SATELLITE OPERATIONS SERVICES OPTIMIZER

1 SYSTEM DEFINITION

1.1 GENERAL OPTIMIZATION PARAMETERS

As this is an optimization problem there must be some high level objectives around which the designed algorithm will prioritize its solution. There are three main objectives:

1. Fulfill as many orders as possible. Note that it may not be possible to fulfill all orders.
2. Use as few resources as possible.
3. Equally use space-based assets.

Beyond these three objectives your algorithm can prioritize whichever parameters you choose.

1.2 GROUND STATION PARAMETERS

The system should be able to handle a variable number of ground stations, which may or may not have identical capabilities/constraints. All stations will have, at a minimum, the following parameters:

TABLE 1 GROUND STATION PARAMETERS

Parameter	**Description**
Latitude	The latitude of the ground station antenna.
Longitude	The longitude of the ground station antenna.
Height	The height above Mean Sea Level of the antenna.
Station Mask	The minimum elevation that the station can receive and transmit signals at.
Uplink Rate	The bitrate at which the station can uplink data.
Downlink Rate	The bitrate at which the station can downlink data.

Other constraints include that a station can only receive a signal from one satellite at a time, and that a station requires 5 minutes between individual contacts to reconfigure.

1.3 SATELLITE PARAMETERS

The system should be able to handle a variable number of satellites each of which can have variable capabilities and constraints. All satellites will have, at a minimum, the following parameters:

Parameter	**Description**
Two Line Element	This is a string that contains the Two Line Element. The Two Line Element contains all the information necessary to determine the position of a satellite at a point in time. Most propagators take the TLE as an input.

Onboard Storage Capacity	The amount of storage that the satellite has onboard.
Power Capacity	Simplifying the power system, it can be assumed that while illuminated by the sun the satellite is able to generate enough power to support any activity as well as charge the batteries. Therefore, while illuminated power is unrestricted. In eclipse all activities that are completed must use less power than a predefined limit.
Field of View	The area that can be seen from the satellite expressed as a range of angles from the ground track of the satellite.

2 PRODUCT DEFINITION

2.1 IMAGE ORDER PARAMETERS

An Image Order is a request from a customer to receive an image of a given region with, at a minimum, the following parameters:

Parameter	Description
Region to Image	This is a point defined by a latitude and longitude on the Earth Surface that must be imaged.
Priority	This is the relative priority of an image, higher priority images should take precedent over lower priority in the event of a conflict.
Image Type	There are three types of images that a customer can request: 1. Spotlight, a high-resolution image of a square area x by y km that takes z time to complete. 2. Medium resolution, a medium resolution of a rectangular area x by y km that takes z time to complete. 3. Low resolution, a low resolution image of a rectangular area x by y km that takes z time to complete.
Imaging Time	A time range during which the image must be taken.
Delivery Time	The time by which the image must be downlinked to the ground.
Revisit Time	The number of times, and how often to retake the same image, if requested.

The Region to Image parameter designates the centre of the image, the Image Type parameter provides the area around that must be within the Field Of View of the spacecraft to successfully take the image.

Upon receipt of an Image Order Request an Image ID should be created which can be used to track the lifecycle of the image.

2.2 SPACECRAFT MAINTENANCE REQUEST PARAMETERS

A Maintenance Request details an activity that occurs on a satellite which may make it unavailable to complete payload activities until the maintenance is complete. A Maintenance Request will include, at a minimum, the following parameters:

Parameter	Description
Target	The asset that is undergoing maintenance
Window	The window during which the maintenance must be completed
Duration	The duration it takes to complete the maintenance.

Repeat Cycle	Some maintenance must be completed regularly, this should include the number of times and how often the maintenance is to be completed.
Payload Operations	This flag will designate whether payload operations can continue during the maintenance or not.

