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Canadian Space Agency

MULTI-MISSION OPERATION CENTER (MMOC)

Multi-Mission Antenna Reservation System Concept of Operation

Revision 1.5

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REVISION HISTORY

Rev.	Description	Initials	Date
0.1	Initial Draft	JFL	October 31, 2014
1.0	Initial Release	JFL	February 6, 2015
1.1	Integrated comments from R2 operations Integrated update from new RCM MPS ConOps resulting from TIM with Prime (notably the new Service for Contact Opportunity)	JFL	March 27, 2015
1.2	Cleaned up redlines	JFL	May 8, 2015
1.3	Corrected typos as redlined by G. B.	JFL	May 13, 2015
1.4	Integration of CCMEO comments	JFL	June 17, 2015
1.5	Update of Fig 4-1 (Service F4), Process Flow Diagram (Service F4), some typos and links corrected	JFL	July 13, 2015

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1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to define the concept of operations of the CSA Antenna Reservation System (ARS). The ARS fulfills the need of antenna resource management in the context of a multi-mission satellite control center. The ARS is a functional sub-system part of the CSA's Multi-Mission Operation Center (MMOC) architecture.

1.2 SCOPE

The ARS Concept of Operation document complies with the requirements of actual missions and missions under development such as the RCM. This document comes with the ARS companion Interface Control Document (ICD) (AD-3), which describes the interfaces with both the satellite missions and the ground station facilities.

1.3 APPLICABILITY

This document is applicable to the ARS companion ICD (AD-3) and the Requirements Document (RD-2), and to both the supported Mission and Facilities interface, as per Definitions 2.2, in which case:

- All supported Missions will be flexible to accommodate the ARS interface, namely: Radarsat-2, Scisat, NEOSSat, M3MSat, RCM, Cassiope, TET-1, Terrasar-X, Tandem-X, and Grace.
- All supported Committed Facilities will accommodate the ARS interface; it is assumed that the following stations be considered Committed Facilities:
    - Polar-Epsilon 2 Facilities in Aldergrove (CAAL) and Masstown (CAMA),
    - All Network Stations as required by Radarsat and RCM,
- All supported Canadian Uncommitted Facilities will be flexible to accommodate the ARS interface, namely:
    - CCMEO's Prince-Albert (PASS), Gatineau (GSS) and Inuvik Canadian Satellite Station (ICAN) (SXGT), and
- The ARS will be flexible to accommodate all other expected Uncommitted Facilities, which become applicable to this document, namely:
    - MDA's St-Hubert (SHUB) and Saskatoon (SASK) Facilities,
    - DRDC Shirley's Bay Satellite Facility (DRDC) in Ottawa,
    - NASA Facility in Fairbanks, Alaska,
    - KSAT's Facility operated from Norway,
    - SSC Facilities operated from Kiruna, Sweden,
    - DLR Facilities operated from Oberpfaffenhofen, Germany, and
    - CNES Facilities.

2 DEFINITIONS

2.1 ACRONYMS AND ABBREVIATIONS

ACS	Attitude Control System
AD	Applicable Document
AOS	Acquisition of Signal
ASCII	American Standard Code for Information Interchange
CAAL	Canadian Aldergrove Facility
CAMA	Canadian Masstown Facility
CCMEO	Canada Centre for Mapping and Earth Observation
CM	Configuration Management
CNES	Centre National d'Études Spatiales
CSA	Canadian Space Agency
DCS	De-Conflict System
DLR	Deutches Zentrum für Luft- und Raumfart (German Space Agency)
DR	Data Reception
DRDC	Defence Research and Development Canada
ARS	Antenna Reservation System
GFE	Government Furnished Equipment
GS	Ground Segment
GSS	Gatineau Satellite Station
GUI	Graphic User Interface
HBR	High Bit Rate
ICAN	Inuvik Canadian Satellite Station
ICD	Interface Control Document
ID	Identification
INSS	Inuvik Satellite Station
kbps	Kilobit per second
KSAT	Kongsberg Satellite Services
LEOP	Launch and Early Operations Phase
LOS	Loss of Signal
MDA	MacDonald, Dettwiler and Associates Ltd.
MMOC	Multi-Mission Operation Center
MPS	Mission Planning Subsystem
NGT	Northern Ground Terminal
NORAD	North American Aerospace Defense Command

NRT	Near-Real-Time
OGD	Other Government Department
OSI	Open Systems Interconnection model
PASS	Prince-Albert Satellite Station
PD	Parent Document
PE2	Polar Epsilon 2
RCM	RADARSAT Constellation Mission
RD	Reference Document
RF	Radio Frequency
RNG	Ranging
RT	Real-Time
SAR	Synthetic Aperture Radar
SASK	Saskatoon Facility
SCS	Satellite Control Subsystem
SF	Store and Forward
SHUB	St-Hubert Facility
SOE	Satellite Orbit Ephemeris
SRD	System Requirement Document
SSC	Swedish Space Corporation
SXGT	S-Band and X-Band Ground Terminal
TBC	To Be Confirmed
TBD	To Be Determined
TC	Telecommand
TLE	Two-Line Elements
TM	Telemetry
TT&C	Telemetry, Tracking & Commanding
UTC	Coordinated Universal Time
XML	Extensible Markup Language

2.2 TERMINOLOGY

TABLE 2-1 TERMINOLOGY DEFINITIONS

System Elements:	
System	Is the physical implementation (hardware and software) of the ARS functionalities. (Note: In addition to the System, the overall ARS may include other elements such as a Backup System, the Operator interface, the network connectivity, the voice interface, the System maintenance, the programmatic layer, etc.).
Operator	Is the personnel that commands and controls the System. The Operator has delegated rights to operate the ARS, approve Schedules, generate or edit Configurations, modify scheduling rules and algorithms, and manually reserve Antenna time. On the implementation side, there might be several classes of Operator allowing different levels of authorization and privileges on the System. However, the terminology Operator is referred to as the overarching element representing human control and decision making over the ARS.
Satellite	Consist of an Earth-orbiting spacecraft with one or multiple payloads that require ground infrastructure to allow its commanding and payload Data Reception (DR)
Mission	Consists of one or multiple Satellites, and appropriate ground segment functional elements and personnel required to conduct the mission operations such as the Mission Planning Subsystem (MPS).
Antenna	Is composed of a tracking dish reflector with RF components and baseband equipment required to conduct ranging, TT&C and/or Data Reception (DR) operations for a Satellite.
Facility	Consists of one or multiple unique ground station Antennas, and appropriate equipment, connectivity and personnel to enable either or both TT&C and DR operations.
Committed Facility	Is dedicated to the ARS for any one or all of its supported Missions and that is committed to fulfill the Committed Schedule that is being given to it by the ARS. A Schedule sent to an Committed Facility is assumed by the ARS to be blindly accepted and committed with the only exception of unforeseen events such as Antenna breakdown. It is expected that Committed Facilities be able to process the Committed Schedule within few minutes if they want to qualify for Missions that have Fast-Tasking requirements.

Uncommitted Facility	Is a Facility, domestic or foreign, that is controlled by a third-party organization but allows tasking of its Antennas through a request and confirmation process. The Approved Schedule is sent to the Uncommitted Facility in the form of an Antenna Access Request. The ARS is expecting a responsive Confirmation of the requested Schedule from the Facility by acceptance of the individual Satellite Contact entries on the submitted Antenna Access Request. Responsiveness of the Antenna Access Confirmation from the Uncommitted Facility is key to ARS' overall responsiveness in producing a Committed Schedule for the Missions Therefore, it is expected that Uncommitted Facilities be able to reply with the Confirmation within few minutes if they want to nominally be qualified for Missions that have Fast-Tasking requirements.
Network Station	Is an Antenna station used for local DR of commercial data dedicated to a commercial client of a given Mission. A Network Station is controlled by the data user and generally tasked by the user synchronously with the order of data from the Mission
Satellite Orbit TLE	Is the Orbit information at an epoch time required to propagate a Satellite's orbit and provided in a standard message format like the NORAD Two-Line Elements (TLE) AD-3.
Orbit Propagator	Is the module or set of functions (such as SGP4) required to extrapolate the Satellite's geographical position in the future from the TLE at Epoch in order to predict Satellite Contacts over Facilities. The Orbit Propagator does not necessarily require the orbit determination module to produce its own TLE from Satellite tracking data, as the TLE is generally provided by Missions or available from the online catalogue.
Satellite Attitude Ephemeris	Describes de satellite attitude in standard type like quaternion, which is required to determine RF contacts, particularly in the case of inertial pointing satellites and when the satellite antenna radiation pattern is far from the ideal isotropic case.
Satellite Antenna Definition	Describes the location, bore-sight and cone angle of receiver/transmitter antenna to be used in conjunction with the Satellite Attitude Ephemerides to determine RF contacts
Satellite Contact and Time	
Time Window	Is the time span referring to the Scheduling exercise. This may spans over several days or weeks depending on operational needs. It may also be specified to start in the future to prevent unnecessary rescheduling of imminent Committed Contacts.
Availability Time Window	Is a Time Window used in Configurations referring to the availability time of resource or personnel.

