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Constellation of Earth Observation Satellites over the Middle-East

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ABSTRACT: Middle Eastern countries and especially Israel's space activity increases largely during the last decade, they declare the main objective of their Ofeq constellation as the "watch eye" over the Middle Eastern countries. The commercially published satellite catalog data does not include the military or the "Reconnaissance" satellites data. In this paper, a survey is carried out on the Israeli's launching capability showing a description of the SHAVIT launch vehicle and its launch sequence, survey also covers the types and quantity of launched reconnaissance satellites with the used payloads and platforms.

The method of collecting and predicting the operational Ofeq constellation satellites is described, and an overview of how combined Israel's constellation can observe and identify a target over the territory of the Arab Republic of Egypt. Also, the Ofeq series constellation parameters are described showing how the Israeli's reconnaissance constellation satellites are increasing with high technology payloads (optical and radar base).

KEYWORDS: Satellite constellation, TLE, Launch Vehicle, observation gaps.

I. INTRODUCTION

The commercial services for high-resolution satellites payload market experienced fast growth during the last 5 years, permitting the availability of commercial imagery less than 1m in the market. Artificial satellites are classified according to their mission as scientific research, weather, communications, navigation, Earth-observing, and military. There are four major types of reconnaissance satellites [1] utilized in military activities:

- i. *Ballistic Missile Early Warning*, provide warning of an attack by detecting ballistic missile launches (Missile Defense Alarm System).
- ii. *Nuclear explosion detection*, monitors, identifies and characterizes nuclear explosions in space.
- iii. *Photo surveillance*, provides high-resolution photography of earth from space. images can be a survey of military places, strategic projects, or military activities.
- iv. *Radar imaging*, most space-based radars use synthetic aperture radar, can be used at night or through cloud cover, it is very expensive and high technology.

At the beginning of 1980, the Technion Israeli Institute of Technology in Haifa designed, built, and launched a micro-satellite, this institute is one of the few universities worldwide to close the cycle between designing and production up to the insertion of a satellite in its working orbit.

Israel officially entered the space age with the lift-off of its first satellite, Ofeq-1, from the locally built Shavit launch vehicle on September 19, 1988. With that launch, Israel joined an exclusive club of space countries - Russia, the United States, England, Japan, India, France, and China - that have developed, produced, and launched their own satellites. They made important contributions in a number of space areas including satellites subsystems especially space propulsion (Hydrazine monopropellant, cold gas system, hall thruster), payloads such as high-resolution telescope, and SAR, their space activities focus on high-resolution imaging satellites in low earth orbits and geosynchronous telecommunication satellites.

Israel launched its 1st AMOS communication satellite to GEO orbit in 1996 with a partnership with Alcatel Espace (France) and Daimler-Benz Aerospace (Germany), it is Launched by the French Ariane-4 launch vehicle, to provide high-quality broadcasting and communication services for the growing markets of Eastern countries.

In 2003, NASA launched the space shuttle Columbia (mission STS-107). The seven crew members on board included the first Israeli astronaut, Ilan Ramon. On October 30, 2015, the UN accepted Israel as a member of the United Nations Committee on the Peaceful Uses of Outer Space followed by joining the UN Committee on Space Affairs as an official member in 2016.



Israel has a formal space research cooperation agreement with France, Germany, Russia, Ukraine, India, and the Netherlands, this cooperation yields numerous significant projects as VEN μ S Project for scientific objective, SHALOM Project, which is aimed to launch a hyperspectral satellite; MEIDEX Project that studies the Mediterranean region and its influence on the weather and climate. They also will participate in the European Global Navigation system.

Israel launched a military reconnaissance satellite with the ability to have an eaves-drop on Arab neighbors especially Egypt, Syria, Iraq, Saudi Arabia, and Iran (Iranian ballistic missiles activities and nuclear weapons program) amid heightening tensions in the region, all launchings are under the cloak of secrecy at a retrograde orbit. Such an orbit would bring the satellite over portions of the world between ± 40 north and south Earth latitude, including all of Israel's Arab neighbors.

