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# Spacecraft Emergency Cross Support (SECS) Standard Operating Processes and Procedures


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## 1. INTRODUCTION

### 1.1 Purpose

The Spacecraft Emergency Cross Support (SECS) Working Group (SECSWG) was established under Interagency Operations Advisory Group (IOAG). Its primary objective was to identify strategies that allow for both user missions (also known as Service Users) and Service Providers to streamline their responses during a spacecraft emergency. These strategies include:


- Defining standard Service User-Service Provider operational interfaces, including a standard spacecraft specification template that allows the Service Users to specify its requirements (see Appendix C);
- Formalizing the Service Provider’s Point-Of-Contact (PoC) for coordinating emergency support (see Section 3.1);
- Defining common terminology at the process and procedure levels and associated information parameters and data items; and
- Collecting high-level information about the Service Providers, including the following:
  - High-level characteristics about Radio Frequency (RF) assets available to provide SECS communications (see Appendix A);
  - Guidance on accessing a Service Provider asset registry.<sup>1</sup>

This Standard Operating Process and Procedure (SOP) describes the services used during emergencies and preparation tactics for both Service User and Service Providers to enable timely cross support services for spacecraft emergencies.

### 1.2 Scope

This SOP applies to IOAG member agencies for SECS purposes, although the use cases may potentially apply to non-IOAG agencies in the future. This SOP defines the operational interfaces between the SECS Service User and Service Provider during emergency conditions specified in Section 1.3. It describes the services used during emergencies, such as engineering services and standard housekeeping services (i.e. telemetry (TM), telecommand (TC) and radiometric services). While the general processes outlined in this SOP could apply to most emergency cases, this SOP is intended for Service Users whom are compliant with applicable Consultative Committee for Space Data Systems (CCSDS) core standards specified in the IOAG Service Catalog #1. Non-CCSDS compliant Service Users may be limited to engineering services, if available.

<sup>1</sup> Establishing the Service Provider asset registry task is considered forward work and will be included in future revisions of this SOP.

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All data transfer between a MOCC and Service Provider’s ground station will only be supported by CCSDS Space Link Extension (SLE) services. SLE services were specifically developed to facilitate Inter Agency Cross Support. The supported services include:

- Return Session:
  - Return All Frames (RAF)
  - Return Channel Frames (RCF)
- Forward Session:
  - Command Link Transmission Unit (CLTU)

Additional services, depending on the complexity of the mission, include:

- Return Operational Control Field(ROCF)
- Forward Space Packet (FSP)

For the SECS services, the Service Provider is not liable for any consequential damages resulting from its actions, if requested to provide emergency support. In turn, the providing agency does not have to guarantee the availability and readiness of its tracking facilities for the support.

### 1.2.1 **Engineering Services**


Ground stations may provide engineering services for downlinks and uplinks. The ground station executes these services locally, as described in Sections 2.2 and 2.3. These services do not include exchanging data between the ground station and the Service User’s control center. In the event of an extreme spacecraft emergency, the Service User may request the implementation of exceptional uplink acquisition techniques as described in Section 2.3, Uplink Engineering Services. However, these techniques may not be available at every ground station due to local RF licensing policies and required infrastructure. Service Providers perform these non-nominal techniques on a best-effort basis.

### 1.2.2 **Standard Services**

Standard services are available for downlinks and uplinks and include sending data to the Service User’s control center. The provision of downlink services is considered to be global, i.e. any ground station with the required performance specifications can support spacecraft emergency recovery operations. Currently, some geographical limitations exist in the provision of uplink services, i.e. numerous national agencies prohibit radiating over frequencies without an existing uplink RF license. Table A-1, SECS Assets, indicates which ground stations can support uplink services for Non-Registered spacecraft emergency recovery operations.

### 1.2.3 **Service Limitations**

1. SECS Services are not available to:

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- a. Service Users from non-IOAG member agencies
  - b. Non-CCSDS compliant Service Users (for standard online uplink and downlink services)
2. Standard TC (uplink) services are not available to Service Users planning to use:
    - a. Ground stations without appropriate RF license (uplink)
  3. Standard TC (uplink) services are only available to Service Users using:
    - a. Satellites with appropriate International Telecommunications Union (ITU) filing, granting ground station RF license. The filing also includes a permit for the spacecraft to radiate over a ground station region (downlink)
  4. Online support is not immediately available for Service Users with:
    - a. No ground (direct or bent pipe) communication lines between Service User control center and Service Provider, or
    - b. No Space Link Extension (SLE) services available

### 1.3 Assumptions

- The context of emergency cross support is as follows:
  - Spacecraft emergency mode is the anomalous state of the spacecraft in which its persistence will result in the loss of the spacecraft entirely or the loss of any of the spacecraft’s essential faculties (payload excluded).
  - For human space flight missions, any external or internal conditions that could negatively affect the health and safety of the crewmembers are causes for spacecraft emergency mode.<sup>2</sup>
  - Any ground station failure by itself is not a direct cause for declaring the spacecraft in emergency mode.
  - SECS is only related to establishing a Telemetry, Tracking and Command (TT&C) link to the spacecraft for recovery operations as well as engineering services. It does not apply to science or mission data acquisition.
- This SOP only applies to spacecraft emergencies during which the planned primary and backup service providers are unavailable or incapable of providing recovery operations.
- The IOAG recommends that Service Users follow the approach recommended in this procedure to maximize emergency support.

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<sup>2</sup> This SOP is intended for robotic Service Users, only; however, the processes described in this SOP may be applied to human space flight missions in the future.

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- The SOP is developed based on the current processes and procedures of the agencies in the participating working group.
- Agencies will follow the previously-approved IOAG priority list for emergencies:
  - Priority 1: Emergency with astronauts affected.
  - Priority 2: Emergency during critical phases such as LEOP after the separation from the launch vehicle or the disposal phases.<sup>3</sup>
  - Priority 3: Spacecraft emergency for missions with bi-lateral agreement.
  - Priority 4: Spacecraft emergency for missions with no bi-lateral agreements.
- Service User uses CCSDS Orbit Data Message (ODM) format or Two-Line Element (TLE) as described in ODM standard to exchange on-orbit and visibility predictions.
- Service User will follow the established emergency procedures of the Service Provider. This SOP only describes the procedures that the Service User should follow to obtain emergency support from a Service Provider.
- For the SECS services, the Service Provider shall not be held liable for any consequential damages resulting from its actions. That also means any providing agency does not have to guarantee the availability and readiness of its tracking facilities for the support.
- ITU Radio Regulations Paragraph 4.9 states the following:
  - *No provision of these Regulations prevents the use by a station in distress, or by a station providing assistance to it, of any means of radiocommunication at its disposal to attract attention, make known the condition and location of the station in distress, and obtain or provide assistance*


Under this clause, no ITU regulation prohibits a ground station from providing support to a spacecraft in distress, even if the ground station does not have an RF license to radiate on that specific frequency. Domestic regulations regarding emergency support generally reflect the ITU regulations; however, certain countries may be subject to additional domestic regulations (i.e. require an RF license even for emergency cross support). Table A-1 identifies Service Providers and their respective assets that do not require RF licensing to provide uplink services during spacecraft emergencies.

- It is assumed that both the Service Provider and Service User ensure the confidentiality of the request and execution of emergency support.

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<sup>3</sup> Assumes planned primary and backup Service Providers during LEOP are not capable of providing contingency support



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## 1.4 Support Scenarios


The amount of coordination and preparation between a Service Provider and a Service User directly affects a Service Provider’s response time to support an emergency. Early coordination between the Service Provider and the Service User can significantly reduce a Service Provider’s response time during an emergency; however, preparing a ground station for an emergency support that may never happen incurs costs to both the Service User and Service Provider. This SOP describes three types of Service User support scenarios that vary in the amount of preparation by a Service Provider prior to an emergency and associated response time that can be expected by a Service User. Three Service User scenarios are:

- Committed Service User:** A Service User has contacted a Service Provider, and the Service Provider agreed that some of its assets can be used in the SECS process, guaranteeing functioning pre-validated TT&C services. The Service User has previously identified the assets that it considers appropriate to the recovery of the spacecraft. The selected stations are tailored to support the spacecraft acquisition downlink and/or uplink, the configurations have been validated for telemetry recovery and/or command transmission, and end-to-end communications infrastructure have been validated for data transference. The Service Provider periodically tests the configuration and ground communication lines. An RF license for the uplink and ITU filing for the downlink are required to test the configuration.
- Acknowledged Service User:** A Service User has contacted a Service Provider, and the Service Provider agreed that some of its assets could be potentially used in the SECS process. Such identified assets were considered appropriate to the recovery of the spacecraft. The selected ground stations are tailored to provide the Service Users with engineering services, at a minimum. Standard TT&C services can be provided depending on the level of support readiness such as availability of ground communication lines, RF license for the uplink, and ITU filing for the downlink, etc. The ground station configuration may not have been pre-validated or tested, periodically. A Service User and Service Provider may negotiate the level of support readiness to an affordable level so that further standard TT&C services are available for emergency support.
- Non-Registered Service User:** A Service User that has not coordinated SECS services with the selected Service Provider prior to an emergency. Ground segment configuration is not available.

Appendix B Table B-1 provides additional details regarding these support scenarios.

## 1.5 Terms and Definitions

Table 1-1 lists the key terms used throughout this document and their subsequent definitions when used in the context of spacecraft emergency cross support.

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**Table 1-1. Terms and Definitions**

Term	Definition
<b>Service User</b>	Mission that requests SECS services
<b>Service Provider</b>	Agency that supplies SECS services to a Service User in emergency mode
<b>Initial Point of Contact (IPoC)</b>	The IPoC is the first person when coordinating emergency cross support for all three of the support scenarios, including during an emergency (for Non-Registered Service Users). The IPoC is generally at the managerial level and corresponds to the function responsible for providing (and receiving) cross support to (from) IOAG partners. The IPoC coordinates any legal and administrative steps required to prepare for cross support and oversees the technical and operational steps required to prepare the Service User assets for providing actual emergency support.
<b>Operational Point of Contact (OPoC)</b>	The OPoC is the real time interface in case of an emergency support request being issued. This is the (24/7) position, responsible for operating the assets requested for emergency support. The OPoC contact information is provided to the Service User by the IPoC.

