Satellite Orbit design and trade study analysis of a CubeSat using STK

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Abstract–***The MTCsat is a 3U CubeSat with mass of 4Kg which is designed as a graduation project with a mission of earth observation and a digital camera is used as a payload. It's required to make coverage on ten vital points as Al-Nahda dam in Ethiopia and nine vital locations in Egypt due to its importance in different aspects. In this work, we aim to design an orbit to satisfy the mission requirements. To achieve that, a trade study using STK/Matlab is carried out to select an orbit that can fulfil the mission requirements. The trade study showed inclination 35 deg has the maximum access duration for the group of vital points and also this duration increases with altitude. Three orbits are selected to be compared. One of them is (MTCsat-A) which has the same parameters of EGYPTSAT-A. The second is (MTCsat-B) that has an inclination 35 deg and the same altitude of EGYPTSAT-A. The last one (MTCsat-C) is proposed to be launched from Inter National Space Station (ISS). The three CubeSats are analysed and compared from the point of view of coverage, beta angle, lighting times, power collected from solar cells and life time. As a result of comparison and analysis MTCsat-B is selected to achieve the required mission***

Keywords— STK, Mission, Design, Analysis, Matlab, LEO, CubeSat, Payload, Structure, Orbit, Satellite

I. INTRODUCTION

In recent years, the CubeSat has become very important tool in scientific community. The main advantage to using CubeSats is due to their small size, flexibility of platform design, and simplicity of internal components [1]. Students could design and construct their own CubeSats through several college and high school programs. The mission of a CubeSat is what defines the design and analysis of the space orbit to be used [2]. The orbit specifications should be determined and orbital elements calculated to meet the requirements of the mission [3]. In our work, we aim to design, analyze an orbit with the aid of trade study analysis which achieves high coverage for Egypt and some vital points. In Egypt we have some vital places that need a continuous monitoring. We aim to achieve high coverage for these vital places.

We chose nine vital points in Egypt which are military technical college which is the ground station for our mission, Suez Canal, Aswan High dam, The New capital city, Sinai, Cairo, Al-dabaa station, Sharm Elshiekh and Rafah city. We also chose and one point in Ethiopia which is Al-Nahda Dam. By

Canal, Aswan High dam, The New capital city, Sinai, Cairo, Al-dabaa station, Sharm Elshiekh and Rafah city. We also

chose and one point in Ethiopia which is Al-Nahda Dam. By monitoring these points we can achieve safety at places as Rafah, Sharm Elshiekh and Sinai. We can also observe any changes that can affect the safety of civilians and army in these areas. Monitoring Suez Canal enable us to monitor the flow of ships. It's important to achieve high coverage for ground station for good communication so we chose MTC as a vital point. We also chose Al-Nahda Dam as vital point for monitoring the changes in that region and for early alarming for any threats.

One of the greatest methods used for the design is the trade study approach. It was used for space craft swarm mission design [4]. In constellation, it was used for design orbital parameters for designing orbit of satellites and also in selecting number of planes and numbers of satellites per plane [5]. Also, it was used for satellite designing communication system [6]. Remote sensing satellites are designed by trade study too [7]. Trade study process gave better results than its counterparts.

We will use Systems Tool Kit (STK)/MATLAB Interface for the trade study to design orbit and then we will use STK for the mission analysis and for achieving that, the paper is organized in six sections and they are introduction, concept, methodology, mission analysis and discussion, conclusion and future work.

II. CONCEPTS

A. Sun-synchronous Orbits

An orbit that maintains a stable angle with regard to the Earth-sun direction is said to be sun-synchronouun-synchronous. It visits the same spot at the same local time every day. That is important for our mission because images can be compared to show changes of somewhere over time. Image series can be used to investigate how weather patterns emerge to help predict weather, storms or floods. Most Earth observation satellites are placed in sun-synchronous orbits, usually between 500 and 1000 km above the surface of the planet. An object in a Sun-Synchronous orbit has a nodal regression rate that is equal to the speed of the Earth's orbital revolution around the Sun [8]. This type of geocentric orbit combines height and inclination. The Sun's continual illumination of the object in this orbit. Inclination i varies with the altitude depending on the equation 1.

Fig 1 describes the relation between altitude and inclination.

$$i = \frac{180^o}{\pi} cos^{-1}\left(\frac{-2h}{3R_e}\right)^2 \frac{w_e}{n_p j_2} \qquad (1)$$

Where

i is The orbital mean inclination

j_2 is the second zonal gravity harmonic of earth.

n_p is perturbed mean motion.