Ofeq series is the designation of a series of Israeli reconnaissance satellites built by Israel Aerospace Industries (IAI) for the Israeli Ministry of Defense.

Ofeq-9 is a twin brother of Ofeq-7 and Ofeq-10 is a similar version of Ofeq-8, Israeli reconnaissance satellites have two generations of Ofeq series, they have optical or Synthetic Aperture Radar (SAR) payloads with high resolution reaches 0.5m, intended for surveillance of Israel's neighbors. The SAR payload is fitted with a large dish-like antenna to transmit and receive radar signals that can penetrate the darkness and thickness of clouds.

The Ofeq series is unusual in having a retrograde orbit. This is due to the geographical location of Israel, which gives only an unobstructed launch path over the Mediterranean Sea. These satellites are an improved version of the first generation Ofeq reconnaissance satellites, they are similar to the EROS-A civilian Earth observation satellite.

II. CONSTELLATION DESIGN

Space constellation can be for satellites or orbits, commonly using satellite constellation with communications service can be traced back to 1945. The 1st proposed scheme is using three GEO satellites to provide continuous coverage for the equatorial region [2]. The GEO satellite cannot provide a good service for earth observation, since the orbit of the GEO satellite is extremely high besides, the huge power requirement of the transmitter and receiver terminals. LEO and MEO satellites have smaller link loss and limited coverage area; the application of LEO and MEO satellites is larger than GEO satellites for earth observation. The limited coverage area of LEO and MEO satellites makes constellation design more complex.

Orbit constellation can be for:

1. GEO constellation for broadcasting and communication purposes,
2. Molniya constellation for communication purposes.
3. LEO/MEO constellation for Earth observation, Navigation, and communication,
 - Polar orbit constellation,
 - Inclined orbit constellation,
 - Single orbit constellation

Constellation design parameters can be discussed as the following:

- Mission objectives.
- Orbit type (LEO, MEO, SSO, Molniya orbit).
- Orbit parameters,
 - Altitude (resolution, swath width),
 - Inclination (earth coverage area, ground station).
- Delta-velocity budget,
 - Orbit corrections,
 - Station keeping,
 - Re-phasing.
- Collision avoidance,
 - Maximizing the spacing between satellites,
 - Remove satellite at the end of life.
- Number of satellites.
- Launch option.
- Life time.
- Cost.

The constellation of satellites mission has the following evaluation:

Advantages:

- Earth coverage enhancement,
- System simplicity,



- Survivability.

Disadvantages:

- Launch cost,
- Limited capability.

Once the satellites in their constellation orbit, all satellites need to correct the orbital elements once perturbing forces (oblateness of the Earth, J2, drag, attraction of the sun and moon, solar radiation pressure) have altered them and also to adjust constellation performance requirements. For the orbit over 200 km, the effect of the J2 is the most important. The orbit suffers by two main changes:

1. Rotation of orbital plane around the North-South axis, called regression of nodes $d\Omega/dt$ [3]:

$$=-32]2R21-e22a72\cos i \tag{1}$$

2. In plane rotation called rotation of apsides $d\omega/dt$ [3]:

$$=-32]2R21-e22a7252i -2 \tag{2}$$

Where: a, e, i orbit semi-major axis, eccentricity and inclination respectively.

Satellite repeating ground tracks is a vital parameter for constellation mission.

The ground track repeatability (GTR) is the time period (days) between the satellite revolution having a similar ground track, this parameter is vital for imaging mission planning and prediction.

