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

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DIRECTORATE OF TECHNICAL & OPERATIONAL SUPPORT
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INTEGRAL
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Mission Anomalies

Book 1
Anomaly Handling Process

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5.1 Book 1: Anomaly Handling Process

5.1.1 Space Segment

5.1.1.1 Anomaly Identification

The MOC is responsible for the Health and Safety of the satellite.

Health Monitoring includes the real-time monitoring of TM parameters that are relevant to the performance of the satellite. It includes also the monitoring of parameter trends, i.e. long term behaviour of parameters to identify the degradation of satellite subsystems.

Safety Monitoring includes the real-time monitoring of TM parameters that indicate the functional status of the satellite. This includes the limit checking of parameters.

The MOC only processes the satellite HK parameters that are downlinked in VC0. Instrument malfunctions that can be identified from an analysis of the science TM data that are downlinked in VC7 have to be detected by ISDC.
Since the MOC is in charge to handle all anomalies that require a ground intervention within less than 24 hours it is assumed that the appropriate information can be derived solely from the HK parameters.

The MOC performs two types of parameter monitoring:

- The first type concerns the automatic monitoring by the IMCS. The database contains the limits relevant to the parameters that are checked by the IMCS. The IMCS generates a warning when soft limits are violated by marking in yellow the parameter values on the display. When the hard limits are violated the parameter values are marked in red and an audible alarm is generated, which is to be acknowledged by the SPACON on shift.
  The violation of a hard limit or the generation of an Anomaly On Event Message triggers the SPACON to execute the corresponding contingency procedure.

  In addition, the IMCS supports the status and consistency checks of parameters. This ensures that the on-board configuration corresponds to the satellite mode and it is possible to identify modifications of the on-board configuration that are not due to telecommanding.

- The second type concerns the manual monitoring by the SPACON on shift. The SPACON regularly monitors essential parameters, e.g. by looking at plots of parameters over the time. This will indicate a non-nominal behaviour of the Satellite.

5.1.1.2 Decision Process and Reporting

As soon as the SPACON identifies an anomaly he applies the appropriate contingency procedure as defined in the FOP and notes the anomaly in the Shift Logbook.

If the anomaly can be solved by applying the procedure and if there are no further impacts on the satellite functions he simply informs the next SPACON on shift or the S/C Analyst if the

anomaly occurred during normal working hours. In addition the SOM or his nominated representative is to be informed.

Each morning of normal working days a S/C Analyst will check the Shift Logbook and will inform the SOM, who decides on the further process.

If the anomaly cannot be solved by the SPACON on shift or if there are impacts on the satellite functions he informs the SOE on duty or the SOM as indicated in the procedure. The SOE on duty or the SOM will decide on the further process. He will assess the nature of the anomaly and identify the necessary steps to be taken to analyse and resolve the problem. He will decide whether additional personnel are to be involved. This may involve MOC personnel but also external personnel if required.

In case of instrument related anomalies the situation is slightly different. The MOC will inform the SGS of all violations of limits of instrument related parameters through the Observation Log that is provided to ISDC on an hourly basis. In addition, the MOC will inform ISOC and ISDC about all anomalies that impact the instrument / service operations through an Anomaly Notification.

The SOM or his nominated representative is also to inform the higher management, i.e. Head of TOS-OF and the PS, of anomalies that impact the mission.

5.1.1.3 Anomaly Recovery and Offline Processing

The first step after detecting an anomaly is to identify the type of the anomaly and the appropriate Contingency Recovery Procedure (CRP). If it is possible to identify the anomaly the corresponding CRP will be followed. If it is not possible to identify the anomaly the satellite is to be put into a predefined safe state.

The SPACON on shift is only entitled to execute predefined CRPs. He might be authorized to resolve simple contingencies, e.g. switch on a heater if a temperature gets out of range. However, in case of more complex contingencies he is to inform the SOM or SOE on duty and to wait for their advice.