R_e is the Earth radius.

h is the height from the Earth surface

W_e is the Mean motion of the Earth in its orbit around the Sun [rad/s]

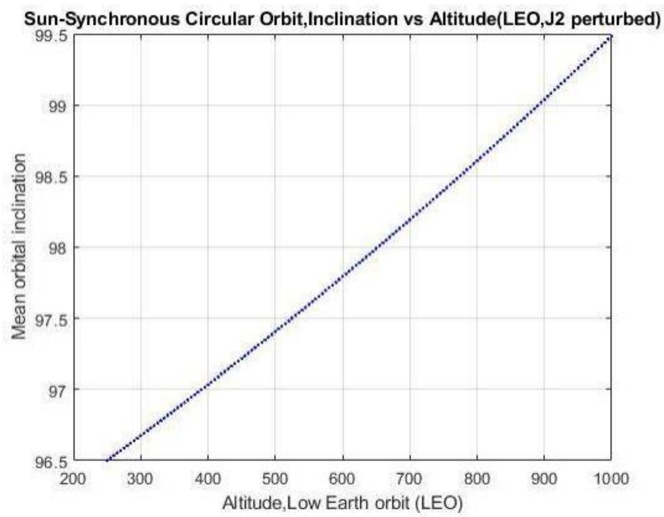


Fig. 1. Sun-Synchronous Circular Orbit, Inclination vs Altitude Curve.

B. Designing structure

For our work, we designed a 3U pumpkin CubeSat. The 3U CubeSat structure model is the most used model in CubeSats [9]. We designed rectangular pumpkin which achieves simple design, simple manufacturing process, simple solar panel at-attachment, easy installations of subsystems, less joints and link elements. We manufactured this structure from aluminium 6061 which provides High strength-to-mass ratio, Easy manufacturing, High ductility, High thermal conductivity, relatively low density and its Cost effective [10]. For our mission this model has a sufficient volume for containing all CubeSat subsystems and for the payload. We use an imaging camera "NanoCam C1U" as a payload which shown in Fig 2 which is a CMOS sensor. The system without optics weighs 77 g and size of 79.7*91.7*23.2 mm. The 70 mm lens has a focal length is 70.5 mm and resolution less than 30m per pixel from 650 Km altitude and weighs 200g.

Fig. 2. MTCsat payload

STK has its own default CubeSat models that can be loaded into the mission, their solar panel area and efficiency cannot be edited. We won't use one of these default model in our analysis and simulations. For completing building our own design (MTCsat), we used blender to create solar cells group, add textures, define sensor attachment point and define the axis alignment [11]. The final structure is shown in Fig 3.

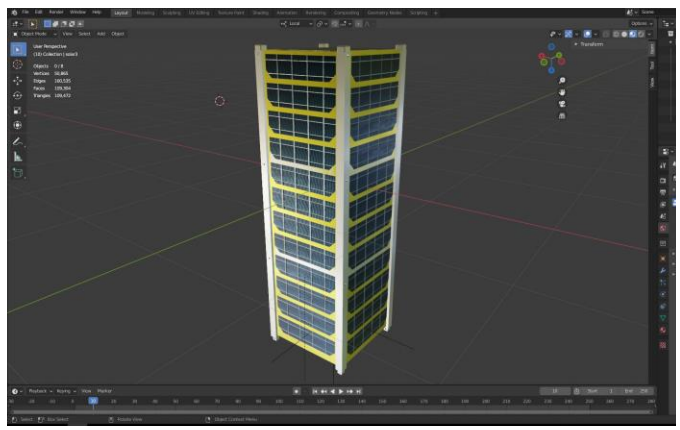


Fig. 3. Final Design of MTCsat

And For MTCsat to work properly in STK, we export collada file (.dae extension) from blender to load it in STK and ancillary file was added to determine articulation of MTCsat. The Collada file (.dae) defines the model geometry and node names, while the ancillary file (.anc) is the driving code behind all articulations, sensor attach points, solar panels and solar panel efficiency in STK. We defined the efficiency of solar panel to be 28 %. This is reliable value as the space standard solar cell reaches up to 30 %.

C. Launching platform

The launch of conventional satellites into orbit requires sophisticated technologies and a launch vehicle. To ensure that a satellite will endure the harsh environment during launch and its operational term in space, the space environment tests must be passed by the satellite. Among them, the satellite is severely stimulated during the vibration test, which simulates the vibrations generated during launch.

Because they are positioned in the same region as the primary satellite, piggyback satellites must pass this test. In contrast, satellites that are deployed from the space station are transported by cargo spacecraft, where they are packed with packing material and stored in a soft bag. They experience less vibration during launch to the space station than piggyback satellites have. From the International Space Station (ISS), which orbits the Earth at an altitude of 408 km and an inclination of 51.6 deg, CubeSats can be deployed to study the area below. It may develop into a permanent launch site for the fleet of tiny satellites that is deployed often or in response to demand. The ISS has the benefit that the deployment of these tiny satellites is not reliant on locating an appropriate ground-based launch opportunity. Complete coverage of the mid-latitudes and the equator is also made possible by the comparatively high ISS orbit inclinatio. Launching satellites from ISS can reduce the cost of launching as it doesn’t need a special launcher platform and consequently reduce the total cost of the project so it’s preferred to launch satellites specially CubeSats from ISS as they have relatively smaller life time of operation.