Using the equation of two-body motion for GTR, if the period, P1, satisfies an integer number for revolutions, n, per integer number of sidereal days, m (1 sidereal day=1436.068 min), as the following relation:

$$n=m/P1 \tag{3}$$

Due to the effect of Earth’s oblateness, J_2 , which changes the right ascension of ascending node, $\Delta\Omega$. The modified satellite’s period, P_{new} is

$$P_{new}=P1+\Delta\Omega \tag{4}$$

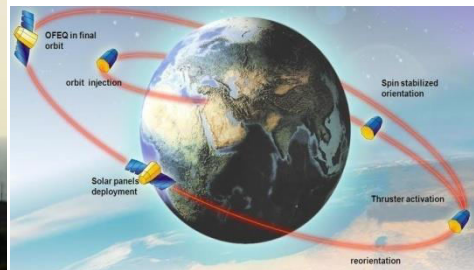
Where, ω is the Earth’s angular velocity.

III. METHODOLOGY

On 11 April 1949, Palmachim Israel's primary spaceport is established by former members of the Palmach underground organization's Yiftach Brigade. It is used to launch the Shavit space LV into retrograde orbit over the Mediterranean sea from launchpad situated at 31°53'04"N 34°40'49"E.

The Israel Space Agency is one of only seven countries that both build their own satellites and launch their own launchers. The Shavit is a space launch vehicle (LV) capable of sending spacecraft (SC) into low earth orbit (LEO). The Shavit LV is used to send almost all Ofeq satellites to date. It is developed by Malam factory, one of four factories in the IAI Electronics Group. The factory is very experienced in developing, assembling, testing, and operating system for use in space.

Shavit LV is created in cooperation between South Africa and Israel during the development of the RSA-3 ballistic missile in the 1970s to 80s. It is based on the Jericho-II ballistic missile that is developed in the 1980s with cooperation with French aerospace manufacturer and modified by stretching the first stage to increase the LV’s performance in 1994, after two failed launches, Shavit-2 LV is upgraded by adding an upper stage liquid propulsion engine, it acts as a fourth stage, Figure 1., to reach a higher performance orbit and provide precise insertion capability.