## 1.6 Applicable Documents


- IOAG Terms of Reference, Issue 4.0 dated February 2014
- Interoperability Plenary (IOP)-4 Communique, December 10-20, 2018

## 1.7 Technical References


- CCSDS Standards: Space Link Extension (SLE)
- IOAG Service Catalog #1, Issue 2, Revision 1 - 28/02/2017

## 1.8 Document Structure

- **Section 1: Introduction** – this section includes purpose, scope, assumptions, support scenarios, terms and definitions, references, and document structure.
- **Section 2: Services Available for Emergency Cross Support** – this section describes the TT&C & engineering services provided during an emergency cross support.
- **Section 3: Cross Support Information Exchange** - this section describes the Service Provider information and Service User information exchanged prior to and during an emergency support.
- **Section 4: Standard Operating Processes and Procedures** - this section steps through each SECS service process. It defines who is responsible for initiating and supporting the process and references Section 3 and other documentation, as applicable.
- **Section 5: Acronyms**
- **Appendix A: Participating Communications Assets in the SECS**
- **Appendix B: Example SECS Service Scenarios**

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- **Appendix C: Spacecraft Specification Template**

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## 2. SERVICES AVAILABLE FOR EMERGENCY CROSS SUPPORT

This section describes the available SECS services.

### 2.1 General

This document defines two types of service: engineering services and standard services. If a spacecraft is in an emergency condition, some spacecraft functionality is lost which may prevent the provision of standard services specified in IOAG Service Catalog #1. In such cases, the Service Provider may provide engineering services, as available, using ‘a best-effort approach’ to determine the status of the spacecraft and/or recover from the anomaly condition. The engineering services are not defined in IOAG Service Catalog #1; however, SOP Sections 2.2 and 2.3 provide descriptions of available engineering services.

This SOP assumes that the available SECS services are first those specified in IOAG Service Catalog #1 as core services as well as engineering services and forensic (i.e. spectral analysis), as available. In other words, the cross support scenarios assumed in this document is the ABA scenario depicted in Figure 2-1 of IOAG Service Catalog #1, in which Agency B provides services to Agency A Control Center for accessing an Agency A spacecraft.


The definition of service given in IOAG Service Catalog #1 Section 2.1 applies to this document. A service is solely specified in terms of its behavior and performance without reference to a particular implementation. SOP Section 2.4 provides the pre-conditions for providing each standard service.

### 2.2 Downlink Engineering Services

#### 2.2.1 Categories of Downlink Engineering Services

Downlink engineering services can be classified based on the anomaly condition of the spacecraft. Although these services are not specified in IOAG Service Catalog #1, most ground stations can provide basic downlink engineering services.

Spacecraft Search Service is the first downlink engineering service category. This category applies to cases in which the spacecraft trajectory is different from its expected trajectory causing the ground station to not point the antenna precisely in the spacecraft’s direction. These cases typically occur after launch or after a trajectory correction maneuver in which the launch vehicle or the on-board thruster did not perform as predicted. These services attempt to locate the spacecraft. If this anomaly occurs, the ground station does not receive any signal from the spacecraft and needs to determine if the spacecraft trajectory is wrong or the on-board communications system is not functioning correctly. If the ground station does not receive any signal after launch or a trajectory correction maneuver, services of this category recommend performing a search for the spacecraft signal. If the search is successful, the first outcome of the service is the confirmation that the on-board transmitter is “ON”. The antenna should then continue to track the satellite and collect

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passive measurements (e.g., antenna position angles, raw 1-Way Doppler) to allow computation of a new trajectory. Additionally, Flight Dynamics might provide orbit diagnostics for a short-term extrapolation, if requested and available.

Downlink Signal Analysis Service is the second downlink engineering service category. This category applies to cases in which the spacecraft downlink signal is received but not correctly. Examples includes the ground station not locking on to signal or not being able to demodulate or decode. This anomaly may be caused by the spacecraft’s on-board communications system not functioning correctly due to some trouble in the spacecraft. These services attempt to analyze the spacecraft’s signal and provide the Service User with useful information (e.g., spectrum, AGC recording) to help the Service User prepare for a corrective action.

### **2.2.2 Spacecraft Search Service**

This engineering service attempts to search for the spacecraft and detect a spacecraft signal at the supporting ground station. This service applies to the following cases: after launch or after a trajectory correction maneuver. While different parameters apply to these two cases, the basic service strategy is the same. Below describes sub-services applicable to this service.

#### **(A) Use of Antenna with Wider Beamwidth**

The supporting ground station uses an antenna with a wider beamwidth (i.e., an antenna with a smaller aperture) to track the spacecraft, if available and as the link budget allows. There is a higher possibility of capturing a spacecraft signal using a wider beamwidth if the trajectory of the spacecraft is offset from the expected trajectory.

#### **(B) Antenna Scanning and Offsetting**

The supporting ground station applies antenna search pattern (e.g., conical scan) or an offset to the predicted antenna angles to search for the spacecraft signal.

#### **(C) Use of Multiple Trajectories**


The supporting ground station applies trajectories different from the nominal trajectory. For cases after launch, trajectories corresponding to incorrect injection cases (such as +/- three sigmas against the correct case) may be used. For cases after a trajectory correction maneuver, trajectories corresponding to no-burn case or 50% burn case may be used.

### **2.2.3 Downlink Signal Analysis Service**

This engineering service attempts to analyze the received spacecraft signal to determine the condition of the signal or the spacecraft. Below describes sub-services applicable to this service.

#### **(A) Spectrum and Level Analysis**

The supporting ground station captures the spectrum of the received signal. The supporting ground station will provide the spectral trace to the Service User to validate the frequency, form, and level of the spectrum by comparing it to the spectrum taken at a test before launch or during a normal

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tracking pass at a ground station. Plotting the received signal level may assist in determining the spin rate if the signal level is fluctuating periodically.

**(B) Check Lock Status**

The supporting ground station checks the statuses of carrier lock, subcarrier lock, symbol lock, Viterbi node lock, and frame lock to determine up to what point the signal is processed correctly. If applicable, the supporting ground station checks the number of Reed-Solomon errors or Cyclic Redundancy Check (CRC) errors against the number of received frames.

**(C) Open Loop Recording**

The supporting ground station records the digitalized received signal using an open loop recording system and the Service Provider reconstructs the received signal in an offline mode.

**2.3 Uplink Engineering Services**

**2.3.1 Categories of Uplink Engineering Services**

The uplink engineering service applies to cases in which the downlink signal from the spacecraft is acquired, which is proof-of-life and proof-of-trajectory. Failure to acquire the spacecraft downlink does not preclude the Service Provider from uplinking in the blind on instruction from the Service User. This anomaly may be caused by the spacecraft’s on-board receiver or data processing system not functioning correctly due to some trouble in the spacecraft. These services attempt to establish a functioning uplink to the spacecraft for commanding.

**2.3.2 Uplink Adjustment Service**


This engineering service attempts to increase the probability of the on-board receiver locking on to the uplink signal transmitted from the ground station. Below describes sub-services applicable to this service. Please note that if the commands sent from the ground station are not accepted by the spacecraft even though symbol lock onto the acquisition sequence is achieved, the cause of the anomaly may be that the commands generated at the spacecraft control center are incorrect.

**(A) Sweep Range/Rate Adjustment**

The supporting ground station uses a sweep range wider than the nominal value and/or uses a sweep rate slower than the nominal value to increase the probability that the on-board receiver locks onto the uplink signal transmitted from the ground station.

**(B) Acquisition Sequence Adjustment**

The supporting ground station uses an acquisition sequence longer than the nominal value to increase the probability that the on-board symbol synchronizer locks onto the acquisition sequence transmitted from the ground station.

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### 2.3.3 *Local Radiation Service*

In situations of imminent danger to the spacecraft, the Service User may request the Service Provider to radiate to the spacecraft despite the fact that there is no communications link to the Service User Mission Operations Control Center (MOCC).

This service can facilitate clarification of the spacecraft condition, i.e. if the spacecraft is coherent, the on-board lock can be confirmed by monitoring the downlink frequency tracking the uplink sweep. This is termed acquiring the spacecraft 2-way.

Flight Dynamics (FD) prefers using 2-Way Doppler measurements because these make orbit determination more accurate and reliable. If the spacecraft's ranging transponder is enabled, 2-way ranging measurements may also be performed.

Please note, the availability of this service is limited by the Service Provider radiation policy regarding RF licenses.

### 2.3.4 *Local Commanding Service*

Assuming that the Local Radiation Service is activated and the spacecraft is in imminent danger, the Service User may decide to transfer the details of a single or multiple Telecommands (TC) to Service Provider. The Service Provider then sends these commands locally to the TC chain of the supporting ground station who then transmits the commands to the spacecraft. The choice of the commands depends on the type of contingency and what activity on the spacecraft should be activated. This service can also be provided without a downlink acquisition.


### 2.3.5 *Terminal Uplink Beamwidth Expansion*

When the spacecraft trajectory has an extremely high uncertainty, radiation of an uplink signal from a standard station configuration may not be capable of acquiring the spacecraft during an emergency. This type of contingency event occurs typically during the LEOP in which the spacecraft injection is flawed.

In order to expand the beamwidth (coverage) of an uplink signal, a smaller antenna, e.g. horn antenna, is fixed to the tracking antenna and connected to the station transmitter. This approach is primarily used on Low Earth Orbiting (LEO) missions. The expanded beamwidth corresponds to a drastic limitation on the uplink power; therefore, the link budget determines whether this technique can be effective or not.

## 2.4 **Standard Services**

The Standard Services available for SECS include the core services specified in IOAG Service Catalog (SC) #1 provided that the pre-conditions stated below are satisfied.

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#### 2.4.1 ***Return Data Delivery Services***

Any core Return Data Delivery Service specified in IOAG Service Catalog #1 can be used as a standard SECS service provided that:

- Service Provider receives, demodulates, and decodes telemetry on downlink correctly;
- The ground link between the ground station and the spacecraft control center is established using SLE.

#### 2.4.2 ***Forward Data Delivery Services***

Any core Forward Data Delivery Service specified in IOAG Service Catalog #1 can be used as a standard SECS service provided that:

- Service Provider receives, demodulates, and decodes telemetry on downlink correctly;
- Spacecraft receives the uplink signal correctly and accepts commands correctly; and
- The ground link between the ground station and the spacecraft control center is established using SLE.