III. METHODOLOGY

A. MATLAB/STK Interface

The MATLAB/STK interface allows overall simulation parameters, satellite orbital parameters and constraints, and different system models to be defined in MATLAB and related to STK. With the integration of MATLAB and STK, both of them can operate through each other to access the capabilities of both tools without switching between application sessions. To automate STK from MATLAB, STK/Integration license is required to open the connection between MATLAB and STK that can be done through a COM connection or TCP/IP connectors. STK can be commanded by a select number of mexConnect commands via TCP/IP connectors, which are a limited subset of core MATLAB/STK interface commands that can be found by exploring the MATLAB help menu and all of them are prefixed with STK. We used COM connection to automate STK and pull data back into MATLAB. The COM interface is the recommended approach since it is extremely dependable, compatible with any STK and MATLAB configuration, and doesn't require any additional installations. COM interface open application programming interface (API) for programming, which is a set of subroutine definitions, communication protocols, and tools for building or tasking software. In our work we will use COM connection to automate STK for doing a trade study for selecting, comparing, analysing and designing the mission orbit.

IV. STK/MATLAB TRADE STUDY

Knowing the effect of orbital parameters on mission requirements is much important before designing the orbit [12]. Orbital parameters such as altitude, inclination and eccentricity have a great effect on mission requirements as coverage, sensitivity, environment, launch capability, communication and lifetime. Fulfilling these requirements as best as possiple is the base of mission success. For our satellite the mission is make imagery coverage for Egypt. This observation mission need high altitude to achieve better coverage and communication. Also high altitudes gives longer lifetime. From the point of view of camera payload, the low altitude is better for the quality and resolution of images and that is a trade-off [3]. This trade off repeats for the major of orbital parameter so we are always in need to find the optimum orbit that achieves the longest lifetime, best communication, minimum revisit times, highest power budget angle and all mission requirements.

We designed a MATLAB code to automate STK and generate trade-offs of orbits and calculate the maximum access time for the group of the vital points for every orbit. And for achieving that purpose, we vary two orbital parameters simultaneously as shown in table I.

TABLE I
VARIATION OF ORBITAL PARAMETERS

parameter	Start value	Last value	Step value
Altitude(Km)	375	788	10
i (deg)	0	90	5

From the variation of these parameters, we have 817 trade-offs. These trade-offs, possible orbits, can be increased by increasing numbers of varying parameters, increasing range between start value and final value or reducing step value. As a result of this trade study, the relation between altitude, inclination and access time can be shown in Fig 4. From the resulted relation between altitude, inclination and access time.

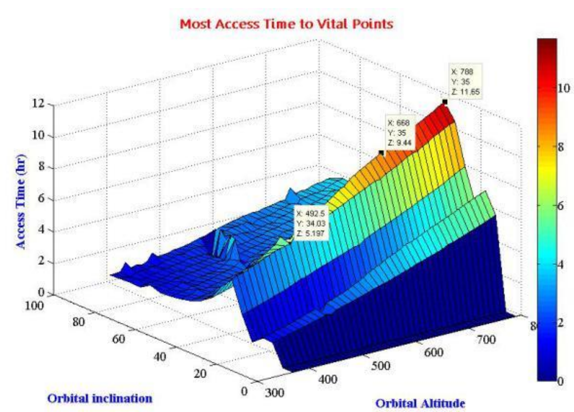


Fig. 4. Altitude, Inclination vs. Access time

It’s obvious that inclination of 35 deg has the maximum access times for the grouping vital points for our mission and the access time increases gradually with increasing altitude at this inclination until it reaches its maximum value 11.646 hr. at the maximum simulated altitude 778 Km at 30 days of simulation.

For designing an orbit for our mission we will analyse and compare three CubeSats. The first CubeSat (MTCsat-A) will have the same parameters as Egyptsat-A. From the trade study we will choose the second CubeSat (MTCsat-B) that will have the same altitude of Egyptsat-A but has inclination of 35 deg. As mentioned before, launching CubeSats from ISS have many advantages and can reduce the budget of the all project. In addition, satellites in lower altitudes have smaller ground resolution and that is required for observation missions for increasing of quality of images taken by satellite payload. So, the third satellite (MTCsat-C) is supposed to be launched from ISS. The orbital parameters of the three satellites are shown in table II. The three CubeSats in STK platform are shown in Fig 5.

