EUROPEAN SPACE AGENCY
DIRECTORATE OF TECHNICAL & OPERATIONAL SUPPORT
MISSION OPERATIONS DEPARTMENT

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FLIGHT OPERATIONS PLAN

Volume 4
Ground Station Operations

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LIST OF CONTENTS

Volume 4
Ground Station Operations

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INTEGRAL
FLIGHT OPERATIONS PLAN

Volume 4
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Book 1
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LIST OF CONTENTS

4 Vol. 4: Ground Station Operations

4.1 Book 1: ESA Ground Stations

The book is replaced by the Network Operations Plan (NOP).

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INTEGRAL
FLIGHT OPERATIONS PLAN

Volume 4
Ground Station Operations

Book 2
DSN Ground Stations

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LIST OF CONTENTS

LIST OF TABLES

4 Vol. 4: Ground Station Operations

4.2 Book 2: DSN Ground Stations

4.2.1 Overview of Planning Process

This chapter defines the planning strategy with the emphasis on the planning I/F with JPL.

4.2.1.1 Nominal Planning

This chapter deals with the nominal planning process.

4.2.1.1.1 Long Term Planning

The Long Term planning is performed 6 months in advance and covers a period of 6 months. The goal of this activity is to provide the required long term planning inputs to the JPL resource planning meeting that is performed twice per year.

Flight Dynamics (FD) are to produce a Long Term Event Plan that identifies the required Goldstone service slots. The rule for the utilisation of Goldstone and Redu is that the utilisation of Redu is maximised considering an overlap period of 40 minutes if possible. This overlap period is used to allow ISOC to allocate the station hand-over windows at convenient times.

FD are to produce a file to the Scheduling Office (SO), which is extracted from the Long Term Plan and identifies the required Goldstone utilisation times.

The SO is to co-ordinate the requests with the SOM. Then the SO is to contact the Project Representative at JPL, who will put the INTEGRAL requests into the system. The I/F between the SO and the JPL Rep will be established via e-mail, telecon or FAX. The WEB I/F exposed by the 26 m NIS will be used at a later stage to input service requests. If necessary an iteration will take place involving the SOM, the SO and the JPL Rep.

In addition, FD is to provide orbit predictions in form of Satellite Planet Kernel (SPK) files and provide them to JPL via the dedicated ESOC-JPL communications I/F. This will be established using the serial line provided by NISN or as an alternative via ISDN. This SPK file is to be used for the long term planning. The SPK file to be used for the operations will be provided shortly before the required services.

4.2.1.1.2 Medium Term Planning

The Medium Term planning is performed about 1 month in advance to the concerned planning period of 30 days covering a period of 30 days (10 revolutions). The output of this planning phase are the Planning Skeleton File (PSF) that is the input to the ISOC planning activities and a refinement of the Goldstone service slots.

FD is to produce the PSF. A set of 10 PSF's covering 10 revolutions is to be provided to ISOC about 1 month in advance to the concerned period of 30 days. The PSF must be in line with the agreements that have been reached with JPL at this stage concerning the availability of

Goldstone. It is assumed that the SO will be kept informed by the JPL Rep about possible conflicts but he can also query the Goldstone schedule using the 26 m NIS I/F. The SO is to keep informed FD about already identified outages and / or conflicts. To produce the PSF it is irrelevant whether the service is provided by a 26 m or 34 m antenna.

FD have an utility, which filters one or more PSFs for the events relevant to a single ground station. A report can be produced, which will be provided via E-mail to the SO. This report will identify the required Goldstone service slots, which might have been changed with respect to the Long Term Plan due to orbit predictions.

The SO is to update the Goldstone planning considering the inputs from FD. The SO is to contact the INTEGRAL Rep at JPL, who is then to update accordingly the Goldstone schedule. This activity is only required if the Goldstone times differ noticeable from the Long Term Planning or if the Goldstone services have to be extended.

At this stage the MOC should know in principle whether the Goldstone service will be provided by a 26 m or a 34 m antenna.

4.2.1.1.3 Short Term Planning

The Short Term planning starts about 2 weeks, i.e. 5 revolutions, in advance.

4.2.1.1.3.1 POS Generation & Processing

ISOC is to produce the Preferred Observation Sequence (POS). ISOC is to provide a set of 5 POS's, i.e. covering 5 revolutions, about 2 weeks in advance to the start of the concerned period. The POS will be routed to the Flight Dynamics System (FDS). The POS identifies the actual station hand-over periods, i.e. implicitly the actual Goldstone service slots. ISOC is to ensure that the hand-over periods are within the identified overlap periods, i.e. only a reduction of Goldstone services is envisaged at this stage. If not, the POS will be rejected.