These services can potentially be provided without downlink acquisition.

#### 2.4.3 ***Radiometric Services***

Any Radiometric Service specified in IOAG Service Catalog #1 (except for the Delta-Differential One-way Ranging (DDOR) Service) can be used as a standard SECS service provided that:

- Service Provider receives and demodulates the downlink correctly;
- Supporting antenna tracks the satellite successfully;
- Spacecraft receives the uplink signal correctly;
- Spacecraft establishes coherency between uplink and downlink (for cases that require 2-Way Doppler);
- The ground link between the ground station and the spacecraft control center is established and the Service Provider is able to deliver Tracking Data Message (TDM) in the CCSDS format; and
- Alternatively, the Service Provider may process the radiometric data and deliver an orbit diagnostic in an ODM in the CCSDS format.



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### 3. CROSS SUPPORT INFORMATION EXCHANGE

#### 3.1 Points of Contact

##### 3.1.1 Initial Point of Contact (IPoC)

The IPoC is the first person the Service User contacts when coordinating emergency cross support for the three support scenarios described in Section 1.4. In general, the IPoC is at the managerial level and corresponds to the function responsible for providing (and receiving) cross support to (from) IOAG partners. The IPoC coordinates any legal and administrative steps required to prepare for cross support and oversees the technical and operational steps required to prepare the Service Provider assets for providing actual emergency support. Whenever the provision of services is ready, the IPoC provides the Service User with the Operational Point of Contact (OPoC) information, as described in Section 3.1.2.

Table 3-1 lists each agency’s IPoC email information, which connects prospective Service Users to the key personnel for coordinating emergency support within each agency.

**Table 3-1. Initial Points of Contact (IPoC)**

Agency	E-mail
ASI	ioagSCemergency-ipoc@asi.it
CNES	L-ioagSCemergency-ipoc@cnes.fr
DLR	ioagSCemergency-ipoc@dlr.de
ESA	ioagSCemergency-ipoc@esa.int
JAXA	ioagSCemergency-ipoc@ml.jaxa.jp
KARI	ioagSCemergency-ipoc@kari.re.kr
NASA	ioagscemergency-ipoc@lists.nasa.gov


##### 3.1.2 Operational Point of Contact (OPoC)

The OPoC is the real time interface during an emergency support. This is the 24/7 position, responsible for operating the assets requested for emergency support. The OPoC contact information is provided by the IPoC to the Service User. During an emergency, Committed and Acknowledged Service Users contact the OPoC to request support. For Non-Registered Service Users, the IPoC continues to be the first point of contact and the IPoC may transfer this interface to the OPoC at a later stage.

A spacecraft emergency declaration is normally issued by the Mission Operations Manager. This declaration cannot be triggered autonomously by mission operations staff “on console”. Each Service Provider is responsible for validating request for support per their respective internal agency procedures.

Initial contact with the OPoC triggers the Service Provider’s internal reporting process to:

1. Authenticate the emergency declaration and commit the resources requested;

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2. Prepare the ground stations and ensure that there will be no operational impact on other missions; and
3. Notify any missions that may be impacted by the emergency support.

Each agency executes their local SECS procedures for “Call Out”, scheduling functions and any other required actions.

### 3.2 Service Provider Information

When identifying possible assets to provide emergency cross support, the Service User considers the following criteria. The selection criteria of usable assets are similar for these scenarios:

- Is the asset in the preferred location for visibility?
- Is the asset compatible with the spacecraft?
- Does the asset have sufficient performance?
- Does the selected Service Provider require RF uplink licenses for the asset per domestic regulations and possible lead times for implementation and approval? (possible for Acknowledged and for Non-Registered Service Users only)
- Does the asset have a communications infrastructure connectivity to the Service User premises and capable of supporting the emergency with a short notice? (possible for Acknowledged and for Non-Registered Service Users only)


#### 3.2.1 Service Provider Information to Coordinate and Prepare Support

Each member agency recommended various assets that may provide the services described in this SOP. Appendix A summarizes and assists in the initial selection of candidate Service Providers and ground stations. Table A-1 summarizes the ground station characteristics including geographical location, antenna characteristics, downlink and uplink RF band availability, and finally any “local” uplink license issues.

##### 3.2.1.1 Asset Characteristic Information

After selecting the candidate ground stations, the Service User can find the performance specifications of each station using a web-accessible asset characteristic database. (Please note, as of the publication of this document, this database is not yet available.) This database provides technical information such as:

- Antenna Coordinates
- Figure of Merit (G/T)
- Demodulation Schemes
- Decoding Types for Telemetry
- Uplink Modulation
- Radiometric Techniques
- Effective Isotropic Radiated Power (EIRP)
- Available SLE Services

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- Coding Types for TC
- Communications Interfaces

These data can be used to assess acquisition and link budget compatibility.

### 3.2.2 ***Service Provider Information Exchange During Emergency Support***

The following actions assume that the interaction at the management level is complete via the IPoC (Table 3-1), i.e. the Service Provider agrees to make the requested assets available for emergency support. The following actions depend on the categories of the required SECS services:

- Service Provider confirms receipt of the latest orbital predicts and report on the computed tracking times and ephemeris for each contingency pass which can be provided.
- Service Provider assesses and mitigates any scheduling conflicts concerning the use of the proposed asset.
- Service Provider provides a confirmation of Acquisition of Signal (AOS), i.e. proof of life.
- Service Provider provides an orbit diagnostic in the ODM format, if applicable.
- Service Provider reports on the characteristics of the acquired signal.
- Service Provider confirms receipt of Telemetry (TM) frames.
- Service Provider transmits TM frames, if applicable.
- Service Provider confirms transmission of commands, if applicable. Service User confirms onboard receiver lock and reception of TC data, if applicable.
- Service Provider provides radiometric data, if applicable.


### 3.3 **Service User Information**

The required Service User information, listed in Appendix C, is standard for emergency support. Committed and Acknowledged Service Users provide this data prior to an emergency. Non-Registered Service Users are expected to provide this data in real-time.

#### 3.3.1 ***Service User Information to Coordinate and Prepare Support***

The Service User provides orbit/trajectory predictions in the form of ODMs or TLE. For further details on preferred Service Provider format, refer to the Service Provider's respective User's Guide or Interface Control Document.

- **Committed and Acknowledged Service Users:** Orbit/trajectory predictions delivery infrastructure are in-situ
- **Non-Registered Service Users:** Orbit/trajectory predictions will be delivered via email to the IPoC (IPoC forwards the information to OPoC)

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To facilitate the acquisition of the downlink and/or uplink by a supporting ground station, the Service User provides the Service Provider with spacecraft information, as applicable, using the Spacecraft Specification Template provided in Appendix C upon first contact.

### **3.3.2 Service User Information Exchange During Emergency Support**

The Service User provides a Pre-Pass Voice Briefing, to ensure all parties are aware of the objectives and any limitations for the upcoming pass, and if the ODM or TLE is the latest


After starting the track and acquiring the spacecraft, the Service User Flight Control Team (FCT) provides updates to the Service Provider throughout the service.

The Service User FCT confirms the receipt of “GOOD” TM Frames.

The Service User FCT summarizes the health of the spacecraft and the condition of the operational transponder including:

- Coherency Mode
- Subcarrier Lock
- On-board Automatic Gain Control (AGC)
- Receiver Lock
- Bit Lock
- On-board Receiver Offset

The Service User FCT should provide advanced notice of any recovery operations that could result in a Loss of Signal (LOS), a change in frequency, or a change in TM or TC rates.

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## 4. STANDARD OPERATING PROCESSES AND PROCEDURES

### 4.1 Process Overview

This section describes the following processes:

**Process 1:** Identify Service Provider

**Process 2:** Assess Viability of Service Provider for Emergency Cross Support

**Process 3:** Support Preparation

**Process 4:** Pass Support

**Process 5:** Support Termination

The response time is dependent on the type of Service User (e.g., Committed, Acknowledged, Non-Registered). While each emergency support sequence is the same for each Service User, the time at which each step is executed may vary.

### 4.2 Process 1: Identify Service Provider


**Participants:** Service User

**Purpose:** This process describes the steps in which a Service User identifies a candidate SECS Service Provider. This process includes the Service User's evaluation of a particular Service Provider's viability, using the information available in this SOP, on the IOAG website or the open internet. The Service User executes this process prior to contacting the Service Provider(s) and is true for all three support scenarios.

**Table 4-1. Identify Service Provider**

Step	Action Description	Service User	Service Provider
1	Identify the need for SECS services	R	-
2	Download latest SOP from the IOAG website to view potential Service Providers <a href="#">(see Appendix A.)</a> Note: All Service Users must create an IOAG account to gain access to the SOP.	R	-
3	Using site parameters, perform initial analysis of whether a ground station could provide support during an emergency	R	-
4	Complete the Spacecraft Specification using the template provided in Appendix C	R	-

R = Responsible, S = Supports

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### 4.3 Process 2: Assess Viability of Service Provider for Emergency Cross Support

**Participants:** Service User, Service Provider IPoC


**Purpose:** This process describes the steps for when the Service User first contacts a Service Provider. The Service Provider assesses the viability of providing SECS services to that particular Service User. This process requires that Process 1 has been completed by the Service User.

This process addresses two cases:

1. Table 4-2-1 describes the cases in which a Service User has *not* declared an emergency situation; Service User is contacting Service Provider to evaluate possibility of agreement.
  - a. Applies to Committed and Acknowledged Service Users.
2. Table 4-2-2 describes the cases in which a Service User *has* declared an emergency situation; Service User is contacting Service Provider to evaluate the possibility of SECS services.
  - a. Applies to Non-Registered Service Users.