Satellite Contact	Is the time span where the Mission Satellite have a contact line-of-sight with a Facility Antenna resource, and which the resource can be allocated to the Mission on a Schedule.
Compliant Contact	Is a Satellite Contact that satisfies all the System, Mission and Facility Configuration Constraints while being a valid Contact as propagated from the Satellite Orbit TLE. The outcome of this validation process forms the Compliant Satellite Contact List.
Contact Opportunity	Is a Compliant Contact that may potentially be made available to the Mission but without being validated with the Facility. Such a contact may be in conflict with an already Committed Contact, in which case, the contact will be marked accordingly for selection purposes. The outcome of this validation process forms the Contact Opportunity Report that may be requested by the Mission as a preliminary selection tool prior a formal Satellite Contact Request.
Time Period	Is the time span specified in a Satellite Time Request within which the ARS has to allocate the Satellite Contact Times.
Satellite Contact Time	Is the total time duration specified in a Satellite Time Request to be allocated by the ARS within a Time Period. The Satellite Contact Time can be sliced across more than one Satellite Contacts depending on the availability of Antennas within the Time Period and according to specific Mission constraints relative to minimal Contact Time.
Satellite Contact States:	(see APPENDIX B Contact State Change Transition Diagram)
AVAILABLE	Is the status of a Contact Opportunity requested by the Mission through a Contact Opportunity Request that is *a priori* not in conflict with other ARS Committed or Reserved Satellite Contacts. However, an Available Contact does not guarantee that the Mission will be allocated the Contact upon a formal Satellite Contact Request.
UNKNOWN	Is the status of a Contact Opportunity requested by the Mission through a Contact Opportunity Request which availability is *a priori* not known to the ARS. This is mostly the case for all Contacts pertaining Uncommitted Facilities as the Facility has to accept the Requested Contact during the Antenna Access Request process.
CONFLICT	Is the status of a Contact Opportunity requested by the Mission through a Contact Opportunity Request that is *a priori* in conflict with another ARS Committed or Reserved Satellite Contact. The Mission may still request the Conflicted Contact to the ARS for tentative allocation with a formal Satellite Contact Request.

	That request may in some cases overrule (bump) the previous Contact during the de-conflicting and optimization process, either automatically or manually by the ARS Operator, and according to specific rules. Otherwise, the Requested Contact will still allow the rescheduling capability of the ARS to search for an alternate Satellite Contact for the Mission.
RECEIVED	Is the status of a requested Satellite Contact by the Mission through a Satellite Contact/Time Request that has been received by the ARS and nominally validated as Compliant but is pending Operator's admittance for scheduling.
ADMITTED	Is the status of a validated Satellite Contact that has been admitted by the Operator for scheduling.
REQUESTED	Is the status of a consolidated Satellite Contact/Time that is being processed by the Scheduler or has been submitted to the Facility through an Antenna Access Request.
RESERVED	Is the status of a Satellite Contact that has been manually reserved by the Operator from the Compliant Satellite Contact List and that is approved for scheduling along with Requested Contacts/Times.
ACCEPTED	Is the status of a requested Satellite Contact through an Antenna Access Request that has been accepted by the Facility but is pending commitment by the ARS Operator.
COMMITTED	Is the status of a Satellite Contact that has been accepted by the Facility and committed by the ARS.
WITHDRAWN	Is the status of a previously requested Satellite Contact that has been withdrawn by the Mission on a subsequent Satellite Contact/Time Request.
REJECTED	Is the status of a requested Satellite Contact that has been rejected either by the Facility or by the ARS.
CANCELLED	Is the status of a previously Accepted or Committed Satellite Contact that has now been cancelled by the Facility for exceptional reasons.
RESCHEDULED	Is the status of a requested Satellite Contact that has been rejected either by the Facility or by the ARS and that has been automatically rescheduled from another available Contact by the ARS. The replacement Contact will follow the acceptance and commitment process like any other requested Contact. Once Committed, the Rescheduled Contact will keep the Rescheduled label in order to notify the Mission/Facility of a time and/or Antenna change from the initial Request.

CONTINGENCY	Is the status of a Satellite Contact that has been added by the ARS as a backup to another EMERGENCY Contact on a different Antenna but without being formally allocated. The Contingency Contact is meant not to be de-conflicted, but just a fall-back option in case of urgent spacecraft emergency situation where the associated Committed EMERGENCY Contact has failed. At this stage, any bumping of pass will be handled live by the Operator and the Facility's operator, on a case by case basis, and according to agreed upon rules.
ADDED (secondary internal state)	Is the status of a Satellite Contact that has been added by the ARS or the Operator and is not directly tied to a specific Satellite Contact/Time Request. This internal status is secondary and goes in addition to any other status pertaining the approval and commitment process of a Schedule.
LOCKED (secondary internal state)	Is the status of a Committed Contact that has been Locked by the Operator to prevent any future automatic unallocation or rescheduling by the System. This internal status is secondary and goes in addition to any other status pertaining the approval and commitment process of a Schedule.
Contact Criticality	Is the qualifier of a Contact that allows prioritization during the de-conflicting process in the computation of a Schedule. Criticality ratings could be defined in importance as EMERGENCY, Important, Routine, and Proficiency.
Criticality Ratings:	
EMERGENCY	Is considered the highest priority Contact type and relates to the spacecraft Health & Safety (launch, collision avoidance, Satellite emergency recovery).
IMPORTANT	Is considered the second highest priority Contact type and relates to time-sensitive or emergency operations of the Mission (Fast-Tasking, Near-Real-Time (NRT) download, disaster monitoring, national security, etc.).
ROUTINE	Relates to all other nominal and operational Contacts.
PROFICIENCY	Is considered the lowest priority Contact type and relates to a contact that is required for periodical or ad-hoc validation and testing of the end-to-end ground systems with a specific Facility.
Schedule	
Schedule	Is a list of time-tagged Satellite Contacts for all Missions that have been allocated amongst the pool of Facility Antennas for a given Time Window. **A Schedule is conflict-free**, that is only a single Satellite Contact is allocated at any given time to an Antenna and

	with enough time margin to allow Antenna setup between Contacts. It contains, in addition, a set of fields describing for each Contact the Mission Satellite ID, the Facility Antenna ID, the Acquisition of Signal (AOS) time, Contact duration, Loss of Signal (LOS) time, maximum antenna elevation, RF bands, RF data rate, etc. The Schedule in the context of the ARS does not contain data downlink, processing or management information specific to the execution of the Data Reception contact for a given Mission. This detailed information has to be provided by the specific Mission to the Facility through another channel than the ARS.
Facility Schedule	Is a subset of the Schedule that represents only the Satellite Contacts and fields relevant to a given Facility.
Mission Schedule	Is a subset of the Schedule that represents only the Satellite Contacts and fields relevant to a given Mission.
Schedule States:	(see APPENDIX C Schedule State Change Transition Diagram)
PRELIMINARY	Is the status of a Schedule that has been generated by the System but is pending Operator's approval before sending Antenna Access Requests to Uncommitted Facilities.
APPROVED	Is the status of a Preliminary Schedule that has been approved by the Operator for access request to Uncommitted Facilities.
ACCEPTED	Is the status of a Schedule containing all Accepted Contacts from Facilities but is pending Operator's final commitment.
COMMITTED	Is the status of an Accepted Schedule that has been approved by the Operator for distribution to Missions and Committed Facilities.
OBSOLETE	Is the status of a Schedule that has been overruled by a new Committed Schedule.
Interface Messages:	
Satellite Contact Request	Is a list of desired specific Satellite Contacts that are requested by the Mission for allocation by the System on the Schedule. A Request may also include added, removed and modified Contacts from a previous Request with respect to the same Schedule Time Window.
Satellite Time Request	Is a list of desired Satellite Contact Times over desired specific Time Periods that are requested by the Mission for allocation by the System on a Schedule. Those Contact Times may exceed any single Contact duration and overlap across several Contact opportunities or Facilities. The System requires advanced

	allocation processing in order to efficiently distribute and allocate time requests amongst specific Contact opportunities in conjunction with the other standard Satellite Contact Requests.
Standing Request	Is a specific Satellite Time Request that repeats itself periodically (i.e. daily, weekly or monthly) and for a finite Standing Time Period.
Request Validity Report	Is a Satellite Contact/Time Request that was checked and validated by the System against a Compliant Satellite Contact List. The Report includes an invalidity explanation field. The report is used internally by the ARS but also is intended to be used as a form of acknowledgment to a Satellite Contact/Time Request when sent back to the Mission.
Compliant Satellite Contact List	Is the list of all Compliant Contacts for all Satellites and all Antennas generated by the Orbit Propagator and associated with a defined Schedule Time Window.
HBR Contact List	Is the list all Compliant Contacts for all Satellites and all Antennas generated by the Orbit Propagator in conjunction with the propagation of the Satellite Attitude Model, when provided in the Mission Configuration. The HBR Contact List is therefore a more constrained version of the Compliant Satellite Contact List.
Contact Opportunity Report	Is the list of all Contact Opportunities over the qualified Antennas for the specified Satellites that are generated by the Contact Opportunity Request Handler and associated with a defined Schedule Time Window.
Contact Opportunity Request	Is a simple query from a Mission to obtain the Contact Opportunity Report over a Time Period.
Antenna Access Request	Is a list of Contact Times where the System requests access to Uncommitted Facility Antenna resources in support of Missions.
Request Acknowledgment	Is a return message acknowledging reception of a Satellite Contact/Time Request by the ARS or Antenna Access Request by the Uncommitted Facility.
Antenna Access Confirmation	Is a return message accepting, rejecting or canceling Satellite Contacts from the Schedule of an Antenna Access Request. Responsiveness of the Confirmation from the Uncommitted Facility is key to ARS' overall responsiveness in producing a Committed Schedule for the Missions.
Antenna Unavailability Report	Is a list of Time Windows where the Facility Antenna is not available for allocation to a Mission. Antenna Unavailability Reports are unsolicited by the ARS and could be received at any time from the Facilities. The reasons for Unavailability can be