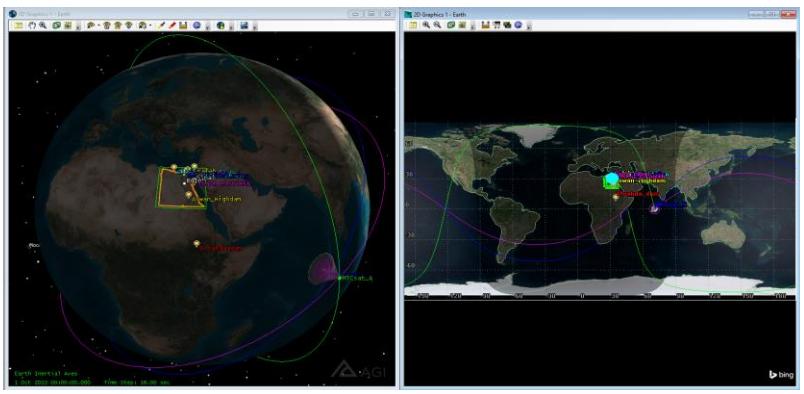


Fig. 5. The three CubeSats in STK platform

V. MISSION ANALYSIS AND DISCUSSIONS

In this section we will introduce mission analysis for the three CubeSats. Also, we will introduce a comparison between them in some Fig of merits (FOM) as coverage, revisit times, beta (β) angle, lighting times and power collected from solar cells. The STK scenario simulates the mission from start date of May 1st, Oct, 2022, at 00:00 and lasts to 30th, Oct, 2022 at 00:00.

A. STK setup

In this section we will introduce all STK setup for this CubeSats, sensor and places which are simulated in this software.

TABLE II
ORBITAL PARAMETERS OF THE THREE CUBESATS

CubeSat	Altitude(Km)	Inclination(deg.)
MTCsat-A	668	98.0631
MTCsat-B	668	35
MTCsat-C	398	51.6

TABLE III
THE THREE CUBESATS PARAMETERS

MTCsat	RAAN	80 deg.
	AOP	0 deg.
	TA	0 deg.
	propagator	J2 propagator
	3D model	MTCsat
	Mass	4 Kg

TABLE IV
LOCATION OF VITAL POINTS

Vital point	LAt.(deg)	LONG.(deg)
MTC ground station	30.08	31.3
Suez canal	30.61	32.347
Aswan High Dam	23.97	32.87
New capital city	30.04	31.48
El-Nahda dam	11.2	35.09
Sinai	29.67	34.001
Cairo	30.04	31.23
Eldabaa station	31.05	28.44
Sharm El-Shiekh	27.969	34.36
Rafah	31.38	34.24

B. Coverage

The coverage network is extremely important to the success of the whole mission. A reliable and professional coverage is a high priority Fig of merit for any satellite.

1) Egypt access duration and number of accesses: Access Duration measures the intervals during which coverage is available from a single asset. Fig 6 clarifies the numbers of access times of each satellite sensor for 30 days simulation. The access times for that period of simulation can be more illustrated in table V.

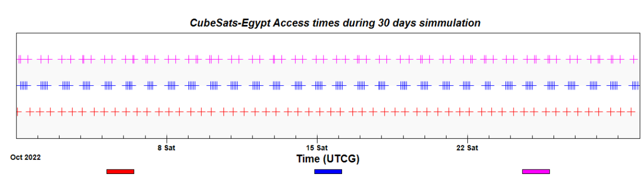


Fig. 6. CubeSats-Egypt Access times during 30 days simulatio

TABLE V
SUMMARY OF CUBESATS-EGYPT ACCESSE DURING 30 DAYS SIMULATION

CubeSat	Minimum Duration(min)	Maximum Duration(min)	Total Duration(min)	No. of Accesses
MTCsat-A	1.537	5.296	263.823	58
MTCsat-B	0.746	6.510	765.718	161
MTCsat-C	0.217	5.251	223.192	74

From these results, it's obvious that MTCsat-B has the most accesses times to Egypt and consequently the longest total access duration. MTCsat-B is preferable from the point of view of this Fig of merit during 30 days simulation. It can be noticed that MTCsat-A and MTCsat-C have a close total time access duration but MTCsat-B provides more than double period of each of the individually.

4) Revisit Time: Revisit Time measures the intervals during which coverage is not provided (also known as "the gaps"). The dynamic definition of Revisit Time computes the duration of the current gap in coverage for each grid point. If a grid point is accessible at the current time, the gap duration is computed as zero. The average revisit time is computed as in equation 4. A comparison between the three CubeSats is illustrated on latitudes from deg. in Fig 7.

