Planning the Usage of the ESTRACK Network

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Abstract. In this paper, we introduce the concept and modelling required to support the automated planning and scheduling of ESA's ESTRACK Network usage, and propose an initial approach to the resolution of the corresponding planning problem.

1 Introduction

The ESTRACK network comprises all the ESA facilities deployed around the world in order to provide the tracking services required by the Agency. This includes ground stations, communications and control facilities.

Typically ground stations were almost exclusively dedicated to a given ESA mission, operated locally by the Ground Station staff with practically no systems between the ground stations and the control system (only communications lines when the operations centre was co-located on the ground station site).

The network management and scheduling systems were designed in accordance with those principles, and planning performed manually at the scheduling office. Ground stations were scheduled as directly requested by the mission as exclusive users of the facilities.

The ESTRACK network has now grown in size, capability and also in complexity, and it keeps growing. Stations are remotely operated on a routine basis. They are supporting multiple missions, within and outside ESA. The requests from the users are evolving from direct request of specific facilities to more generic tracking service requirements.

A new network management and scheduling operational concept is required in order to accommodate this evolving scenario and the automation of some of these tasks.

This paper introduces the new ESTRACK Management System concept, and the associated modelling required to support the automated planning and scheduling of the ESTRACK network.

2 Operations to be Planned

The initial step in the definition of an automated approach to planning and scheduling of ESTRACK is to clarify the type of operations requested by the client missions and supported by the network.

The operations to be planned are decomposed hierarchically from top-level operations abstracting the needs of client mission to low-level operations that can be compiled into executable commands that drive the facilities.

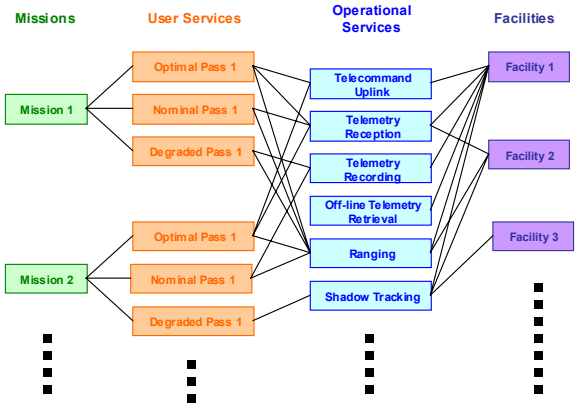

Figure 1 Relationship between Missions, User Services, Operational Services, and Facilities

At the top of the hierarchy we have the user service, which represents the abstraction of a service that can be requested by a client mission. User services are typically mission-dependent, as they include all characteristics that are needed by the mission in terms of the content of the passes.

At the lowest level of the hierarchy we have the operational services, which represent abstractions of services that are provided by the facilities. The operational services are mission-independent, although their availability at a facility is constrained by the availability of the mission configuration profiles, which represent the facility configuration corresponding to specific spacecraft modes, and are therefore limited to a set of missions.

The operational services can be combined with constraints to define a user service. A user service can have several alternative definitions, representing for instance degraded modes of the service, which can be used to ensure a minimal implementation when the resources required for the nominal implementation of the service are not available.

3 Facility Model

The provider facilities are constituted by all the elements required for the support of user service requests to the network. This includes ground stations but also operations teams, communications lines, network interfaces systems, etc. External provider facilities are also considered, such as DSN stations, as EMS will act as an interface between ESA missions and the external provider scheduling office.

The operational services provided by a facility rely on the use of equipment provided by the facility. The availability of an operational service at the facility depends therefore on the availability of the equipment. The capability to provide operational services concurrently at the Facility is represented in a resource model of the facility, which provides an abstract view of the available equipment.

Each operational service is constrained by requirements on these abstract resources, in a pattern including temporal dependencies between the resource requirements.

4 Problem Definition

The requirements on ESTRACK usage are defined for each mission in mission agreements. A mission agreement includes

- Mission-specific user service definitions for optimal, nominal, and degraded modes of operations
- Specification of the planning goals for the mission in terms of standing order (every pass over Kourou, as many passes over Kiruna as possible), capacity required (minimum 8 GB of data per week), etc. associated to user services for optimal, nominal and degraded modes of operations

The essential requirement on the ESTRACK planning are summarised in four points.

- All the planning goals valid for the considered planning range must be implemented for the ESTRACK timeline to be acceptable.
- The internal ESA network must be used up to saturation, in order to maximize the mission returns. This requires that most goals are expressed as a minimum to be achieved, and a maximum that will be of benefit to the mission, provided the capacity is available.
- No global optimisation of the resource allocation is required.
- If no solution can be found which implements all nominal planning goals for all missions, nominal goals are replaced by goals corresponding to degraded modes of operation, which are explicitly enabled by the operator. Degraded modes are allowed in specific circumstances only (LEOP, etc.).

5 EMS in the Mission Planning Cycle

Traditionally, the availability of the ESTRACK Network resources to the mission is provided statically (e.g. Envisat is given all the passes over Kiruna between 06:15 am and 01:15 am the following day), the conflicts between missions being avoided by construction.

The introduction of more dynamics in the allocation of the network resources to the missions opens a new direct interface between a resource provider and the mission, with an additional level of negotiation for the allocation of the resource which may have a significant impact on the overall mission planning cycle.

Furthermore, the individual client missions will be subject to their own planning cycles – whilst the aim of the proposed system is to provide a mechanism that is flexible and adaptable, it may simply not be possible for certain missions to accommodate changes very late in the day. Configurable thresholds will be in place for each defined mission, such that all station planning must be firmed up prior to this time.

6 Conclusion and Future Work

We have introduced here above the concepts needed to automate the planning of ESA's ESTRACK network. The modelling of the activities to be planned relies on a hierarchical definition of mission-specific user services into operational services provided by the network facilities (ground stations).

A prototype of the EMS planning system is currently being developed at ESOC, which will validate the proposed concepts and technical approach, and will be used as a requirement capture tool. On the basis of this analysis, a User Requirements document will be written in spring 2004, and the development of the operational system will follow later in the year.

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