LUX - A SMALL, VERSATILE GEO PLATFORM FOR TURNKEY SYSTEMS

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ABSTRACT

Due to the renewed emphasis on providing satellite based communication services to consumers, the market potential of small geostationary multi-purpose platforms has been assessed in an in-house study at OHB-System. The market analysis led to the conclusion, to further develop a small and versatile GEO platform in order to be able to offer to the market a turnkey system with low investment risk for the customer and a short development time.

Key design features are a high flexibility in order to accommodate a very wide range of future telecommunication missions, a short development time and the objective to build the system based on ITAR free subsystems and components. The system will provide a long lifetime of up to 15 years in orbit operations with high reliability.

This paper provides an overview of the envisaged LUX missions and the LUX system design.

1. INTRODUCTION

In the course of the year 2005, the OHB System in-house development activities for a small geostationary satellite, which were co-funded by the DLR (see [1]), initiated at ESA a new programme within the Advanced Research in Telecommunications Systems (ARTES) framework, called ARTES 11.

In the frame of ARTES 11, a number of advanced and new technologies (see descriptions in section 4.1) will be used in order to provide a competitive edge in the telecommunication market and, as a side effect, these new technologies can obtain the heritage expected by many customers and will be also used for the subsequent LUX missions. On the other hand, the design of the LUX platform is largely based on existing well proven technology and relying strongly on the legacy from existing satellites. This approach provides a competitive edge in the market now and with respect to the future product evolution.

The LUX product portfolio ranging from Satellite platform delivery up to in-orbit delivery of a turnkey system including satellite and ground control station is designed to serve the commercial telecommunication market for applications in the range 300 kg payload mass and up to 3 kW payload power. Applications considered include, but are not limited to Scalable Multimedia Ka-band [2], Hybrid-band, Data Relay and Ku-band TV-broadcast missions.

A high performance but cost effective design is ensured by an innovative design concept. On the one hand the design is based to a large extent on existing and well proven technology with long heritage to minimize the investment risk. On the other hand advanced, but well qualified technologies are utilized to increase the payload to platform ratio of satellite resources.

2. LUX REFERENCE MISSIONS

The reference missions listed in TAB 1 and the respective system requirements were taken into account to define the LUX system and platform requirements which are summarized in section 3.

	Reference Missions			
	SMM Ka-band Mission	**Hybrid Band Com-SAT Mission**	**Data Relay Mission**	**TV Broad-cast Mission**
Frequency band	Ka-band	P-Band (UHF), X-Band, Ka-band	Ka-band, optical	Ku-band
P/L mass	257 kg	296 kg	271 kg	303 kg
P/L power	2588 W	2244 W	1215 W	3019 W*)
TM/TC channels	464	401	252	556
Trans-ponders	16 of 22	15 of 23	6 of 10	32*) of 40
Coverage areas	16 Rx 16 Tx	7 Rx 7 Tx	5 Rx/ 5 Tx 2 optical	2 Rx 2 Tx
Antennas	4 (dual grid)	10 (1 helix, 5 reflector, 4 global horn)	5 antennas 2 optical terminals	3 (1 dual grid, 2 single shell)
Deployable reflectors	2	1	2 (one is assy. of 3 reflectors)	2
Required pointing accuracy	± 0.1 deg.	± 0.1 deg.	± 0.1 deg	± 0.1 deg

*) or reduced number of transponders with equivalent overall P/L power consumption

