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# Science Article

# Optimal decision making in designing an Earth observation mission with considering the technical challenges of the platform and the impossibility of injection into the sun-synchronous orbit

Asad Saghari[1], Amirreza Kosari[2]*, Masoud Khoshsima[3]
1&2 – Tehran Faculty of New Sciences and Technologies
3 - Satellite Research Institute, Iranian Space Research Center
*Tehran, Postal code: 1417935840

**Email: *kosari_a@ut.ac.ir**

*This paper deals with the problem of optimal selection of orbital parameters for an Earth observation mission in the absence of the possibility of injection into sun-synchronous orbit by considering the requirements and limitations of the mission and the satellite platform. By modeling the existing relationships between each of the three areas of orbit, mission and platform, the effects of changes in each of the parameters have been analyzed and tracked. One of the important advantages of the proposed solution is that in the process of optimal selection of relevant parameters, all aspects of the orbit, mission and platform are considered simultaneously. This, in turn, can lead to an implementable and operational option for accomplishing the mission. In evaluation of effects of changing orbital parameters on the mission characteristics and requirements of the satellite platform, a developed computer code has been used.*

***Keywords***: *Optimal decision-making, Multi sun-synchronous orbit, Earth observation mission, Repeat ground track, Satellite platform*

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## Symbols & Abbreviations

| | |
|---|---|
| semi-major axis | $a$ |
| Orbital altitude | $h$ |
| Orbital altitude for the repeat ground track property | $h_{RGT}$ |
| Orbital altitude for the multi-sun-synchronous property | $h_{MSS}$ |
| Orbital inclination | $i$ |
| Orbital eccentricity | $e$ |
| Local time of ascending node | $LTAN$ |
| Rate of ascending node of the orbit position change | $\dot{\Omega}_h$ |
| | |
| Angular velocity of the sun in relation to the Earth | $\dot{\Omega}_S$ |
| Nodal day | $D_n$ |
| Rotational velocity of Earth about its axis | $\omega_e$ |
| Orbit nodal period | $T_n$ |
| Earth second-order zonal harmonic | $J_2$ |
| Gravitational parameter of the Earth | $\mu$ |

1 Ph.D. student
2 Professor (Corresponding Author)
3 Associate Professor

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## Introduction

In Earth observation missions, one of the key requirements is the ability to recognize and compare images taken at specific time intervals from a specific location. This requirement has been created with the aim of comparing and archiving the received images and leads to design of the mission requirement " repeat ground track " and " local time remaining the same in imaging".
Specifically, and commonly, the first requirement can be satisfied through the use of sun-synchronous orbits, and the second requirement adds the condition of repeat ground track Orbit to the orbit design constraints. These two mission requirements are of particular importance for all space remote sensing missions. It is very important and necessary to consider the first requirement, especially for those remote sensing satellites that have the task of regularly observing the changes of Earth using optical payloads in visible spectrum. On the other hand, direct injection into the sun-synchronous orbit is not possible from any geographical region, and indirect injection is uneconomical and uncommon [1].
If it is impossible to access sun-synchronous orbits, a proposed alternative solution is to use multi-sun-synchronous orbits with repeat ground track [1&2]. These types of orbits make it possible for the lighting and repeat ground track conditions to be exactly repeated and the captured images to be comparable and archivable at certain time intervals.
The choice of orbital parameters as the main part in the design of the satellite mission will have a parental effect on other requirements and characteristics related to the satellite and mission. In addition to the features related to repeat ground track requirements and lighting conditions, requirements for satellite mission life time, required delta-V, required downlink data rate, revisit time, required tilt angle, satellite power consumption, solar array generation power and the dimensions of the optical payload are among the most important issues that are generally affected by orbital parameters [3-5].
On the other hand, due to the development of satellite design approach based on pre-designed platforms, although as much flexibility has been considered in the architecture of satellite platforms, but this flexibility has been limited by considering the advantages of cost reduction and design time. Generally, in existing platforms, we will encounter a set of specific subsystems which are modular at certain levels. [3&4]. According to these cases, determining the characteristics of the operating orbit will be affected by the following two facts:
1-The functional requirements of satellite subsystems in different missions will change according to the mission goal and operational (orbital) conditions [3&4].
2-The characteristics of platform subsystems and supportable performance by them are generally fixed (For example, the supportable delta-V by the propulsion system or the supportable downlink data rate by the transmitter), and will change in cases affected by orbital and mission conditions (power generated by solar panels) [3&4].
In order to solve this challenge and achieve the appropriate and operational orbital parameters, in choosing the orbital parameters, in addition to taking into account the requirements related to imaging, the functional requirements of the mission should be analyzed and the supportable functions of the platform should be considered as constraints of decision making.
So far, in the field of mission design and determination of optimal orbital parameters of remote sensing missions, several articles have been published, each of which has identified the optimal parameters from a specific perspective. The following is an overview of some of the research conducted in the field of optimal orbit design for a remote sensing mission.
Zayan et al. (2008), Designed and simulated a sun-synchronous orbit considering the effects of orbit perturbations [6]. Luo et al. (2017), Proposed a new method for computing the optimal revisit time by considering the parameters related to the orbit, the swath width of payload and the tilt angle [7]. Ravanbakhsh et al. (2013), Designed a remote sensing satellite, taking into account the design considerations of the orbit, payload and satellite platform, to study the effects of changes in altitude and revisit time on the total mass of the satellite. In the mentioned research, the satellite is assumed to have no propulsion system and no maneuverability [8]. In his 2010 Doctoral Dissertation, Sharon designed an optimal orbit of a remote sensing satellite taking into account the requirements of imaging location, imaging conditions, and payload characteristics [9]. Torabi et al. (2017), Determined the orbital characteristics with repeat ground track [10]. He et al. (2017), Designed a precise sun-synchronous orbit with repeat ground