	anything from planned Antenna maintenance to reserved time slots for any other Mission or reason at the Facility's discretion, in the case of an Uncommitted Facility. In the Case of an Committed Facility, as the Facility is dedicated to the ARS, it is not expected that the Committed Facility be unavailable for other commitments except for maintenance.
Scheduling Report	Is a summary of Mission requirements fulfillment and Facility usage resulting from a specific Schedule. This may include the total time allocated for each Mission Satellite on Facility Antennas, the unallocated/reallocated Satellite Contacts from Requests, and relative figures of merit of allocation time and requirement fulfillment.
Facility Scheduling Report	Is a subset of the Scheduling Report that displays the specific Antenna usage relevant to a Facility.
Mission Scheduling Report	Is a subset of the Scheduling Report that displays the Satellite Contact allocation relevant to a Mission.
Configuration	Is a set of user-configurable parameters that captures the definition, constraints and requirements of a Facility, a Mission or the System . Its format could be stored as readable, binary or XML file, or simply captured by a user interface. Every System, Facility and Mission Configuration use their respective structure type but each individual has its unique parameter Configuration.
Configuration Constraints	Is a subset of the Configuration parameters that specifically addresses constraints to be used during orbit propagation and also for validation of Satellite Contact/Time Requests.

3 DOCUMENTS

3.1 APPLICABLE DOCUMENTS

The following documents of the exact issue date and revision level shown are applicable and form an integral part of this document to the extent specified herein.

Ref #	Document Number	Revision	Title
AD-3	MMCSA-IC-0003	2.7	Multi-Mission Antenna Reservation System (ARS) Interface Control Document

3.2 REFERENCE DOCUMENTS

The following documents provide additional information or guidelines that either may clarify the contents or are pertinent to the history of this document.

Ref #	Document Number	Revision	Title
RD-1	http://en.wikipedia.org/wiki/OSI_model		Open Systems Interconnection (OSI) model
RD-2	MMCSA-SP0001	2.9	Multi-Mission Antenna Reservation System (ARS) Requirements Document

4 OVERALL CONCEPT OF OPERATIONS

4.1 OVERVIEW

The ARS is a multi-mission tool part of the MMOC necessary to coordinate antenna resource allocation to multiple satellite missions. The ARS becomes more necessary when the number of satellites sharing the same pool of available antenna increases and when conflicts to antenna resource access occur more frequently. The ARS is therefore responsible to receive contact time requests from missions and best meet all mission requirements by carefully reserving antenna time to the various missions on a priority and performance basis.

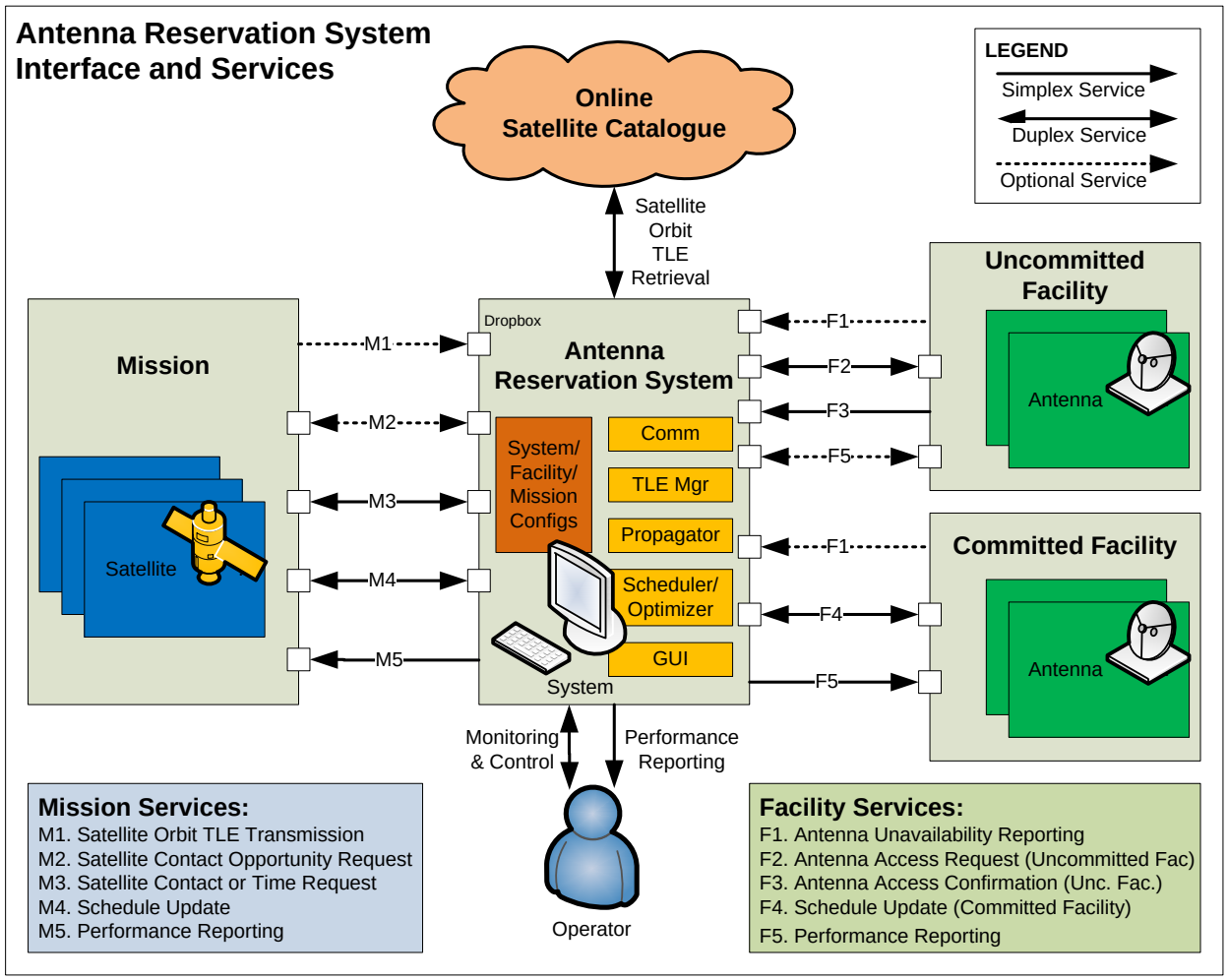


FIGURE 4-1 ARS INTERFACE AND SERVICES OVERVIEW

The ARS may be seen as the central point where all mission requests for antenna time converge to a single reservation system and where all facility resources are allocated for both TT&C and DR (For a detailed Process Flow Diagram, refer to APPENDIX A). The ARS does not deal with actual satellite operation requirements or direct commanding interfaces between the missions and the facilities (like the Spacecraft Control Subsystem (SCS)). However, the ARS does provide missions with a central antenna reservation tool to coordinate all Satellite Contacts and mitigate conflicts. In addition, the ARS does provide one interface definition to the missions therefore

saving the missions from having to manage several scheduling interfaces with the various facilities. Finally, the ARS provides one point of decision making, through the Operator and user-configurable System Configurations, when it's the time to handle different contact priority levels and mitigate conflicts.

4.2 OPERATIONAL SEQUENCE OF EVENTS

The ARS typical nominal sequence of events goes as follow:

Event 1. Reception of an unsolicited message: The ARS receives any asynchronous and unsolicited message (stimulus) amongst:

a. Contact Opportunity Request from a Mission;

b. Satellite Contact/Time Request from a Mission;

c. Satellite Orbit TLE from a Mission or manually entered by the Operator;

d. Antenna Unavailability Report from either an Committed or an Uncommitted Facility;

e. Changes to a previously received Antenna Access Confirmation from an Uncommitted Facility.

Event 2. Generation of Compliant Satellite Contact List: Upon reception of stimuli (b), (c), or (d) from Event 1, the ARS automatically propagates the orbits from Satellite Orbit TLE and generates the List of all Satellite Contacts opportunities that are compliant to Mission and Facility Constraints.

Event 3. Generation of Contact Opportunity Report: Upon reception of stimuli (a) from Event 1, the ARS generates a Contact Opportunity Report from the Compliant Satellite Contact List and the previous Committed Schedule, then sends back a Request Validity Report to the Mission.

Event 4. Validation of Satellite Contact/Time Request: Upon reception of stimuli (b), (c), (d), or (e) from Event 1, the ARS (re-)verifies the validity of all Contacts or Times in the Satellite Contact/Time Request against the Compliant Satellite Contact List and then sends back a Request Validity Report to the Mission.

Event 5. Admittance of Satellite Contact/Time Request: The ARS submits the Request to the Operator for modification and admittance to scheduling. (Note that modification and admittance is made in accordance with operational procedures and directives from the Mission Control Board in order to insure proper operation of the ARS.)

Event 6. Consolidation of Satellite Contact/Time Requests: The ARS consolidates separate and complementary Requests that may cover different services or RF bands but pertaining the same Satellite Contact. (This especially addresses the RCM concept where TT&C and DR Requests are submitted independently by the MPS). The ARS also creates/spawns individual Satellite Contact Times from accepted Standing Requests and Mission Configuration (for Autonomous Contact Management) over the Schedule Time Window.

