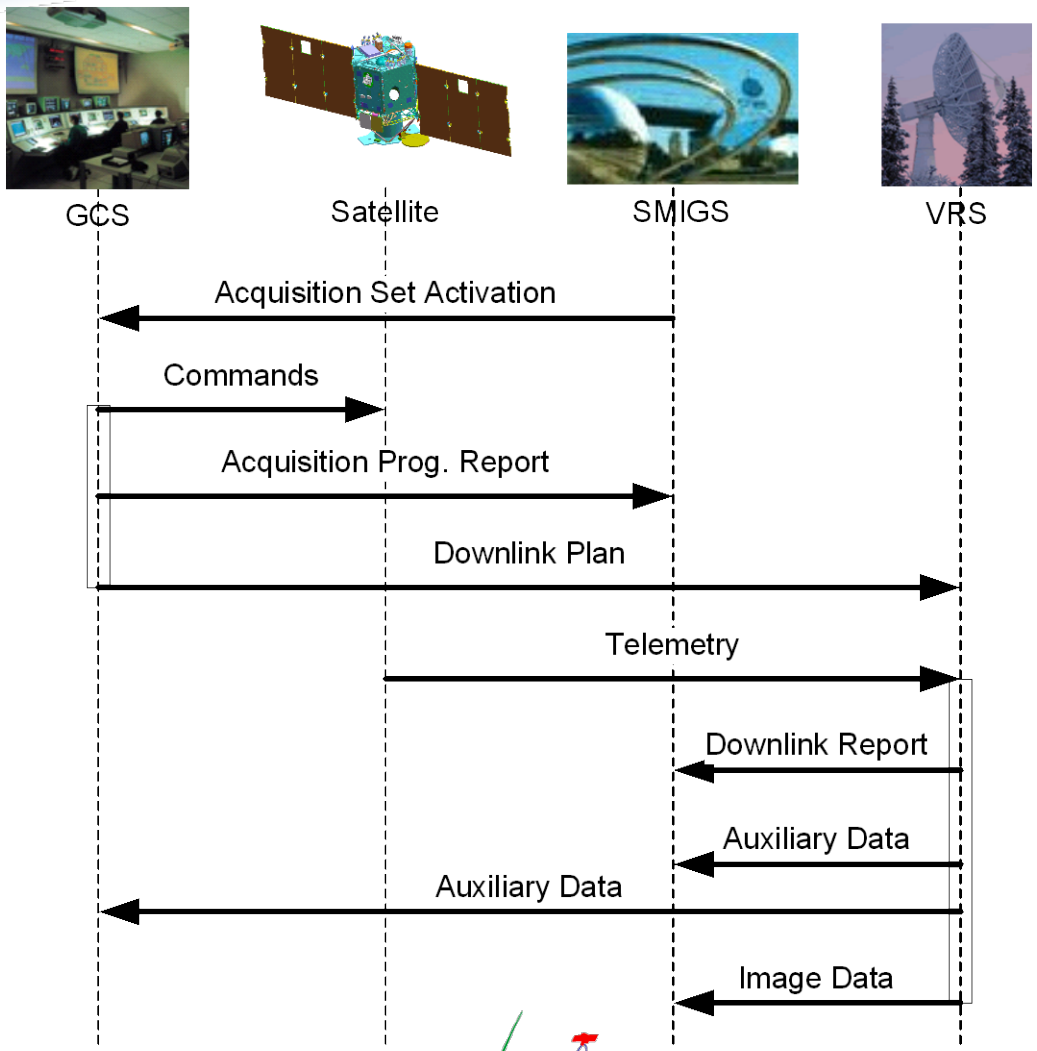
Feasibility check mode



VENµS mission operation concept (3)

Operational mode

(Scientific mission, but same principle for technological mission)



Development Guidelines – Concepts Summary

VENμS Ground Centers development guidelines:

- Interface standardization
- For each ground center: Architecture based on the reuse of existing software
- Simple but optimized Scientific mission planning
- Automation for minimum operators workload
- Elaboration of 2 mission plans at TMC (for technological mission) and at SMIGS (for scientific mission), and combining the 2 mission plans at GCS.
- Low coupling between the centers

Development Guidelines (1)