track and analyzed atmospheric drag effects on the semi-major axis of the orbit [11]. Nadoushan et al. (2014), Designed an optimal orbit with a repeat ground track orbit with the aim of achieving the desired revisit time and minimum tilt angle [12]. Asad Saghari et al. (2018), Designed an optimal orbit for an Earth observation mission with the aim of minimizing the total propellant mass and satellite payload [13]. Sanad et al. (2012), Selected the optimal orbit of the sun-synchronous orbit for a remote sensing satellite without propulsion subsystem, taking into account the requirements of revisit time, satellite maneuvering angle, and ground sample distance (GSD) [14].

In the field of multi-sun-synchronous orbits design, without considering the requirements and limitations of the satellite system, several articles and reports have been presented [1&15-18].

By reviewing the articles, a research gap on the optimal selection of multi-sun-synchronous orbits parameters with repeat ground track is given for an Earth observation mission, taking into account the limitations related to the supportable performance of the satellite platform and mission performance requirements. Due to this problem, the main purpose of this paper is to identify operational orbital options with minimum repeat cycle of ground track and local time in the absence of the possibility of injection into the sun-synchronous orbit by condition of satisfying all the requirements and constraints of mission, transfer to orbit and satellite platform requirements.

## Defining the problem

As mentioned, in this research we are looking for operational orbital options with minimum cycles of repeat ground track and local time in the absence of the possibility of injecting into the sun-synchronous orbit for a typical Earth observation mission. In this regard, in addition to considering the requirements and constraints related to the mission, the limitations of the platform used in the mission should also be considered. The requirements and constraints of transfer to orbit and mission are listed in Table 1.

**Table 1 -** High level constraints and requirements related to the transfer to orbit and mission

| Parameter | Amount |
|---|---|
| Orbital altitude range | 450 to 650 km |
| Orbital inclination range | 54 to 56 degrees |
| Injection error in orbital altitude | ± 30 km |
| Injection error in orbital inclination | ± 0.02 degrees |
| Portable payload mass at base altitude (550 km) | 200 kg |
| Maximum payload fairing | A cylinder with dimensions of 100 by 120 cm |
| Mission life time | 5 years |
| GSD | 2.5 m panchromatic and 5 m multispectral |
| Swath width of the imaging payload | 20 km |
| Maximum ground track error due to orbital perturbations and atmospheric drag force | 10% of swath width |
| Revisit time | 4 days |

The characteristics of the satellite platform for this mission are presented in Table 2.

**Table 2 -** Satellite platform characteristics

| Parameter | Value |
|---|---|
| Configuration | Hexagonal with solar arrays attached to six lateral faces |
| Supportable downlink data rate | 70 MB/s |
| Supportable pointing accuracy | 0.15 degrees |
| Supportable tilt angle | 30 degrees |
| Maximum diameter of aperture | 30 cm |
| Maximum supportable mass for imaging payload | 30 kg |
| Maximum supportable power for imaging payload | 70 watts |
| Maximum propellant mass | 10 kg |

Changing the orbital parameters as a main design variable will directly and indirectly affect the mission characteristics and sizing of the satellite:

- The direct effect is due to the direct relationship between the orbital parameters with a mission characteristic or the sizing of a subsystem under design. For example, changing the dimensions of the imaging payload by changing the orbital altitude or changing the required propellant mass by changing the orbital altitude (assuming other parameters remain constant)
- Indirect effect is the changing effect of a mission attribute on another mission attribute or the

effect of sizing changes of a subsystem on sizing of other subsystems. For example, the effect of changing the size of the deployable solar panel on the attitude determination & control subsystem (ADCS) and propulsion subsystem is due to changes in the moment of inertia of the satellite and the effective area in atmospheric drag. Also, the effect of changing the orbital altitude on the electrical power required by the communication subsystem and as a result changing the entire satellite power consumption, which can lead to changing in sizing of the satellite's electrical power supply system, is another example of this problem.

