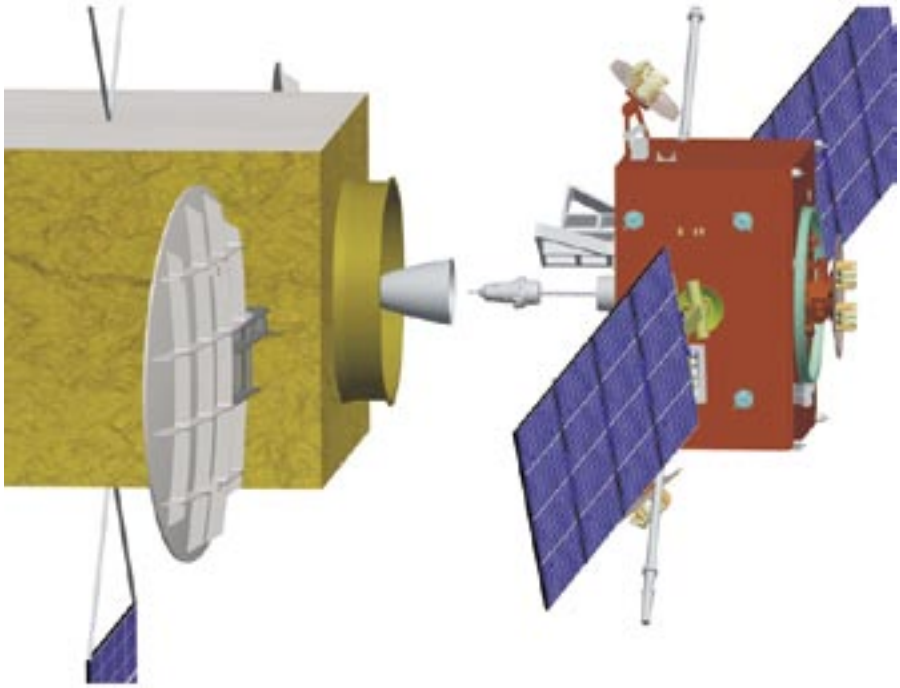
The “space tug” SMART-OLEV

Prolong the satellites’ lifespan



Many of the communication satellites in orbit are still in perfect condition, but are about to run out of fuel. Very costly, but there’s nothing one can do about it – until now. If a rescue mission proposal from a European industrial group proves a success, the satellites’ lifespan may be prolonged to the time the technology is out of date.

Large telecommunications satellites typically cost in excess of EUR 200 million to place in orbit, with an average useful on-orbit lifespan of 10-15 years. Once their on-board propellant has been depleted, the satellites are boosted into a disposal orbit and decommissioned, even though their revenue-generating communications relay payloads are still functional. During the next 10 years alone, there are more than 140 viable commercial satellites due for decommissioning in spite of the fact that they can still be used for several more years.

That was the commercial basis for the development of “space tugs” to extend the satellites’ lifespan.

Baard Kringen, Nordicspace
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Behind the industrial group that launched the idea, and prime contractor, is the Swedish Space Corporation (SSC), a company that over long time has built up great experience in managing, developing and building smaller satellite systems. In the group, in addition, one finds well known companies such as Germany’s Erwin Kayser-Threde GmbH, and Sener Grupo de Ingenieria SA from Spain. The project has been headed by the group Orbital Satellite Services (OSS).

Ready to be used

Chief Executive Officer Baard Eilertsen at Orbital Satellite Services said to Nordicspace that the general technological development is nearly finalized. The SMART-OLEV’s preliminary design review (PDR) is complete, validating the spacecraft’s configuration, systems and operation is carried out. This design review is being performed by a team of international experts, and is a key programme milestone that confirms SMART-OLEV’s readiness for development and production.

The project is therefore at a milestone, says Baard Eilertsen. If a contract with a customer is signed, the specific development for a satellite can start and the satellite will be built within a time frame of three years, meaning that the first satellite can be launched already in 2011.

So far no contract is signed, but OSS is in real negotiations with Eutelsat, one of the world’s largest satellite operators, with 24 satellites in orbit and seven new in contract.

Eutelsat’s evaluation of the SMART-OLEV’s capabilities is an important step for our company, he says. As one of the world’s largest operators of commercial telecom satellites, Eutelsat can fully benefit from the SMART-OLEV’s services

in prolonging the revenue-generating lifetimes of its in-orbit resources.

We have worked closely with Eutelsat's team during the past several months, continues Eilertsen, and Orbital Satellite Services looks forward to the opportunity of advancing our relationship into the SMART-OLEV's operational phase. Also among other possible customers the interest in the SMART-OLEV continues to grow.

