A DIFFERENT YEAR 2000 CHALLENGE: ESOC's PEAK LOAD IN DEVELOPMENT AND OPERATIONS

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Abstract

ESOC is presently entering a peak load period, which could be unique in its entire history. Several "Firsts" in terms of development have to be mastered in parallel to a number of challenging critical operations. Between mid 1999 and end 2003 the Flight Dynamics Group in ESOC is involved in 15 major Launch (or Launch-equivalent) Support Operations. At ESOC, altogether 16 spacecraft have to be taken care of in that period:

- ERS-1 and ERS-2, in orbit already, with an increased demand for orbit and track keeping manoeuvres (solar maximum)
- XMM to be launched in January 2000, to be operated as an observatory for at least 2 years (design life time is 10 years)
- ARTEMIS to be launched in February 2000 and operated in Italy with planned support by ESOC for the Launch Operations
- ENVISAT to be launched in mid 2000 and to be operated at least for 2 years (involving also a high number of orbit manoeuvres -> solar maximum)
- CLUSTER, the first 2 spacecraft to be launched in June, the second 2 in July 2000, followed by almost 2 years of operations including 3 constellation change manoeuvre periods separated by 6 months
- MSG, the first to be launched in autumn 2000, followed by 2 further spacecraft to be launched within 18 months each
- INTEGRAL to be launched in April 2001, to be operated as an observatory (parallel to XMM) for at least 2 years
- SMART-1 to be launched in January 2002 and to be operated for about 1 year
- ROSETTA to be launched in January 2003 and to be operated for 10 years
- MARS-EXPRESS to be launched in mid 2003 and to be operated for 2.5 years.

The paper briefly addresses the Flight Dynamics characteristics of above missions and highlights the launch schedule dependencies and conflicts. It also addresses organizational aspects w.r.t. staff deployment, expertise re-use and facilities usage.

Introduction

Development for and operations of spacecraft in the Flight Dynamics area are traditionally performed at ESOC by one and the same organizational unit, the Flight Dynamics Division. This approach is best characterised by its known acronym "End-to-End, Multi-Project Service for Mission Operations". It has turned out that mission success and service quality are important results, but specifically cost efficiency has been demonstrated and proven in a number of cases.

The way the totality of the work has been and is organised will be challenged extremely in the preparation for and during the peak load expected. The effort required will peak sharply and rise as much as 100 % above the 1998 level. It might such not be excluded, that adaptations to our approach are needed here and there.

The Missions

The missions as briefly mentioned with their schedule in the abstract, are a true mix of practically all kinds, ranging from standard to exotic, from single to series and constellations, from short to long, from critical to routine. There are ESA missions and external customer missions, near-Earth and outer Space missions. We have spin- and 3-axes-stabilised spacecraft, and different launchers from different providers.

Mission Characteristics

We have three Earth Observation missions, ERS-1, ERS-2 and ENVISAT. Their LEO orbits are polar and sun-synchronous. The attitude is 3-axis stabilised, Earth-pointing under Yaw-steering control for the nominal mission. In addition to the standard, highly automated Flight Dynamics support we provide POD (Precise Orbit Determination) products using Laser, Altimeter, PRARE and DORIS measurements. Other non-standard tasks are the tandem operations with their demands on high-accuracy track keeping and the debris avoidance manoeuvres.

There will be two observatory missions, XMM and INTEGRAL, for x-ray and gamma-ray astrometry respectively. Their HEO orbits last 48 resp. 72 hours. Controlled by wheels, the spacecraft will perform high-accuracy pointing and scanning. Wheel unloading with thrusters will be scheduled such as to maintain the orbit phasing w.r.t. the ground station(s). XMM is planned for an ARIANE-5 launch, whereas INTEGRAL will use a PROTON.

The re-built four CLUSTER satellites will have to be manoeuvred into a polar, 19 R_e orbit for magnetospheric research (cusp and sheet). Contrary to the original ARIANE-5 launch scenario, where the spacecraft were planned to be manoeuvred up to moon distance, the new baseline with two SOYUS launches requires a completely new sequence. The tetrahedron constellation requirements with half-yearly changes remain valid for the new mission.

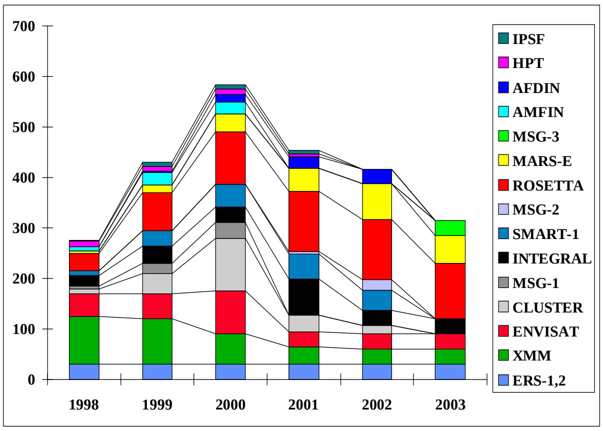
In the GEO domain we will first support the LEOP of the H-II launched ARTEMIS, which will be conducted at an Italian control centre in Rome. For EUMETSAT, ESOC will perform the LEOP operations of their three second generation meteorological MSG satellites.