In order to study the effects of changing orbital parameters on mission characteristics and satellite sizing we need a design and simulation code in which the connections between changing orbital characteristics and changing mission characteristics and satellite sizing are formed. This code has already been developed and has been used in the past work of authors [3&4&13]. It is noteworthy that the developed computer code has been evaluated with various references and software such as STK and has been used in several academic and industrial projects.

The developed design and simulation code makes it possible to simulate various mission conditions and for each of the different mission scenarios and orbital parameters, the requirements and functional characteristics of the satellite platform subsystems and payload are provided.

## Problem solving process

The process of solving the optimal decision-making problem will include the following four main steps:

Step 1: Generating the multi sun-synchronous orbital options with repeat ground track property.

Step 2: Narrowing the decision space of the orbital options by considering the high-level constraints and requirements of the transfer to orbit and the mission.

Step 3: Narrowing the decision space of the orbital options by considering the constraints related to the characteristics of the satellite platform.

Step 4: Selecting the operational orbital options with the minimum cycle of repeat ground track and local time

Figure 1 shows the problem solving algorithm.

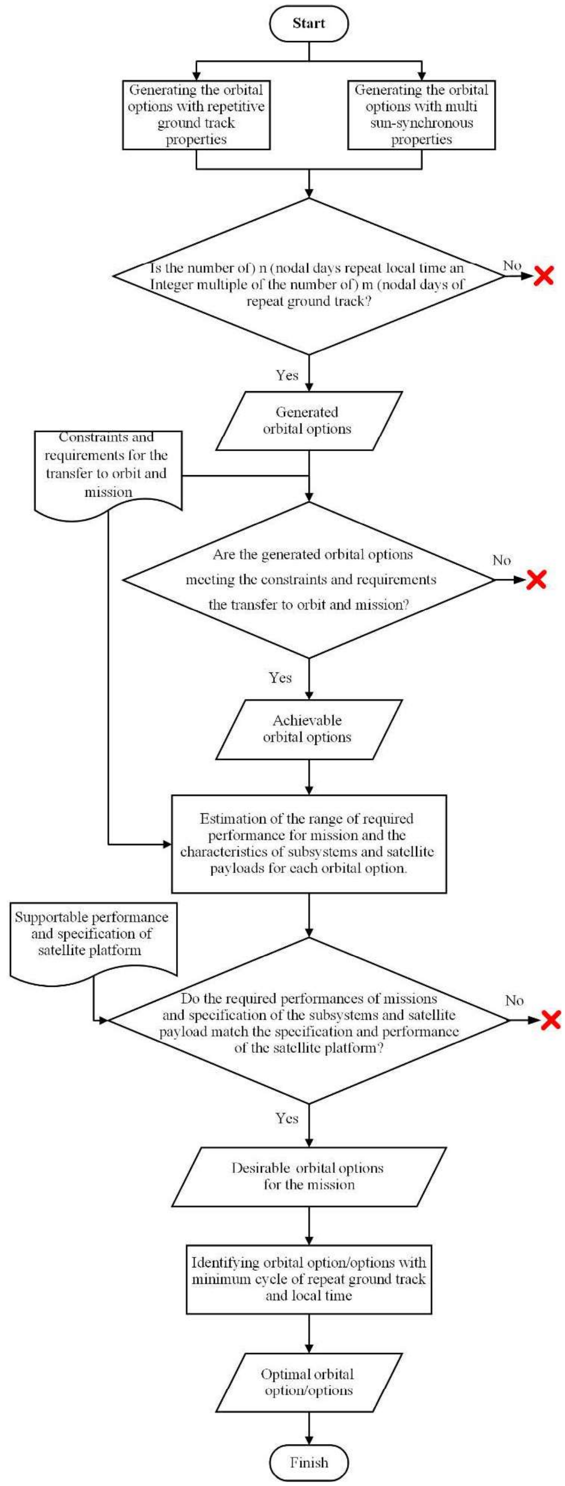


**Figure 1 -** Problem solving algorithm

### Step 1: Generating the multi sun-synchronous orbital options with repeat ground track property

In sun-synchronous orbits, the local time of ascending/descending node crossing remains almost constant for certain values of inclination, altitude, and orbital eccentricity. This feature occurs for orbital inclinations greater than 95 degrees. We can find other values of inclination, altitude, and orbital eccentricity, for which the local time of the ascending/descending node crossing is repeated at certain time intervals. Orbits with this property are called multi sun-synchronous orbits [15-18].