The next step is to ensure that the satellite is in a safe state. If there is no clear CRP identified, the satellite will be put into a Safe Mode and the nominal Timeline will be interrupted. However, if there is a predefined CRP available a configuration will be established, which isolates the failure and allows to resume the nominal Timeline as soon as possible.

The recovery of the Timeline depends on the time when the interruption occurred and its duration. The SPACON is to decide when the Timeline can be resumed. He is to select the appropriate re-entry point.

While the recovery actions are ongoing an offline analysis of the HK data will be performed in order to compile a proper Anomaly Report. The FCT will utilize the Performance Analysis System (PAS) to perform the analysis. The PAS offers some functions to further process the TM data, e.g. to generate diagrams.

The MOC will keep ISOC and ISDC informed about the progress of the analysis and will notify them when the nominal status has been reestablished.

5.1.1.4 Post Anomaly Activities

In some cases it might be necessary to perform a more detailed analysis of the data in order to identify the cause of the anomaly and to decide on the further progress. The MOC will trigger this process.

In case of problems related to the S/C the MOC might contact the S/C manufacturer to get some support. In this case the SOM will coordinate the relevant activities with the manufacturer and the FCT will implement the agreed recovery steps.

In case of anomalies related to the instruments the MOC will only contact the instrument teams directly if the situation is critical and recovery steps are to be implemented quickly. Otherwise, the MOC will put the concerned instrument into a safe state and will continue with the operations of the instruments that are not affected. The MOC will inform ISOC and ISDC. ISDC is then to coordinate the support to be provided by the instrument teams.

The MOC will support the SGS and the instrument teams in the analysis of the anomaly and in the determination of the relevant follow-on operations. As soon as the analysis is finalized the MOC and the SGS will agree on the steps to be taken to reestablish a nominal configuration and on upgrades of the system if required.

5.1.2 Ground Segment

5.1.2.1 Introduction

This chapter deals with the handling of anomalies related to the OGS and the communications between MOC and SGS. Anomalies concerning the SGS are dealt with internally by the SGS.

The procedures to be applied in case of a ground segment related anomaly depend on the equipment, which is concerned, and on the criticality of the anomaly. The most critical anomalies concern the functions that are needed for the real-time operations, i.e. control of the satellite. The prime objective of the recovery actions is to reestablish as soon as possible the control of the satellite. The way to achieve this depends on the failed equipment, e.g. whether redundancy is available.

One problem in this context is that the various ground segment elements have to provide sufficient information to enable the operator to detect a malfunction. This is not always straightforward because not all elements perform a regular health check or are continuously used. Therefore, it might be possible that a malfunction is only detected when the impacted function is utilized.

5.1.2.2 Failure Isolation and Recovery

5.1.2.2.1 MOC

The MOC comprises basically the following elements:

- IMCS
- FDS
- PAS
- Mission Planning
- NCTRS
- OBSMS
- Simulator.

As mentioned above, the critical elements are those needed for the real-time operations, which are the IMCS, real-time functions of the FDS and the NCTRS. The IMCS and the real-time functions of the IMCS are operated from the Dedicated Control Area (DCA) by the SPACON on shift. The NCTRS is operated normally from the Ground Control Room (GCR) by the GCR operator on shift. The SPACON has the capability to monitor the set-up in the DCA..

If the satellite control is impacted the relevant operator is to reestablish the control as soon as possible, e.g. by switching to the redundant equipment or by reinitializing the prime equipment, e.g.:

- If the Out Of Limit (OOL) Display of the IMCS stopped it might be sufficient to reinitialize the relevant task of the IMCS.
- If the prime IMCS chain failed completely for an unknown reason it might be necessary to switch to the redundant chain.

The operator is to decide which recovery action is more appropriate. Depending on the skills of the operator the recovery might take only a few seconds. The minimum goal is to reestablish the real-time control within a few minutes.
In case of more severe problems, e.g. in case of broken H/W, the operator can call for special support from the ESOC support team.