Event 7. Manual Contact Reservation: In parallel, the Operator may at this point directly reserve Contacts from the Compliant Satellite Contact List, with superseding priority over the Satellite Contact/Time Requests. (Note that direct reservation is made in accordance with operational procedures and directives from the Mission Control Board in order to insure proper operation of the ARS.)

Event 8. Generation of the Preliminary Schedule: From accepted Satellite Contact/Time Requests and manually Reserved Contacts, the ARS automatically de-conflicts and computes a Preliminary Schedule based on priority and performance factors.

Event 9. Approval of Preliminary Schedule: The ARS submits the Preliminary Schedule to the Operator for approval. If approval is refused by the Operator, the Operator can change Configurations or Requests, thus forcing re-execution from Event 2, Event 5 or Event 7.

Event 10. Antenna Access Request: The ARS sends the Approved Schedule to Uncommitted Facilities in the form of Antenna Access Requests for their acceptance.

Event 11. Antenna Access Confirmation: Uncommitted Facilities reply with a Request reception acknowledgement and send an Accepted Schedule as a Antenna Access Confirmation. (Note that at any later time, an Uncommitted Facility could change its Schedule acceptance status by resubmitting an unsolicited modified Confirmation referring to the appropriate Antenna Access Request, in which case the ARS will be forced back to Event 6)

Event 12. Commitment of the Accepted Schedule: The ARS submits the Accepted Schedule from the Facilities to the Operator for commitment. If commitment is refused by the Operator, the Operator can change Configurations or Requests, thus forcing re-execution from Event 2, Event 5 or Event 7.

Event 13. Distribution of the Committed Schedule: The ARS distributes the Committed Schedule to Missions and Committed Facilities (Uncommitted Facilities are expected to abide by their own Antenna Access Confirmation at Event 11).

Event 14. Committed Schedule Acknowledgment: Missions and Committed Facilities reply with a Schedule reception acknowledgement.

Event 15. Distribution of Scheduling Reports: The ARS computes and sends Scheduling Reports to Missions and to the Operator.

In parallel to the whole sequence of events, the ARS retrieves periodically the Satellite Orbit TLE from online satellite catalogues to make sure the information is always up to date in case the Mission doesn’t send it during Event 1.

Also, at any time, the Operator can manually abort and start the computation of a Preliminary Schedule and make changes to Configurations, thus forcing the re-execution of the Sequence from Event 2, Event 5 or Event 7.

For a detailed Process Flow Diagram, refer to APPENDIX A.

5 MISSION SERVICES

Mission interface is detailed in AD-3. Also, the ARS knows, through the Mission Configuration, all information pertaining the Mission that is required to do appropriate compatibility validation with Facilities and Satellite Contacts.

As presented on Figure 4-1, and defined in Terminology Definitions in Section 2.2, there are five (5) services associated with Missions, which are further described below:

- M1: Satellite Orbit TLE
- M2: Contact Opportunity Request
- M3: Satellite Contact/Time Request
- M4: Schedule Update
- M5: Reporting

5.1 M1: SATELLITE ORBIT TLE

The ARS contains an orbit propagator allowing prediction of Satellite Contacts over Facilities. Although the propagator will have connection with Online Satellite Catalogues, Missions may provide Satellite Orbit TLE to help the ARS keep orbit propagation up-to-date and accurate, especially in the case of projected Satellite orbit maneuvers. (see also 9.1 Use Case: Mission sends a Satellite Orbit TLE file)

5.2 M2: CONTACT OPPORTUNITY REQUEST

Missions may request Contact Opportunities from the ARS for preliminary planning before submitting a formal Request. (see also 9.3 Use Case: Mission sends a Contact Opportunity Request)

After validation of the request the ARS will mark conflicted contacts from the Compliant Satellite Contact List and filter the list for the specific Mission. Then, the ARS returns the Contact Opportunity Report to the Mission that contains the following information:

- Facility ID,
- Facility type [COMMITTED, UNCOMMITTED],
- Spacecraft ID,
- Start and End time of Contact in UTC,
- Contact Status [AVAILABLE, CONFLICT, UNKNOWN]
- Others .

5.3 M3: SATELLITE CONTACT/TIME REQUEST

The ARS can support two (2) types of Requests from Missions as described below. (see also 9.4 Use Case: Mission sends a Satellite Contact/Time Request)

5.3.1 Generic Satellite Contact Requests

Most missions will use the Generic Satellite Contact Request method as specified in AD-3. Therefore this method is considered the *de facto* standard to be followed. Satellite Time Request is an exception and will be detailed below.

The Generic Satellite Contact Request consist of sending to the ARS a list of Satellite Contacts to be used for a mission and, the required times the Antenna should start and stop tracking the Satellite . Other parameters are also present in the request to complete the information required.

RF Bands and Channels

For this type of request, it is possible to specify a single RF band or multiple RF bands or channels as required for the support. In any cases the Mission is responsible to merge, prior to the reservation request, the various RF band and channel Requests in a single multi-band Request for support.

Supported Missions

It is expected that all Canadian Missions will be flexible to accommodate this Satellite Contact Request interface, namely: Radarsat-2, Scisat, NEOSSat, M3MSat. (note that the interface with RCM is specified in another ICD)

5.3.2 Satellite Time Requests (Optional)

There is an optional case where a Mission may use a Satellite Time Request instead of the Generic Satellite Contact Request. The Satellite Time Request is based on the submission of a Time Period in which a Total Contact Time is requested. The Time Period is define in UTC and consist of a start and end time. The Total Contact Time Requested is the duration of Satellite Contact within the Time Period.

Acceptable Facility

For each Contact Time Request, the Mission will also provide a list of Acceptable Facilities. In the event the downlink needs to be performed from specific Antenna, the Acceptable Facilities field will contain only one Antenna and the ARS will have to use this as constraint during scheduling.

Bands

Similar to 5.3.1 Generic Satellite Contact Requests, it is possible to specify RF Bands and the Mission is expected to provide a consolidated Request.

ARS Supported Missions

Note that no Mission is foreseen to support Satellite Time Requests yet, although some relatively low priority operational Missions may benefit greatly from using Satellite Time Requests as it is more flexible and allows a greater probability of Contact allocation by scheduling around other more restrictive and high-priority Mission requests.

5.4 M4: SCHEDULE UPDATE

After each de-conflicting and optimizing cycles, the ARS issue a Schedule update to the Missions and Committed Facilities. As these cycles may be triggered manually by the Operator or automatically from by various stimuli such as incoming Antenna Unavailability Reports, the

Schedule update is expected to be issued in an asynchronous fashion and several times a day. However, any Mission Configuration Constraints pertaining change to previous schedules and re-planning lead-times will be taken into account inside the Scheduler in order to prevent incompatible changes to previous commitments when the updated Schedule is resubmitted to the Mission (and Facility).

5.5 M5: REPORTING

Periodically and according to Mission Configurations, the ARS issue Scheduling Reports on the usage of Antenna resources and (successful) execution of Satellite Contacts.

6 FACILITY SERVICES

Facility interfaces are detailed in AD-3.The ARS knows, through the Facility Configuration, all information pertaining the Facility that is required to do appropriate compatibility validation with Missions and Satellite Contact Requests.

As defined in Terminology Definitions in Section 2.2, two types of Facilities are considered by the ARS and have their specific interface description.

- Committed Facility
- Uncommitted Facility

In addition, as presented on Figure 4-1, and defined in Terminology Definitions in Section 2.2, there are five (5) services associated with Facilities, which are further described below:

- F1: Antenna Unavailability Reporting
- F2: Antenna Access Request (Uncommitted Facility only)
- F3: Antenna Access Confirmation (Uncommitted Facility only)
- F4: Schedule Update (Committed Facility only)
- F5: Reporting

The stations that are expected to support services F2 and F3 are CCMEO's PASS, GSS and ICAN, DRDC, MDA'a SHUB and SASK, KSAT and SSC stations.

The only stations that are expected to support service F4 (so far) are Polar Epsilon 2: CAMA and CAAL

There are also a number of other stations that have not yet been categorized with Facility type such as Fairbanks, and Hartbeeshoek (HBK).

6.1 F1: ANTENNA UNAVAILABILITY REPORTING

Facilities may provide Antenna Unavailability Reports to help the ARS schedule around specific unavailability time periods such as scheduled maintenance downtimes. (see also 9.2 Use Case: Facility sends an Antenna Unavailability Report)

6.2 F2: ANTENNA ACCESS REQUEST

As per Definitions, the Uncommitted Facility will not be provided with a Committed Schedule, but rather an Antenna Access Request as ARS will not know in advance if the requested Contacts are available when the Mission first request for it. The Request is followed with an Acknowledgment from the Facility within few minutes.

Eventually, the ARS will be expecting the reception of an Antenna Access Confirmation accepting or refusing Contacts on the related Request.

6.3 F3: ANTENNA ACCESS CONFIRMATION

Following a previous Antenna Access Request from the ARS, the Facility sends the Antenna Access Confirmation. Accepted Contacts received back from the Facility through the Antenna Access Confirmation will be considered Committed at the Facility unless the ARS cancels it on a

sub-sequent Antenna Access Request. (see also 9.5 Use Case: Facility updates an Antenna Access Confirmation)

6.4 F4: SCHEDULE UPDATE

As per Definitions, the Committed Facility will be provided only with the Committed Schedule to be assimilated integrally for the baseline operations.