TAB 1: Reference Mission Characteristics

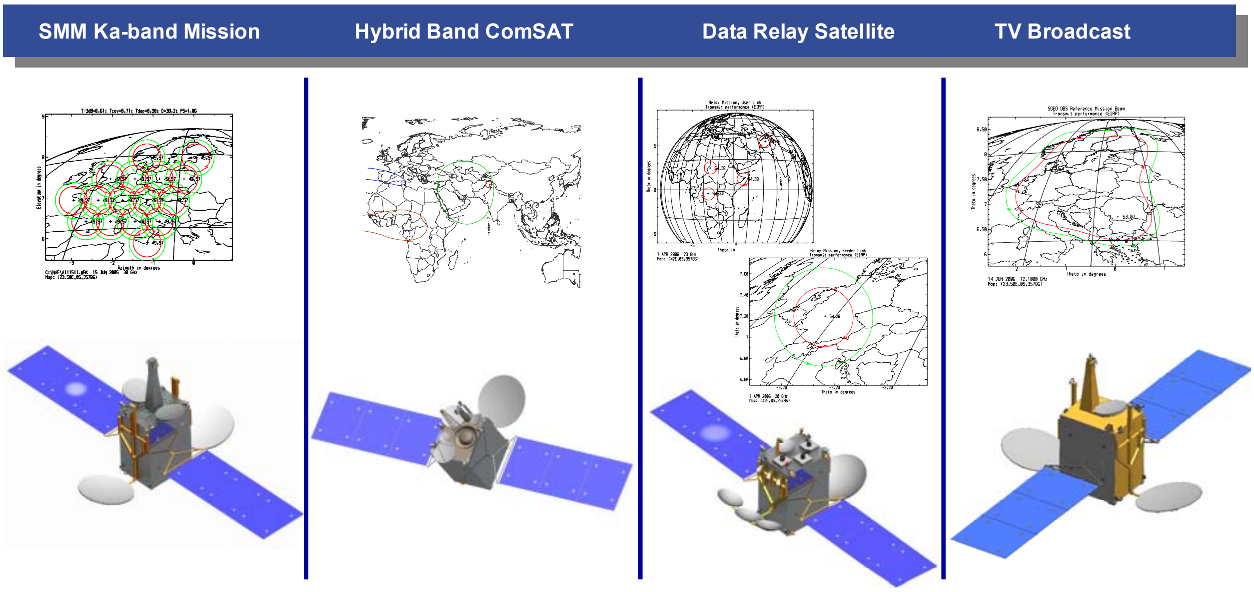


FIG 1: LUX Reference Missions

3. SYSTEM REQUIREMENTS

The objective is to develop within the frame of ARTES 11 a versatile, small GEO platform. The most important performance characteristics, which the LUX system will be designed to comply to are:

- Flexible, modular design to accommodate a very wide range of future telecommunication missions.
- Cost-effective design based on innovative technologies to increase the payload-to-platform ratio (i.e. to maximise the resources for the payload).
- An operational lifetime of 15 years.
- A platform reliability of at least 0.88 over the operational lifetime; the overall spacecraft reliability depends on the payload characteristics
- ITAR-free subsystems and components, as far as practicable.
- A recurring delivery time of 18 – 24 months, depending on payload characteristics.
- Compatibility with all commercially available launchers, including those capable of direct injection into GEO.
- Payload mass varying between 100 kg and 300 kg.
- Payload power consumption of up to 3 kW.
- Thermal control capable of max 2.4 kW of payload heat dissipation, and 0.5 kW of platform dissipation.
- Antenna pointing accuracy (half cone) in GEO better than 0.1 deg.
- Ability to perform a number of GEO repositioning manoeuvres equivalent to 6 deg per day.
- Onboard computer calculation performance of approximately 5 MIPS.
- Launch baseline is direct to GEO launch; if a GTO launch is required an external Apogee Engine Module (AEM) will be attached.

4. THE LUX PRODUCT PORTFOLIO

The LUX portfolio, see FIG 2, will comprise the following set of products and services:

- A geostationary platform of 300 kg class payload mass and ~3 kW payload power
- A corresponding telecom payload
- Further elements on demand:
  - launch / LEOP
  - ground control segment elements
  - mission operations elements
  - training, maintenance...
- In addition, the LUX consortium offers individual small GEO satellites or platforms for institutional customers (government/defence agencies)

