Promoting ESA Software as a European Product: The SCOS-2000 Example

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ESA has been allowing re-use of the high-quality software that it has developed for its own operational purposes by granting non-exclusive licenses within the Member States for the software's use for space research and technology purposes. The licensing is normally free of charge and is seen as a good way of allowing the European space community to benefit from ESA-developed assets. This article looks at an initiative to take this approach further through the promotion of ESOC's latest SCOS-2000 mission control infrastructure as an ESA product.

ESOC software products and their marketing

ESOC develops high-quality software for its core business of spacecraft operations. This includes:
- mission-control software
- flight-dynamics packages
- mission-analysis packages
- simulator software, etc.

Much of this software is used and rigorously tested in the demanding arena of supporting spacecraft operations. Such software falls within a relatively small 'niche' market, which consists primarily of spacecraft operators. It is developed using European funding and because of ESOC's need to apply it to many missions, it is designed for reuse. The question then arises: Why not encourage other spacecraft operators to use this software and benefit from the investments that have been made?

In fact, ESA has been doing this via the licensing of its software for many years, although the idea of promoting software as a supported 'product' is relatively recent. If we define 'productisation' as the activities needed to make ESA software usable by a wider community that includes external users, its advantages are that:
- the software can be improved further by enlarging the user community: this benefits both ESA and the user community as a whole
- wider use of such products can contribute to the consolidation of European space technology and can help make European industry more competitive (in Europe and globally)
- such use can also help save money, by avoiding unnecessary repetitive, and possibly risky, re-development
- better use is made of European public funds, both by better leveraging of the products developed using these funds and by avoiding waste through unnecessary redevelopment.

SCOS-2000 as a software product

At ESOC, it has been the practice for over 25 years to use a generic mission control system as the basis for the control system of each mission. The control system is a potentially expensive and tricky system to develop. It supports the monitoring and control of the spacecraft, including the various displays and facilities that one sees in a typical mission-control facility, like ESOC's Main Control Room (Fig. 1). Having a generic system significantly lowers costs and risks. The rub, of course, is that developing a generic spacecraft control system with adequate flexibility and performance for all missions is difficult and is itself a very costly investment. ESOC has developed such a generic control system using the latest software technology: the Spacecraft Control and Operations System SCOS-2000.

The SCOS-2000 development effort had the following main strategic aims:
- ease of configuration and/or customisation, thereby lowering associated costs

Figure 1. The Main Control Room at ESOC

– functional richness, reducing the need for mission-dedicated functions and thus lowering mission-specific costs
– scalability, allowing the system to be adapted to missions of any size or for any phase of a mission, e.g. by adding work stations according to the performance required or the number of users; scalability provides flexibility
– vendor independence, which reduces or avoids the need for periodic porting exercises as hardware platforms or commercial off-the-shelf (COTS) software become obsolete.

All four aims have been achieved and as a consequence the costs of the ESOC control systems have come down by a factor of between two and three. Vendor independence has also been largely achieved with the recent acceptance of the so-called 'evolution version' of SCOS-2000.

Work started on SCOS in about 1992 and it supported its first ESA missions – Huygens, Meteosat (MTP) LEOP and Teamsat – in 1997. Since then, the software has been continuously improved with the re-engineering of the tele-commanding chain in 1998–2000, numerous functional improvements, and the recent evolutionary work to improve vendor independence. The total investment in SCOS-2000 to date, including internal ESA effort in managing the project and supporting studies, is of the order of 15 MEuro.

Since SCOS-2000 has been developed to cope with the wide ranging demands of ESA missions, from the simple to the most complex, it can obviously be of benefit to other spacecraft operators outside ESA. Hence the decision to promote it as a specific software product.