Some maintenance requests will have durations that equal the window in which they must occur, in this case it means the maintenance must occur at that time. Other maintenance requests will be shorter than the window in which they must be completed is, in those cases it is up to the planning algorithm to schedule them in such a way as to minimize the impact.

The maintenance activity must be uplinked to the satellite, therefore it must be included in the Satellite Activity Schedule.

Satellites can still receive Satellite Activity schedules during a maintenance period.

2.3 OUTAGE REQUEST

An Outage Request details an outage that occurs on either a satellite or a ground station that results in the asset being completely unavailable until the outage has completed. An Outage Request includes, at a minimum, the following parameters:

Parameter	**Description**
Target	The asset that is undergoing an outage.
Start Time	The start time of the outage.
End Time	The end of the outage.

For satellites an outage means they are entirely unavailable for operations until the outage has been completed.

2.4 SATELLITE ACTIVITY SCHEDULE

Parameter	**Description**
Satellite Name	Unique name for each satellite
Schedule ID	A unique identifier for the Ground Station to be able to know which activity schedule to send to the spacecraft
Activity Window	The time of the first activity in the schedule as well as the final activity in the schedule
Image Activities	The imaging activities to be performed by the spacecraft will contain: • Image ID • Type • Priority

	• Image Time
Maintenance Activities	The maintenance activities to be performed by the spacecraft. Will contain: • Activity ID • Description • Priority • Activity Time • Payload Flag • Duration
Downlink Activities	The list of image downlinks for the spacecraft to carry out. Will contain: • Image IDs • Downlink Start (Note this needs to align with a scheduled ground station contact…) • Downlink Stop

2.5 GROUND STATION REQUEST

The Ground Station Request includes all the information necessary for a station to communicate with the satellite. It includes, at a minimum, the following parameters:

Parameter	**Description**
Station Name	This is the station receiving the request
Satellite	This is the name of the satellite being contacted
Acquisition of Signal	This is the time when the satellite is expected to come into the field of view of the ground station.
Loss of Signal	This is the time when the satellite is expected to leave the field of view of the ground station.
Satellite Schedule ID	Satellite schedule to be uplinked to the spacecraft
Images to be Downlinked	This is the list of the images that will be downlinked including the following information: 1. ImageID 2. Duration of Downlink

	3. Size of Image

3 APPENDIX

3.1 TWO-LINE ELEMENT SETS

Below are five satellite TLEs that you can use to begin modelling your scenario

SOSO-1

1 00001U 23274.66666667 .00000000 00000-0 00000-0 0 00001

2 00001 097.3597 167.6789 0009456 299.5645 340.3650 15.25701051000010

SOSO-2

1 00002U 23274.66666667 -.00000000 00000-0 00000-0 0 00003

2 00002 097.4451 167.7017 0017417 313.0688 199.0918 15.16151277000016

SOSO-3

1 00003U 23274.66666667 .00000000 00000-0 00000-0 0 00003

2 00003 097.4153 167.6514 0009336 322.4617 181.5409 15.20925385000019

SOSO-4

1 00004U 23274.66666667 .00000000 00000-0 00000-0 0 00004

2 00004 097.4153 167.6514 0009339 322.4652 253.5376 15.20925382000012

SOSO-5

1 00005U 23274.66666667 .00000000 00000-0 00000-0 0 00005

2 00005 097.4450 167.7015 0002739 252.0353 116.1326 15.16151280000015

3.2 GROUND STATION PARAMETERS

Station Name	Latitude	Longitude	Height	Station Mask		Uplink Rate	Downlink Rate
Inuvik Northwest Territories	68.3195	-133.549	102.5	Receive	>5° elevation	40kbps	100Mbps
				Send	>5° elevation		
Prince Albert Saskatchewan	53.2124	-105.934	490.3	Receive	>5° elevation	40kbps	100Mbps
				Send	>5° elevation		
Gatineau Quebec	45.5846	-75.8083	240.1	Receive	>5° elevation	40kbps	100Mbps
				Send	>5° elevation		