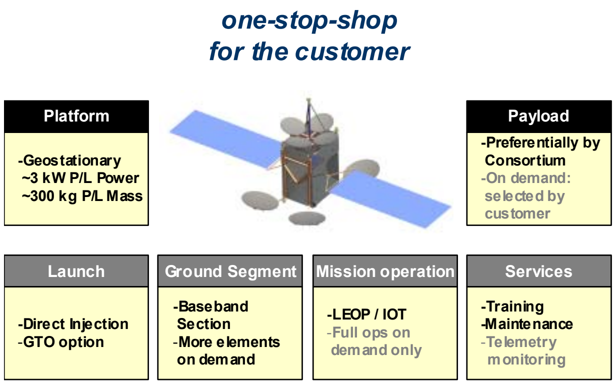


FIG 2: The LUX Product Portfolio

4.1. Platform Design

The satellite platform contains all subsystems which are required for the operation of the satellite. A detailed accommodation study of the platform was performed and is summarized in FIG 3 in an expanded view of the Payload and Platform Module. The platform accommodation is identical for all reference missions and is shown here for the SMM Ka-band reference mission (refer to section 2).

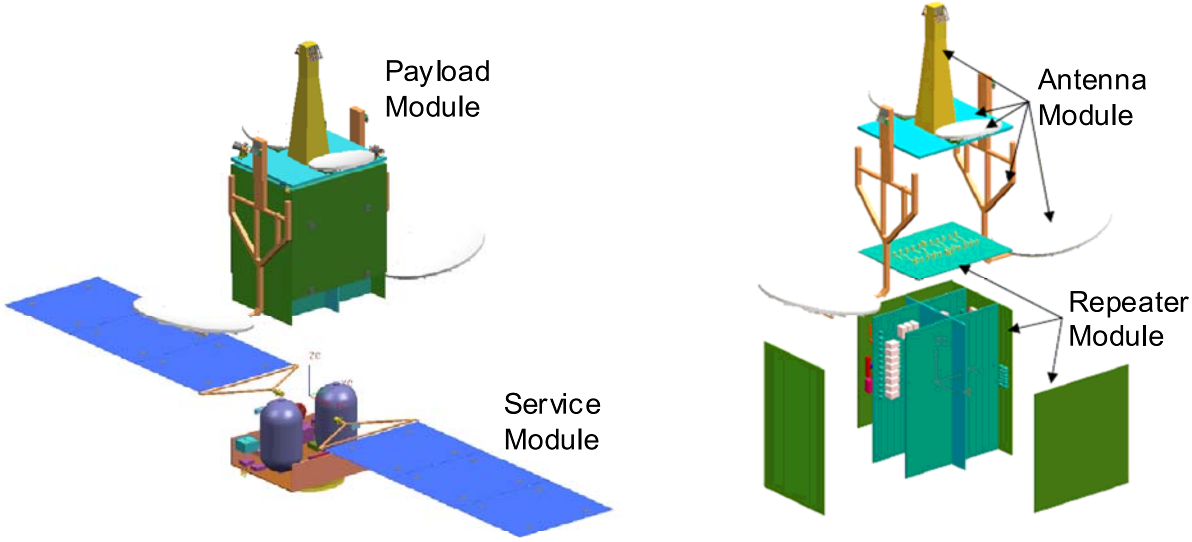


FIG 3: LUX Platform Design

The Payload Module (PM) houses all payload equipment. The payload equipment can be split in the Repeater Subsystem and the Antenna Subsystem. The separation of the telecommunication payload in repeater and antenna subsystem also highlights the possibility to separate the Payload Module in two submodules. The fact that the requirements for a repeater and antenna supporting structure are completely different and the circumstance that in most cases the repeaters and antennae are delivered by different suppliers support the separation of the PM in a Repeater Module (RM) and Antenna Module (AM). The split in a RM and AM allows to optimise the two structures for their specific needs. Each of the two modules can follow in parallel their AIV approaches which consist of different steps. This allows optimising the AIV approach and to save cost and schedule.

The Service Module (SM) basically houses all elements which are related to the satellite bus. The SM will be as generic as possible, i.e. changes on the SM between different missions will be minimised. Some of the service module equipment has to be mounted on the earth-deck (e.g. Star Trackers). The Solar Arrays (SA) will be mounted on the Repeater Module since its size anyway does not allow the accommodation on the SM. This approach allows the complete integration of the SA on the Payload Module without the SM.