$$Average\ revisit\ time = \frac{\sum_{i=0}^{N} Gap\ duration_i}{N} \quad (4)$$

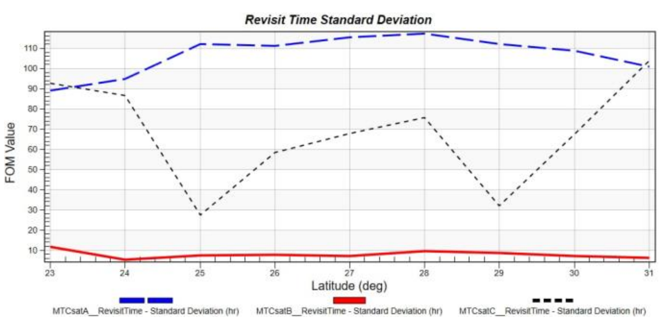


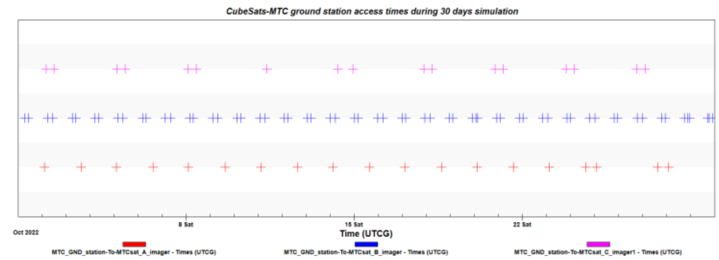
Fig. 7. Average Revisit Time Comparison

From the Fig above, it's obvious that MTCsat-B provides the least Time average gab. Less average revisit time means less gap duration time. It's important for earth observation mission to have a small revisit time on the covered area.
So, MTcsat-B is preferable for our mission.

5) Ground station access duration and number of

CubeSat	Minimum	Maximum Duration(min)	Total Duration(min)	NO. of Accesses
MTCsat-A	0.051	1.969	28.903	22
MTCsat-B	0.299	2.11	59.574	105
MTCsat-C	0.342	1.152	12.068	25

accesses: The coverage network is extremely important to for ground stations to communicate with the satellite. Fig 8 clarifies the numbers of access times of each satellite during 30 days of simulation. The access times during that period of simulation can be more illustrated in table VI.



CubeSat	Minimum Duration(min)	Maximum Duration(min)	Total Duration(min)	No. of Accesses
MTCsat-A	0.751	2.582	54.384	27
MTCsat-B	0.623	2.768	200.057	91
MTCsat-C	0.654	1.520	26.749	21

Fig. 8. Satellites-Ground station Access times

TABLE VI
SUMMARY OF CUBESATS-GROUND STATION ACCESSES

From the results above, MTCsat-B is preferable because it provides the longest total access times and duration. Increasing this FOM is very important for communication system as it represents the time of transferring data from and to satellites.

6) Al-Nahda dam access duration and number of accesses: It's important for us to monitor the changes occur in this area. That will help us to protect any threat may happen to Egypt. Fig 9 clarifies the coverage times for the three CubeSats for the dam for 30 days of simulation. Table VII provides more illustration about these periods of duration during 30 days of simulation.

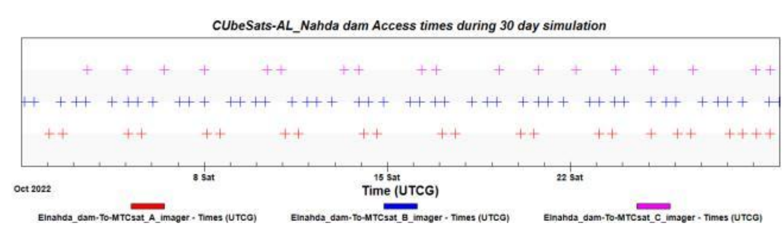


Fig. ٩. CubeSats-Al-Nahda dam Access times

TABLE VII
SUMMARY OF CUBESATS-AL-NAHDA DAM ACCESS

From results above, MTCsat-B is preferable from this FOM because it provides the longest total access duration Achieving long periods of access of this vital area is required for achieving good prediction of any threat earlier to deal with it.

C. Beta angle

Beta angle is defined as the angle between the orbit plane and the vector from the sun (which direction the Sun is shining from). The beta angle determines the percentage of time that a satellite in low Earth orbit (LEO) spends in direct sunlight and absorbing solar energy. The beta angle varies between +90 and −90 deg and the direction in which the satellite orbits its primary body determines whether the beta angle sign is positive or negative. Fig clarifies the definition of beta angle. Beta angle for the three satellites for 30 days of simulation can be shown in Fig 1١.