The relevant information concerning the actual Goldstone service times is to be provided to the SO. The reason is that the times must be the same in all planning products.

The PSF tool mentioned in section 2.2 will be extended to work with POSs or EPOSs such that the SO will be informed about the revised ground station requirements. Since POSs might have to be rejected for various reasons it is foreseen to wait until the various POS checks have been performed before the Goldstone schedule is revised. The POS checks performed by FD when generating the EPOS are sufficient in this context because the checks performed by the FCT using the IMCS concern mainly the instrument commanding but not the support times.
FD will summarise the Goldstone station requirements after having generated the EPOS and provide them to the SO. The implication is that the SO might get input at various times derived from different mission planning products.

The SO is to inform JPL about any updates concerning the Goldstone service times. The 26 m NIS WEB I/F can be used to query the schedule but schedule change requests will be routed via the JPL Rep at this stage. Hence the SO will contact the JPL Rep to coordinate the scheduling as far as needed.

FD are to derive the Enhanced POS (EPOS) from the POS. A set of 5 EPOS's, covering 5 revolutions, is to be provided to the Flight Control Team (FCT) within two working days on reception of the POS from ISOC.

4.2.1.1.3.2 SPK File

FD had to provide already relevant SPK files to JPL in the context of the Long Term planning. Two weeks in advance a refined SPK file is to be provided to JPL. FD will provide the SPK file to the Ground Control Room (GCR). A terminal will be located in the GCR to transfer the SPK file to JPL. This might be a NCTRS W/S. The SPK file will be transferred to the Support Product Processor Assembly (SPPA) at JPL via the dedicated ESOC – JPL communications I/F. The GCR operator will handle manually this transfer.

4.2.1.1.3.3 Operations Timeline

On reception of the EPOS the FCT will process the EPOS's using the planning functions of the INTEGRAL Mission Control System (IMCS). The purpose is to perform the relevant checks of the EPOS to identify potential inconsistencies that may lead to a rejection of the POS.

About one week in advance to the concerned period the FCT will produce the relevant Timeline Summary Files (TSF) covering about one week, i.e. 2 to 3 revolutions, and provide them to ISOC for verification and to ISDC for information.

Potential Problem Area:

If the Goldstone planning has been updated in accordance with the POS, see section 4.2.1.1.3.1, then the Operations Timeline should be in line with the Goldstone planning because both products are in principle derived from the POS. However, no S/W exists that verifies the consistency between the various products. This is to be ensured by following strictly the relevant planning procedure.

4.2.1.1.3.4 Service Instance Configuration File & Command Schedule

The final 7-days Schedule (SDS) of Goldstone will be available on Thursday morning for the following week (starting on Monday). The GCR operator is to download the SDS using the allocated terminal, probably a NCTRS W/S. This SDS is to be provided to the SO to verify whether there are late changes regarding the agreed Goldstone schedule. If not, the Service Instance Configuration File (SICF) is to be generated using the Service Instance Configuration Manager (SICM) tool. The tool will be running on a PC, which is connected to the OPSLAN. The tool will be operated by the GCR operator. It is used to produce three different outputs:

1. SICF files to be provided to JPL covering the complete following week;
   One SICF file is to be generated per Goldstone pass, i.e. one for each line in the SDS that presents an INTEGRAL activity. Hence a set of files is to be produced to cover the complete week.
2. SICF files to be provided to the NCTRS covering the complete following week;
   One SICF file is to be generated per Service Instance. Hence a set of files is to be produced to cover the complete week.
3. One file to be provided to the SOM / Mission Planner for verification;
   The file is to provide an overview of the allocated services in a readable form to allow the SOM / Mission Planner to verify the schedule.

The SOM / Mission Planner is to provide a feedback to the GCR operator. If the schedule has been approved, the GCR operator is to set the Harmonisation Flag in the SICF. Then the GCR operator is to transmit the SICF to the SPPA at JPL via the dedicated ESOC – JPL communications I/F. In addition the SICF files for the NCTRS are to be stored in such a way that they can be made available to the operational NCTRS when required.

After the confirmation of the schedule the SOM will authorise the Command Schedule, which is then to be provided to the SPACON for implementation.

This process is performed each Thursday on a weekly basis.

Potential Problem Area:

The two main operational products, i.e. the SICF and the Command Schedule, are produced by independent entities using different tools. No tool is available that allows to verify the consistency between the products. The consistency is to be ensured by applying the appropriate procedures.

4.2.1.2 Replanning

This chapter deals with the replanning process.