If the problem concerns an offline function the problem is to be dealt with by the day time staff, e.g. the S/C Analyst. He is to coordinate the required support. The goal is to reestablish the failed function within a few hours.

If the problem occurs on a week-end the operator on shift is to decide whether the failed function is needed or not. If yes, he is to call for the necessary support.

5.1.2.2.2 Communications

Since it is important that the various elements of the ground segment can communicate with each other a proper monitoring of the links is to be performed. Though it might be the SPACON on shift in the DCA who detects the malfunction it is the task of the GCR operator to reestablish the proper communications.
The GCR operator is to decide how the communications can be reestablished as soon as possible. If necessary, he is to coordinate relevant support, e.g. by providers of the communication services.

5.1.2.2.3 Stations

The anomaly handling regarding the stations depends highly on the concerned station. If an ESA station, e.g. Redu, failed it is the task of the GCR operator to reestablish the services. This can be done either by using the remote control functions of the Station Computer (STC) or if the failure cannot be cured using the STC he is to call up the maintenance services of the station. In the first case it might be possible to solve the problem within a few minutes. In the second case the recovery might take a few hours, in particular when the maintenance service is required outside normal working hours.

If the problem cannot be solved within a few hours or if the satellite is in a critical state the SOM is to be informed. If necessary, he is to declare an emergency to get the support of another station, e.g. Villafranca, which is the B/U for Redu.

The situation is different if the anomaly concerns Goldstone. In this case the GCR operator is to contact the operator at Goldstone. The responsibility for the recovery is solely with JPL.
If the services cannot be reestablished from the 26 m antenna and if the satellite is in a critical state the SOM is to be contacted. If necessary, he will declare an emergency to get the support from another station or antenna. In this case JPL might be contacted in order to get the support from the B/U antenna (34 m).

5.1.2.3 Ground Segment Upgrade

In case of a permanent malfunction, e.g. if an equipment is broken, it might be necessary to upgrade the ground segment by replacing the failed equipment. If this can be achieved using the available resources, e.g. spare parts, the SOM will coordinate the upgrade with the relevant Technical Officer. If additional resources are required the SOM will contact the Head of TOS-OF and the Project Scientist if necessary.

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5.2 Book 2: Anomaly Handling Procedures

5.2.1 Introduction

This book provides the high level procedures that the operations team has to apply in case of anomalies. They should be used as a guideline.

The procedure to be applied depends mainly on the concerned subsystem and on the severity of the problem. While major anomalies require the presence of the SOM or the SOE on call for the recovery, less significant anomalies can be handled by the operations personnel on shift. In order to identify the category the operations team will be provided with a list of potential failure cases and with a set of Contingency Recovery Procedures (CRP). In case of doubts the next higher failure category is to be applied.

The ground procedures will identify the steps the operations personnel on shift are to apply. They will identify the operations, which can be performed by the personnel on shift and which require the presence of the on call Engineers.

5.2.2 Satellite Anomalies

5.2.2.1 Introduction

This section defines the ground procedures that the operations personnel are to follow. The actual flight procedures are defined in the volumes 8 and 9 of the FOP.

The basic categories of Anomalies are:

Major

These anomalies endanger the safety of the satellite. One example is the ESAM. In case of such an anomaly the SOM or the nominated deputy and the SOE on Call are to be informed.

Medium

These anomalies do not endanger the safety of the Satellite but might impact the execution of the planned satellite operations. In case of such an anomaly the SOE on call is to be informed.

Minor

These anomalies do not endanger the safety of the Satellite and do not impact the execution of the Timeline. One example is a temperature that is out of limits. In case of such an anomaly the SPACON on shift is to apply the relevant CRP. In case of doubts he is to inform the SOE on call.