Pre-conditions

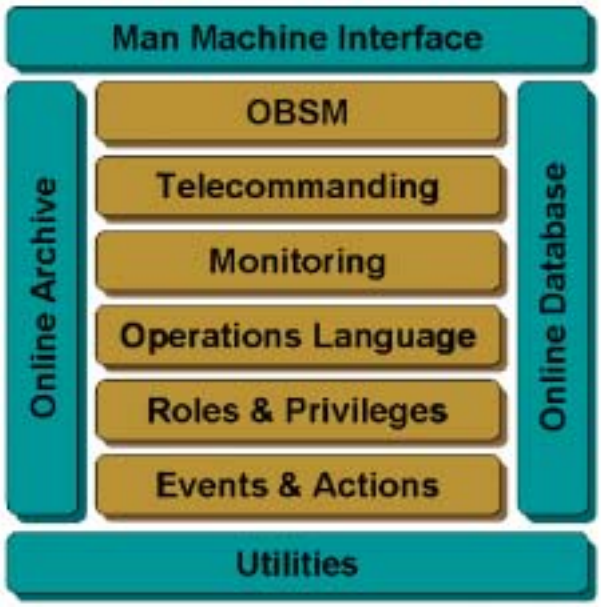
Candidate software for 'productisation' must be:
– fit for its intended use
– well-defined
– vendor-independent, or at least supported on popular platforms.

It is also desirable that it has long-term support from ESA, so users know that it will be maintained and kept up-to-date.

SCOS-2000 satisfies all of these criteria. It has been specified and designed to meet the needs of ESOC-supported missions, which range from relatively simple ones to complex earth-observation and scientific missions. It is fully defined in documentation available on an electronic database. Its functional and other requirements are detailed in software-requirements documents and its architecture is well specified (Fig. 2). Figure 3 shows the available external interfaces.

SCOS-2000 was originally developed to run on Sun Solaris platforms, compatible with Unix

Figure 2. The SCOS-2000 architecture



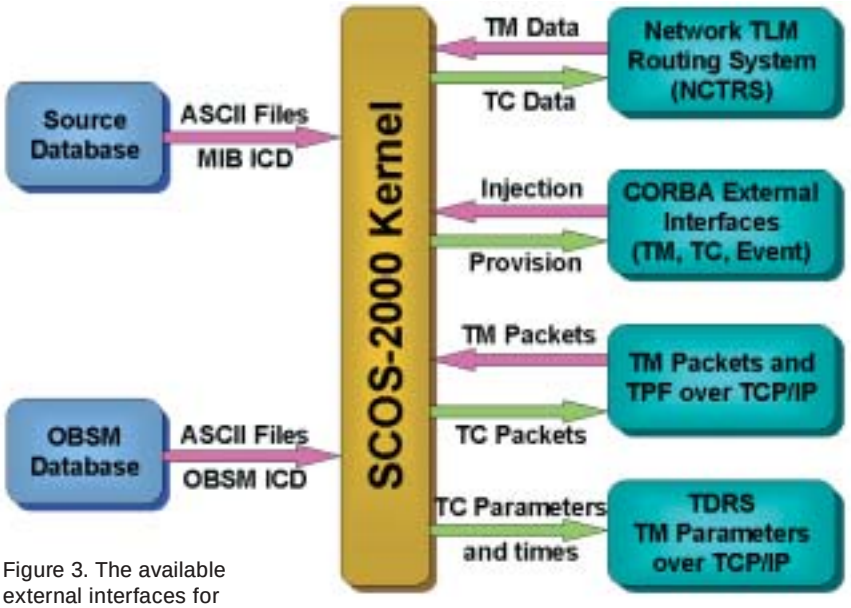


Figure 3. The available external interfaces for SCOS-2000

System V Release 4. While this represented increased vendor independence compared with the earlier Vax VMS systems, vendor independence was still limited because of dependencies on the Solaris environment, and the use of potentially changing COTS software. To address this first point, SCOS-2000 was modified so that it could run under the Linux operating system, which has a good track record for mission-critical systems, and is a Unix variant not very different from the original SCOS-2000 platform, Solaris. However, Linux also runs on Intel PCs, which is an important point since some potential users require a PC-based control infrastructure. Last but not least, Linux is itself 'open-source', and therefore by definition vendor-independent.