6.5 F5: REPORTING

Periodically and according to Facility Configurations, the ARS issue Scheduling Reports on the usage of Antenna resources and (successful) execution of Satellite Contacts.

7 SYSTEM OPERATIONS

7.1 SYSTEM MODES

7.1.1 Autonomous Behavior

The ARS is expected to automatically handle files in and out to the Missions and Facilities. In addition, based on the Process Flow Diagram in APPENDIX A, the ARS is expected to have automated functions to:

1. manage TLEs from various sources and for various Epoch,
2. generate the Compliant Satellite Contact List,
3. acknowledge and validate Requests from Missions,
4. consolidate the Requests and generate the de-conflicted Schedule,
5. request Antenna access at Uncommitted Facilities, and
6. produce the Committed Schedule and reports to the Missions and Facilities.

However, the Operator's intervention is required to:

1. edit the System, Mission and Facility Configurations,
2. enter manually the TLE, if required by Missions,
3. reserve contacts from the Compliant Satellite Contact List as needed,
4. admit Requests to the scheduling process,
5. approve the Preliminary Schedule before submitting Antenna Access Requests,
6. commit the Accepted Schedule from the Facility, and
7. monitor the System's performance from Reports

7.1.2 Override of Manual Intervention

As the System is commissioned and made more robust to exceptions, it is expected that the System become more automated. As such, the System has provision through the System Configuration and specifically through the Mission Configuration to allow override of manual interventions defined above. It is envisioned that, unless there are specific contacts to be reserved by the Operator, any Requests would be handled and processed automatically from the Request to the delivery of an updated Schedule to the Missions and Facilities. This has the expected benefit to reduce Operator's workload and accelerate Request turnaround time in the context of a modern multi-mission operation center.

7.2 HARDWARE OPERATIONS

The hardware operations of the ARS is expected to be a computer system including a terminal for manual operations, system diagnosis and maintenance. It is expected that a main and backup system will be used to ensure a high availability and that switchover to the backup unit will be transparent to the operations.

The system will inform the Operator of a malfunction, failure or that a manual intervention is required via the means listed below in section 7.4. The Operator will also be responsible to inform the depending Missions when a planned downtime is expected.

The system will be in operations 24/7.

7.3 SOFTWARE OPERATIONS

(Section to be completed during the Design Phase)

7.3.1 TLE Management

7.3.2 Contact Predictions

7.3.3 Contact Opportunity Request Handling

7.3.4 Satellite Contact/Time Request Handling

7.3.5 De-conflicting and Optimization

7.3.6 Antenna Access Handling

7.3.7 Data Product Handling

7.4 OPERATOR

7.4.1 Operator Availability

The Operator will be present 24/7 in the Multi-Mission control center and will perform several tasks including the ARS operations. Therefore the ARS is expected to inform and attract attention to the operations personnel on-site when a malfunction, failure or a manual intervention is required.

7.4.2 System Health Monitoring

The ARS will have the capability to monitor its health and status to preserve the operational availability and timeline.

Via visual and audible means or any other efficient means, the ARS will be able to inform the Operator and attract his/her attention when a malfunction, failure or a manual intervention is required.

(Section to be completed during the Design Phase)

7.4.3 Manual TLE Entry

7.4.4 Admittance of Requests

7.4.5 Manual Contacts Reservation

7.4.6 Approval and Commitment of Schedules

7.4.7 System Configuration Parameters

7.4.7.1 Scheduling Period

7.4.8 Schedule Optimization Algorithm Tuning

(See also APPENDIX C Schedule State Change Transition Diagram)

7.4.8.1 Admittance of Requests

7.4.8.2 Approval of Preliminary Schedules

7.4.8.3 Commitment of Accepted Schedules

7.5 CONFIGURATION CONTROL

Configuration control of the hardware and software will be governed by approval boards and formal CM processes.

The ARS will display the software version on the screen to allow the Operator to easily confirm the running version of the software on the main and backup unit.

7.5.1 System Change

The Operator will be able to access the System for operational parameter change, produce report and perform system maintenance via a standard modern Graphical User Interface (GUI). Operational Parameter change will allow the Operator to change the System in order to optimize its performance and the potential changes required by the operational environment.

Changes will be under CM control.

7.5.2 System Upgrades

Operational reality will require the software to be updated as required to fix bugs and improve performance and functionality. It is expected that system upgrades will be tested prior to implementation into the operational system.

Once successfully tested the main ARS computer system will be upgraded while the backup will remain operational with the previous software version. Once the new software has been confirmed operationally satisfactory, the backup computer will be upgraded to the new software.

It is expected that during this whole upgrade process, the main/backup switchover functionality, the specified performance, availability and functionality will be preserved.

Upgrades will be under CM control.

8 OPERATION PROCESSES

8.1 MULTI-MISSION PLANNING

(Section to be completed during the Design Phase)

8.1.1 Missions Coordination Board

8.1.1.1 Missions Relative Priority

8.1.1.2 Facility Preferences

8.1.1.3 Contact Criticality

8.1.2 Schedule Period Definition

8.1.3 System, Mission and Facility Configurations

8.2 OPERATIONS EXECUTION PROCESSES

8.2.1 Antenna Access Request Iterations

8.2.2 Satellite Contact/Time Request Iterations

8.3 EVALUATION PROCESSES

8.3.1 Scheduling Reports

8.4 DATA RECEPTION

Data transfer formats and transportation mechanisms between the ARS and the Missions, and between the ARS and the Facilities, are described in AD-3

8.5 DATA TRANSMISSION

Data transfer formats and transportation mechanisms between the ARS and the Missions, and between the ARS and the Facilities, are described in AD-3

8.6 DATA PROCESSING

8.7 SATELLITE CONTACT/TIME REQUEST TURNAROUND TIME

In order to enable higher flexibility for Fast-Tasking, the ARS is meant to update and distribute an updated Committed Schedule within 15 minutes from reception of a Satellite Contract/Time Request. Figure 2 depicts the timeline from a given Request to the Schedule.

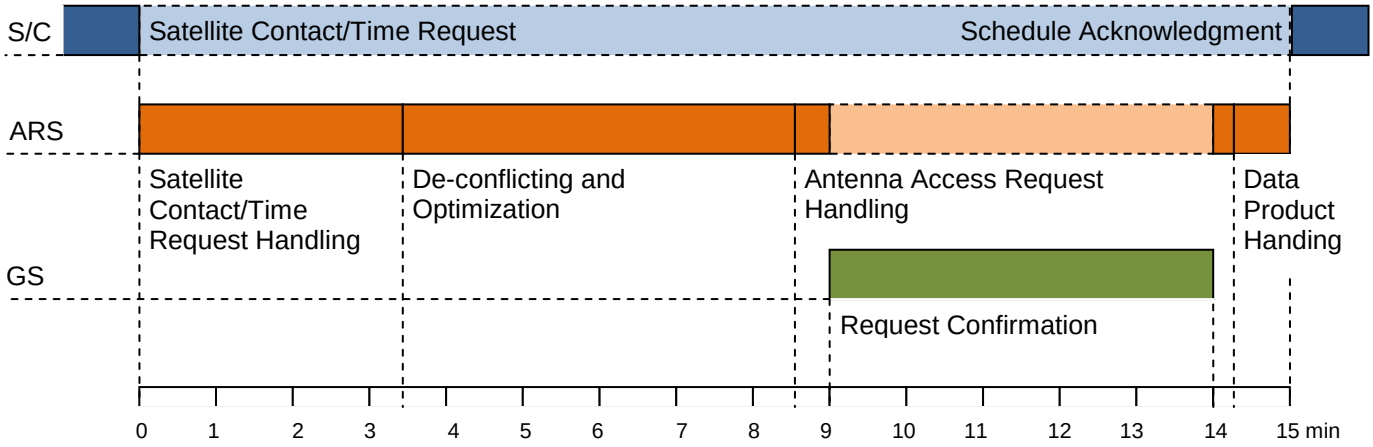


FIGURE 2 SATELLITE CONTACT/TIME REQUEST TURNAROUND TIME

The overall turnaround time is constrained to 15 minutes for fast turnaround and Fast-Tasking purposes. The flexibility inside the timeline lies in the De-conflicting and Optimization process, where an internal timeout period is used to limit the optimal solution finding, such as to insure a close-to-optimal Schedule solution is issued in a timely fashion.

The only external dependency to this timeline is related to the Antenna Access Confirmation turnaround time from the Uncommitted Facility, in which case a timeout of 5 minutes will be set in the System Configuration in order to guarantee the overall turnaround time. The Schedule will keep the unaccepted Contacts marked as Received until explicitly Accepted or Rejected by the Uncommitted Facility. If an Antenna Access Confirmation is received by the ARS after the set timeout period, the ARS will commit another Schedule to the Missions reflecting the Facility acceptance changes, as required.

9 USE CASE SCENARIOS

The Use Cases are based on the Process Flow Diagram in APPENDIX A. The Process Flow suggests a specific design implementation by modules to help understand the interactions with the external interfaces (Missions or Facilities). However, the module functional boundaries can be flexible to accommodate another implementation as long as there is no impact at the interfaces. Also, to ease the tracing of events, each box in the Diagram are numbered and referred to with brackets in the text.