5.2.2.2 Satellite Anomaly Handling Procedure

The Satellite Anomaly Handling Procedure (S_01_SATANO) is to be applied to identify and to handle anomalies concerning the Satellite. It includes basically the following steps:

- Routine monitoring of Satellite HK data;
- Identification of an anomalous situation;
- Identification of problem severity;
- Identification of process to handle the anomaly;
- Apply relevant contingency procedure.

Step	Time	Actionee	Description
1		SPACON	Monitor Satellite Telemetry
1.1		SPACON	Monitor Routine System Display Note: This is a display that contains the main TM parameters that are needed to follow the execution of the routine satellite operations.
1.2		SPACON	Monitor the Out Of Limit Display
1.3		SPACON	Monitor the Event Logger
2		SPACON	Identification of a Non-nominal Satellite status
2.1		SPACON	Identification of a parameter OOL Note: This concerns Soft and Hard Limits. The difference is that Soft Limits can mostly be handled by the SPACON on shift while Hard Limits often require to inform the SOE on call.
2.2		SPACON	Identification of non-expected On Event Messages Note: The Event Logger is to be verified to identify whether the Satellite generated a message that is not expected.
2.3		SPACON	Log anomalous condition in the Log Book
3		SPACON	Identification of Problem Severity
3.1		SPACON	Verify the Anomaly List Note: This the list that provides an overview about possible satellite anomalies and the associated severity. In addition it identifies the corresponding CRP.
3.2		SPACON	Verify the CRP's If a CRP is available it will identify the further steps to be performed.
4		SPACON	Identification of further Process
4.1		SPACON	If the anomaly is covered by the anomaly list and a CRP is available continue with step 5.
4.2		SPACON	If the anomaly is not covered by the anomaly list or a CRP call SOE on call. Continue the nominal operations (Timeline) if not instructed differently by the SOE on call. Monitor the Satellite status in particular the subsystem indicating the anomalous condition. Wait for SOE.
5		SPACON	Execute instructions defined in the CRP
5.1		SPACON	If defined in the CRP inform the SOE on call or the SOM. Note: In case of a problem that concerns the instrument operations ISDOC and ISDC are to be informed.
5.2		SPACON	Execute CRP as far as allowed
5.3		SPACON	Finalise CRP or hand-over to SOE

6		SOE	Completion of Process
6.1		SOE	Completion of CRP as far as required
6.2		SOE	When Satellite is in a safe state produce Anomaly Notification and distribute as required. The anomaly notification should be distributed within 1 hour after occurrence if possible. Note: ISDC and ISOC are to be provided with the Anomaly Notification in case of a problem related to the instruments.
6.3		SOE	Put Satellite back into nominal status and resume routine operations.
6.4		SOE	Produce Anomaly Report.

Table 1 GP S_01_SATANO

5.2.3 Ground Segment Anomalies

This section identifies the procedures that the operations personnel are to follow in case of problems related to functions of the ground segment. The following elements of the ground segment are addressed:

- IMCS,
- NCTRS,
- FDS,
- Communications,
- H/W,
- Stations,
- I/F to SGS.

The principle of the procedures is to recover the ground segment functionality as soon as possible. This means that if the failure is not immediately identified and a re-initialisation of the prime equipment / function is not possible a switch-over to the redundant equipment / function is to be performed. A detailed failure analysis is to be performed after the re-establishment of the system services.

5.2.3.1 IMCS

This section only provides some guidelines on how to handle malfunctions of the IMCS. The detailed procedures to operate the IMCS are provided in Vol. 2 Book 4 of the FOP and in the IMCS Users Manual.

This section addresses the Routine Mission Phase when only the SPACON is operating the system. In addition the redundant IMCS chain is configured in cold stand-by during this phase.