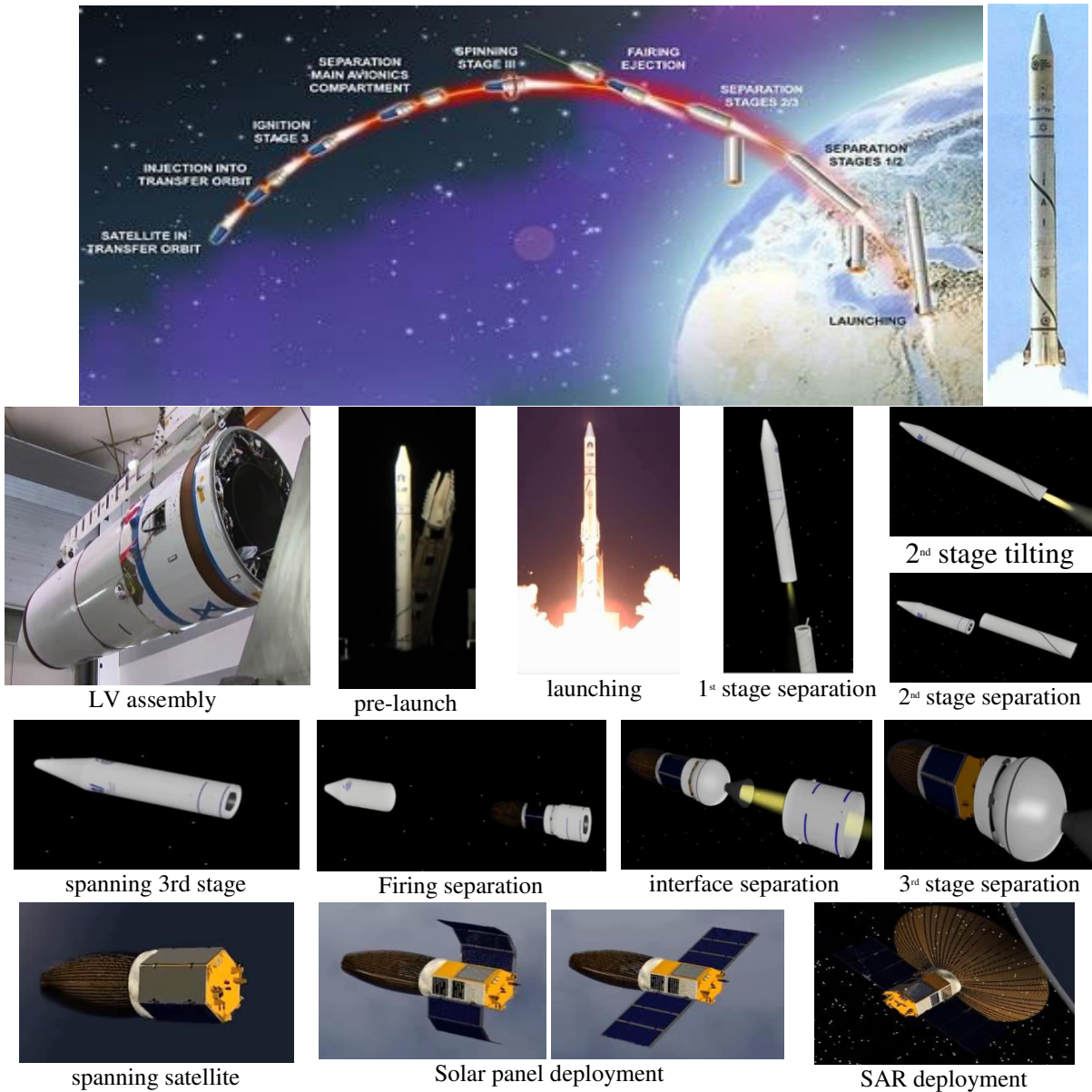


Fig. 1. SHAVIT LV Mission Launch Sequence

In 1988, first launch from the Palmachim Airbase carrying the ≈ 155 kg Ofeq-1 SC, Israel launch Shavit LV to the west direction (retrograde orbit), across the Mediterranean Sea, which required the launcher to compensate for Earth's rotation, needing additional performance to reach the retrograde orbit that reduced the overall payload mass capacity. Launching to the West is the only option for Israel because of worried relationships with Arab countries located east that would be hit by LV stages debris (drop zone areas) and also for avoiding flight path trajectory over neighboring Arab countries, leaving only the westward launch option. That's why polar and sun-synchronous orbits cannot be accessed from Israel with the current LV Shavit-2.

Israel's Shavit LV is a three-stages using solid propulsion technology with optional liquid propulsion in the upper stage as fourth-stage for precise insertion capability. The fourth stage is a small mass 240-Kg using hydrazine mono-propellant and several thrusters to provide a thrust of 402 N with re-ignition capability and a cumulative burn time of up to ten mins. Shavit-2 made a total of three launches to date premiering in 2007 with the launch of Ofeq 7 followed by the launch of Ofeq 9 in 2010, Ofeq 10 on April 9, 2014, and finally Ofeq 11 on Sep. 13, 2016.

The Shavit LV has a protective SC fairing with a 1.35m diameter and ≈ 4 m long. The separation of the second stage from the third stage at an altitude of ≈ 110 Km, the launcher enters a coast phase to reach apogee so that the third stage



burn can serve as a circularization maneuver to deliver the stack to orbit. The third stage engines are manufactured by Rafael Advanced Defense Systems.

A launch failure in September 2004 caused the loss of Israel’s planned Ofeq-6 satellite.

Three versions of Shavit LV have flown to date, the first version is launched twice (Ofeq 1, 2), using ATSM-9 solid motors as first and second stages used on the Jericho-II, the second stage is equipped with an extended nozzle optimized for operation in vacuum and AUS-51 solid motor as the third stage.