**Table 4-2-1. Assess Viability of the Service Provider to Provide SECS Services - Committed or Acknowledged Cases**

Step	Action Description	Service User	Service Provider
1	Contact the Service Provider IPoC to assess viability of part or all of the SECS services (to be specified) provided by the ground asset(s) that were pre-selected by the Service User.	R	S
2	Provide details regarding the spacecraft to be supported and Appendix C: Spacecraft Specification	R	
3	Provide nominal trajectory information for the spacecraft to be supported	R	
4	Confirm the feasibility of the required support by the Service Provider, based on: <ol style="list-style-type: none"> <li>1. ground assets technical compatibility and readiness to support</li> <li>2. availability, and restrictions, if any, of the ground assets</li> <li>3. A Priori RF licensing requirements, as applicable</li> <li>4. the need to identify communication line resources to provide the considered SECS support(s).</li> <li>5. the need to perform mission-specific preparation or not (Acknowledged Service Users, only)</li> </ol>	S	R
5	Provide confirmation that the Service Provider can provide support	-	R
6	Provide instructions regarding next steps	S	R

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**Table 4-2-2. Assess Viability of the Service Provider to Provide SECS Services - Non-Registered Case**

Step	Action Description	Service User	Service Provider
1	Contact the Service Provider IPoC to request SECS services	R	S
2	Provide details regarding nature of the spacecraft emergency and Appendix C (Spacecraft Specification Template), provide trajectory information and request the required SECS services	R	S
3	Initiate internal emergency notification process to obtain authorization to provide SECS, considering the nature of the emergency	-	R
4	Confirm the feasibility of the required support by the Service Provider, based on: <ul style="list-style-type: none"> <li>1. the assumed compatibility of ground assets</li> <li>2. the ability of the ground assets to support the required SECS services</li> <li>3. the need of an RF license (depending the required services)</li> <li>4. the readiness of communication line resources to provide the support as applicable for providing data to Service User. For example, data file exchange may use internet or e-mail to provide Service User data.</li> <li>5. the availability of the ground assets</li> <li>6. the anticipated readiness date / time of ground station to provide services</li> </ul>	S	R
5	Provide confirmation that the Service Provider can provide emergency support and indicate which specific services could possibly be supported	-	R
6	Provide instructions regarding next steps including OPoC information	S	R

#### 4.4 Process 3: Support Preparation

**Participants:** Service Provider IPoC, Service User

**Purpose:** This process describes the steps executed by a Service Provider and a Service User to prepare for SECS services support. Preparing for support may be time consuming; therefore, this SOP recommends that the Service User be cognizant of the required configuration parameters that a Service Provider will request, prior to requesting SECS services; to some extent, the Appendix C serves that purpose. For Committed and Acknowledged cases, Service Providers and Service Users execute this process prior to any emergency. For Non-Registered case, Service Providers and Service Users execute this process at the time of the service request on a best-effort basis. Please note that periodic testing and validation of the ground station configuration is performed for Committed Service Users, only, and not Acknowledged nor Non-Registered Service Users. This amplifies the criticality of this process for successful SECS. Support Preparation is

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coordinated between the Service User and the Service Provider IPoC or ground station engineering personnel.

**Table 4-3. Support Preparation Procedure**


Step	Action Description	Committed	Acknowledged	Non-Registered
1	Service User: Provide the spacecraft specification which contains the Service User configuration data to the Service Provider	Required	Required	✓
2	Service Provider: Configure ground station for the pre-selected specific services	Required	Required	✓
3	Service Provider: Obtain RF license (see Section 4.4.1 for details)	Required	May be Required	---
4	Both: Determine ground communication line routing path between Service User MOC and Service Provider, including security aspects	Required	May be Required	---
5	Both: Test and validate ground communication line routing path	Required	✓	---
6	Both: Conduct periodic validation & testing for ground station configuration (6-12 months)	Required	---	---
7	Both: Agree upon parameters for engineering services (e.g.: search pattern and scanning method)	✓	✓	✓
8	Both: Establish and maintain functioning FD infrastructure	Required	May be Required	---
9	Service User: Provide spacecraft trajectory file	✓	✓	✓
10	Both: Establish operations concept for offline data transfer	Required	May be Required	✓
11	Both: Exchange contact information (OPoC) and all relevant phone, Internet Protocol (IP) addresses, etc.	Required	Required	✓
12	Service Provider: Provide instruction regarding next steps to the OPoC	Required	Required	✓

Required = Completed prior to emergency; ✓ = Completed at the time of emergency

#### 4.4.1 A Priori RF Licensing Procedure

The A Priori RF licensing procedure applies to Committed Service Users, only, and is required for emergency uplink support from certain ground stations and for periodic downlink testing. For downlink services, the Service User (mainly for Committed Service Users) should follow the recommended A Priori licensing procedure and attain the appropriate RF license from the ITU.



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For uplink services, the Service User must coordinate with Service Provider so that the Service Provider can acquire the appropriate local RF license.

This A Priori licensing procedure ensures the timely availability of RF licenses at the supporting agencies for the SECS. The scheme features:

- All communications assets potentially needed by a mission for the SECS are licensed in advance to use the frequencies to support that subject mission
- The subject mission is committed, in terms of its support, by these communications assets in time of spacecraft emergency.
- During the mission formulation phase at the ITU, when Mission X from Agency A submits frequency authorization applications to the national and/or local RF licensing agency, it includes filings for the corresponding ground communications assets (i.e. Station Y of another IOAG agency, Agency B) that are potentially needed for the SECS.
- Agency A informs Agency B of such a potential need for SECS by Station Y for Mission X.
- Agency B grants the approval based on the applicable interagency agreement.
- Agency B spectrum management submits a Radio Frequency Authorization (RFA) to its national and/or local RF licensing agency for approving Station Y to use the frequencies to support Mission X.


#### 4.5 Process 4: Pass Support

**Participants:** Service User, Service Provider OPoC

**Purpose:** This process describes the steps the Service User and Service Provider execute as well as the information exchanged during an SECS service scenario. This process assumes that the Processes 1-3 are complete.

**Table 4-4. Pass Support Procedure**

Step	Action Description	Service User	Service Provider
1	Service User calls the Service Provider OPoC, declares a spacecraft emergency and notifies Service Provider (refer to Section 3.3.2)	R	S
2	Service Provider and Service User establish verbal communications (preferred method) via telephone or a voice link (if necessary, together with other means such as email or fax), to specify the nature of the spacecraft emergency, the assumed situation of the spacecraft (as needed) and the required support: asset(s), services, etc...	R	R
3	Service Provider initiates internal notification and approval processes, as applicable	S	R

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Step	Action Description	Service User	Service Provider
4	Service User provides updated trajectory information	R	S
5	Service Provider provides support confirmation, scheduling information (earliest contact time) and any pertinent status about the ground station(s)	S	R
6	Service Provider executes the emergency support and frequently updates the Service User about pass execution including service duration	S	R
7	Service Provider coordinates the pass termination exchanges, identifies the next contact time, and exchanges "End of Pass" information (including success results and anomalies) and post-pass data files	S	R
8	Service Provider communicates any restriction on the ground station utilization if extended emergency support is required		R


#### 4.6 Process 5: Support Termination

**Participants:** Service Provider IPoC and OPoC, Service User

**Purpose:** This process describes the steps the Service User and the Service Provider execute when terminating SECS services, including the necessary reporting and accounting of the pass supports.


**Table 4-5. Support Termination**

Step	Action Description	Service User	Service Provider
1	Service Provider issues a reporting summarizing the services provided to the Service User	S	R
2	Service Provider uses agency-specific outputs of scheduling and statistics systems	S	R


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## 5. ACRONYMS

Acronym	Definition
AGC	Automatic Gain Control
AOS	Acquisition of Signal
ASI	Agenzia Spaziale Italiana
BOT	Beginning of Track
CADU	Channel Access Data Unit
CCSDS	Consultative Committee for Space Data Systems
CLTU	Communications Link Transmission Unit
CNES	Centre National d'Etudes Spatiales
CRC	Cyclic Redundancy Check
DDOR	Delta Differential One-way Ranging
DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V.
DS	Deep Space
EIRP	Effective Isotropic Radiated Power
ESA	European Space Agency
FCT	Flight Control Team
FD	Flight Dynamics
G/T	Gain to Noise Temperature
GEO	Geosynchronous Earth Orbit
IOAG	Inter-agency Operations Advisory Group
IP	Internet Protocol
IPoC	Initial Point of Contact
ITU	International Telecommunication Union
JAXA	Japan Aerospace Exploration Agency
LEO	Low Earth Orbit
LEOP	Launch and Early Orbit Phase
LHC	Left Hand Circular
LOS	Loss of Signal
MOCC	Mission Operations Control Center
NASA	National Aeronautics and Space Administration

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Acronym	Definition
ODM	Orbit Data Message
OPoC	Operational Point of Contact
PN	Pseudo-Noise
PoC	Point of Contact
RF	Radio Frequency
RFA	Radio Frequency Authorization
RHC	Right Hand Circular
RNG	Ranging
SC	Service Catalog
SECS	Spacecraft Emergency Cross Support
SECSWG	Spacecraft Emergency Cross Support Working Group
SLE	Space Link Extension
SOP	Standard Operating Process and Procedures
TBC	To Be Confirmed
TBD	To Be Determined
TBP	To Be Provided
TC	Telecommand
TDM	Tracking Data Message
TLE	Two-Line Element
TM	Telemetry
TOV	Time Offset Value
TT&C	Tracking, Telemetry and Command
USAAF	United States Army Air Force

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## APPENDIX A. COMMUNICATIONS ASSETS IN THE SPACECRAFT EMERGENCY CROSS SUPPORT

The IOAG member agencies identified a set of candidate communications assets (e.g., ground stations) which may be available to provide SECS services and are listed in Table A-1. These assets are designated as "SECS assets." An SECS asset is "equipped" with or possesses some of the key attributes of the SECS:

A given Service User can consider a SECS asset to suit its potential needs, obtain an acknowledgment from the owner of the asset, a Service Provider agency, of the use of their asset, and confirm the willingness to execute the A Priori licensing scheme, as required. This case of SECS is considered as "Committed" by the Service User and Service Provider agencies but in some cases may also apply to an "acknowledge service".


Selection of an SECS asset by a given mission may be dependent on the following factors:

- Site location: how well does the asset, relative to other assets, ensure the needed geometric coverage?
- Spectral bands:
  - Near Earth S-/X-band allocation for missions at or below Geosynchronous Earth Orbit (GEO) distance;
  - Near Earth S-/X-band allocations for missions between GEO and 2M km from Earth;
  - Deep space X-band allocation for missions beyond 2M km from Earth
- Capabilities: G/T, EIRP, etc.

Given the above considerations, Figures A-1 and A-2 are site maps that further illustrate the SECS assets listed in Table A-1. Figure A-1 shows ground stations with an antenna(s) whose diameter is less than 15 meters. Figure A-2 shows ground stations with an antenna(s) whose diameter is greater than/equal to 15 meters.