Major progress also is being made on the technical side. Requests for proposals on various spacecraft subsystems have been issued to prospective worldwide suppliers by our three lead companies. This is an international process, with proposals being solicited from top manufacturers around the globe. Responses currently are being received, readying us for upcoming decisions on the composition of our industrial supply chain, Eilertsen says.

This is therefore an exciting time for Orbital Satellite Services and for the SMART Orbital Life Extension Vehicle, says Baard Eilertsen!

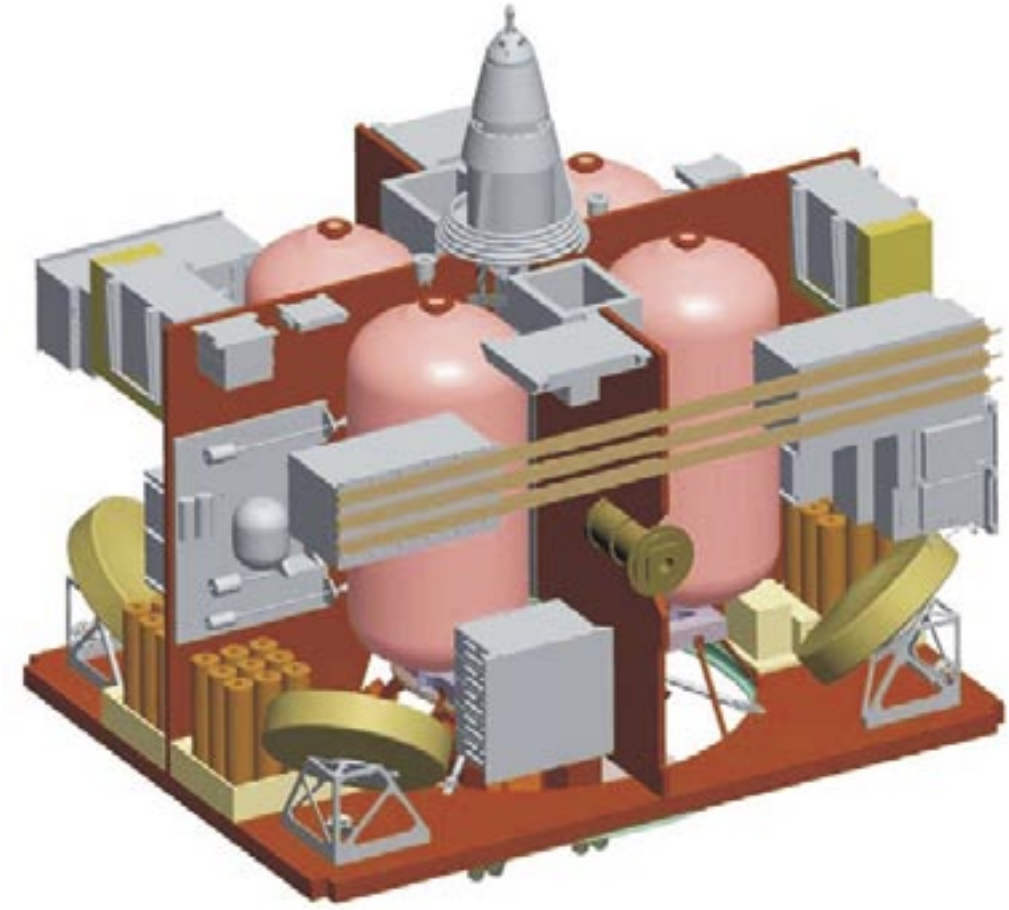
To our question about possible launch systems for the satellite he says that the satellite weighs 1150 kg and that there are several types of launchers to choose from. The choice will be taken based on capacity, prize and availability. Launched as "piggy back" can also be an alternative, but experience has shown that such possibilities are infrequent and the satellite must be launched when the need is there.

Several market possibilities

One market for SMART-OLEV, says Baard Eilertsen, is that the operators within the weight frame for a satellite lay in maximal capacity, but fuel for only five to six year. Before the fuel runs out SMART OLEV will be launched, attached and the lifespan prolonged for several more years. One of the advantages is that the investment can be distributed over two periods, thus making it easier for the operators to finance a new satellite.

With its ability to dock/undock up to five times, a single SMART-OLEV can also be used to service several satellites, which will hold them in proper slots for until 12 additional years for only 30% of the cost for a new satellite.

The last year, two satellites have been placed in wrong orbits and will use most of the fuel onboard to reach the correct orbit. These are clearly relevant candidates for a SMART OLEV mission. With connection to a launched "space tug", the mission can be prolonged to the original lifetime, even a lengthened one.