The use of such orbits can somehow reduce the constraints of the launch site's geographical location and allow remote sensing missions to be defined over a wide range of orbital inclinations. The equations governing the design of multi sun-synchronous orbits are as follows [1&15-18]:

$$n.D_n = \frac{2\pi}{\left|\dot{\Omega}_s - \dot{\Omega}_n\right|} \quad (1)$$

$$D_n = \frac{2\pi}{\omega_e - \dot{\Omega}_n} \quad (2)$$

$$n = \frac{\omega_e - \dot{\Omega}_n}{\left|\dot{\Omega}_s - \dot{\Omega}_n\right|} \quad (3)$$

According to Equation (1), the local time is repeated at (n) nodal days.

As mentioned earlier, one of the requirements in remote sensing applications is the ability to repeat ground track on defined time intervals. In fact, in order to compare and analyze images, they must be taken from the same geographical location under the same lighting conditions. The governing equations of the orbits with repeat ground track are as follows [7], [19-21]:

$$T_n = \left(2\pi\sqrt{\frac{a^3}{\mu}}\right)\left[1 - \frac{3}{2}J_2\left(\frac{R_e}{a}\right)^2\left(3 - 4\sin^2 i\right)\right] \quad (4)$$

$$m.D_n = k.T_n \quad (5)$$

In relation (5) the (m) and (k) are integers. According to the altitude and orbital inclination, for each number of (m) nodal days, there will be several number of (k) orbital nodal period.

In order to design an operational orbit with a remote sensing application in a non-sun-synchronous orbit, the following three conditions must be met simultaneously:

1- The orbit has multi-sun-synchronous nature or in other words, applies to relation (1).
2- The orbit has repeat ground track nature or in other words applies to relation (5).
3- The cycle of local time repetition ((n) nodal days) must be an integer multiple of the cycle of ground track repetition ((m) nodal days).

This design problem can be defined as a constrained search problem as follows:

$$\text{Find all}\left(n \,\&\, m\right)\text{for :}$$

$$g_1(n, m):\ n.D_n\left(\left|\dot{\Omega}_s - \dot{\Omega}_n\right|\right) - 2\pi = 0$$

$$g_2(n, m):\ m.D_n - k.T_n = 0$$

$$g_3(n, m):\ n - c.m = 0 \quad \text{c:Integer}$$

$$g_4(n, m):\ h_{RGT} - h_{MSS} \le 200$$

### Step 2: Narrowing the decision space of the orbital options by considering the high-level constraints and requirements of the transfer to orbit and the mission

By solving the constrained problem for the orbital inclination range between 54 and 56 degrees and the altitude range between 450 km to 650 km, the possible orbital options are obtained. In calculating these options, the assumption of 0.01-degrees change steps for the orbital inclination and the altitude difference range equivalent to the two properties of sun-synchronous and repeat ground track of less than 200 meters has been considered. Figure 2 shows these calculated orbital options.

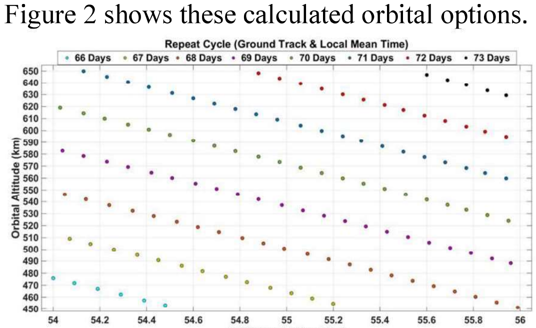


**Figure 2** – Existing orbital options in the range of orbital altitude and inclination

According to Figure 2, there will be only 124 orbital options that apply to the defined constrained search problem. Of course, it should be noted that the solutions must be within the allowable range of defined orbital altitude and inclination. The number of achievable cycle of repetition for local time and ground track in this constrained decision space will be from 66 to 73 nodal days.

**Step 3: Narrowing the decision space of the orbital options by considering the constraints related to the characteristics of the satellite platform**

Due to the stated characteristics for the satellite platform and the range of supportable performance by the platform, the search space for the orbital parameters will be narrowed. Using the developed computer code, the required mission performances that need to be supported by the platform can be determined for each of the orbital options. Based on this, it is possible to identify orbital options in which the platform has the ability to support the defined mission.

**The required downlink data rate**

The required downlink data rate to transfer the imaging payloads data to the ground station is a function of the number of ground stations, the ground station view angle, the orbital characteristics and the volume of generated data by the payload. Assuming the number of ground stations, the ground station view angle and the activating time of payload are constant, the effect of changing orbital characteristics on the required downlink data rate can be investigated. Figure 3 shows the amount of required data transfer rate by the mission for each of the orbital options.