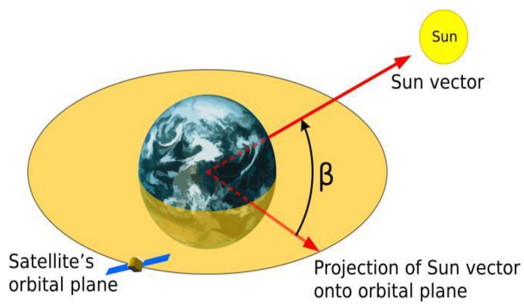


Fig. ١٠. Definition of beta angle

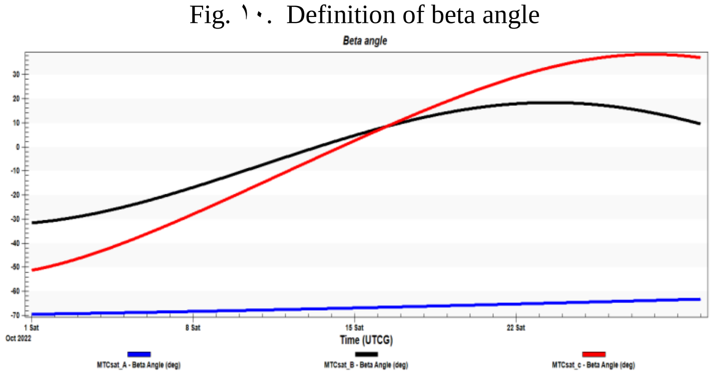


Fig. ١١. Beta angle for the three satellites

For a satellite to be in sunlight as much as possible for conversion of sun light by its solar panels beta angle must be as close to +90 or -90 as possible. From the Fig above, MTCsat-A is expected to be directed to sun light for the longest period of time. In our mission, Sun light is much important as it represents the only source of electrical power and all subsystems need this power to operate efficiently. So, MTCsat-A is preferable from the point of view of Beta angle.

D. Lighting times

There will be some periods when the satellites will not be illumined. It occurs when the Earth blocks the sunlight, or if there is a moon eclipse between Earth and Sun. The sunlight periods can be shown in Fig ١٢ and also eclipse periods are shown in Fig ١٣. The two Figs show the eclipse and sun light times for only one day simulation. Also, the details of lighting times for 30 days of simulation are illustrated in table VIII.

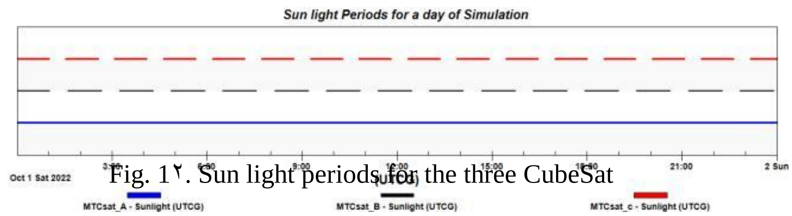


Fig. 1٢. Sun light periods for the three CubeSat

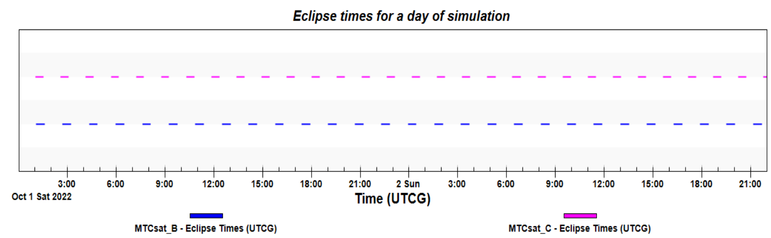


Fig. 1٣. Eclipse periods for the three CubeSat

TABLE VIII
SUMMARY OF CUBESATS LIGHTING TIMES FOR 30 DAYS OF SIMULATION

CubeSat	total sunlight Duration(day)	Total eclipse Duration(day)
MTCsat-A	28.514 day	1.486
MTCsat-B	18.824	11.176
MTCsat-C	18.26	11.74

Direct sun light times determines the periods of producing solar energy. That is more important for our mission as mentioned before. From results above, MTCsat-A is in direct of sun light during the whole day. The two other CubeSats are directed to sun light for nearly the same period that represent two thirds of the whole day. For MTCsat-A it achieves 28.5 from 30 days in direct sun light and for the first day of simulation it doesn't have any eclipse times as shown in Fig 15. That means we have days of full sun light and the there are some days that have eclipse times.

E. power gathered from solar panels

It's important to obtain a good estimation of the power collected by solar cells. That is important for designing of the power supply system. The Solar Panel tool in STK enables us to model the exposure of solar panels mounted on spacecraft, aircraft, and ground vehicles over a given time interval. To compute the electrical power captured by the solar panels at a given point in time, the Solar Panel tool applies equation 5 which is called the basic power equation.

Power = efficiency* Solar Intensity * Effective area* Solar Irradiance (5)

The power gathered from the MTCsat-A, MTCsat-B and MTcsat-C for five months of simulation are shown in Figs 1٤, 1٥ and 1٦ respectively. Now, it's obvious that these values depend on multiple parameters as efficiency of solar panels of the satellite which is 28% in our model, solar intensity which ranges from zero at umbra times through (0 < intensity <1) at penumbra times to one at full sunlight times and solar irradiance.