The second pattern is named by Shavit-1 LV, having ATSM-13 solid motor as the first stage, retaining the ATSM-9 and AUS-51 solid motors as the second and third stages. The Shavit-1 LV was used from 1995 to 2004 for the launch of Ofek-3 to 6.

The third configuration, Shavit-2 LV, replaced both ATSM-9 motors with ATSM-13S and AUS-51 solid motor remains unchanged as the third stage. Starting from 2007 up till now, all launches used the Shavit-2 LV for Ofeq 7, 9, 10, 11. Shavit LV is mainly designed and manufactured for reconnaissance Israeli satellites’ Ofeq program.

The Shavit LV by third stage (AUS-51) is capable to eject Ofeq satellites to 262 x 774 km LEO at 141.23deg. inclination.

The Shavit LV is launched 10 times, success to full placing the Ofeq series into LEO eight times, the 4th and 6th trips, the LV failed during the flight in space. The Shavit launcher allows low-cost and high-reliability launch of micro/mini-satellites to an LEO. The Shavit-2 LV is said to be made available for commercial launches in the near future.

Table 1. Shavit LV performance parameters

Shavit LV characteristics					
Height, m	21.0 - 26.4				
Diameter, m	1.35 - 2.30				
Mass, kg	31,500 up to 70,000				
Number of Stages	4				
Fairing (length, diameter), m	1.35, 4.0				
Capacity	Satellite to LEO 350 – 800kg				
Launch direction, deg.	eastward (retrograde orbit), 141.23°±0.5°				
Launch sites	Palmachim Airbase, Tel Aviv area at the coast of the Mediterranean Sea, Israel				
launch pad	31°53'04" N - 34°40'49" E				
Total launches, failure	10, 2				
Reliability	80%				
First flight	19 September 1988				
Performance	First stage		Second stage	Third stage	Fourth stage
Engines	LK-1	LK-2	1 LK-1	AUS-51	1 LK-4
Thrust at ground, KN	564.0	1202.4	---	---	---
Thrust in Vacuum, kN	774.0	1650.2	629 - 774.0	58.8 - 60.4	0.400 - 0.402
Isp, sec	268	280	268	298	200
Burn time, sec	55	82	53 - 55	91 - 94	600 - 800
Length, m	7.3 and 7.8			2.1	
Diameter, m	1.35		1.35	1.3	
Dray mass, kg	1,240		1,380	200	
Propellant mass, kg	12,750		12,750	1,850	240
stabilizing	fins with span 2.3m		---	spin	
Solid propellant	HTPB polymer-based propellant				N2O4/UDMH



IV. OFEQ SATELLITES LAUNCH CAPABILITY AND ITS HISTORY

Five satellites in the Ofeq constellation are now in service, to know the approximate orbital location of these SC’s, Two Line Elements data generated by NORAD in Cheyenne Mountain, Colorado [4],

Ofeq-7 satellite: it is launched at 2340 GMT Sunday (7:40 p.m. EDT), with the ability to eavesdrop on Iran and Syria.

Two Line Element Set (Ofeq-7) as:



1 31601U 07025A 16321.16717398 0.00006500 00000-0 21561-3 0 02
 2 31601 141.7151 195.1602 0004000 208.4419 151.5574 15.30336863 05

Ofeq-8 satellite: It is capable of imaging with a resolution of up to 10 cm through an X-band radar system. The satellite's maximum resolution is believed to be around 1 meter. TecSAR is the first Israeli satellite to feature SAR, which will provide images day or night and under all weather conditions.

Two Line Element Set (Ofeq-8) as:

1 32476U 08002A 16124.06933819 0.00000000 00000-0 00000-0 0 08
 2 32476 41.0206 15.7936 0004999 315.1782 44.8212 15.15829250 05

Ofeq-9 satellite: it is a top-secret reconnaissance satellite; the optical telescope's specifications are classified. It joins two other Israeli reconnaissance satellites currently operating in orbit Ofeq-7 and 8.