9.1 USE CASE: MISSION SENDS A SATELLITE ORBIT TLE FILE

1. At the earliest convenience, the Mission may optionally provide an unsolicited Satellite Orbit TLE file to the ARS according to AD-3. The file can include more than one TLE entries at different Epochs in order to reflect prediction of orbit changes due to modeled perturbations and projected orbit maneuvers.
2. The TLE file handled by the TLE Management module:
    a. The TLE file is received and handled by the ARS interface manager [1a] but there is no communication handshaking between the Mission and the ARS beyond the transport layer (RD-1).
    b. The TLE file is ingested by the TLE Manager [1c], along with the TLE from other sources such as manually entered [1b] and Online Satellite Catalogs. Based on System Configuration and Operators inputs, the TLE Manager select the most relevant set of TLE to push to the Orbit Propagator
3. The TLEs are handled by the Contact Prediction module.
    a. The Orbit Propagator [2c] executes the orbit models and generate an updated Compliant Satellite Contact List for the configured Schedule Period.
4. The updated Compliant Satellite Contact List is processed by the Request Handling module:
    a. The Request Handling module re-validates previous Satellite Contact Requests [4d] with respect to the updated Compliant Satellite Contact List
    b. The Request Handling module updates and resubmits a Request Validity Report [4e] in the unlikely case where the Contact time update had an impact on the validity of a Request.
5. The updated Compliant Satellite Contact List is processed by the De-conflicting and Optimization module:
    a. From the List, a new Preliminary Schedule is generated [8] in the unlikely case where the Contact time update had an impact on the committed Schedule.
    b. The Preliminary Schedule is submitted for approval to the Operator [9]
6. The Preliminary Schedule is proceeded to the Antenna Access Handling module
    a. New Antenna Access Requests are submitted to Uncommitted Facilities [10a], as required.

b. Antenna Access Confirmations are received and handled by the ARS interface manager [11a] but there is no communication handshaking at this point between the Mission and the ARS beyond the transport layer (RD-1)

c. The Confirmation file is scanned for any Rejected Contacts and a new Accepted Schedule is formed [11b]. The Rejected Contacts are signified to the De-conflicting and Optimization module.

7. The Accepted Schedule is processed by the Data Product Handling module

   a. The Accepted Schedule is submitted to the Operator for commitment [12]

   b. Once committed by the Operator, the Schedule is transmitted to the Mission [13a]. There is communication handshaking in this process as the ARS interface manager will be polling its inbox [13b] for acknowledgment of reception of the new Schedule by the Mission.

   c. The Schedule is transmitted to the Committed Facilities [14a] but there is no communication handshaking between the Mission and the ARS beyond the transport layer.

   d. The various reports are generated and distributed to the Operator, the Missions and Facilities [15].

9.2 USE CASE: FACILITY SENDS AN ANTENNA UNAVAILABILITY REPORT

1. At the earliest convenience, the Facility may optionally provide an unsolicited Antenna Unavailability Report file to the ARS according to AD-3. The file can include more than one entry, and may add, modify or withdraw entries from previous files.
2. The Antenna Unavailability Report file handled by the Contact Prediction module:

   a. The file is received and handled by the ARS interface manager [2a] but there is no communication handshaking between the Mission and the ARS beyond the transport layer (RD-1).

   b. The Orbit Propagator [2c] executes the orbit models and generate an updated Compliant Satellite Contact List for the configured Schedule Period.

3. The updated Compliant Satellite Contact List is processed by the Request Handling module:

   a. The Request Handling module re-validates previous Satellite Contact Requests [4d] with respect to the updated Compliant Satellite Contact List

   b. The Request Handling module updates and resubmits a Request Validity Report [4e] in the unlikely case where the Contact time update had an impact on the validity of a Request.

4. The updated Compliant Satellite Contact List is processed by the De-conflicting and Optimization module:

   a. From the List, a new Preliminary Schedule is generated [8] in the unlikely case where the Contact time update had an impact on the committed Schedule.

   b. The Preliminary Schedule is submitted for approval to the Operator [9]

5. The Preliminary Schedule is proceeded to the Antenna Access Handling module
    a. New Antenna Access Requests are submitted to Uncommitted Facilities [10a], as required.
    b. Antenna Access Confirmations are received and handled by the ARS interface manager [11a] but there is no communication handshaking at this point between the Mission and the ARS beyond the transport layer (RD-1)
    c. The Confirmation file is scanned for any Rejected Contacts and a new Accepted Schedule is formed [11b]. The Rejected Contacts are signified to the De-conflicting and Optimization module.
6. The Accepted Schedule is processed by the Data Product Handling module
    a. The Accepted Schedule is submitted to the Operator for commitment [12]
    b. Once committed by the Operator, the Schedule is transmitted to the Mission [13a]. There is communication handshaking in this process as the ARS interface manager will be polling its inbox [13b] for acknowledgment of reception of the new Schedule by the Mission.
    c. The Schedule is transmitted to the Committed Facilities [14a] but there is no communication handshaking between the Mission and the ARS beyond the transport layer.
    d. The various reports are generated and distributed to the Operator, the Missions and Facilities [15].

9.3 USE CASE: MISSION SENDS A CONTACT OPPORTUNITY REQUEST

1. At the earliest convenience, the Mission may optionally provide an unsolicited Contact Opportunity Request according to AD-3.
2. The Request file is handled by the Contact Opportunity Request Handling module.
    a. The Request file is received and handled by the ARS interface manager [3a] but there is no communication handshaking at this point between the Mission and the ARS beyond the transport layer (RD-1)
    b. The module filter the computed Compliant Satellite Contact List for the mission and validates it against the Committed Schedule[3b] in order to produce Contact Opportunity Report.
    c. The module transmits a Contact Opportunity Report [3c] to the Mission containing all contact opportunities and qualifying each contact whether it is available or conflicting with another committed contact.
3. The Mission may follow up with 9.4 Use Case: Mission sends a Satellite Contact/Time Request

9.4 USE CASE: MISSION SENDS A SATELLITE CONTACT/TIME REQUEST

1. At the earliest convenience, the Mission provides an unsolicited Satellite Contact or Time Request according to AD-3. The file can include more than one Contact/Time entries and may add, modify or withdraw entries from previous Requests.

2. The Request file is handled by the Request Handling module.
    a. The Request file is received and handled by the ARS interface manager [4a] but there is no communication handshaking at this point between the Mission and the ARS beyond the transport layer (RD-1)
    b. The Request Handling module correlates the Request with respect to previous request submission to seek for added, withdrawn and modified Contact/Time entries [4b].
    c. Satellite Time Requests are validated against Facility and Mission Configuration constraints [3c] and Satellite Contact Requests are validated against the previously computed Compliant Satellite Contact List [4d]
    d. The module produces and transmits a Request Validity Report [4e] to the Mission containing all historical Contact/Time entries received so far with their status (received. withdrawn, rejected).
    e. The Received Request entries are submitted to the Operator for admittance to scheduling [5].
3. The Admitted Request is processed by the De-conflicting and Optimization module:
    a. Standing Requests are stored and specific Time Requests are spawned for the Scheduling Period [6a]
    b. All Admitted Contact/Time Requests are consolidated with spawned Standing Requests [6b]
    c. A new Preliminary Schedule is generated [8] from the Requested Contacts/Times and the Reserved Contacts.
    d. The Preliminary Schedule is submitted for approval to the Operator [9]
4. The Preliminary Schedule is proceeded to the Antenna Access Handling module
    a. New Antenna Access Requests are submitted to Uncommitted Facilities [10], as required.
    b. Antenna Access Confirmations are received and handled by the ARS interface manager [11a] but there is no communication handshaking at this point between the Mission and the ARS beyond the transport layer (RD-1)
    c. The Confirmation file is scanned for any Rejected Contacts and a new Accepted Schedule is formed [11b]. The Rejected Contacts are signified to the De-conflicting and Optimization module.
5. The Accepted Schedule is processed by the Data Product Handling module
    a. The Accepted Schedule is submitted to the Operator for commitment [12]
    b. Once committed by the Operator, the Schedule is transmitted to the Mission [13a]. There is communication handshaking in this process as the ARS interface manager will be polling its inbox [13b] for acknowledgment of reception of the new Schedule by the Mission.

c. The Schedule is transmitted to the Committed Facilities [14a] but there is no communication handshaking between the Mission and the ARS beyond the transport layer.

d. The various reports are generated and distributed to the Operator, the Missions and Facilities [15].

9.4.1 Request Modification

A new Request or the modification of a previous Request pertaining the same Contact/Time entries are handled as the same. After reception of the Request, the Request Handler correlates each entries with previous information [4b] before doing any more processing. This is possible since each entry is using a unique entry ID and any later reference to this entry ID from the Mission would suppose a Request entry modification or deletion.

From the Mission interface, it is expected that the only actions that can be directed through the Request by the Mission for a given entry are:

- ADD, or
- WITHDRAW.

It is expected that any ADD action pointing to an already used entry ID will be considered as an actual Request modification in any cases, whereas WITHDRAW will remove it from the System and from any further scheduling.

9.4.2 Standing Request

A Standing Request is a special case of Satellite Time Request where the Time is requested to be recurring over time. The recurring pattern and time range would be specified as fields within the first submission of the Satellite Time Request. A Standing Request entry can therefore be added, withdrawn or modified by the Mission at anytime like any other Request. The automatic generation of recurring entries will happen at the ARS [6a] prior de-conflicting and scheduling process and spans for the configured Schedule Period.