4.2.1.2.1 Change of Goldstone Availability

Two cases have to be distinguished:

- Change of Goldstone availability long term in advance,
- Change of Goldstone availability on short term notice.

4.2.1.2.1.1 Change of Goldstone Availability long term in advance

If the change of the availability of Goldstone is known at least 2 working days in advance to the concerned period then a normal replanning process can be started. FD are to produce a new PSF and provide it to ISOC to trigger the process. Then the nominal planning process is repeated. This activity is only needed if the service times are impacted but not if the 34 m antenna can be used instead of the 26 m antenna.

The SO is to contact JPL to check whether a B/U can be used in case that the prime antenna is not available. If necessary, the SO will involve the S/C Operations Manager (SOM) in the negotiation. If JPL confirms the non-availability of Goldstone the SO is to inform immediately FD via email to trigger the replanning process. This interaction should be finalised within two working days considering the time difference to JPL.

It is important to take into account in the case of replanning that the 34 m antenna has a different constraint regarding the elevation angle than the 26 m antenna. The 34 m antenna only supports operations down to an elevation of 10 degrees while the 26 m antenna supports operations down to an angle of 6 degrees. This is to be considered for the planning because the S/C visibility is different.

4.2.1.2.1.2 Change of Goldstone Availability on short term

If the Goldstone schedule changes on a short term, e.g. the SDS available on the Thursday before the upcoming week shows differences regarding the agreed schedule, it might not be feasible to run again the complete planning process. JPL is to keep the MOC informed about late changes. It is expected that the INTEGRAL Rep at JPL will inform the SOM and the SO via E-mail about late changes.

If there is sufficient time left, a new Operations Timeline will be produced. It is not envisaged to manually edit the EPOS because this would mean that the safety checks embedded in the EPOS generation tool are bypassed. Instead, it is foreseen to manually update the existing POS. Assuming that the POS cannot be regenerated by ISOC, the FCT or FD will edit the

POS and create a new revision of the POS. The revised POS will be processed by the FDS to generate a revised EPOS. Thus, the integrity of the AOCS commanding is ensured.

This editing process is to be performed in such a way that the essential operations, e.g. RWB manoeuvres, are considered. The changes of the POS / ICP should be restricted to:

- The deletion of Science EDs,
- The deletion of MOUTs and MOUTPs,
- The deletion or movement of PREQs,
- The deletion or movement of RWBs.

An alternative approach is that FD generate a new PSF. This PSF is provided to ISOC and ISOC can perform a replanning to generate a new POS / RPOS when possible. In the meantime FD can generate an “intermediate” POS directly from the PSF that only considers the essential Satellite EDs that are necessary for the safety and health of the Satellite, i.e. Science related EDs are not considered. The Safe Perigee Attitude will be considered for the pointing. This “intermediate” POS could be used to produce an EPOS and subsequently a temporary Timeline, which would be used until a new POS / RPOS is provided by ISOC.

Since the first approach minimises the interruption of the science activities because it allows to execute the science activities as planned for the remaining part of the orbit it will be applied if possible. The second approach is considered in contingency cases.

In the case that there is not sufficient time to modify the planning products the non-availability of a station is to be handled on operational level. In this case the SPACON is to interrupt the nominal schedule and to resume the nominal schedule at the next predefined re-entry point, which is marked by the Conditional Configuration Change Flag (CCCF). This may lead to the loss of some science exposures because the corresponding operations will simply be dropped.

Potential Problem Area:

The SPACON is to check that no essential Satellite operation is impacted. If the outage period comprises an essential Satellite operation the SPACON is to inform the SOE on duty. The SOE is to re-plan the essential operations. He might have to run the FD “RECOVER SCHEDULE” tool to introduce a new RWB manoeuvre.

If the outage comprises slews the SPACON is to run the FD tool to determine the necessary slew to reach the target attitude that corresponds to the re-entry point. This slew is to be executed before resuming the nominal schedule.

The SICF defines the envelope for the services. Assuming that the station hand-over times do not require an extension of the agreed Goldstone schedule, the planning files are not to be updated. The actual station hand-over times are to be co-ordinated between the GCR and the Goldstone operators over the voice loop. The hand-over must be finalised within the 5 minutes window allocated in the Operations Timeline.

4.2.1.2.2 Modification of POS

ISOC might revise the planning and create a modified POS or a RPOS. In this case ISOC is to ensure that the station hand-over times do not violate the agreed Goldstone schedule.

Potential Problem Area:

It is to be considered that the availability of Goldstone has changed with respect to the corresponding PSF because the Goldstone schedule will have been adjusted according to the initial POS. The Goldstone services times have been revised according to the station hand-over windows defined in the initial POS. The current approach is that ISOC must not change the times of the hand-over windows with respect to the initial POS when a revised POS or RPOS has been created.