SCOS-2000 in its 'classical' form used three major COTS products: ObjectStore, Orbix and ILOGViews. The first two of these were subsequently replaced by open-source equivalents: POST++ and Omniorb, respectively. ILOGViews, which supports the graphical user interfaces, will eventually be replaced by Java technology, but this is not urgent in view of this product's modest cost.

SCOS-2000 will be used for all future ESA missions and will be fully maintained and supported for many years to come. It is intended to retrofit it for some of the older missions that are currently based on an earlier infrastructure. SCOS-2000 will be used, for example, to support the Rosetta mission, which extends up to 2013. Certain features introduced by the many missions expected over this period will be considered generic and will be incorporated into the product, which will also benefit from ongoing R&D funded by the Agency's various study programmes.

Licensing aspects

The current ESA licensing scheme

Normally, ESA's special conditions concerning intellectual property and associated rights assign the International Property Rights (IPR) for software developed under ESA contract to the contractor, with ESA having full rights to use the software for its own purposes. The rules also define a category called 'operational software', for which ESA may claim full IPR. This 'operational software' clause is usually applied for software needed in operations, which requires, for example, full inspection rights for the source code, or the possibility of passing software from one contractor to another (say from development to maintenance). Claiming IPR for 'operational software' also safeguards the Agency's independence from the original author and so helps the long-time support of the software. For software for which ESA owns the IPR, it may grant a non-exclusive licence to a Member State body for use of the software for peaceful purposes in fields of space research and technology. Such licences are normally free of charge.

A further complication relates to the rights given in the licence, and these depend on the objectives of the licensee. Basically, licences can either allow use of the ESA software unchanged or with minor changes – leaving the IPR with ESA – or permitting the licensee to gain IPR for changed code or modules under certain conditions. This second approach was used for the licensing of ESOC's Multi-Satellite Support System (MSSS), but was later found to have drawbacks: for example, it can result in 'forking', which may generate a different product from that licensed, and then there is little feedback to help to improve the original product.

In the absence of detailed rules for writing licensing agreements, ESOC has in practice adopted three different types of licences:
– Run-time Licences, granted for temporary use and trial, without the right to change the software or investigate the source code.
– Development Licences, granted for upgrade developments of existing 'operational software' for ESOC's own use and under ESA contract, including work on the source code.
– Full Licences, to make developments based on the software, e.g. to develop a product. They also allow the licensee to make changes to the software.

The future ESA licensing scheme
The Agency's rules concerning information, data and IPR are presently being revised. The policy document prepared by the IPR Drafting Committee has been submitted to ESA's Administrative and Finance Committee (AFC) and Industrial Policy Committee (IPC). The novel feature introduced in this paper is a scaled and differentiated treatment of information, data and IPR with respect to the body which has borne the cost of its development. Different treatments are foreseen for the result of activities fully-paid by the Agency, not fully-paid by the Agency, and for partnerships.

For 'operational software', however, there will be no change in the licensing approach and so the impact for SCOS-2000 promotion will be negligible.

Open-source licensing
Because of the aforementioned shortcomings, the product approach for SCOS-2000 has caused us to look at an alternative 'open-source' licensing model, in which the source code is accessible and may be modified, albeit with some obligations depending upon the particular open-source licence used.

The advantages of the 'open-source' approach are that:
– the source code is open to inspection by everyone
– the programmer community tests the software and fixes bugs
– new features are added to the software by the programmer community; indeed features may be added that could not possibly have been foreseen by the original authors.

Open-source software is in an 'intellectual marketplace', in the sense that peer review improves the software quality in a kind of 'survival of the fittest' scenario. The economic basis for the open-source approach has been explained in the book 'The Cathedral and the Bazaar', by Eric S. Raymond. Another economic model advocates the 'give away the recipe, open up a restaurant' approach, i.e. provide your software as open source, but sell services around it, such as packaging, consultancy, integration and applications. This is the model that external licensees of SCOS-2000 may adopt.