The interior of SMART OLEV
Figure: Swedish Space Corporation

The satellite

The SMART Orbital Life Extension Vehicle is as the name indicates in large degree based on technologies developed for SMART-1 satellite, the European Moon probe that crashed on the Moon's surface in 2006. The technology is in principle simple, a small satellite with its own supplies of fuel and its own engine takes the control of the satellites, and holds it in correct orbit and position.

SMART-OLEV will provide life extension and other services from 2011 onwards for geostationary communication satellites suffering from propellant depletion. SMART-OLEV will use a purposely designed and built spacecraft to mechanical dock with a client satellite's zenith face using its liquid apogee engine nozzle and launch vehicle interface ring. Neither electrical nor any other connections are necessary to perform the on orbit servicing except the mechanical link through the nozzle. SMART-OLEV will take over the attitude and orbit control functions for the client satellite allowing the client to continue to operate the other functions on the communication satellite as normal. In this way valuable geostationary hardware and orbital slots can be maintained and secured in a very cost effective manner.

SMART-OLEV will be controlled before and during docking from a dedicated operation control centre. After docking SMART-OLEV control may be transferred to the clients' own control centre if desired.

The SMART-OLEV is designed for up to twelve years of operations in near geostationary orbit. The service lifetime for a particular mission will depend on the mass of the client's satellite and the type of operations required. The so-called anchor point for that mission definition is to serve a two tons client satellite over a period of eight years. Keeping in mind that the life extension service will start close to End-of-Life (EOL) of the client spacecraft, the two ton class anchor point covers a wide range of existing telecom satellites in orbit.

In addition to the standard operations the vehicle can provide various other services as requested by a client including the following;

- Undocking and re-docking from one client satellite to another. SMART-OLEV is capable of up to five such docking and undocking manoeuvres.

- Relocating a satellite in the geostationary orbit. This is a relatively low mass cost manoeuvre and is dependent on the client satellite mass and angular velocity.

- Removing inclination from a client satellite. This is a relatively significant mass cost manoeuvre and is dependent on the client mass and the inclination to be removed to.

- Rotation the orbital nodes for a client satellite in an inclined orbiting satellite. The corresponding propellant consumption is a function of spacecraft mass as well as orbital inclination

In orbit storage OSSL or a client may choose to store SMART-OLEV in a near geostationary orbit whilst awaiting other applications or for contingency purposes.

A typical rescue mission

Launch & Early Orbit Phase (LEOP).
Typical 2-3 days from lift-off through injection of SMART-OLEV into a standard geostationary transfer orbit. The solar array, TT&C antennas and electrical thrusters will be deployed and the spacecraft commissioned. Command, tracking and real time telemetry contact will be made using a worldwide network of ground stations.

Orbit transfer.
This will take approximately 150 days during with SMART-OLEV will continuously fire its electric thrusters to spiral out to geostationary orbit whilst reducing orbit inclination. During this phase all spacecraft systems, including the docking payload will be tested. It will be daily contact with the spacecraft during this period.

The rendezvous and docking phase.
That is the most challenging one during the entire mission and will finally happen within some days. It is the key phase to derive to a composite configuration with the client satellite to start the real service for the client. Main characteristics for that phase is a relative navigation up to final docking.

Rendezvous with the client satellite takes a few days and can occur anywhere within the geostationary arc, but not 24 h a day due to the specific illumination needed by the sun. SMART-OLEV and the client satellite will be tracked from the ground to within 2 km of each other. Far fields cameras will then guide the spacecraft within 5 meters of the client satellite by manoeuvring SMART-OLEV via series of "stationary points" using the reaction control subsystem. Command, tracking and teal-time telemetry will be via the dedicated OCC and Ground Station.

The approach will be timed for an optimum local time of day to ensure illumination of the client satellite. During the approach SMART-OLEV will be rotated to align its solar array wings in a East-West orientation in order to minimising the shadow of the client satellite's solar panels with are aligned North-South.

At end-off life the client will be transferred to a disposal orbit at GEO + 300 km and an undocking process will be performed. SMART-OLEV will after that return to the next client, starting again with the phase of rendezvous and docking.

A large communcation satellite ready for launch. One can see the apogee engine nozzle at the bottom. Photo: ESA/CNES/ARIANESPACE

On-station operations: When the docking procedure is completed, all attitude and orbital control functions for the client's satellite are assumed by the SMART-OLEV, including control and execution of station-keeping manoeuvres. Command and telemetry for SMART-OLEV will be handled by a dedicated ground station.