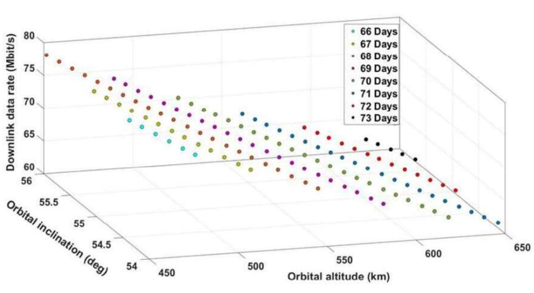


**Figure 3 -** The amount of required downlink data rate for each of the orbital options

Figure 4 shows the removed orbital options due to the application of the downlink data rate related constraint that is supportable by the satellite platform. As it is obvious, this constraint is considered as an active constraint and by applying it, there will be no more orbital options with the 66 and 67 nodal days ground track and local time cycle of repetition. On the other hand, some orbital options related to other repeat cycles will also be removed.

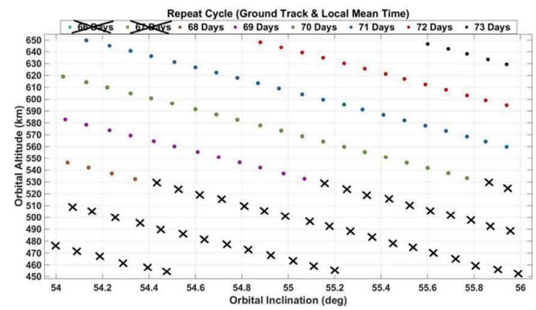


**Figure 4 -** The remaining orbital options by applying the constraint related to the supportable downlink data rate by satellite platform

The required pointing accuracy for the mission

The required pointing accuracy for the mission is generally expressed as a percentage of the swath width of the imaging payload (about 5 to 10% of the swath width). Accordingly, the required pointing accuracy for the mission will be a function of the swath width of the imaging payload and the orbital characteristics. Figure 5 shows the required pointing accuracy for the specified swath width in the table1 for orbital options.

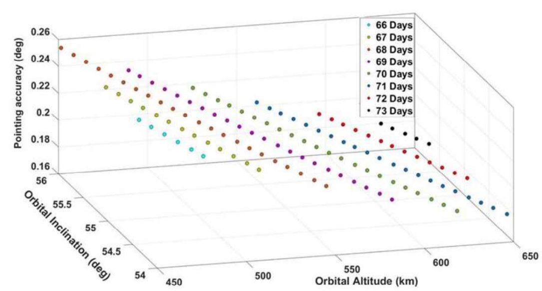


**Figure 5 -** The required pointing accuracy for the mission in each of the orbital options

Figure 6 shows the orbital options after applying the constraint related to the pointing accuracy.

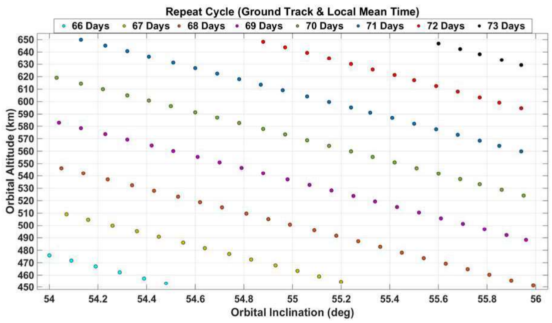


**Figure 6 -** The remaining orbital options by applying a constraint related to the supportable pointing accuracy by the satellite platform

As can be seen, this constraint is not an active constraint and does not lead to the elimination of any of the orbital options.

### The imaging payload aperture diameter

Imaging payload aperture diameter is a function of orbital altitude, GSD, and wavelength of the imaging spectrum. For the GSD and the specific imaging spectrum, the changes in the diameter of the optical payload relative to the orbital characteristics for each of the orbital options are shown in Figure 7.

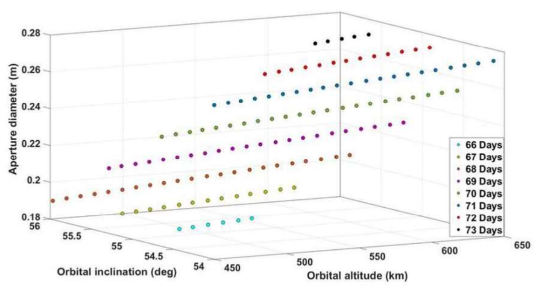


Figure 7 **-** The amount of the imaging payload aperture diameter in each of the orbital options

Figure 8 shows the orbital options after applying the constraint on the optical payload aperture diameter.