Please note that Table A-1 includes the assets of the IOAG/SECS participating agencies. Service Providers have many factors they need to consider before agreeing to provide SECS services. For example, the Service Provider needs to ensure that no new emergency situation is caused when trying to support another spacecraft.

Standard services may not be available in all ground stations (e.g., data interface (including SLE) is not established); however, those ground stations may be able to provide engineering services, Table A-1 identifies ground stations with assets that can provide engineering services by noting *Engineering Services Only* in the *Available Support Services* column.


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**Table A-1. SECS Assets**

Agency	Size (M)	Location	Antenna ID	Typical Station usage <sup>1</sup>	S-band		X-band		Conditions to take into account for providing support		Remarks
					Max EIRP (dBm)	G/T (dBK)	Max EIRP (dBm)	G/T (dBK)	Available Support services <sup>2</sup> (specify if any constraint)	Is Uplink RF license required for Emergency support? <sup>3</sup>	
ASI	10	Malindi, KEN		LEO	98.0	21.3	-	-	IOAG SC#1 core services (TM, TC, RNG)	An S-band full coverage annual license is available	It supports Arianespace launches from Kourou CSG (A5, VEGA) and SpaceX launches. SLE compliant.
	13	Malindi, KEN		LEO	99.0	21.3	-	-	IOAG SC#1 core services (TM, TC, RNG)	An S-band full coverage annual license is available	It supports Arianespace launches from Kourou CSG (A5, VEGA) and SpaceX launches. SLE compliant.
CNES	11	Kourou, GUF		LEO, G	101.0	22.5	-	35.5	All	-	
	10	Kerguelen Islands, FRA		LEO, G	101.0	21.5	-	-	All	-	
	11	Aussaguel, FRA		LEO, G	101.0	22.5	-	35.5	All	-	
	6.4	Aussaguel, FRA		LEO	85.0	17.0	-	-	All	-	
	11	Hartebeesthoek, ZAF		LEO, G	101.0	22.5	-	35.5	All	-	
	13	Kiruna, SWE		LEO, G	98.0	22.5	-	34.0	All	-	
DLR	13	Inuvik, NT, CAN		LEO, G	98.0	22.5	-	34.0	All	Required	
	15	Weilheim, DEU		LEO, G, L, H	108.0	26.7	-	-	All	-	
	15	Weilheim, DEU		LEO, G, L, H	109.0	27.8	-	-	All	-	
	30	Weilheim, DEU		H, D	-	-	-	44.0	All	-	also L-Band DL
	7.3	Neustrelitz, DEU		LEO	-	17.0	-	31.0	All	-	
	7.3	Neustrelitz, DEU		LEO	90.0	17.0	-	31.0	All	-	
	7.3	Neustrelitz, DEU		LEO	90.0	17.0	-	31.0	All	-	
	11.5	Neustrelitz, DEU		LEO	93.0	22.0	-	36.0	All	-	also Ka DL
	9	O'Higgins, ANT		LEO	92.0	19.5	-	32.0	All	-	
ESA	13	Inuvik, NT, CAN		LEO	100.0	22.4	-	35.9	All	Required	
	4.5	New Norcia, AUS	NNO2	LEO	-	-	101.5	28.0	All	-	Includes 0.75m Acquisition Aid
	15	Kiruna, SWE	KIR1	LEO, G, L, H	102.9	29.5	-	39.2	All	-	
	13	Kiruna, SWE	KIR2	LEO, G, L, H	98.3	22.8	-	36.5	All	-	
	15	Kourou, GUF	KRU1	LEO, G, L, H	105.0	29.4	114.0	42.0	All	-	
	35	Cebreros, ESP	CEB1	G, L, H, D	-	-	139.0	52.4	All	Required	also K & Ka DL
35	New Norcia, AUS	NNO1	G, L, H, D	128.0	39.2	138.7	51.2	All	Required for S-band <sup>4</sup>		

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Agency	Size (M)	Location	Antenna ID	Typical Station usage <sup>1</sup>	S-band		X-band		Conditions to take into account for providing support		Remarks
					Max EIRP (dBm)	G/T (dBK)	Max EIRP (dBm)	G/T (dBK)	Available Support services <sup>2</sup> (specify if any constraint)	Is Uplink RF license required for Emergency support? <sup>3</sup>	
	35	Malargue, ARG	MLG1	G, L, H, D	-	-	139.5	52.1	All	-	also K & Ka DL and Ka UL
KARI	13	Daejeon, KOR		LEO	88.0	23.0	-	36.0	Engineering service only	Required	SLE is not operational yet
	9	Daejeon, KOR		LEO, G	85.0	19.0	-		Engineering service only	Required	SLE is not operational yet
	7.3	Daejeon, KOR		LEO	83.0	19.5	-	34.0	Engineering service only	Required	SLE is not operational yet
	11	Jeju, KOR		LEO	83.0	20.0			Engineering service only	Required	SLE is not operational yet
NASA	4.7	Wallops Island, VA, USA	LEO-T	LEO	89.2	17.0	-		All	-	
	11.3	Wallops Island, VA, USA	WG1	LEO,G,L,H	94.6	23.6	-	34.5	All	-	
	11.3	Fairbanks, AK, USA	AS1	LEO,G,L,H	94.6	22.0	-	35.2	All	-	
	9.1	Fairbanks, AK, USA	AS2	LEO,G,L,H	89.0	21.2	-	36.2	All	-	
	11	Fairbanks, AK, USA	AS3	LEO,G,L,H	95.7	22.9	-	35.2	All	-	
	18.3	White Sands, NM, USA	WS1	LEO,G,L,H	102.0	29.6	-	-	All	-	
	11.3	Kennedy Space Center, FL, USA	KUS	LEO,G,L,H	87.0	17.2	-	-	All	-	
	11.3	Ponce De Leon, FL, USA	PDL	LEO,G,L,H	87.0	17.2	-	-	All	-	
	70	Canberra, AUS	43	D,L,H	135.6 (2110 - 2118 MHz) 127.4 (2090-2091 MHz)*	49.8	145.8	61.5	All	-	In all cases for all stations the JPL Frequency Spectrum Mgr will follow up post support for license if needed. (2090-2091 MHz) Emergency only
	70	Goldstone, CA, USA	14	D,L,H	135.6 (2110 - 2118 MHz) 127.4 (2090-2091 MHz)*	49.8	145.8	61.5	All	-	(2090-2091 MHz) Emergency only
	70	Madrid, ESP	63	D,L,H	135.6 (2110 - 2118 MHz) 127.4 (2090-2091 MHz)*	49.8	145.8	61.5	All	-	(2090-2091 MHz) Emergency only (2110 -2118 MHz) Emergency only
	34	Canberra, AUS	34	D,L,H,G	128.7	40.8	139.5	54.2	All	-	LEOP support for Geosynchs S or X Band
	34	Canberra, AUS	36	D,L,H,G	108.8	40.8	139.5	54.2	All	-	LEOP support for Geosynchs S or X Band
	34	Canberra, AUS	35	D,L,H,G			139.5	54.2	All	-	LEOP support for Geosynchs X Band only
	34	Goldstone, CA, USA	24	D,L,H,G	128.7	40.8	139.5	54.2	All	-	LEOP support for Geosynchs S or X Band
34	Goldstone, CA, USA	25	D,L,H,G			139.5	54.2	All	-	LEOP support for Geosynchs X Band only	
34	Goldstone, CA, USA	26	D,L,H,G	108.8	40.8	139.5	54.2	All	-	LEOP support for Geosynchs S or X Band	

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Agency	Size (M)	Location	Antenna ID	Typical Station usage <sup>1</sup>	S-band		X-band		Conditions to take into account for providing support		Remarks
					Max EIRP (dBm)	G/T (dBK)	Max EIRP (dBm)	G/T (dBK)	Available Support services <sup>2</sup> (specify if any constraint)	Is Uplink RF license required for Emergency support? <sup>3</sup>	
	34	Madrid, ESP	54	D,L,H,G	128.7	40.8	139.5	54.2	All	-	LEOP support for Geosynchs S or X Band
	34	Madrid, ESP	55	D,L,H,G			139.5	54.2	All	-	LEOP support for Geosynchs X Band only
	34	Madrid, ESP	65	D,L,H,G	108.8	39.4	139.5	53.2	All	-	LEOP support for Geosynchs S or X Band
JAXA	10	Katsuura, JPN		LEO, G	101.0	22.5	-	-	All (see note1)	Required	<b>Note1:</b> For Radiometric Services, the Pseudo-Noise [PN] Ranging Systems is available only from DS stations but not conform to the CCSDS standard. JAXA LEO stations have presently no plan to implement the PN ranging system. Therefore, only satellite transparent mode is available in the regenerative mode and JAXA's internal format is used for this service.  <b>Note2:</b> "Engineering service only" stations are not connected to SLE.
	20	Katsuura4, JPN		LEO, G, L	97.7	27.7	-	39.0	All (see note2)	Required	
	10	Masuda, JPN		LEO, G	101.0	22.5	-	-	All (see note1)	Required	
	10	Okinawa, JPN		LEO, G	101.0	22.5	-	-	All (see note1)	Required	
	18	Okinawa2, JPN		LEO, G	104.8	25.5	-	-	All (see note1)	Required	
	10	Mingeneue, AUS		LEO, G	101.0	22.5	-	-	All (see note1)	Required	
	10	Santiago, CHL		LEO, G	101.0	22.5	-	-	All (see note1)	-	
	10	Kiruna, SWE		LEO, G	101.0	22.5	-	-	All (see note1)	(being confirmed)	
	10	Maspalomas, ES		LEO, G	101.0	22.5	-	-	All (see note1)	-	
	20	Uchinoura, JPN		LEO, L, H	110.0	32.8	-	43.0	Engineering service only	N/A	
	34	Uchinoura, JPN		LEO, L, H, D	115.0	38.4	138.7	50.0	All (see note1)	Required	
11	Uchinoura, JPN		LEO	103.6	23.8	-	-	Engineering service only	N/A		
64	Usuda, JPN		L, H, D	-	40.0	143.0	49.5	All (see note1)	Required		

<sup>1</sup> Typical Station usage

This section shows the type of satellites most-typically operated by the ground station. Service User may refer to this section to ensure the suitability of assets in terms of frequency band and/or antenna drive speed when identifying which antenna(s) can be used.