The LUX subsystems are shown in the satellite functional overview in FIG 4. The most important aspects about the subsystems are:

- OBDH Subsystem
  The OBDH System controls the single subsystems by transferring and processing commands and acquiring sensor information and other data. New technology is integrated in the OBDH approach by following the System on Chip (SoC) philosophy as far as possible. LEON, MIL-STD-1553B and Telemetry IP Cores (supported by ESA) are intended for be used in order to follow this approach. This allows the OBDH to have software independent telemetry and telecommand capabilities for S/C operations.

- TT&R Subsystem
  The TM/TC transceiver unit receives commands from the satellite control ground station and transmits satellite status data to the ground station. The orbital position is acquired via tracking.

- Attitude & Orbit Control System
  The function is to control the standard attitude, to perform the reorientation manoeuvres for nominal functions and emergency attitude control, in which the satellite will be manoeuvred in a stable attitude to maintain the vital functions. The Attitude Control System (ACS) features stabilization via reaction wheels and attitude information via star trackers based on Active Pixel Sensors (APS). The Orbit Control System (OCS) is used to keep the satellite in its orbit and allocated position within the orbital slot. The orbital position is acquired via tracking.

- Propulsion Subsystem
  The actuator system concept is presently subject to trade. Depending on the launch concept either Electric Propulsion for direct to GEO launches or a bi-propellant propulsion system for GTO launches are investigated. Though the Propulsion Subsystem (PPS) is an actuator for the AOCS, this subassembly is handled as a separate subsystem due to its complexity.

- Satellite Structure Subsystem
  The structure contains all subsystems of the satellite bus and assimilates the launch loads. The structure consists of separate parts for the service, the repeater and the antenna module. The structure concept (shear web or central tube) is also subject of a trade which strongly depends on the chosen PPS baseline.

- Electrical Power Subsystem
  The additionally required power for the electrical propulsion option will be generated by a small extra solar array area and mainly be stored in a slightly larger battery.

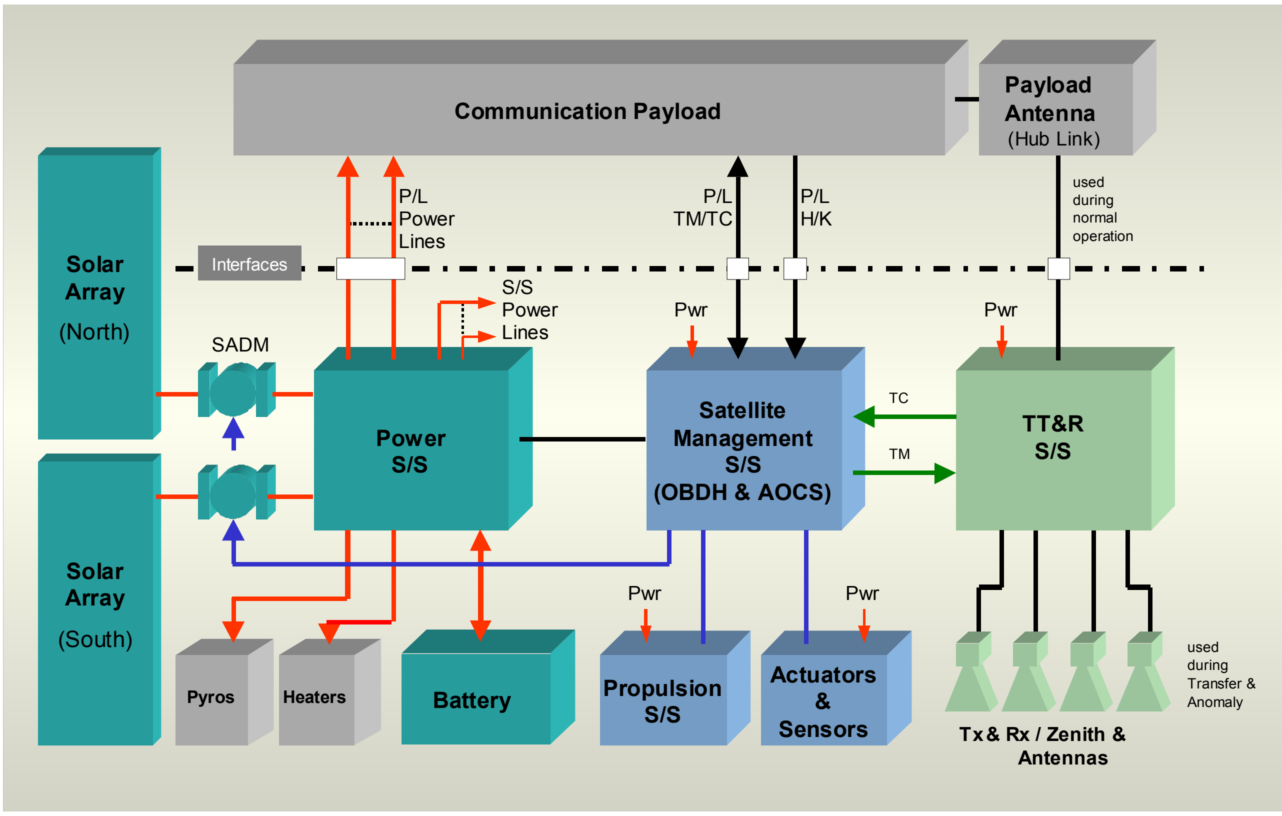
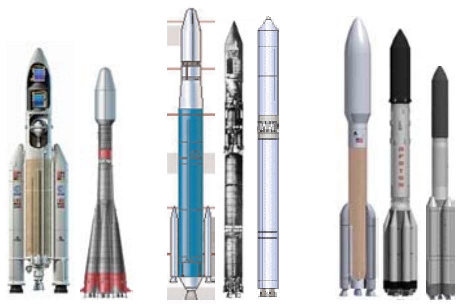