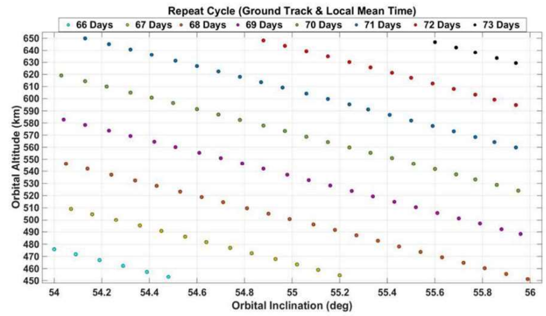


**Figure 8 -** The remaining orbital options with the constraint related to the optical payload aperture diameter

As shown in Figure 8, this constraint is not an active constraint and does not remove any of the orbital options.

### The imaging payload mass

The imaging payload mass, assuming that the type of technology does not change, is a function of the required GSD, the swath width, the number and type of imaging spectrum, and the orbital characteristics. With the type of payload technology, the swath width, the ground resolution and the imaging spectrum being fixed, the payload mass for each of the orbital options will be as shown in Figure 9.

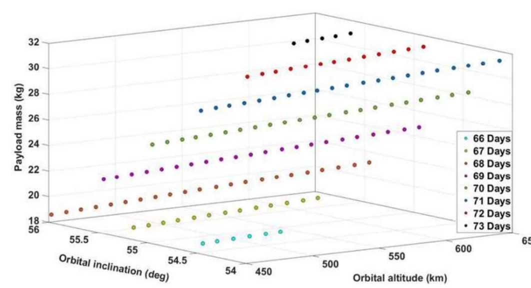


**Figure 9 -** The imaging payload mass in each of the orbital options

Figure 10 shows the orbital options after applying the constraint related to the imaging payload mass.

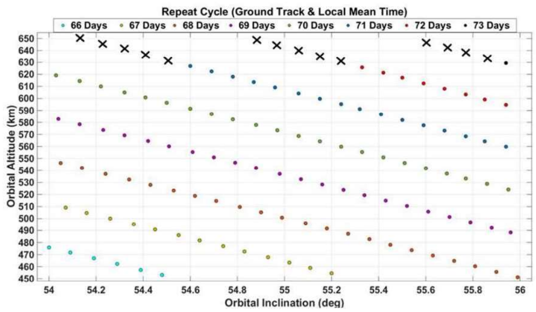


**Figure 10 -** The remaining orbital options by applying the constraint related to the imaging payload mass

As shown in Figure 10, some orbital options related to repeat cycle 73, 72, and 71 nodal days are removed.

### The power consumption by the imaging payload

The power needed by imaging payload, like the payload mass, assuming that the type of technology does not change, is a function of the required GSD, the swath width, the number and type of imaging spectrum, and the orbital characteristics. Assuming the type of payload technology, the swath width, the GSD and the imaging spectrum are constant, the payload power for each of the orbital options will be as shown in Figure 11.

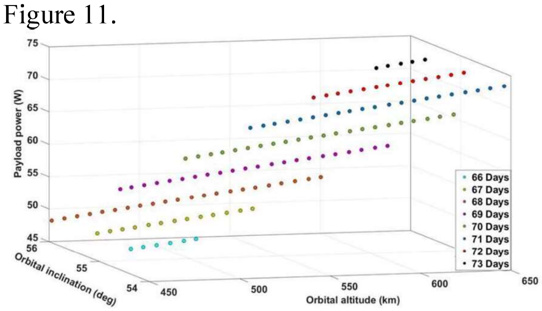


**Figure 11 -** The amount of power consumption of the imaging payload for each of the orbital options

Figure 12 shows the orbital options after applying the constraint related to the power consumption of the imaging payload.

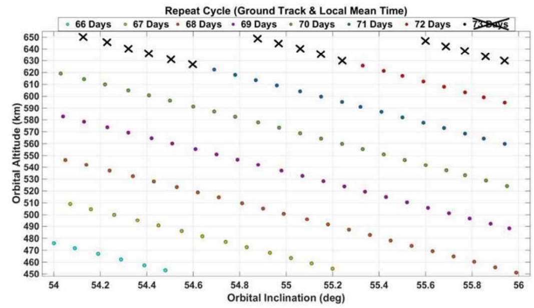


**Figure 12 -** The remaining orbital options with a constraint on the power consumption of the imaging payload

As can be seen in Figure 12, this constraint is an active constraint, and by applying it, there will no longer be any orbital option with 73 nodal days cycle of repetition of ground track and local time. On the other hand, some orbital options related to other repeat cycles will be removed.

### The required tilt angle for the mission

The required maneuvering tilt angle is a function of the revisit time, the swath width and the orbital characteristics. Assuming that the payload swath width and the revisit time are constant, the relationship between the orbital options and the required tilt angle will be shown in Figure 13.