9.4.3 Fast-Tasking Request

Fast-tasking refers to a Request for a Contact/Time than happens on a short notice (less than few hours) and requires the ARS to quickly respond with a Committed Contact. In order to enable higher flexibility for Fast-Tasking, the ARS is meant to update and distribute an updated Committed Schedule within 15 minutes. (See Section 8.7 Satellite Contact/Time Request turnaround time)

9.5 USE CASE: FACILITY UPDATES AN ANTENNA ACCESS CONFIRMATION

1. At any time, the Facility may submit an unsolicited Antenna Access Confirmation file to the ARS pertaining a pending Antenna Access Request or overriding a previous Antenna Access Confirmation, and according to AD-3. The file can include more than one entries and may add, modify or withdraw entries from previous Confirmations.
2. The Confirmation file is handled by the Antenna Access Handling module

a. Antenna Access Confirmation is received and handled by the ARS interface manager [11a] but there is no communication handshaking at this point between the Mission and the ARS beyond the transport layer (RD-1).

b. The Confirmation file is scanned for any Canceled Contacts and a new Accepted Schedule is formed [11b].

3. The Cancelled Contacts are signified to the De-conflicting and Optimization module:

   a. A new Preliminary Schedule is generated [8] from the Requested Contacts/Times and the Reserved Contacts, taking into account the new unavailability window.

   b. The Preliminary Schedule is submitted for approval to the Operator [9]

4. The Preliminary Schedule is proceeded to the Antenna Access Handling module

   a. New Antenna Access Requests are submitted to Uncommitted Facilities [10a], as required.

   b. Antenna Access Confirmations are received and handled by the ARS interface manager [11a] but there is no communication handshaking at this point between the Mission and the ARS beyond the transport layer (RD-1)

   c. The Confirmation file is scanned for any Rejected Contacts and a new Accepted Schedule is formed [11b]. The Rejected Contacts are signified to the De-conflicting and Optimization module.

5. The Accepted Schedule is processed by the Data Product Handling module

   a. The Accepted Schedule is submitted to the Operator for commitment [12]

   b. Once committed by the Operator, the Schedule is transmitted to the Mission [13a]. There is communication handshaking in this process as the ARS interface manager will be polling its inbox [13b] for acknowledgment of reception of the new Schedule by the Mission.

   c. The Schedule is transmitted to the Committed Facilities [14a] but there is no communication handshaking between the Mission and the ARS beyond the transport layer.

   d. The various reports are generated and distributed to the Operator, the Missions and Facilities [15].

9.6 USE CASE: OPERATOR ENTERS A TLE MANUALLY

Same as 9.1 Use Case: Mission sends a Satellite Orbit TLE file

9.7 USE CASE: OPERATOR CHANGES FACILITY OR MISSION CONFIGURATIONS

Same as 9.2 Use Case: Facility sends an Antenna Unavailability Report

9.8 USE CASE: OPERATOR CHANGES ADMITTANCE OF REQUESTS

Similar to 9.4 Use Case: Mission sends a Satellite Contact/Time Request

9.9 USE CASE: OPERATOR RESERVES CONTACTS FROM LIST

1. At any time, the Operator may (un)reserve Contacts from the Compliant Satellite Contact List [7].
2. The Reserved Contacts are processed by the De-conflicting and Optimization module:
    a. A new Preliminary Schedule is generated [8] from the Requested Contacts/Times and the Reserved Contacts.
    b. The Preliminary Schedule is submitted for approval to the Operator [9]
3. The Preliminary Schedule is proceeded to the Antenna Access Handling module
    a. New Antenna Access Requests are submitted to Uncommitted Facilities [10a], as required.
    b. Antenna Access Confirmations are received and handled by the ARS interface manager [11a] but there is no communication handshaking at this point between the Mission and the ARS beyond the transport layer (RD-1)
    c. The Confirmation file is scanned for any Rejected Contacts and a new Accepted Schedule is formed [11b]. The Rejected Contacts are signified to the De-conflicting and Optimization module.
4. The Accepted Schedule is processed by the Data Product Handling module
    a. The Accepted Schedule is submitted to the Operator for commitment [12]
    b. Once committed by the Operator, the Schedule is transmitted to the Mission [13a]. There is communication handshaking in this process as the ARS interface manager will be polling its inbox [13b] for acknowledgment of reception of the new Schedule by the Mission.
    c. The Schedule is transmitted to the Committed Facilities [14a] but there is no communication handshaking between the Mission and the ARS beyond the transport layer.
    d. The various reports are generated and distributed to the Operator, the Missions and Facilities [15].

9.10 USE CASE: OPERATOR CHANGES SYSTEM CONFIGURATION

Similar as 9.9 Use Case: Operator Reserves Contacts from List

APPENDICES

APPENDIX A PROCESS FLOW DIAGRAM

1 Satellite Orbit TLE Management
   a. Reception of Satellite Orbit TLE
   b. Manual TLE Entry
   c. TLE Manager
2 Satellite Contact Prediction
   a. Reception of Antenna Unavailability Report
   b. Manual Facility/Mission Configuration Change
   c. Orbit Propagation and Contact Prediction
   d. Attitude Propagation and HBR Prediction
3 Contact Opportunity Request Handling
   a. Reception of Contact Opportunity Request
   b. Generation of Contact Opportunity Report
   c. Transmission of Contact Opportunity Report
4 Satellite Contact/Time Request Handling
   a. Reception of Satellite Contact/Time Request
   b. Deletion of Satellite Contact/Time Request
   c. Validation of Satellite Time Request
   d. Validation of Satellite Contact Request
   e. Transmission of Satellite Contact/Time Request Validity Report
5 Admittance of Satellite Contact/Time Requests
   a. Manual Admittance of Satellite Contact/Time Requests
   b. Admittance evaluation of Satellite Contact/Time Requests
6 Standing Request Management
   a. Spawning of Standing Time Requests
   b. Consolidation of Satellite Contact/Time Requests
7 Manual Contact Reservation
   a. Manual Contact Reservation
   b. Manual System Configuration Change
8 De-conflicting and Optimization
9 Manual Approval of Preliminary Schedule
10 Antenna Access Requesting

a. Transmission of Antenna Access Request
b. Reception of Antenna Access Request Acknowledgment

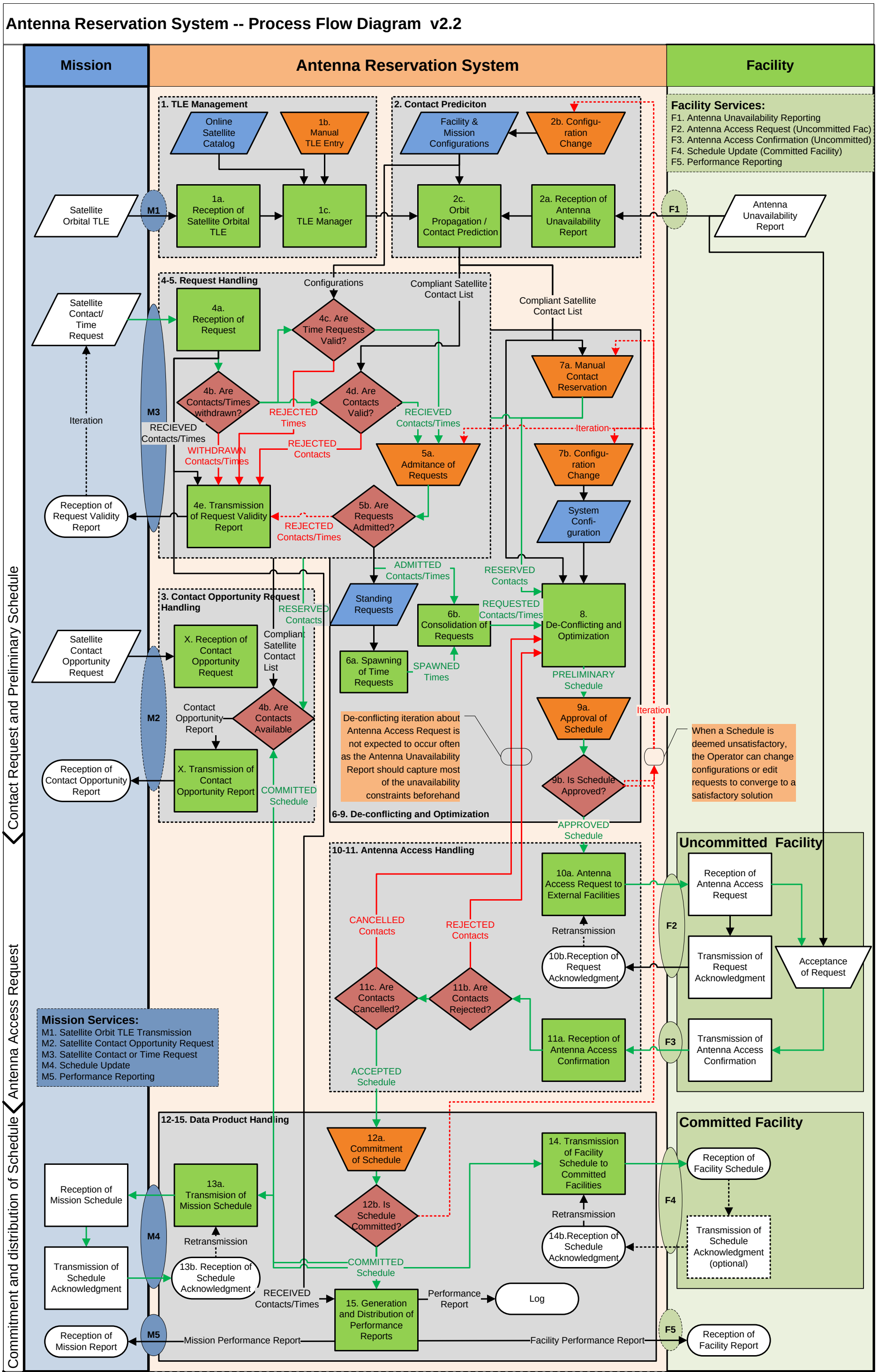
11 Antenna Access Confirmation
a. Reception of Antenna Access Confirmation
b. Evaluation of Antenna Access Confirmation