Standardization

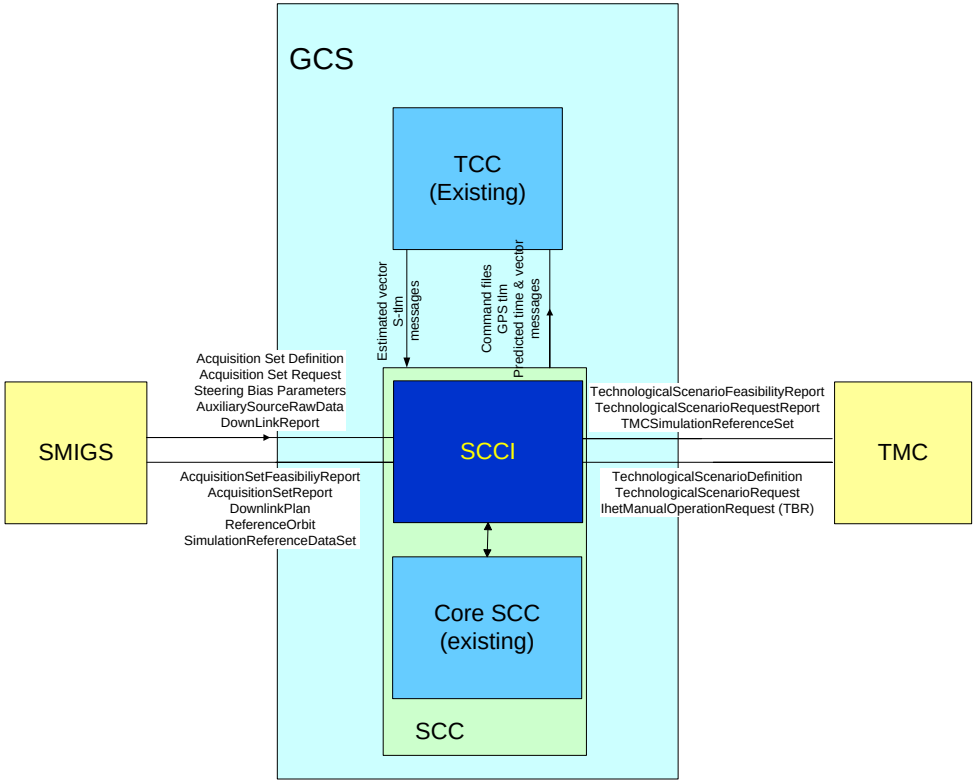
- CCSDS standard for
  - Ephemeris
  - Orbital reference frame
- XML standard for interfaces headers
  - ESA Earth Explorer (EE) format, based on XML, for interface structure (heritage of the dictionary, products split into headers and data blocks etc…)
- Standards for image binary files
  - Products are composed of the standard EE headers + data blocks which conform to other standards (Tiff/GeoTiff for images, HDF for grids…)

Development Guidelines (2)

AT GCS

Architecture based on existing software

- A new application called SCCI (SCC-Interface) was developed
- Functions as an interface between the existing SCC and the two MPCs
- Rationale: Introduce minimum changes to the existing SCC



Development Guidelines (3)

AT SMIGS

Re-use: Architecture based on existing software

- Use of validated software libraries for space mechanics
  - But new interactive tool for plan simulation (specific to the mission, many constraints related to constant acquisition angle conditions)
  - New software for monitoring of the programming loop message (VENµs specific)

Simple but optimized Scientific Mission Planning

- As much as possible, plans remain the same during operations (for multi-temporal series acquisition)
- It is an “mission optimization tool” rather than a plan generation tool.
- No “priority” between candidate sites, they are selected by the PIs

Development Guidelines (4)

Automation for minimum operators workload

- **Working hours operators only : No operator during night, week-end and holidays (which are different in France and in Israel…)**
- **Implementation in the different centers**
  - **at GCS**
    - Almost a fully automated system operation, enabled by the new “SCCI” application
    - The “SCCI” performs:
      - Polls the hub for receiving new messages from SMIGS and TMC
      - Runs the existing SCC applications
      - Creates & sends to the hub the GCS output messages
    - Aim: 2 command file uploads per week only

Development Guidelines (5)

Automation for minimum operators workload (cont.)

- **At SMIGS**
  - Plans are pre-prepared and independent of the actual orbit (based on the reference one)

    They can be sent to GCS in advance, for later activation
  - Monitoring of the plans (checking the overall loop between image request and product reception at SMIGS) is fully automatic
  - This monitoring is only “informative”, no action is possible on a short term, so no real time operation is necessary
  - Image processing is data driven and automatic: products are processed automatically on data arrival. Products remain on line 10 days for quality control by operator, if necessary.

Development Guidelines (6)

Low coupling between the centers

- **Asynchronous interfaces**
  - **Central “Hub” service makes available the relevant data for all centers**
  - **The centers connect when they want and download the data (ftp)**

- **Off-line mission plan elaboration**
  - **SMIGS and TMC build “generic” plans**
    - Plans built with the reference orbit
    - MPCs plans are complete, but not instantiated for a given date nor for an actual orbit
  - **GCS sends different configuration files to SMIGS and to TMC**
    - Contains only the relevant data for the mission plan elaboration

Development Guidelines (7)

AT GCS

Integration of the different payload operation plans

- **Integration & interleaving of different mission plans**
  - **Create a unified timeline**
  - **Integration of technological & scientific plans in the same command file**
    - VM1: different Venus cycles
    - VM3: in the same Venus cycle
  - **Resolve conflicts**

Conclusion

The VENµS Operation concept design has been a challenging task:

VENµS is a small satellite, having both scientific and technological mission, with limited resources (in development and in operation)

- **Operational concept has been kept simple despite**
  - **The international cooperation framework**
  - **The three separated mission centers**
  - **The imaging and IHET payloads operating in interleaved periods**
- **This has been achieved implementing**
  - **The concept of Off-line and On-line modes for mission plans elaboration**
  - **The use of standardized and asynchronous interfaces in all centers**
  - **A design orientated toward the maximization of automatic operations**