SCOS-2000 licensees will be encouraged to accept 'open-source-type' conditions, i.e. to hand back improvements made in the SCOS-2000 kernel. The intention is to reflect this in licensing agreements, replacing the older IPR transfer scheme discussed earlier. However, it cannot be imposed and has to be done by agreement. Industry is also free to develop add-on products that inter-operate with SCOS-2000 using the defined interfaces; in such cases they may wish to reserve full IPR over the products of their own investment.

Market aspects
As mentioned earlier, mission-control software, and indeed any kind of space-operations software, falls into a specialised or niche market, dominated by a limited number of space agencies and satellite operators. However, there are a surprisingly large number of commercial geostationary (GEO) and low Earth orbit (LEO) missions, run by organisations such a Intelsat, Inmarsat and Eutelsat. The main products currently on the market come from US commercial suppliers such as Integral Systems, Storm and Braxton Technologies. The first two in particular have solid track records with satellite operators, with a large existing customer base for commercial GEO and LEO missions. Their products have attractive user interfaces, and integrated tools are often available to work with them (e.g. simulators, basic flight-dynamics tools). Their disadvantages are that they are:
– closed systems
– licence fees are incurred, as with all COTS products
– customers have limited or no control over product evolution
– customisation costs may be significant for new classes of missions, since it has to be done at commercial rates by the vendor.

This contrasts with SCOS-2000, which is open in terms of external interfaces and customisability, as well as being open-source within the ESA Member States.

There do not appear to be any European mission control packages, at least ones that are being actively promoted commercially, making the US products the main competition for SCOS-2000.

Support requirements

It has to be recognised that if a piece of ESA software is promoted as a product, considerable efforts and important responsibilities are incurred on the Agency's side. For example:

– Promotional effort.
– Setup and maintenance of a user-community organisation, to allow consultation on product evolution.
– Provision of access to product information.
– Provision of customer technical support in terms of a user help desk.

For SCOS-2000, measures have been taken in all of these areas:

– Product promotion is carried out through meetings with potential customers and also through supporting Industry to make bids to other spacecraft operators based on SCOS-2000.
– A user organisation has been set up.
– Access to documentation is currently provided via an FTP server. A web site is under construction and will be available before the end of the year. It will carry documentation, answers to Frequently Asked Questions (FAQs), registration for different user categories, a software-problem report database, release plans, and an on-line demonstration.
– A help desk has been set-up as part of SCOS-2000 maintenance; users can subscribe to this service for a fee.

We also anticipate possibilities for training courses, installation assistance, consultancy, and specific developments of customer-requested features.

In terms of relations with the user community, ESOC will take the initiative, but the user community is also expected to contribute. ESOC and the user community will be partners in that:

– On the one hand, ESOC will be the custodian of the product, maintaining it, fixing faults (inevitable in a complex system with many users), and keeping it up-to-date with changes in the computer platforms and operating systems. ESOC will also implement new features or integrate features that have been developed by user missions or external users under the open-source approach. ESOC will also conduct the R&D needed to keep the product up to date with technological advances.
– On the other hand, the users will propose new requirements based on their operational experience and will contribute to the product via the open-source approach, e.g. by submitting code updates or coding for new features.