Two Line Element Set (Ofeq-8) as:

1 36608U 10031A 16306.14860876 0.00007000 00000-0 23331-3 0 09
 2 36608 141.7345 223.0928 0006000 261.4103 98.5889 15.30172971 02

Ofeq-10 satellite: it is an upgraded variant of Ofeq-8, which employs a high-resolution SAR PL that is capable of observation at night and through clouds.

Two Line Element Set (Ofeq-10) as:

1 39650U 14019A 14108.11152156 .00093269 00000-0 27218-2 0 08
 2 39650 140.9409 255.1115 0154412 132.0167 229.3866 15.23337433 09

Ofeq-11 satellite: It is an improved Israeli reconnaissance satellite series; it is the last version launched during the last year. Ofeq-11 is launched on the last quarter of 2016, two years after the launch of Ofeq-10. Compared to its predecessor, the new satellite features a new imaging system called "Jupiter High-Resolution Imaging" with resolution increased to 0.5 m, and uses a new satellite platform - OPSAT-3000 - which is a derivative of the satellite bus used in TecSAR.

Two Line Element Set (Ofeq-11):

1 41759U 16056A 16262.14637733 0.00093953 00000-0 25000-2 0 06
 2 41759 141.9581 325.4435 0161478 71.2254 181.1514 15.25030193 01

TLE are interpreted and transferred to the classical orbital elements related to each Ofeq SC, Table 2. comprises all the available orbital elements with its equivalent mission objective.

Table 2. Israeli reconnaissance satellites in services (Ofeq series)

	Ofeq-7	Ofeq-8	Ofeq-9	Ofeq-10	Ofeq-11
Other name	Ofek-7	TechSAR, Ofek-8	Ofek-9	Ofek-10	Ofeq-11
Mission type	Optical imaging	Radar imaging	Optical imaging	Radar imaging	
Manufacturer, Operator, Contractor	Israel Aerospace Industries (IAI), Israeli Ministry of Defense, Israel Space Agency				
Platform	OPTSAT 2000	---	OPTSAT 2000	TECSAR-2	OPTSAT 3000
Weight, kg	300	295	189	330	370
NORAD ID	31601	32476	36608	39650	41759
Int'l Code	2007-025A	2008-002A	2010-031A	2014-019A	2016-056A
Perigee, km	479.2	522.2	478.3	396.8	386.9
Apogee, km	484.7	529.0	486.5	609.1	608.8
Inclination, deg	141.7	41.0	141.7	140.9	142.0
Period, min	94.1	95.0	94.1	94.5	94.4
Semi major axis	6852	6896	6853	6873	6868
stabilization	Three axes stabilized				
Launch Vehicle	Shavit-2	PSLV, India	Shavit-2		
Launch date	10.06.2007	21.01.2008	22.06.2010	09.04.2014	13.09.2016
Launch site	Palmachim, Israel	SIRHARIKOTA, India,	Palmachim, Israel		



Fig. 2. Ofeq series platform shape

V. OFEQ SERIES CONSTELLATION

All satellites are placed in an approximately circular orbit at the same altitude and inclination, using a streets of coverage approach with multiple visibilities as Figure 3. The Ofeq series (Ofeq-7, 8, 9, 10, 11) constellation pattern characterized by these parameters:

1. Inclination $\approx 140 \pm 0.5^\circ$,
2. Altitude $h_p \approx 455 \pm 67 \text{ km}$, $h_s \approx 547 \pm 62 \text{ km}$,
3. Total number of satellites in services, 5
4. Period $T \approx 94.5 \pm 0.5 \text{ min}$
5. Relative spacing between SC in adjacent planes $\approx 1^\circ \div 6^\circ$.

These parameters are chosen to provide best ground tracks repeatability and revisit and Israeli's LV capabilities [5].