Finally we look at the three non-Earth-orbiting spacecraft: The technology mission SMART-1, which is planned to be manoeuvred with ION propulsion to the Moon and then to orbit the Moon; ROSETTA, the cometary in-situ research mission, which will pass MARS, twice the Earth and two asteroids on its way to comet WIRTANEN, which finally will be orbited; and MARS-EXPRESS, a MARS orbiter mission including a lander attached to the ROSETTA-derived spacecraft bus.

Effort for the Major Projects

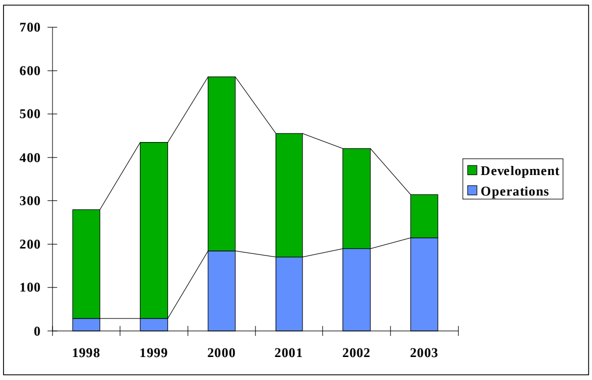
Given the resource requirements for the missions as outlined above, and including the multi-project investments mandatory (IPSF, HPT, AFDIN, AMFIN in Graph 1), the distribution over the five years to come and as compared to the level in 1998 is shown in Graphs 1 and 2.

Graph 1: Project Effort Distribution in Man-months



Graph 1 shows all the major projects, their total requirements as scheduled for the presently valid launch schedule. Graph 2 on the other side illustrates how the total requirements are split in development and operations. One can see that the effort in 2000 more than doubles the effort in 1998, that after 2000 the effort levels off again, but stays well above the 1998 figure, and that the peak in 2000 is a cumulative effect of the increasing development effort and the sharply rising operations effort.

Graph 2: Development/Operations Effort Distribution in Man-months



The Challenge

The period ahead of us presents both a technical and a management challenge. On the technical side, firstly a number of “Firsts” in development and operations have to be mastered, viz.

CLUSTER: Orbit insertion with two launches and Tetrahedron Constellation with changes

SMART-1: Moon Transfer with ION propulsion, Moon injection and orbiting

ROSETTA: MARS Swing-by, Asteroid Fly-by and comet Rendezvous, orbiting and landing necessitating optical navigation and comet characterization

MARS-EXPRESS: MARS Insertion and orbiting.

Secondly, a number of critical LEOP operations will have to be supported, viz. for XMM, ARTEMIS, ENVISAT, CLUSTER, MSG-1,2,3, INTEGRAL, SMART-1, ROSETTA and MARS-EXPRESS.

On the management side one may summarise the challenges into the objective “Multi-project mission success optimisation”. The key items here are the staff resources and expertise distribution, the potential schedule changes (launch postponements) and the conflicts created thereof.

Launcher and Schedule Considerations

The period in question presently starts with the launch of XMM in January 2000 and ends with the launch of MARS-EXPRESS in June 2003 (including the subsquent Mars insertion). Especially the year 2000 is rather crowded and characterised by the multitude of launchers: XMM with ARIANE-5, ARTEMIS with H2, ENVISAT with ARIANE-5, CLUSTER with 2 SOYUZ (with an ARIANE-4 single launch back-up), MSG-1 with ARIANE-4 or 5.

Whereas ROSETTA and MARS-EXPRESS have fixed launch dates (from a launch window point of view), all the other planned launches could potentially slip. There are already indications of that, typically for ENVISAT and INTEGRAL, the latter decided for a PROTON launch. In preparing for the support the necessary flexibility needs to be foreseen to cover firstly the potential launch date changes and secondly the conflicts which might arise from this and the mutual dependencies and independencies of launch dates with the same or different launchers.

Resources and Expertise Utilisation Considerations

The effort load curves from graphs 1 and 2 give a good indication on the minimum number of staff needed over the years. The present complement of staff needs to be increased according to the load curves. It will be achieved via two frame contracts that operate in continuous competitive mode. Short-term, part-time and long-term assignments will be selected depending on the particular project needs. Due considerations will be given to an optimal distribution of existing expertise and experience across the entire division.

One of the most challenging organisational requirements is the minimisation of the project costs (true effort and optimal, multi-project re-use of expertise). Treating each project separately with separate teams is too easy (and very costly), but the ideal multi-project arrangements are heavily constrained by the almost arbitrary schedule changes to be expected.

Facilities Utilisation Considerations

Similar to the constraints as present for launch pad operations, the usage of ESOC facilities (such as operations rooms, computer platforms and ground stations) is constrained. For Flight Dynamics proper this translates essentially into the availability and accessibility of our operations room with its computer platform. The actual LEOP operations (24 hours per day over several days) and its preparation (a period of up to half a year before launch) present the heavy load and usage. Thanks to the set-up of our ORATOS platform (redundant network of SUN servers and clients) and the architectural design of the operations room (flexible arrangement of computer equipment), we are able e.g. to handle all four CLUSTER spacecraft in parallel or to support two LEOP’s with different launchers at the same time.

Conclusion

The expected peak load in development and operations presents both a technical and a management challenge. Seen from the perspective of a single project there is essentially nothing very different as compared to the past. But when considering the multi-project aspects, one realises that the period to come presents a challenge, an order of magnitude bigger than experienced in the past. We are confident that we will master it!