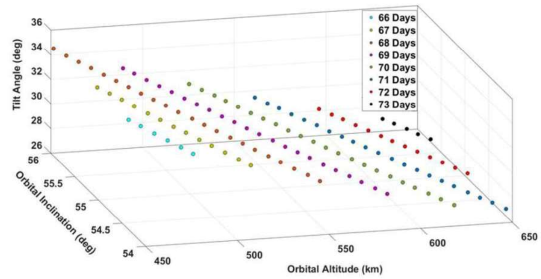


**Figure 13 -**The required tilt angle for each of the orbital options

Figure 14 shows the orbital options after applying the constraint related to the tilt angle.

As shown in Figure 14, this constraint is considered as an active constraint, and by applying it, there will be no more orbital options with the 66, 67 and 68 nodal days cycle of repetition of ground track and local time. On the other hand, some orbital options related to other repeat cycles will be removed.

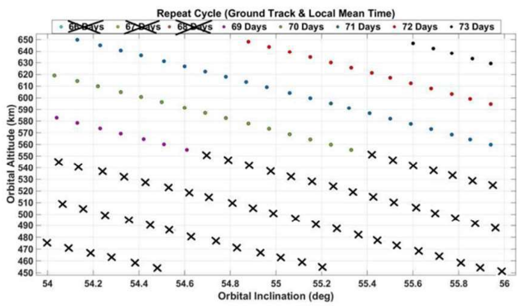


**Figure 14 -** The remaining orbital options by applying a constraint related to the maneuvering tilt angle

## The required propellant mass

The mass of propellant required by the satellite is a function of mission life time, the amount and rate of maneuvering, injection error, ground track deviation, mass and dimensions of the satellite, solar activity, type of propulsion system and of course the laws related to orbital ownership and space debris1. Assuming the dimensions of the satellite, the injection error, and the solar activity are specified and constant for the hydrogen peroxide propulsion system with a specific impulse of 185 seconds, the propellant mass required for each of the orbital options will be as shown in Figure 15.

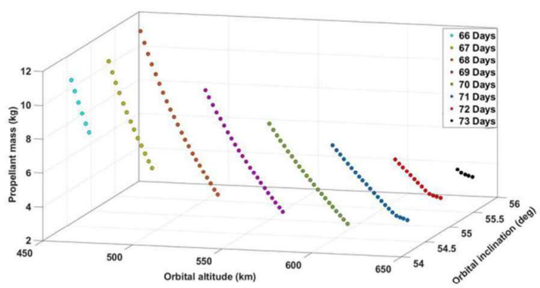


**Figure 15 –** The required propellant mass for each of the orbital options

As shown in Figure 15, with increasing orbital altitude due to decreasing atmospheric density and decreasing required tilt angle, the amount of propellant required will decrease, but for orbital altitude values greater than a certain value, the decreasing trend of the required amount of propellant will stop and with increasing orbit altitude more propellant will be needed. This nonlinear behavior is due to applying constraints resulting from space debris control and indicates an increase in the amount of propellant required to transfer the satellite to orbit with a lifespan of less than 25 years at the end of the mission life time. Figure 16 shows the orbital options after applying the required propellant mass constraint.

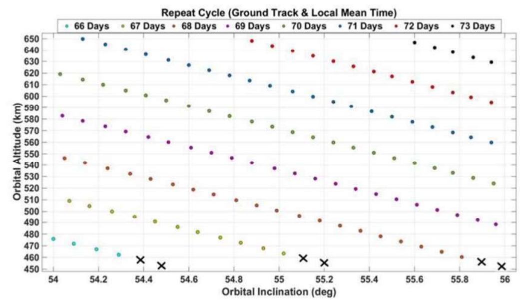


**Figure 16 -** The remaining orbital options with the required propellant mass constraint

As can be seen in Figure 16, this constraint, as a relatively active constraint, has led to the removing of some orbital options.

Finally, with all the constraints and limitations of the satellite platform, out of the 124 orbital options presented in Figure 2, the 45 options shown in Figure 17 will remain.

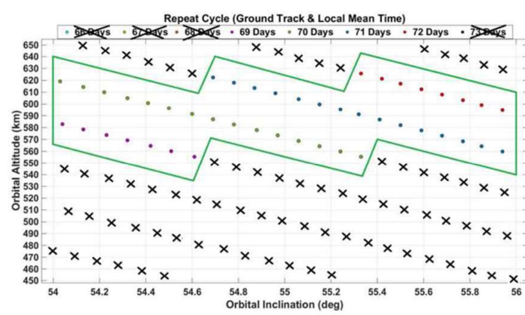


**Figure 17 -** The remaining orbital options considering the limitations of the satellite platform

As can be seen in Figure 17, the remaining orbital options are related only to 71, 70, 69, and 72 nodal days repetition cycle of local time and ground track. The allowable orbital altitude range will be between 555.3 km and 625.75 km and the allowable inclination range will be between 54.03 and 55.94 degrees.