FIG 4: LUX Satellite Functional Overview

4.2. Launch

The LUX satellite will be compatible to the launchers, listed in TAB 2. This includes the technical compatibility with respect to mechanical, thermal and electrical environments during launch and the launch vehicle interface and on the other hand the ability to perform both direct to GEO launches and launches to GTO.



Launch Service Provider	Arianespace/ Starsem	Boeing Launch Services Inc. (BLS)	International Launch Services (ILS)
Rocket	Ariane V, Soyuz Fregat	Delta, SeaLaunch Zenit, LandLaunch Zenit	Atlas, Proton, Angara
Launch Site	Kourou, Baikonur	C. Canaveral, Vandenberg, Pacific Ocean, Baikonur	C. Canaveral, Vandenberg, Baikonur

TAB 2: Launch Vehicle Options for LUX

From this list, the following launch vehicle options are derived:

- Direct to GEO
  - Soyuz / Fregat
  - Zenit / Block DM-SL or DM-SLB
  - Proton / Block DM
- GTO
  - Ariane V
  - Soyuz / Fregat
  - Delta
  - Zenit / Block DM-SL or DM-SLB
  - Atlas
  - Proton K / Block DM

The LUX system will be optimized for a direct to GEO launch. Nonetheless, a classical GTO launch can be realized with the external Apogee Engine Module depicted in FIG 5, which can be attached to the LUX satellite. The AEM provides the delta V to reach the desired final orbit destination by a bi-propellant propulsion system for the 3-axis stabilized LUX spacecraft. Required additional attitude control actuators during main thrust phase (e.g. vernier-thrusters) are part of the AEM. The AEM consists of the following subsystems:

- AEM Propulsion (incl. tanks, thrusters, etc.)
- AEM Structure (incl. Launch Vehicle Adapter)
- AEM Thermal Control System
- AEM Harness