Step	Time	Actionee	Description
1		SPACON	System Monitoring The SPACON is to monitor regularly the system functions to verify that all tasks are working.
2		SPACON	Identification of a malfunction.
2.1		SPACON	If the cause of the malfunction can be identified try to solve the problem
2.2		SPACON	If the cause of the malfunction cannot be identified try to re-initialise the prime chain
3		SPACON	Correction of the malfunction
3.1		SPACON	If only a task has failed try to restart the task using the Task Launcher.
3.2		SPACON	If the task cannot be re-initialised try to run the task from a different client W/S
3.3		SPACON	If the task cannot be re-initialised try to re-initialise the prime IMCS chain
4		SPACON	Check correct functioning of IMCS
4.1		SPACON	If IMCS does not work properly initialise redundant chain
4.2		SPACON	If the system function cannot be re-established call S/W or OSC Support and inform SOE on-call
5		SPACON	Failure Reporting
5.1		SPACON	Log the problem in the Logbook
5.2		SPACON	If problem not fully understood or if there was a real system failure produce Anomaly Report
5.3		SPACON	Inform S/W Support and S/C Analyst or SOE on call
6		S/W Support	Analyse IMCS malfunction and produce a S/W upgrade or a workaround solution is necessary

Table 2 GP G_02_IMCANO

5.2.3.2 NCTRS

This section only provides some guidelines on how to handle malfunctions of the NCTRS. The detailed procedures to operate the NCTRS are provided in Vol. 2 Book 4 of the FOP and in the relevant NCTRS Users Manual.

Step	Time	Actionee	Description
1		GCR OPERATOR	System Monitoring The GCR OPERATOR is to monitor regularly the system functions to verify that all tasks are working.
2		GCR OPERATOR	Identification of a malfunction.
2.1		GCR OPERATOR	If the cause of the malfunction can be identified try to solve the problem
2.2		GCR OPERATOR	If the cause of the malfunction cannot be identified try to re-initialise the prime NCTRS
3		GCR OPERATOR	Correction of the malfunction
3.1		GCR OPERATOR	Try to re-initialise the prime NCTRS
4		GCR OPERATOR	Check correct functioning of NCTRS
4.1		GCR OPERATOR	If NCTRS does not work properly initialise redundant NCTRS The links shall remain to the prime IMCS chain.
4.2		GCR OPERATOR	If the system function cannot be re-established call S/W Support and inform SOE on-call
5		GCR OPERATOR	Failure Reporting
5.1		GCR OPERATOR	Log the problem in the Logbook
5.2		GCR OPERATOR	If problem not fully understood or if there was a real system failure produce Anomaly Report
5.3		GCR OPERATOR	Inform S/W Support and FCT
6		S/W Support	Analyse NCTRS malfunction and produce a S/W upgrade or a workaround solution is necessary

Table 3 GP G_03_NCTANO

5.2.3.3 FDS

This section is replaced by the FD Users Manual.

5.2.3.4 Communications

The communications comprise

- MOC Internal Communications
- MOC – Stations I/F
- MOC – SGS I/F.

The identification of a communications problem might be noted by the SPACON, e.g. interruption of the TM flow, or by the GCR operator. The basic operations rule is to reactivate the failed communications line. If the communications cannot be re-established the redundant line will be activated.

The operations are to be performed by the GCR operator using the standard GCR procedures.

The following table provides an overview of the prime and redundant communication lines.

I/F	Prime Connection	Redundant Connection	Remarks
MOC Internal	OPSNET	OPSNET	
MOC – REDU		ISDN	
MOC - Goldstone	NISN	ISDN	Prime connection provided by JPL
MOC – ISOC	ESACOM	ISDN	
MOC - ISDC	Frame Relay	ISDN	

Table 4 Communication Connection

5.2.3.5 H/W

This section concerns malfunctions of the H/W in the INTEGRAL DCA, i.e. terminals, printers, keyboards, etc.. The basic rule is to use the redundant equipment and to inform the maintenance to get the failed equipment repaired or replaced.