Example:

LEO = Low Earth Orbit; G = Geostationary; L = Lunar or its vicinity including Lagrange Point;  
 H = High Earth Orbit including Highly Elliptical Orbit; D = Deep Space.

<sup>2</sup> Available support services (specify constraints, if any)

Availability of the SOP services. Specify constraints, if applicable.

Example:

All = All Services may potentially be available; however, availability of specific services need to be coordinated with Service Provider.;

Engineering services only (because no real-time interface, such as SLE function, is available at the ground station)

Specify constraints, if any (if any of Core SC#1 functions is not available for standard TT&C services)

<sup>3</sup> Is RF uplink license required for emergency support?

Specify if RF license must be obtained prior to providing uplink services.

Example:

Required: = formal RF license process is required for this station


"-" = Ground station does not require formal RF license for emergency support; however, real-time coordination with relevant administrative bodies may be required. Ground stations do require RF uplink license for uplink services during non-emergency situations, such as periodic testing.

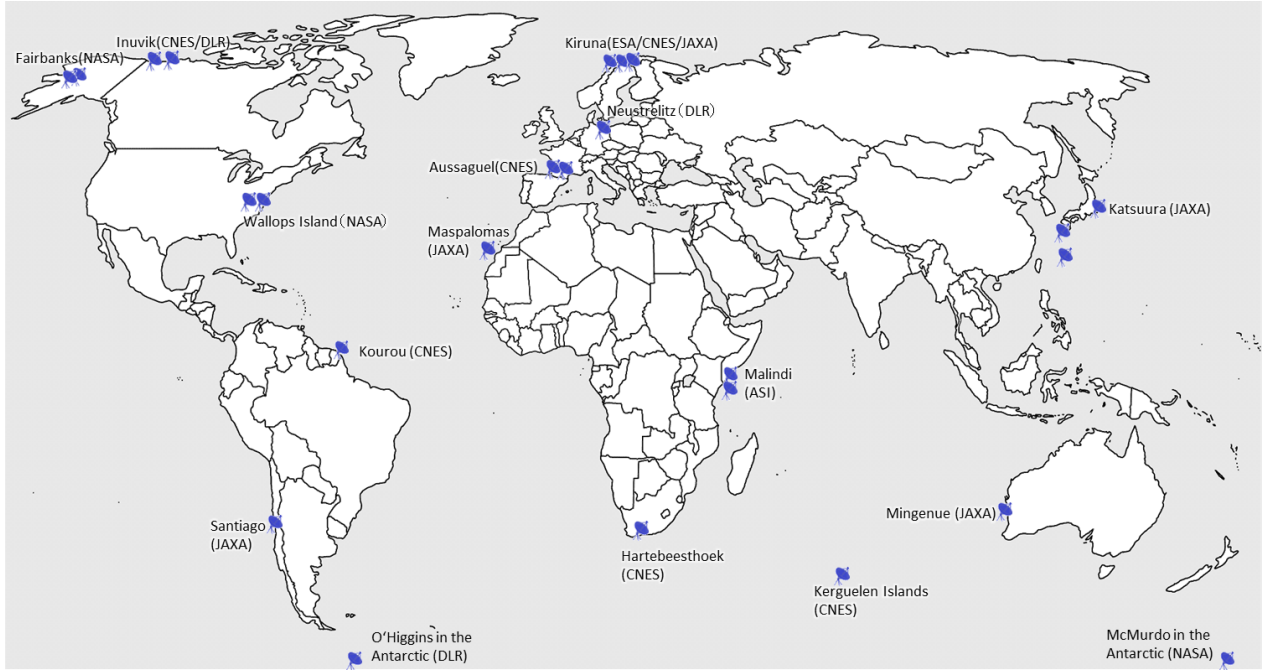
Antenna ID: CCSDS station ID

<sup>4</sup> Full allocation not available.

N/A: Not applicable




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**Figure A-1. SECS Assets Map (Assets with Antenna Diameter Less Than 15 Meters)**



**Figure A-2. SECS Assets Map (Assets with Antenna Diameter Greater Than / Equal To 15 Meters)**

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## APPENDIX B. EXAMPLE SECS SERVICE SCENARIOS


### B.1 Service Provider Preparation Prior to Emergency and Response Time

Characteristics of SECS Service Scenarios	Committed	Acknowledged	Non-Registered
Concurrence of Agency Service Provider to provide best-effort SECS to Service User	Yes	Yes	No
Ground Station Configuration for Service User TT&C	Yes	Yes	No
Periodic Validation & Testing for Ground Station Configuration (6-12 months)	Yes	No	No
Maintain functioning FD infrastructure for processing orbital predicts and radiometric data	Yes	Yes	No
Maintain function communications infrastructure	Yes	As agreed	No
Obtain RF Licenses	Yes	As agreed	No
<b>Response Time for Engineering Services</b>	<b>ASAP</b>	<b>ASAP</b>	<b>Up to x day(s); not guaranteed</b>
<b>Response Time for Return Data Delivery</b>	<b>ASAP</b>	<b>Up to x day(s); not guaranteed</b>	<b>Up to x week(s); not guaranteed</b>
<b>Response Time for Forward Data Delivery</b>	<b>ASAP</b>	<b>Up to x day(s); not guaranteed</b>	<b>Up to x week(s); not guaranteed</b>
Point of Contact Prior to Emergency Support	IPoC	IPoC	N/A
Point of Contact During Emergency Support	OPoC	OPoC	IPoC then OPoC
Associated Costs to Mission for Services	Agency-Specific	Agency-Specific	Agency-Specific

### B.2 SECS Service Scenarios

#### B.2.1 Committed Service User Scenario and Steps


1. Emergency declaration by Service User and alerts Service Provider of requirement for support (this includes a situation summary and any specifics for recovery operations).
  - a. Full TT&C acquisition
  - b. Downlink Engineering Services
  - c. Provision of Radiometric Services
  - d. Uplink Engineering Service
2. Service Provider OPoC alerts Service Provider management and possibly impacted missions in routine operations

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3. Service Provider management confirms go ahead for emergency scheduling of requested facilities
4. Committed Service Providers have pre-existing ground station, FD and network infrastructure “in situ”. Scheduling of facilities is the main activity required by the Service Provider minimizing the interruptions to other flying missions
5. Standard pre-pass activities for configuration of station.
6. Pre-pass briefing from Service User with latest updates of spacecraft condition and targets of the FCT.
7. Service User connects to station for TM and TC
8. Beginning of Track (BOT)

The subsequent processes are defined by the manner of the emergency and include:

- B.2.1.1 – Spacecraft RF & TM Available – The Simplest Scenario
- B.2.1.2 - Spacecraft RF Downlink with Non-Nominal TM Modulation or Unmodulated
- B.2.1.3 - Nominal Trajectory Spacecraft RF Downlink Not Observed
- B.2.1.4 - Non-Nominal Trajectory Spacecraft RF Downlink Not Observed
- B.2.1.5 - No Spacecraft Downlink After Search and Blind Commanding – Worst Case Scenario


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#### B.2.1.1 Spacecraft RF & Tm Available – The Simplest Scenario

1. AOS - Acquisition of signal, RF downlink (confirms spacecraft trajectory).
2. Acquisition of TM.
3. Service User confirms receipt of good TM.
4. Service User gives station go ahead to perform an uplink acquisition service.
5. Service User confirms on-board receiver lock in TM and, if spacecraft is coherent, station confirms receiver lock in downlink frequency (2-way acquisition).
6. Service User confirms command link is operational.
7. Commence emergency recovery operations.
8. Station commences radiometric measurements.
9. Offline delivery of data to Service User.

#### B.2.1.2 Spacecraft RF Downlink with Non-Nominal TM Modulation or Unmodulated

1. AOS. Acquisition of signal and RF downlink (confirms spacecraft trajectory).
2. Perform spectral analysis to identify modulation.
3. Change downlink configuration to attempt TM acquisition, if successful continue with emergency recovery operations as per B.2.1.1.
4. Service User gives station go ahead to attempt an uplink acquisition service; if spacecraft is coherent, supporting ground station can confirm receiver lock in downlink frequency (2-way acquisition).
5. Service User sends TCs to the spacecraft “in the blind” to normalize spacecraft configuration.
6. If TCs are not successful, supporting ground station performs the uplink adjustment service to establish a functioning command link.
7. In parallel to establishing a command link, the station will perform any radiometric measurements possible, e.g. Doppler and antenna auto-track angles to allow FD to continue with orbit determination.
8. Acquisition of TM.
9. Commence emergency recovery operations.
10. Station commences radiometric measurements.
11. Offline delivery of data to Service User.


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### B.2.1.3 Nominal Trajectory Spacecraft RF Downlink Not Observed

1. Station activates open loop monitoring, in the event the spacecraft downlink is too weak to be acquired by closed loop configuration.
2. Station performs a nominal uplink acquisition.
3. Service User sends TCs to the spacecraft “in the blind” to normalize spacecraft configuration.
4. If TCs are not successful, ground station will perform uplink adjustment to establish a functioning command link.
5. Commanding a spacecraft transmitter failover or reset should result in the downlink being acquired and allow commencement of emergency recovery operations.
6. AOS. Acquisition of Signal, RF signal (confirms spacecraft trajectory).
7. Assuming stable downlink lock, begin auto-track to provide antenna angles for FD.
8. Acquisition of TM.
9. If spacecraft is coherent, station can confirm receiver lock in downlink frequency (2-way acquisition).
10. Commence emergency recovery operations.
11. Ground station commences radiometric measurements.
12. Offline delivery of data to Service User.

### B.2.1.4 Non-Nominal Trajectory Spacecraft RF Downlink Not Observed


1. Ground station activates open loop monitoring, in the event the spacecraft downlink is too weak to be acquired by closed loop configuration.
2. Ground station performs various spacecraft search services, e.g. along track, spiral, scan. FD may provide recommendations on search that will provide best possibility of acquisition.
3. If available, Service User request radar confirmation of spacecraft orbit from United States Army Air Force (USAAF).
4. AOS. Acquisition of signal, RF signal.
5. Ground station applies downlink signal analysis service to identify presence of a downlink signal.
6. Attempt to establish a functioning commanding link nominal acquisition or uplink adjustment service at various points through the search ephemerides recommended by FD.