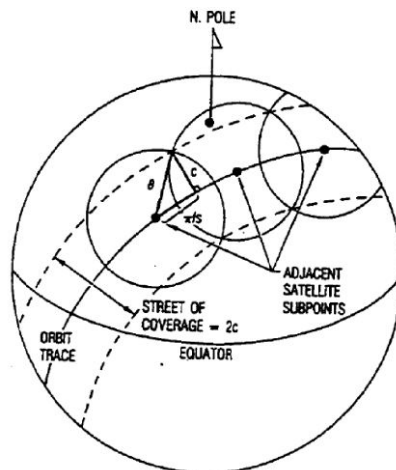
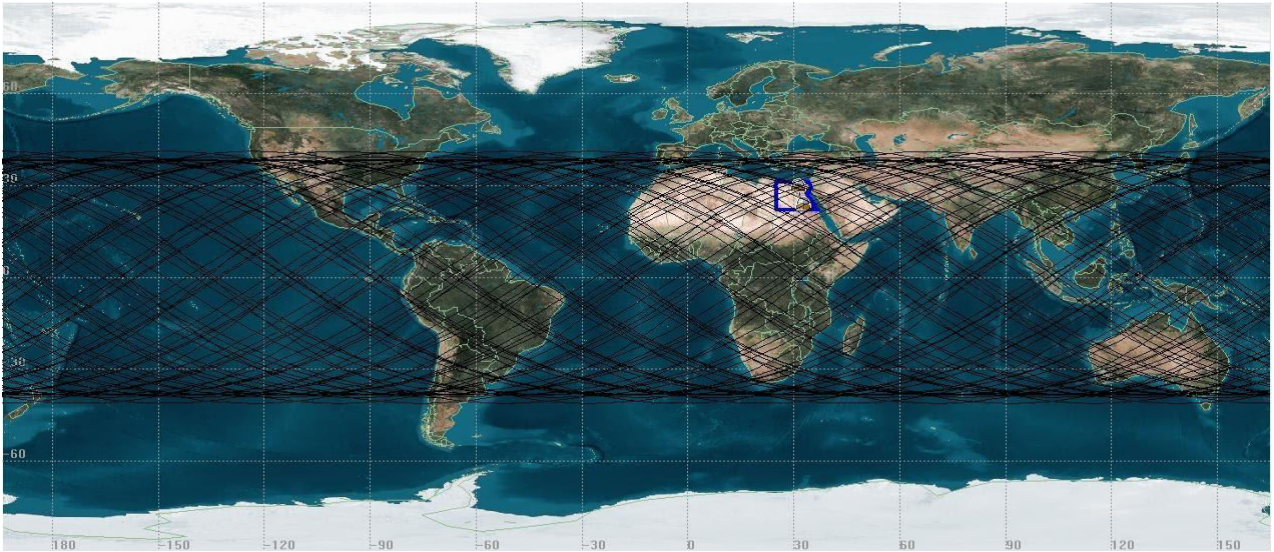