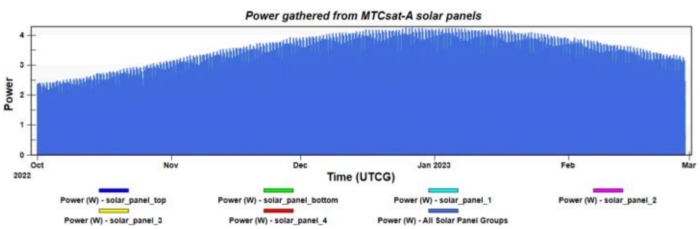


Fig. 1٤. Power gathered from MTCsat-A

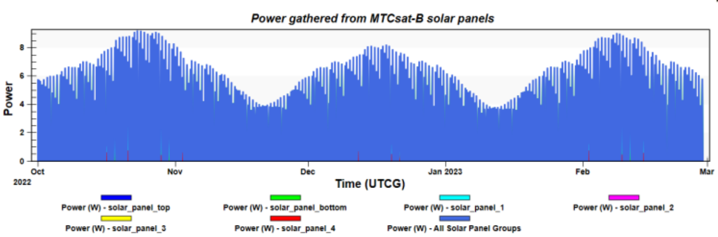


Fig. 1٥. Power gathered from MTCsat-B

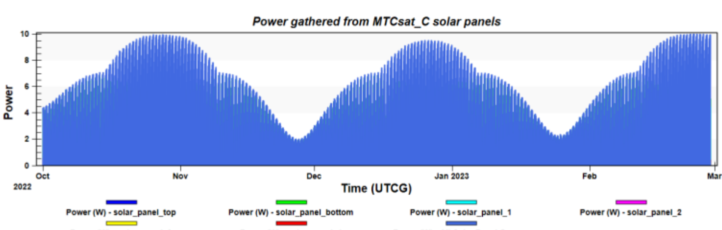


Fig. 1٦. Power gathered from MTCsat-C

From results above, it's obvious that the three CubeSats receives sunlight each day.

Comparing the three graphs, MTCsat-A can gather a peak power of 4 watts. Power gathered has no high variations or peaks and it minimum gathered power is 2.4 watts. The power generated from this CubeSat is almost constant during its life time. On October the power gathered from this CubeSat is minimum and increases on December and on December and January months have almost the peak value in all days. This peak value degrades again on February.

Power gathered from MTCsat-B has three peaks in five months. The peak power gathered from this CubeSat is about 8.4 watts and the minimum value is 4 watts. The days of collecting the minimum value of MTCsat-B is almost equal to the maximum value of MTCsat-A. So, MTCsat-B is preferable.

MTCsat-C also has three peaks of power gathered. The gathered power can reach a maximum of 10 watts and it has a minimum value of 2 watts. MTCsat-C gathered the highest power value of the tree CubeSats. The minimum value collected from MTCsat-C is less than the minimum of MTCsat-B. From the analysis of power system, MTCsat requires around 7 watts to operate all subsystems simultaneously. This analysis of power gathered from the three CubSats can be more illustrated from the analysis of one day of simulation from 1St October 00.00 to 2nd October 00.00.

Figs 1٧, ١٨ and ١٩ show the power collected from MTCsat-A, MTCsat-B and MTCsat-C respectively.