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7. Ground station observes a downlink, acquires and triggers auto-track.
8. Commence emergency recovery operations.
9. Ground station commences radiometric measurements.
10. Offline delivery of tracking or orbit data, if applicable to Service User.

#### B.2.1.5 No Spacecraft Downlink After Search and Blind Commanding – Worst Case Scenario

1. Ground station activates open loop monitoring, in the event the spacecraft downlink is too weak to be acquired by closed loop configuration.
2. Assuming radar confirmation of non-nominal spacecraft orbit from USAAF.
3. FD prepares a set of off-pointing coordinates for uplink acquisition along track with Time Offset Value (TOV) or specific off-pointing selections.
4. **EXTREME CIRCUMSTANCE:** Ground station connects a “horn” to amplifier widen beamwidth of uplink signal. This is limited to LEO spacecraft due to the excessive degradation of uplink EIRP.
5. **EXTREME CIRCUMSTANCE:** Service User can deliver actual TCs to the Service Provider for uplinking locally, effectively commanding the spacecraft “in the blind” to normalize spacecraft configuration.
6. Multiple uplink acquisitions with blind commanding.
7. AOS. Acquisition of Signal, RF signal.
8. Commence emergency recovery operations.


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### B.2.2 Acknowledged Service User Scenario and Steps

1. Service User declares an emergency and alerts Service Provider IPoC of requirement for support (this includes a situation summary and any specifics for recovery operations).
  - i. Downlink acquisition (including TM Recording)
  - ii. Uplink acquisition (RF uplink licensing policy dependent)
  - iii. Engineering services (Spacecraft search service, downlink signal analysis service)
  - iv. Provision of radiometric services, as feasible for operational circumstance
  - v. Uplink adjustment services
  - vi. Emergency deployment of networking services for TM and TC links
2. Service Provider IPoC alerts Service Provider management and possibly impacted missions in routine operations.
3. Service Provider management confirms go ahead for emergency scheduling of requested facilities.
4. Acknowledged Service Providers have pre-existing ground station configuration and FD infrastructure “in situ”. Initially scheduling of facilities is the main activity.
5. An emergency creation of communications infrastructure may be triggered for real-time TM and TC links may be requested but will clearly have a significant lead time before implementation.
6. Standard pre-pass activities for configuration of station.
7. Pre-pass briefing (public phone if no communications lines established) with latest updates on spacecraft condition and targets of the FCT.
8. Beginning of Track (BOT)

The subsequent processes are defined by the manner of the emergency and include:

- B.2.2.1 - Spacecraft RF & TM available – The Simplest Scenario
- B.2.2.2 - Spacecraft RF Downlink with Non-Nominal TM Modulation or Unmodulated
- B.2.2.3 - Nominal Trajectory Spacecraft RF Downlink Not Observed
- B.2.2.4 - Non-Nominal Trajectory Spacecraft RF Downlink Not Observed
- B.2.2.5 - No Spacecraft Downlink after search and blind commanding – Worst Case Scenario

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### B.2.2.1 Spacecraft RF & TM Available – The Simplest Scenario

1. AOS. Acquisition Signal, RF downlink (confirms spacecraft trajectory).
2. Acquisition of TM (this assumes TM Frames are recorded).
3. Service User gives ground station go ahead to perform an uplink acquisition (dependant on RF restrictions).
4. If spacecraft is coherent, ground station confirms receiver lock in downlink frequency (2-way acquisition).
5. Ground station commences radiometric measurements, doppler and ranging.
6. **EXTREME CIRCUMSTANCE:** Service User delivers actual TCs to Service Provider for uplinking locally, effectively commanding the spacecraft “in the blind” to normalize spacecraft configuration.
7. Offline delivery or recorded TM frames to Service User.
8. Offline delivery of tracking or orbit data, if applicable to Service User.
9. After an expected significant delay, communications infrastructure may be deployed thus making TM and possibly TC links available online.
10. Commence emergency recovery operations.

### B.2.2.2 Spacecraft RF Downlink with Non-Nominal TM Modulation or Unmodulated

1. AOS. Acquisition of signal, RF downlink (confirms spacecraft trajectory)
2. Perform spectral analysis to identify modulation.
3. Change downlink configuration to attempt TM acquisition.
4. Acquisition of TM (this assumes TM Frames are recorded).
5. Service User gives station go ahead to attempt an uplink acquisition (dependant on RF restrictions).
6. If spacecraft is coherent, station can confirm receiver lock in downlink frequency (2-way acquisition).
7. Ground station commences radiometric measurements.
8. **EXTREME CIRCUMSTANCE:** Service User delivers actual TCs to Service Provider for uplinking locally, effectively commanding the spacecraft “in the blind” to normalise spacecraft configuration.
9. If TCs are not successful, ground station performs uplink adjustment to attempt to establish a functioning command link.
10. Offline delivery or recorded TM frames to Service User.
11. Offline delivery of tracking or orbit data, if applicable to Service User.



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12. After an expected significant delay, communications infrastructure may be deployed thus making TM and possibly TC links available online.
13. Commence emergency recovery operations.

#### B.2.2.3 Nominal Trajectory Spacecraft RF Downlink Not Observed

1. Ground station activates open loop monitoring, in the event the spacecraft downlink is too weak to be acquired by closed loop configuration
2. **EXTREME CIRCUMSTANCE:** Service User delivers actual TCs to Service Provider for uplinking locally, effectively commanding the spacecraft “in the blind” to normalize spacecraft configuration.
3. Service User gives ground station go ahead to attempt an uplink acquisition (dependant on RF restrictions).
4. If TCs are not successful, ground station performs uplink adjustment to establish a functioning command link.
5. Commanding a spacecraft transmitter failover or reset could result in the downlink being acquired and allow commencement of emergency recovery operations.
6. AOS. Acquisition of signal, RF signal (confirms spacecraft trajectory).
7. Assuming stable downlink lock begin auto-track to provide antenna angles for FD.
8. Acquisition of TM (this assumes TM Frames are recorded).
9. If spacecraft is coherent, ground station can confirm receiver lock in downlink frequency (2-way acquisition).
10. Station commences radiometric measurements.
11. Offline delivery or recorded TM frames to Service User.
12. Offline delivery of tracking or orbit data, if applicable to Service User.
13. .After an expected significant delay, once communications infrastructure may be deployed thus making TM and possibly TC links available online.
14. Commence emergency recovery operations.

#### B.2.2.4 Non-Nominal Trajectory Spacecraft RF Downlink Not Observed


1. Ground station activates open loop monitoring, in the event of spacecraft downlink is too weak to be acquired by closed loop configuration.
2. Ground station performs various search strategies, e.g. along track, spiral, scan. FD may provide recommendations on search that will provide best chance of acquisition.
3. If available, request Radar confirmation on spacecraft orbit from USAAF.
4. AOS. Acquisition of signal, RF signal.

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5. Once acquired, the ground station applies spectral analysis to identify presence of a downlink signal.
6. Assuming stable downlink lock begin auto-track to provide antenna angles for FD.
7. Acquisition of TM (this assumes TM frames are recorded).
8. Uplink acquisition.
9. If spacecraft is coherent, the ground station can confirm receiver lock in downlink frequency (2-way acquisition).
10. **EXTREME CIRCUMSTANCE:** Service User delivers actual TCs to Service Provider for uplinking locally, effectively commanding the spacecraft “in the blind” to normalise spacecraft configuration.
11. After an expected significant delay, once communications infrastructure may be deployed thus making TM and possible TC links available online.
12. Commence emergency recovery operations.

#### B.2.2.5 No Spacecraft Downlink After Search and Blind Commanding – Worst Case Scenario


1. Ground station activates open loop monitoring, in the event the spacecraft downlink is too weak to be acquired by closed loop configuration.
2. Assuming radar confirmation of non-nominal spacecraft orbit from USAAF.
3. FD prepares a set of off-pointing coordinates for uplink acquisition along track with TOV or specific off-pointing selections
4. **EXTREME CIRCUMSTANCE:** Ground station connects a “horn” to the amplifier to widen the beamwidth of uplink signal. This is limited to LEO spacecraft due to the excessive degradation of uplink EIRP.
5. **EXTREME CIRCUMSTANCE:** Service User delivers actual TCs to Service Provider for uplinking locally, effectively commanding the spacecraft “in the blind” to normalize spacecraft configuration.
6. Multiple uplink acquisitions with blind commanding.
7. AOS. Acquisition of signal, RF signal.
8. After an expected significant delay, once communications infrastructure may be deployed thus making TM and possible TC links available online.
9. Commence emergency recovery operations.

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### B.2.3 Non-Registered Service User Scenario and Steps

1. Emergency declaration by Service User and alerts Service Provider IPoC of requirement for support (this includes a situation summary and any specifics for recovery operations).
  - a. Preparation of station configuration for down and uplink acquisition
  - b. Downlink acquisition (including TM recording)
  - c. Engineering services (including spacecraft search service, downlink signal analysis service)
  - d. Provision of radiometric services (possibly limited to antenna angles and 1-way downlink doppler due to RF license issues)
  - e. Emergency deployment of networking services for TM and TC links
2. The Service User provides the spacecraft specifications and the latest orbit data to the Service Provider.
3. Service Provider IPoC alerts Service Provider Management and request Station Engineering support to configure the station to acquire the spacecraft in Emergency. Note this may be a time consuming process, causing response times to vary.
4. Service Provider OPoC alerts Service Provider Management and request Flight Dynamics support to prepare Antenna predictions to acquire the spacecraft in Emergency. Note this may be a time consuming process, causing response times to vary.
5. Service Provider management confirms go ahead for emergency scheduling of requested facilities.

The Non-Registered Service User processes, goals and scenarios are identical to those described in Section B.2.2 for Acknowledged Service Users. The only difference is the lead time to prepare the Service Provider facilities to support the spacecraft during an emergency.