Experience so far

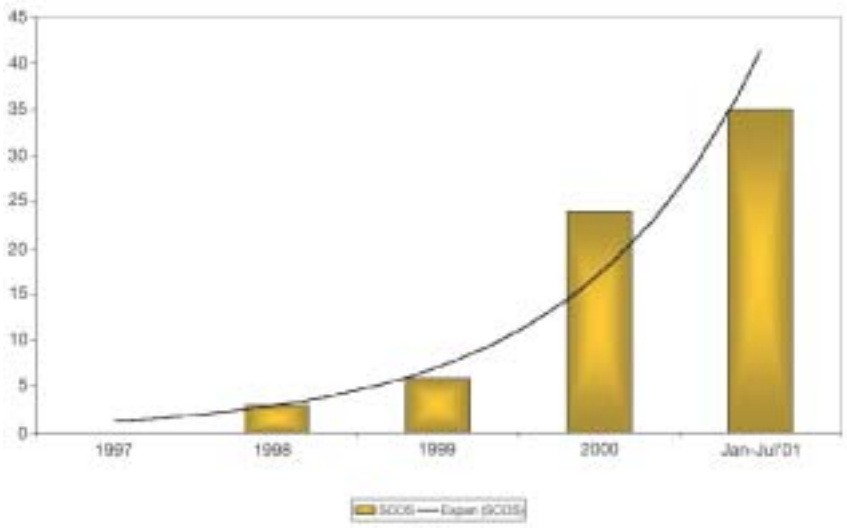
Nearly 100 people from outside ESA attended a very successful SCOS-2000 Users Workshop, held for the first time in April 2001. At this Workshop, which included presentations on the product, plans for its evolution and the proposal to set up a SCOS-2000 User Community, the users also gave presentations on their experience with the product. The proposed open-source approach received a generally positive response.

A number of the companies involved in the development of SCOS-2000 have been marketing the product to other spacecraft operations organisations. This has resulted in the decision by the German Space Operations Centre (DLR) to use SCOS-2000 as the basis of its control centre infrastructure. The Principal Investigators of the Herschel Planck science-mission payloads have also decided to use SCOS-2000 in building their instrument check-out equipment. The changes to SCOS-2000 to enable it to support spacecraft or instrument checkout were pioneered for ESA's Proba (Project for On-Board Autonomy) spacecraft, and have recently been introduced into the evolution version of SCOS-2000. There are also other commercial prospects in the pipeline.

In the meantime, SCOS-2000 has already become the 'best-selling' software product licensed through ESOC's Contract Service. In a little over two years, some 30 licences have been granted, as shown in Figure 4.

What has been found is that breaking into new markets involves considerable effort. Firstly, there is the need to compete against the established suppliers of COTS mission-control systems. This involves convincing potential

Figure 4. Cumulated number of licences issued at the end of the periods indicated



customers of the benefits of using SCOS-2000, and this will become easier as it establishes a track record with organisations or customers outside ESA. Secondly, preparing bids usually involves demonstrating compliance with a set of customer requirements, frequently expressed in different terminologies from that employed at ESOC and possibly reflecting different operational practices or concepts. With such a functionally rich and flexible system as SCOS-2000, preparing a compliant proposal is usually possible. ESOC has been giving help to some of the companies in preparing such analyses.

Our experience has also led us to look at two other aspects – certification and extension to further platforms:

– Together with the ESA Quality Department, we are starting an activity to 'certify' SCOS-2000. This will involve an independent evaluation of the software against a set of agreed quality criteria. The certification method has been customised for space software from ISO Standard ISO 9126 ('Information Technology: Software Quality Characteristics and Metrics') among others. The method has been developed under a study contract with TUV Cologne, which will perform the certification. Certification of space software is a new discipline and we are pleased that SCOS-2000 will be in the vanguard of this. Obviously, certification will be help in SCOS-2000's promotion.
– We have also carried out a short study into the feasibility of porting SCOS-2000 to 'Windows®', keeping the common-source approach that was applied with the earlier Linux porting. This would make the product more attractive to organisations with a Windows® PC infrastructure. This is frequently the case for spacecraft and payload checkout, and is also true of some spacecraft operators. The study has shown that it is indeed feasible, although as yet no decision has been made on proceeding further.

Conclusion

This article has reported an initiative to promote a highly successful ESA mission-control system as a commercial product. There is, however, a significant body of ESA software. For example, from ESOC alone, 93 software products have been licensed in 94 Member State bodies, involving more than 220 licences in total. Given that there is a significant reservoir of such software, the approach has strong potential for being extended to other ESA software to improve the effectiveness of its promotion and use.