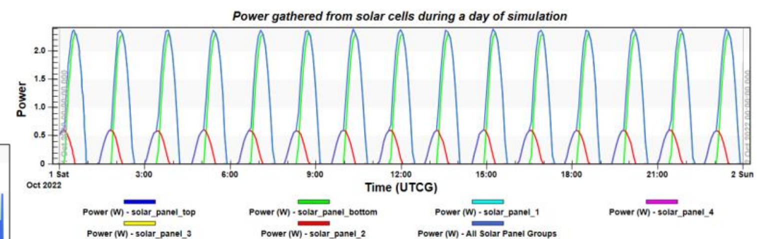


Fig. 1٧. Power gathered from MTCsat-A

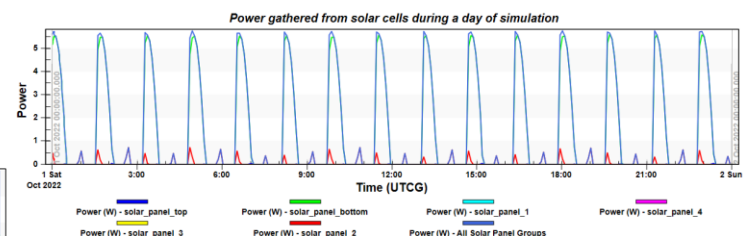


Fig. ١٨. Power gathered from MTCsat-A

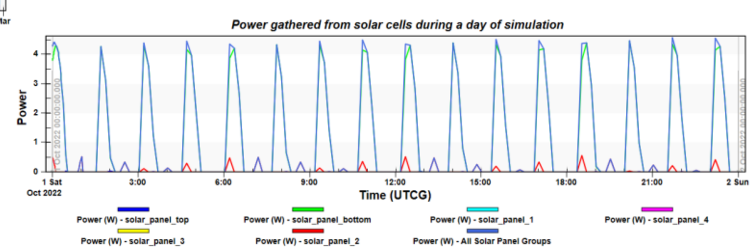


Fig. ١٩. Power gathered from MTCsat-A

F. Life time

The lifetime is an important parameter of a space mission [1] It represents the time at which the satellite carries out its function. The orbit decay of satellites limits the lifetime of most CubeSats missions. So, the lifetime represents a great factor of the success of the whole mission [13]. The satellite lifetime depends on some parameters, the initial satellite orbital parameters, the drag force, the atmospheric density and the solar, geomagnetic activity and batteries lifetime [1][3].

So, selecting these parameters is reflective factor on achieving the space mission requirement [12].

Table X clarify the CubeSats parameters and STK setup used for life time calculations. Estimated life time of the three satellites can be illustrated in in table IX.

TABLE X
STK SETUP FOR LIFE TIME

Parameter	Value
Drag coefficient(c_d)	2.2
Solar flux sigma level	0
Solar Radiation Pressure coefficient(c_r)	1
Mass	4 Kg
Drag Area	0.0233 m^2
Sun Area	0.0233 m^2
Decay Altitude	65 Km
Solar flux	SpaceWeather-v1.2.txt
Atmospheric density model	NRLMSIS 2000

TABLE IX
MATED LIFE TIME OF THE THREE CUBESATS

CubeSat	Life time	NO. of orbits
MTCsat-A	13.1 yr.	7145
MTCsat-B	8.7 yr.	4755
MTCsat-C	44 days	708

MTCsat-A achieved the longest life time period. It's preferable for our mission to have longer life time period to enable us to make use of CubeSat for longer periods. Life time can be enhanced by using control system by some means as reaction wheel or magnetorquer to correct the CubeSat path during orbiting the earth.

VI. CONCLUSIONS

In this paper, we have presented the orbit design for a 3U CubeSat. This CubeSat is designed in Military technical college and named with MTCsat which mainly has a mission of providing imagery coverage for Egypt area. The ground station of this mission is supposed to be located inside Military Technical College. In doing so, we selected the suitable structure for that mission, designed solar cells by the aid of blender, added structure articulations in ancillary file and then made a trade study by a code generated on Matlab interface by integrating with STK. The trade study is made to give information about orbits that gives the highest access duration time for vital points. We selected 3 CubeSat for complete analysis. Then, we implemented different analysis on the 3 CubeSats by using STK. The analysis is made for selecting the most satellite that fulfils the design requirements. In this mission we aims basically to achieve high coverage for area target, vital points and ground station. A quick comparison between the three satellites from different Figs of merits can be shown in table XI.

TABLE XI
COMPARISON BETWEEN THE THREE CUBESATS

Sat. / FOM	MTCsat-A	MTCsat-B	MTCsat-C
Egypt Coverage		The best access	
Vital points coverage		The best access	
Ground station access		The best access	
Beta angle	The best angles		
Lighting times	The longest period		
Power gathered			The maximum value
Life time	The maximum life time		
Cost			The lowest
Launch option			The best

From this trade study and results, MTCsat-B is selected for our mission with altitude of 668 km. and 35 deg. Inclination. MTCsat-B has the same altitude of EGYPTSAT-A and inclination of 35 deg. The selected CubeSats meets the parameters resulted in trade study. That means that this trade study is a good indication when designing orbit. MTCsat-B exceeds the two other CubeSats in coverage Egypt area and vital points as resulted from trade study analysis. It has the most time access to ground station and that is very important for good communication system. From the point of view of beta angle and lighting times it's supposed to be directed to sun at time less than MTCsat-A but it doesn't matter because power gathered from MTCsat-B is nearly the double of that of MTCsat-A. MTCsat-B produces 8.5 watts as maximum value. According to power system analysis, mission requires 7 watts as a maximum value in case of operation all subsystems together. Power system can be managed and the rest of the power can be stored in batteries to be used in eclipse times. Also, it has an acceptable value of life time, 8.7 yr., Compared to life time of MTCsat-A. MTCsat-C isn't preferable because it has very small life time compared to the two other CubeSats. Actually, launching MTCsat-C from ISS can decrease the cost but it's has low coverage for Egypt and provides the lowest access time duration to the ground station. For all these reasons, MTCsat-b is selected for our observation mission.

VII. FUTURE WORK

By This work it's obvious that integration between MATLAB and STK is much effective as it can generate thousands of trade-offs of possible orbits by changing some parameters. So, we intend to develop this trade study to calculate more than one FOM. Also a graphical user interface can be developed to simplify dealing with this trade analysis and enables user to insert parameters and ranges in simple way.

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