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## APPENDIX C. SPACECRAFT SPECIFICATION TEMPLATE

### DOWNLINK

Carrier Frequency (Hz)  
*(\*Minimum requirement for 2.2.2 and 2.2.3 (A))* \_\_\_\_\_

Polarisation  
*(\*Minimum requirement for 2.2.2 and 2.2.3 (A))*     RHC    LHC \_\_\_\_\_

Spacecraft Antenna EIRP  
*(for Deep Space Link Budget)* \_\_\_\_\_

Antenna Pattern  
*(for Deep Space Link Budget)* \_\_\_\_\_

Coherent Turn-around Ratio \_\_\_\_\_

Modulation Type  
*(Possibly TM Rate Dependent \*Minimum requirement for 2.2.2 and 2.2.3 (A))* \_\_\_\_\_

Subcarrier Frequency (Hz)  
*(possibly TM Rate Dependent)* \_\_\_\_\_

Modulation Index  
*(possibly TM Rate Dependent)* \_\_\_\_\_

TM Coding  
*(possibly TM Rate Dependent)* \_\_\_\_\_

TM Symbol Rate (sps) \_\_\_\_\_

TM Info Rate (bps) \_\_\_\_\_

Randomiser                                     Yes    No \_\_\_\_\_

Coded Channel Access Data Unit (CADU)  
CADU=ASM+Data+Trailer *(possibly Coding Dependent)* \_\_\_\_\_

Sync Marker  
*(possibly Coding Dependent)* \_\_\_\_\_

TM Transfer Frame Length \_\_\_\_\_

Virtual Channels  
*(only House-keeping no Science)* \_\_\_\_\_

Ranging \_\_\_\_\_

Others *(to be added as required)* \_\_\_\_\_

### UPLINK


Uplink Frequency (Hz) \_\_\_\_\_

Polarisation (RHC/LHC)     RHC    LHC \_\_\_\_\_

Antenna Pattern *(for Deep Space Link Budget)* \_\_\_\_\_

Antenna Gain *(for Deep Space Link Budget)* \_\_\_\_\_

Spacecraft G/T *(for Deep Space Link Budget)* \_\_\_\_\_

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OB RCVR Pull In Range *(for Deep Space Link Budget)* \_\_\_\_\_

OB RCVR Tracking Range *(for Deep Space Link Budget)* \_\_\_\_\_

OB RCVR RF Power Dynamic Range *(for Deep Space Link Budget)* \_\_\_\_\_

Required Ground Station EIRP *(for LEO MEO, & GEO s/c)* \_\_\_\_\_

Modulation Type \_\_\_\_\_

Subcarrier Frequency (Hz) *(possibly TC Rate Dependent)* \_\_\_\_\_

Modulation Index \_\_\_\_\_

TC Coding \_\_\_\_\_

TC Rate \_\_\_\_\_

CLTU min length (Octets) \_\_\_\_\_

CLTU max length (Octets) \_\_\_\_\_

TC Protocol (PLOP1/PLOP2)     PLOP1     PLOP2

TC Format Standard \_\_\_\_\_

TC Pseudo Randomiser \_\_\_\_\_

Idle Pattern Length \_\_\_\_\_

Uplink Sweep Profile     Sweep range and speed     For Deep Space     Wide Band  
 Intermediate Band     Narrow Band

Others *(to be added as required)* \_\_\_\_\_

**RANGING TYPE**

Ranging Major Tone Frequency *(or OB BW)* \_\_\_\_\_

Modulation Type \_\_\_\_\_

TX Tone Modulation Index (Uplink) \_\_\_\_\_

RX Tone Modulation Index (Downlink) \_\_\_\_\_

Standard RNG Code Lengths *(or OB BW)* \_\_\_\_\_

Ranging Channel Equivalent Noise Bandwidth \_\_\_\_\_

On board transit time \_\_\_\_\_


**GROUND IMPLEMENTATION**

Communications \_\_\_\_\_

SLE Services \_\_\_\_\_

Service Instances \_\_\_\_\_

Voice \_\_\_\_\_

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**EXAMPLE: Venus Express, ESA Interplanetary Mission**

**DOWNLINK**

Carrier Frequency (Hz) <i>(*Minimum requirement for 2.2.2 and 2.2.3 (A))</i>	<b>8419.074073 MHz ( X-Band Deep Space), 2296.111111 MHz ( S-Band Deep Space)</b>
Polarisation <i>(*Minimum requirement for 2.2.2 and 2.2.3 (A))</i>	<input checked="" type="checkbox"/> RHC <input type="checkbox"/> LHC
Spacecraft Antenna EIRP <i>(for Deep Space Link Budget)</i>	<b>HGA X-Band 84.4 dBm, MGA X-Band 73.8 dBm, HGA S-Band 47.1 dBm, LGA S-Band 31.8 dBm</b>
Antenna Pattern <i>(for Deep Space Link Budget)</i>	<b>N/A</b>
Coherent Turn-around Ratio	<b>S/S 221/240, S/X 221/880, X/X 749/880, X/S 749/240</b> <b>PCM/PSK/PM (on square wave) at rates up to 52428.8 sps; PCM/SPL directly on carrier ( for all rates above 52428 ksps)</b>
Modulation Type <i>(Possibly TM Rate Dependent *Minimum requirement for 2.2.2 and 2.2.3 (A))</i>	
Subcarrier Frequency (Hz) <i>(possibly TM Rate Dependent)</i>	<b>8192 Hz (for lower rates); 262144 Hz (for higher rates)</b>
Modulation Index <i>(possibly TM Rate Dependent)</i>	<b>0 to 1.25 radians</b>
TM Coding <i>(possibly TM Rate Dependent)</i>	<b>Concatenated(Reed Solomon R-S 255,223 with Interleaving depth I=5 and Convolutional rate 1/2 with cconstraint length k=7)</b>
TM Symbol Rate (sps)	<b>See Appendix A</b>
TM Info Rate (bps)	<b>See Appendix A</b>
Randomiser	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
Coded Channel Access Data Unit (CADU) CADU=ASM+Data+Trailer <i>(possibly Coding Dependent)</i>	<b>2558 Bytes = 2*(4+1115+160)</b>
Sync Marker <i>(possibly Coding Dependent)</i>	<b>1A CF FC 1D</b>
TM Transfer Frame Length	<b>1115 Bytes</b>
Virtual Channels <i>(only House-keeping no Science)</i>	<b>VC0 (realtime house keeping)</b>
Ranging	
Others <i>(to be added as required)</i>	

**UPLINK**

Uplink Frequency (Hz)	<b>Nominal Carrier Frequency (Hz)7165.780092 MHz ( X-Band Deep Space); Safe Mode Carrier Frequency (Hz)2114.335648 MHz ( S-Band Deep Space)</b>
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	<b>Spacecraft Emergency Cross Support</b>	Issue: <b>1</b>
	<b>Standard Operating Processes and Procedures</b>	Revision: <b>Original</b>
		Date of issue/revision: <b>3-Dec-2019</b>

Polarisation (RHC/LHC)       RHC    LHC

Antenna Pattern (for Deep Space Link Budget)

*See Appendix Cs*

Antenna Gain (for Deep Space Link Budget)

**HGA X-Band 35.52 dBi; MGA X-Band 25.26 dBi;  
HGA S-Band 24.89 dBi; LGA S-Band -2.4 dBi**

Spacecraft G/T (for Deep Space Link Budget)

**HGA X-Band 8.33 dB/K; MGA X-Band -2.15 dB/K;  
HGA S-Band -19.37 dB/K; LGA S-Band -31.24 dB/K**

OB RCVR Pull In Range (for Deep Space Link Budget)

**Not Applicable, Spacecraft may not acquire Uplink at Receiver Rest Frequency!**

OB RCVR Tracking Range (for Deep Space Link Budget)

**±250,000 Hz**

OB RCVR RF Power Dynamic Range (for Deep Space Link Budget)

**Wide Band Acquisition: -80.0 – 123.0 dBm;  
Narrow Band Acquisition: -123.0 - -143.0 dBm**

Required Ground Station EIRP (for LEO MEO, & GEO s/c)

**S-Band LGA, minimum 128.3 dBm at 7 bps for Max Range of 250,000,000 km  
S-Band LGA, minimum 115.6 dBm at 7 bps for Min Range of 55,000,000 km  
S-Band HGA, minimum 117.9 dBm at 7 bps for Max Range of 250,000,000 km  
S-Band LGA, minimum 103.9 dBm at 7 bps for Min Range of 55,000,000 km  
X-Band MGA, minimum 111.5 dBm at 7 bps for Max Range of 250,000,000 km  
X-Band MGA, minimum 98.5 dBm at 7 bps for Min Range of 55,000,000 km  
X-Band HGA, minimum 101.5 dBm at 7 bps for Max Range of 250,000,000 km  
X-Band HGA, minimum 87.8 dBm at 7 bps for Min Range of 55,000,000 km**

Modulation Type      **PCM/PSK/PM**

Subcarrier Frequency (Hz) (possibly TC Rate Dependent)

**16000 Hz**

Modulation Index

**0.1 – 1.4 radians**

TC Coding      **NRZ-L**

TC Rate

**See Appendix B**


CLTU min length (Octets)

CLTU max length (Octets)

**306**

TC Protocol (PLOP1/PLOP2)

PLOP1    PLOP2

	<b>Spacecraft Emergency Cross Support</b>	Issue: 1
	<b>Standard Operating Processes and Procedures</b>	Revision: Original
		Date of issue/revision: 3-Dec-2019

TC Format Standard Packet Telecommand, 5 bytes for Frame leader, max 249 bytes for Frame Data Field, 2 bytes for the Frame Error Control Field

TC Pseudo Randomiser Scrambling YES

Idle Pattern Length \_\_\_\_\_

Uplink Sweep Profile  Sweep range and speed  For Deep Space  Wide Band  
 Intermediate Band  Narrow Band

Others (to be added as required) Nominal Wide Band Acquisition: Offset -10kHz, Sweep Rate 500 Hz/sec, Sweep Range ±10 kHz  
Nominal Narrow Band Acquisition: Offset -500Hz, Sweep Rate 20 Hz/sec, Sweep Range ±500 Hz

**RANGING TYPE**

Ranging Major Tone Frequency (or OB BW) 1,061,683,2 Hz

Modulation Type PSK/PM

TX Tone Modulation Index (Uplink) 0.1 – 1.4 radians

RX Tone Modulation Index (Downlink) 0.1 – 0.7 radians

Standard RNG Code Lengths (or OB BW) 14

Ranging Channel Equivalent Noise Bandwidth +20 dBHz - -10 dBHz

On board transit time \_\_\_\_\_

**GROUND IMPLEMENTATION**

Communications \_\_\_\_\_

SLE Services \_\_\_\_\_

Service Instances \_\_\_\_\_

Voice \_\_\_\_\_