When the modified POS / RPOS is received at MOC the Goldstone schedule must be verified whether it is still valid. If the Goldstone schedule is impacted the POS will be rejected.

It is assumed that the FDS checks automatically the consistency between POS and RPOS regarding the station hand-over times. A warning message will be produced if the hand-over times have changed. Thus the consistency is checked independently of the operator using the FDS.

4.2.1.2.3 Override Sequence Of Events

In case that late changes of the service parameters are required an Override Sequence Of Events (OSOE) is to be produced. This OSOE is to be provided to JPL via the 26 m NIS over the WEB and must be available at JPL at least 20 minutes before the concerned Begin Of Activity (BOA). It is assumed that the OSOE only allows modifying service characteristics including the relative times of activity relevant to an allocated services, e.g. duration of the pre-pass checks. However, it is not possible to modify the times of the services, i.e. the start and end times.

The need for a revision of the SOE might be identified by the GCR or the FCT team. In both cases the teams have to co-ordinate the modification of the SOE. The OSOE will be generated by the GCR operator using the SOE tool installed in the GCR.

4.2.1.3 Real-Time Operations

The real-time operations involve various operators:

- SPACON
- GCR Operator
- Goldstone / JPL Operator.

An important aspect to be considered is that the various operators work with different operational products that have been produced by different tools.
The Goldstone Operator is using the Goldstone schedule. It is currently assumed that the operations are executed in a semi-automatic manner. This means that the operations are manually co-ordinated between the operators.
The GCR Operator is to operate the NCTRS and is to co-ordinate operations with the Goldstone Operator. The input is the SICF that is to be used to operate the NCTRS. It is assumed that this is a manual operation.
The SPACON is using the automatic command schedule. He is to co-ordinate station hand-overs with the GCR Operator.

Assuming that the various operational products are consistent the operations should be straightforward if the proper operational procedures are applied.

However, the situation will become difficult in case of problems regarding the execution of the nominal schedule because a close co-operation between the various operators and systems is required. Deviations concerning the timing of operations may impact the execution of the tight command schedule.
The situation will also become complicated if the various operational products do not match, in particular when the timing is not the same.
These situations have to be solved by a close co-operations of the various operators to resume the nominal schedule and configuration.

4.2.1.4 Summary

The following table provides an overview of the nominal planning process.

Time	Activity	Initiator	Data Product	Remarks
T0 – 6 months	Long Term Planning	MOC FD	Long Term Event Plan	
T0 – 6 months	Goldstone Scheduling Request	MOC SO	NIS Schedule Request	Period of 6 months covered, 6 months in advance
T0 – 6 months	Long Term SPK file	MOC FD	SPK	Period of 12 months TBC
T0 – 1 month	Generation of PSF Provision of PSF to ISOC	MOC FD	Planning Skeleton File	Period of 1 month covered, 1 month in advance
T0 – 1 month	Update of Goldstone Scheduling Request	MOC SO	NIS Schedule Request	
T0 – 2 weeks	Generation of POS Provision of POS to MOC	ISOC	Preferred Observation Sequence	Period of 2 weeks covered, 2 weeks in advance
T0 – 2 weeks	Processing of POS & generation of EPOS	MOC FD	EPOS	Period of 2 weeks covered, 2 weeks in advance
T0 – 2 weeks	Generation of SPK file	MOC FD	SPK	
T0 – 1 week	Generation of Operational Timeline	MOC FCT	Ops Timeline	Period of 1 week covered, 1 week in advance
T0 – 3 days	Download of SDS	MOC GCR	7 days Schedule	Period of 1 week covered, 3 days in advance
T0 – 3 days	Generation of SICF	MOC GCR	Service Instance Configuration File	
T0 – 3 days	Generation of Command Schedule	MOC FCT	Command Schedule	Period of 1 orbit, 1 orbit in advance
T0	Start of the Operations			

Table 1 Planning Process Schedule

In case of replanning the responsibilities for the various products might change with respect to the nominal planning process. The differences are shown in the following table.

Product	Responsible		Remarks
	Nominal Planning	Replanning	
EPOS	FD	FCT	This is needed in case of a RPOS that is to be implemented within 8 hours.
SOE / OSOE	FCT / GCR	GCR	This is needed if the OSOE is to be created outside normal working hours.

Table 2 Responsibles in case of Replaning

4.2.2 MOC – Station Interface Set-Up

This section is replaced by the NOP of JPL that defines the interface set-up.

4.2.3 Interface Procedures

This section is replaced by the NOP of JPL that defines the interactions.