Step	Time	Actionee	Description
1		SPACON	Identification of failed equipment
2		SPACON	Failure Recovery
2.1		SPACON	W/S Failure • Use different W/S • Inform Maintenance In case of a loss of a W/S inform the SOE on call.
2.2		SPACON	Display Failure • Continue operations with 2 remaining displays • Inform Maintenance
2.3		SPACON	Keyboard / Mouse Failure • Continue operations from different W/S • Inform Maintenance
2.4		SPACON	Printer Failure • Try to restart printer • If restart not possible use redundant printer (local or network printer) • Inform Maintenance if problem persists

Table 5 GP G_04_HWDREC

5.2.3.6 Stations

This section is replaced by the ESA and JPL NOPs.

5.2.3.7 I/F to SGS

The SPACON and the ISDC Shift Operator will monitor the communications. In case of a link failure the ISDC operator is to re-establish the link because the ISDC is acting as a client. If the link cannot be re-established the SPACON and the ISDC operator are to coordinate the activities. If necessary, the SPACON can call up additional support.

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5.3 Book 3: Local Command & Telemetry Facility

5.3.1 Introduction

The INTEGRAL OGS is designed considering that the Space Segment can survive at least 36 hours without ground control. Most of the possible ground failures are handled by local redundancy, e.g. redundant IMCS chain. The only exception is a major failure at ESOC, which causes a complete outage of the MOC. In order to cope with such an anomalous situation a Local Command & Telemetry Facility (LVTF) is set-up at the Redu ground station.

The LCTF is to resume the necessary satellite control within 36 hours. The LCTF supports:

- The monitoring of all HK TM data;
- The commanding of all satellite subsystems;
- The attitude monitoring and control.

The above functions are needed to ensure the safety and health of the Satellite. The LCTF is not set-up to support science operations.

Since the requirement is to activate the LCTF within 36 hours the LCTF is not permanently manned and operational. Since the LCTF is only needed when the MOC is not operable it is foreseen to transfer the necessary operations personnel from MOC to Redu when required. The 36 hours activation time include:

- The transfer of the operations personnel from ESOC to Redu;
- The power on and switch-on of the LCTF;
- The set-up of the connectivity;
- The preparation of the relevant telecommands.

The station maintenance team at Redu is only available to perform regular checks of the function of the LCTF and to configure the LCTF if required. This team will not operate the Satellite.

5.3.2 LCTF Configuration

As mentioned before the LCTF is to support the functions that are needed to ensure the safety and health of the Satellite. The necessary infrastructure such as accommodation, power supply and network connectivity is provided by the Redu station. The LCTF itself consists of

- A NCTRS, which provides the I/F to the TM data and allows to transfer telecommands;
- A reduced IMCS chain, that provides the necessary monitoring and command functions;
- A reduced FDS, that provides the functions to monitor and control the attitude and supports orbit determination.

Though it is envisaged that only the Redu station is used to receive TM data and transmit TC's the Redu ground station provides also connectivity to other ESA stations such as Villafranca if this is required. The LCTF cannot be operated using the Goldstone station.

5.3.3 LCTF Maintenance

The LCTF is designed as a stand-alone system. The system is normally kept in cold stand-by. It will be operated only when needed. However, in order to keep the system in an operable state some maintenance is required. This includes:

- The regular activation at least once per year to ensure the operability of the system;
- The implementation of necessary upgrades, mainly concerning S/W (IMCS and FDS) and databases.

Since the LCTF is only to support the basic monitoring and control functions not all updates that are implemented at the MOC will be considered for the LCTF. For example, updates of the planning function or of ED's in the ODB will not be implemented.

It is foreseen to perform the necessary upgrade of the S/W by remote access from ESOC as far as this is possible. It is envisaged that the required switch-on of the system that is needed for the maintenance will be done by trained personnel of the Redu station.