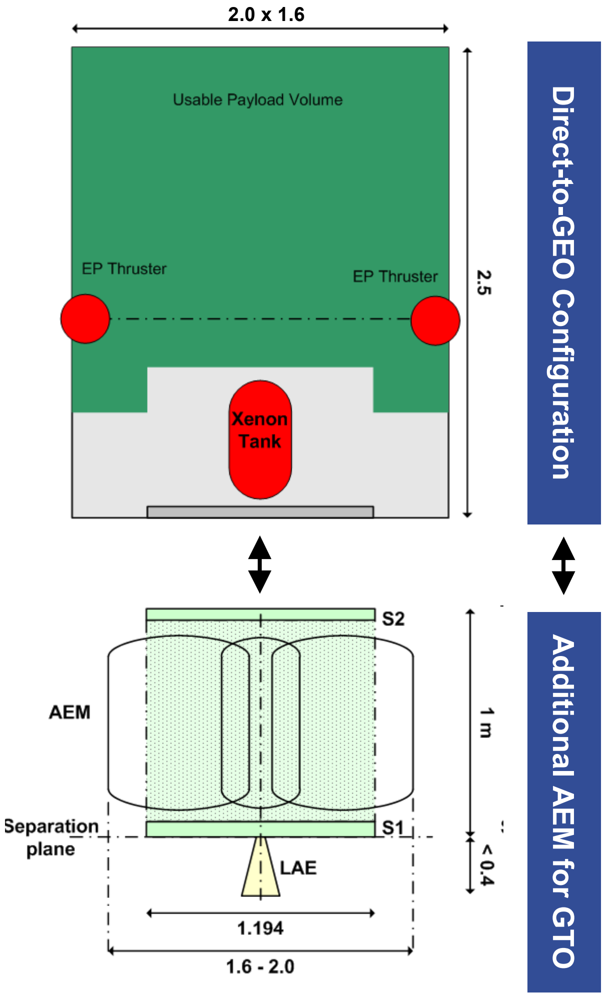


FIG 5: LUX Launch Configurations (Electrical Propulsion Option of the PPS, North View)

5. CONCLUSIONS

The development history of the LUX platform is depicted in FIG 6.

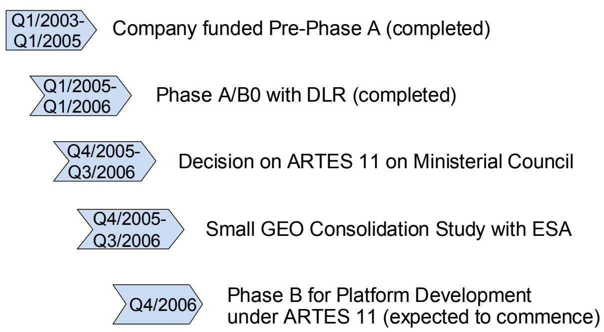


FIG 6: LUX Development Timeline

Under Artes 11, the development of the first mission will be pursued with the following milestones:

- Platform definition (Phase B) 2007
- Mission definition (Phase A/B) 2007
- Platform development 2008-2009
- Payload adaptation / development 2008-2009
- Satellite integration & test 2010
- Launch 2010
- Early Operations 2010/2011

The further development of LUX will be performed by a European consortium of small and medium system integrators which consists of the following companies:

- Contraves Space AG [3]
- LuxSpace Sàrl [4]
- OHB-System AG (lead) [5]
- Swedish Space Corporation [6]

The goal of ARTES 11 is to develop a small GEO satellite platform with emphasis on new technologies to optimize the payload-to-platform ratio, the system performance and the commercial cost-effectiveness.

The need for fast market access suggests an approach whereby the first satellite is built using largely conventional technologies, but with sufficient modularity to allow subsequent introduction of innovative solutions.

6. REFERENCES

[1] "Little GEO Satellite Design – LUX", B. Penné, et al., DGLR Congress, 2004

[2] "The Satellite Alternative for Broadband Applications", B. Ziegler, et al., DGLR Congress, 2004

[3] Website of the Contraves Space AG, Switzerland: http://www.contraves.com

[4] Website of the LuxSpace Sàrl, Luxembourg: http://www.luxspace.lu

[5] Website of the OHB-System AG, Germany: www.ohb-system.de.

[6] Website of the Swedish Space Corporation, Sweden: http://www.ssc.se