12 Manual Commitment of Schedule

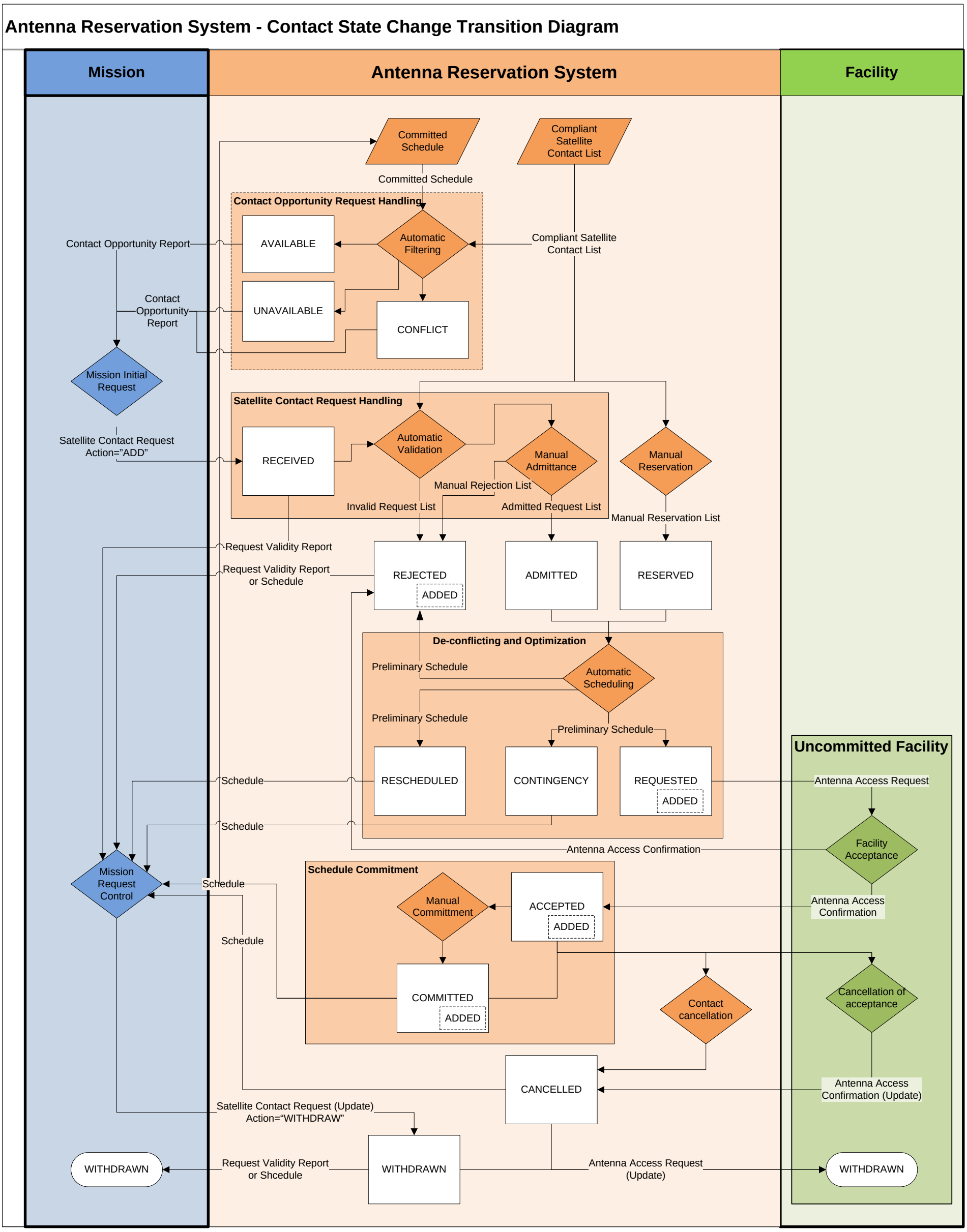
13 Distribution of Mission Schedule
a. Transmission of Committed Schedule to Missions
b. Reception of Mission Schedule Acknowledgment

14 Distribution of Facility Schedule
a. Transmission of Facility Schedule to Committed Facilities
b. Reception of Committed Schedule Acknowledgment

15 Generation and Distribution of Scheduling Reports


Antenna Reservation System -- Process Flow Diagram v2.2
Mission
Antenna Reservation System
Facility
Facility Services:
F1. Antenna Unavailability Reporting
F2. Antenna Access Request (Uncommitted Fac)
F3. Antenna Access Confirmation (Uncommitted)
F4. Schedule Update (Committed Facility)
F5. Performance Reporting
1. TLE Management
Online Satellite Catalog
1b. Manual TLE Entry
1a. Reception of Satellite Orbital TLE
1c. TLE Manager
2. Contact Prediciton
Facility & Mission Configurations
2b. Configu-ration Change
2c. Orbit Propagation / Contact Prediction
2a. Reception of Antenna Unavailability Report
Satellite Orbital TLE
M1
F1
Antenna Unavailability Report
4-5. Request Handling
Configurations
Compliant Satellite Contact List
Satellite Contact/ Time Request
4a. Reception of Request
4c. Are Time Requests Valid?
4b. Are Contacts/Times withdrawn?
4d. Are Contacts Valid?
REJECTED Times
RECIEVED Contacts/Times
REJECTED Contacts
WITHDRAWN Contacts/Times
5a. Admitance of Requests
7a. Manual Contact Reservation
Iteration
M3
RECIEVED Contacts/Times
Iteration
7b. Configu-ration Change
System Confi-guration
Reception of Request Validity Report
4e. Transmission of Request Validity Report
5b. Are Requests Admitted?
REJECTED Contacts/Times
ADMITTED Contacts/Times
RESERVED Contacts
3. Contact Opportunity Request Handling
RESERVED Contacts
Standing Requests
6b. Consolidation of Requests
REQUESTED Contacts/Times
8. De-Conflicting and Optimization
Satellite Contact Opportunity Request
X. Reception of Contact Opportunity Request
Compliant Satellite Contact List
6a. Spawning of Time Requests
SPAWNED Times
PRELIMINARY Schedule
M2
Contact Opportunity Report
4b. Are Contacts Available
9a. Approval of Schedule
Iteration
De-conflicting iteration about Antenna Access Request is not expected to occur often as the Antenna Unavailability Report should capture most of the unavailability constraints beforehand
When a Schedule is deemed unsatisfactory, the Operator can change configurations or edit requests to converge to a satisfactory solution
Reception of Contact Opportunity Report
X. Transmission of Contact Opportunity Report
COMMITTED Schedule
9b. Is Schedule Approved?
6-9. De-conflicting and Optimization
APPROVED Schedule
10-11. Antenna Access Handling
Uncommitted Facility
10a. Antenna Access Request to External Facilities
Reception of Antenna Access Request
CANCELLED Contacts
REJECTED Contacts
Retransmission
F2
Transmission of Request Acknowledgment
Acceptance of Request
10b.Reception of Request Acknowledgment
11c. Are Contacts Cancelled?
11b. Are Contacts Rejected?
F3
Transmission of Antenna Access Confirmation
11a. Reception of Antenna Access Confirmation
ACCEPTED Schedule
Mission Services:
M1. Satellite Orbit TLE Transmission
M2. Satellite Contact Opportunity Request
M3. Satellite Contact or Time Request
M4. Schedule Update
M5. Performance Reporting
12-15. Data Product Handling
Committed Facility
12a. Commitment of Schedule
14. Transmission of Facility Schedule to Committed Facilities
Reception of Facility Schedule
Reception of Mission Schedule
13a. Transmision of Mission Schedule
12b. Is Schedule Committed?
F4
Retransmission
Transmission of Schedule Acknowledgment (optional)
M4
Retransmission
14b.Reception of Schedule Acknowledgment
Transmission of Schedule Acknowledgment
13b. Reception of Schedule Acknowledgment
COMMITTED Schedule
RECEIVED Contacts/Times
15. Generation and Distribution of Performance Reports
Performance Report
Log
Reception of Mission Report
M5
Mission Performance Report
Facility Performance Report
F5
Reception of Facility Report
Contact Request and Preliminary Schedule
Antenna Access Request
Commitment and distribution of Schedule

APPENDIX B CONTACT STATE CHANGE TRANSITION DIAGRAM



APPENDIX C SCHEDULE STATE CHANGE TRANSITION DIAGRAM