The LCTF will be activated regularly (typically every few months) to verify the operability. This will be done as far as possible using the maintenance team at Redu and the remote access to the LCTF. Only in exceptional cases personnel from the FCT and FD team at ESOC will be transferred to Redu.

5.3.4 LCTF Activation & Deactivation

It is foreseen to train also personnel of the Redu station so that they are able to activate the LCTF when needed. However, if personnel from ESOC will be transferred to Redu then they will activate the system.

When the LCTF is not further needed the LCTF will be deactivated and put back into a cold stand-by state.

The LCTF activation comprises:

- The powering of the system;
- The switch-on of the system incl. The S/W activation;
- The establishment of the connectivity to the network.

5.3.5 LCTF Operation

The LCTF will be operated only in case of a major disaster at ESOC, which causes a complete outage of the MOC functions for a longer period. Since the MOC comprises a lot of redundancy this situation is expected only in case of major anomalies such as a fire.

Note:

Since the concept is based on the assumption that the LCTF is manned by ESOC personnel its availability cannot always be guaranteed. For example: It might be possible that personnel cannot be transferred in case of a catastrophe.

If an anomaly occurs at MOC the SOM or his nominated deputy is to decide whether the LCTF is to be manned or not. Depending on the situation the SOM will decide who is to man the LCTF. The LCTF team will normally consist of a SOE, a S/C Analyst or a SPACON and a member of the FD team.

The basic rules for manning the LCTF are as follows:

1. If there is some doubt concerning the safety of the Satellite and if it is not clear when the MOC can resume the operations the LCTF team will be sent immediately to Redu.
2. If the Satellite is in a safe state and if it is expected that the basic MOC functions can be re-established within 12 hours the LCTF will not be manned.
3. If the MOC cannot be re-activated within 12 hours after the occurrence of the anomaly the LCTF team will be sent to Redu.

As soon as the LCTF Team arrives at Redu it will activate the system. Though the LCTF is dedicated to INTEGRAL it might be possible that other resources, e.g. communications, are to be shared with other users. The LCTF Team is to co-ordinate the utilisation of these resources with other users.

If the MOC cannot be re-activated in time the satellite control will be taken over by the LCTF Team at Redu. The SOM is to decide whether further personnel is to be transferred to Redu to ensure the proper continuation of the operations from Redu.

The first operation to be performed by the LCTF Team is to verify whether the Satellite is in a safe state. This includes the monitoring of the TM data to identify parameters that are out of limits and the verification of the attitude to identify for how long the current attitude can remain without violating constraints.

The next step is to switch-off all on-board systems that are not needed. This concerns mainly the Payload because science operations are not supported from the LCTF. The satellite configuration to be established is:

- ACC in IPS;
- CDMU in Ops Mode;
- EPS in sun pointing condition;
- Instruments in Stand-by with DPE's on but peripherals switched off.

The above operation will be done using a predefined set of flight procedures.

Then the proper attitude control is to be established. It is to be verified whether the wheel speeds are in a safe region. If necessary a RWB manoeuvre is to be performed to avoid that an AMD is triggered. In case of time problems default safe wheel speeds are to be commanded. This is to be performed using a predefined flight procedure. If sufficient time is available a proper wheel profile will be determined and a RWB manoeuvre will be executed to establish the required wheel speeds.

In parallel, the attitude is to be assessed. If necessary a slew is to be performed that puts the Satellite into a an attitude that is safe for at least 24 hours. This is performed using the FDS. The FDS is to provide the relevant slew parameters to the IMCS.

The situation will be more difficult during an Eclipse Season because then the ACC Eclipse Timers and the Broadcast Packet have to be set regarding the upcoming Eclipse. The relevant inputs are to be determined using the FDS.

When the Satellite is in a safe state the LCTF Team is to perform the routine monitoring & control operations of the Satellite. It is planned to control the Satellite for a minimum of 6 hours within 24 hours. Depending on the manning of the LCTF Team this time can be extended. However, it is foreseen to limit the utilisation of ground stations and to maximise the use of the Redu passes.