1 "The operator of a space system should perform disposal maneuvers at the end of the operational phase to limit the permanent or periodic presence of its space system in the protected regions to a maximum of 25 years" [21]

### Step 4: Selecting the operational orbital options with the minimum cycle of repeat ground track and local time

According to Figure 17, by applying all the constraints and requirements, orbital options with the 69 nodal days repetition cycle of local time and ground track are identified as the least repetition cycle among the remaining options. This set includes seven orbital options, the specifications of which are presented in Table 3.

**Table 3 -** Values and performances required for the mission for each of the seven orbital options with the least repetition cycle of local time and ground track

| Option | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Orbital altitude (km) | 582.8 | 578.49 | 573.68 | 569.34 | 564.52 | 560.15 | 555.3 |
| Orbital Inclination (degrees) | 54.04 | 54.13 | 54.23 | 54.32 | 54.42 | 54.51 | 54.61 |
| repetition cycle ( nodal day) | 69 | 69 | 69 | 69 | 69 | 69 | 69 |
| Required downlink rate (MB/s) | 65.57 | 65.90 | 66.28 | 66.63 | 67.03 | 67.38 | 67.78 |
| Required pointing accuracy (degrees) | 0.197 | 0.198 | 0.199 | 0.201 | 0.203 | 0.204 | 0.206 |
| Imaging payload aperture diameter (m) | 0.245 | 0.243 | 0.241 | 0.239 | 0.237 | 0.235 | 0.233 |
| Imaging payload mass (kg) | 26.99 | 26.71 | 26.41 | 26.13 | 25.83 | 25.55 | 25.24 |
| Imaging payload required power (watts) | 64.64 | 64.10 | 63.51 | 62.97 | 62.37 | 61.82 | 61.22 |
| Required tilt angle (degrees) | 28.82 | 28.97 | 29.13 | 29.32 | 29.49 | 29.64 | 29.84 |
| Required propellant mass (kg) | 4.27 | 4.35 | 4.44 | 4.53 | 4.63 | 4.73 | 4.85 |

## Supplementary discussion

In order to reach one of the optimal orbital options, other attributes and criteria must be considered. These attributes and criteria are determined by the stakeholders or the design team according to the technical limitations and mission objectives related to satellite system, ground stations and equipment and infrastructure for transfer to orbit. According to the mission requirements and the concept of platform-based design, examples of complementary optimization criteria that can be proposed in this research can include the following:

- Minimization of the required propellant mass
- Minimization of the payload mass

Minimization of the payload mass and required propellant mass
Considering each of the mentioned criteria or a combination of criteria with different weight of importance, the optimal option will be different.
As can be seen in Table 3, Option 1 will be selected for the minimization of the required propellant mass for the satellite, while Option 7 would be appropriate for the minimization of the payload mass. Finally, with the aim of minimizing the total propellant mass and imaging payload mass, option 7 will be considered as the superior option.

## Conclusion

The results obtained in this study show that in the optimal decision-making process with the aim of designing the mission, in addition to the mission requirements, the items related to the capabilities and limitations of the satellite platform will be very important and should be considered as a key factor in decision making. In fact, the relationship between orbital parameters, high-level mission requirements, platform characteristics and payload are unavoidable and inseparable and mission design without considering them can't be a comprehensive and implementable optimal choice. Achieving an optimal and implementable choice requires the development of a comprehensive design computer code with the aim of identifying and modeling these relationships and making it possible to analyze and track the effects of changes in each of the variables and parameters related to the three themes of orbit, mission and satellite. In this research, by using the comprehensive computer code developed with the aim of designing and analyzing the mission and sizing of the satellite, this possibility has been achieved.
In this study, since it was assumed that the Earth observation mission would be performed by a satellite based on a pre-designed platform, the limitations and capabilities of the platform were considered as constraints on the problem. Considering the two problems of required propellant mass and payload mass as complementary criteria for optimization in the selection of the final orbital option has been due to the fact that the required propellant mass and payload mass are as modifiable characteristics of satellites designed based on the platform.
The results obtained from the implementation of this approach will ensure that the defined mission can be implemented and performed by considering all the requirements and constraints related to the satellite transfer to orbit, mission and satellite platform. Finally, the following items can be followed by enthusiasts as research topics related to this research:

- Applying existing uncertainties in the decision-making problem in order to achieve a robust decision
- Considering different options for mission characteristics or platform subsystems, such as solving decision problems for

missions with different life time and different imaging features, or considering different propulsion systems and analyzing the effects of technology change on optimal orbital option selection.

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