The LCTF is to be used only when necessary. This means that as soon as the MOC is back it will resume the control of the Satellite. When the MOC has taken over the control the LCTF will be deactivated and put into a cold stand-by. When this is done the LCTF Team will return to ESOC.

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DATE	ISSUE / REV. NO.	PAGE / PARA AFFECTED	DESCRIPTION	APPROVAL AUTHORITY
13/08/01	Draft / 0	All		
21/12/01	1 / 0	All	Version for Review & Approval	
28/02/02	1 / 1	1	Safe attitude selection modified	
21/02/03	2 / 0	All	General clean-up post Launch	SOM *M. Schmidt*

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5.4.1 High Radiation Environment

This chapter defines the operations to be executed in case that the Satellite is exposed to a high radiation environment. The operations to be selected depend on the situation.

High Radiation outside Eclipse Seasons

If there is a radiation warning outside the Eclipse season the Flight Control Team (FCT) is to be alerted. No special protection measure is to be taken. This is independent on the predicted radiation strength because the Satellite automatisms should be sufficient to keep the Satellite in a safe state.

If the Satellite functions are disturbed by high radiation the FCT is to stop the execution of the nominal schedule. The instruments are to be put into a safe state and a slew to an attitude allowing to select a guide star with a magnitude of at least 3 is to be executed. If no special attitude has been defined the Safe Perigee Attitude is to be used. ISOC and ISDC are to be informed about the situation. The Satellite will remain in this condition until the radiation environment has decreased to a non critical level.
The decision concerning this process is with the SOM or the SOE on duty.

High radiation inside the Eclipse Season

If there is a radiation warning within the Eclipse Season the PS and ISOC / ISDC will be informed immediately. If possible ISOC is to perform some replanning considering an attitude that allows tracking a star with a magnitude of at least 3. If such an attitude cannot be selected by ISOC, Flight Dynamics will select a safe attitude. This could be an attitude that allows tracking a star of sufficient magnitude or could be the Safe Perigee Passage Attitude.

If there is a radiation warning and no special attitude has been selected and the time to the next Eclipse is less than 36 hours the nominal schedule is to be interrupted. A slew to the predicted Safe Perigee Attitude is to be implemented. If there are no different orders from ISOC the instruments are to be put into a safe state.
This operation requires the approval of the SOM or the SOE on duty.

If the Satellite encounters disturbances due to high radiation and if the time to the next Eclipse is less than 36 hours an attempt is to be made to select a Star with a magnitude of at least 3. If no special attitude has been defined the Safe Perigee Attitude is to be used. Before implementing the relevant slew the nominal schedule is to be aborted and ISOC and ISDC are to be informed.
This operation requires the approval of the SOM or the SOE on duty.

If the Satellite encounters disturbances due to the high radiation and the time remaining to the next Eclipse is greater than 36 hours the SOE on duty is to be informed. In this case ISOC is to be informed as soon as possible and a replanning using an attitude with a Guide Star of at least 3 should be considered. If it is not possible to implement this new plan at least 36 hours before the next Eclipse as slew to the Safe Perigee Attitude is to be performed.

The slew to the Safe Perigee Attitude may require several steps depending on the required slew size. The first slew is to perform an Open Loop Slew to the Safe Perigee Attitude. Due to possible slew inaccuracies it might be necessary to implement an additional Closed loop Slew that allows to get close enough to the target attitude to select a proper Guide Star with a magnitude of at least 3. If this Guide Star has not been selected a third step might be required to select the Guide Star by implementing a Search / Track operation.

The FCT will involve the Flight Dynamics Engineer on call to perform the relevant FD related operations.

End of High Radiation

The Satellite will remain in the Safe Attitude using the selected Guide Star as long as the Satellite functions are impacted by the high radiation. The decision to resume the nominal schedule is to be taken by the SOM or the SOE on duty.