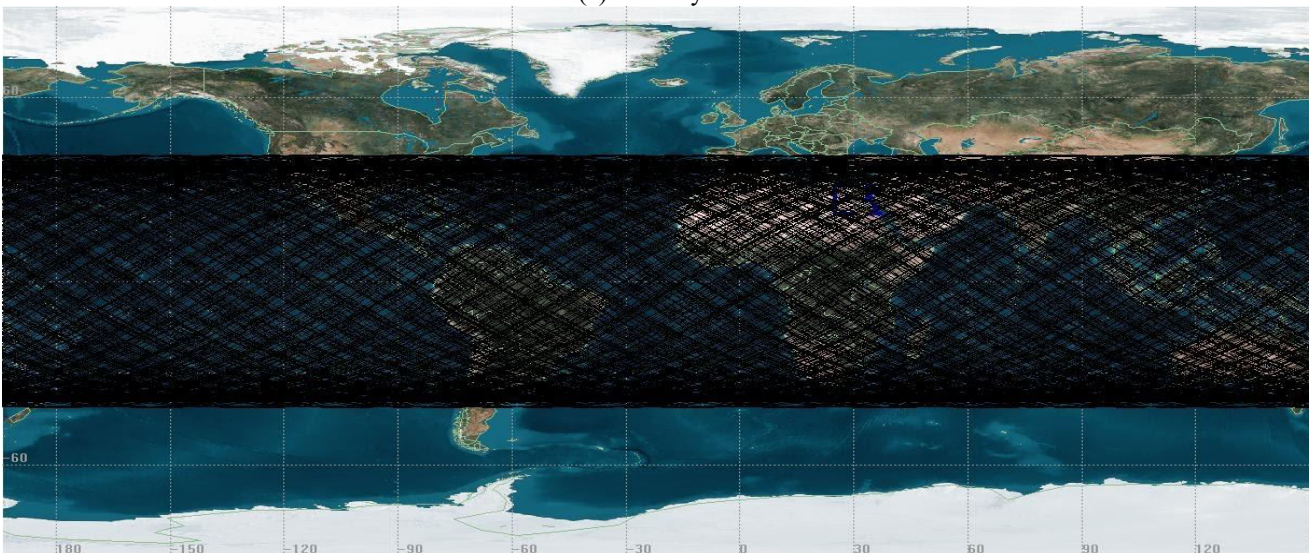
Fig. 3. Street constellation from a single orbital plane

Ofeq satellites require provision of the Earth photo surveillance with 2,000 [6] km radius coverage zones of the ground receiving station, located in Israeli territory. In order to provide the best illumination circumstances in all satellite passes, the descending node time $\approx 09:30 \text{ a.m.}$ for optical imaging to minimize clouds effect and sun angle $\approx 20\text{-}40 \text{ deg.}$ The ground tracks for one day and a week Ofeq series operation as illustrated in Figure 4. The physical coverage of Ofeq series lies between the south to north of an meridians with latitude $\pm 41^\circ$, it is approximately equal to orbit inclination $\approx \pm 41^\circ$.

The low orbit altitude has a tendency to better imaging resolution, conversely the smaller swath width and shorter life time for satellite.



(a) One day



(b) One week

Fig. 4. OFEQ series constellation coverage tracks

VI. CONSTELLATION IMAGING PATTERN

Three areas are selected in the study, a large area representing Egypt's Territory and two targeted areas over two important zones, which are Cairo and Aswan dam, Figure 5.

Egypt's area is approximately one million square kilometers and takes place over the globe in the longitude range from 25° West to the longitude 36.9° East, and from the lower border latitude at 22° to the higher most point at a longitude 31.6° . Cairo and Aswan dam's targeted point are just two points on the globe with coordinates stated in Table 3.



Table 3. Target coordinates

Imaging target name	Geodetic Latitude, deg.	Longitude, deg.
Cairo	30.05	31.25
Aswan Dam	23.9706	32.8778

Fig. 5. Egypt’s territory and the selected targets in study.

As it is shown in Table 2. and Figure 2., Ofeq-7 and Ofeq-9 carry the same optical payload, which is loaded on the same platform, same for the satellites Ofeq-8 and Ofeq-10, both carry a SAR payload on the same pattern, Ofeq-11 payload is also SAR but with special target identification features. In the analysis, the SAR satellites shows better observation gaps pattern.

Constellation under study comprises the last four operable OFEQ satellites, which starts from OFEQ 7 to the latest OFEQ 11 satellites. Global coverage of all satellites is from $\pm 41^\circ$ latitude, Figure 4. (a) show a daily globe tracks of the OFEQ constellation and in Figure 4. (b), a week coverage tracks of the constellation.

Figure 6., as the SAR payload is capable of shooting images in all lighting conditions whether in daylight or at night and even in bad cloudy weather conditions, while for the optical payload, image shooting must be carried out at adequate lighting conditions with sun elevation angle greater than 10° .

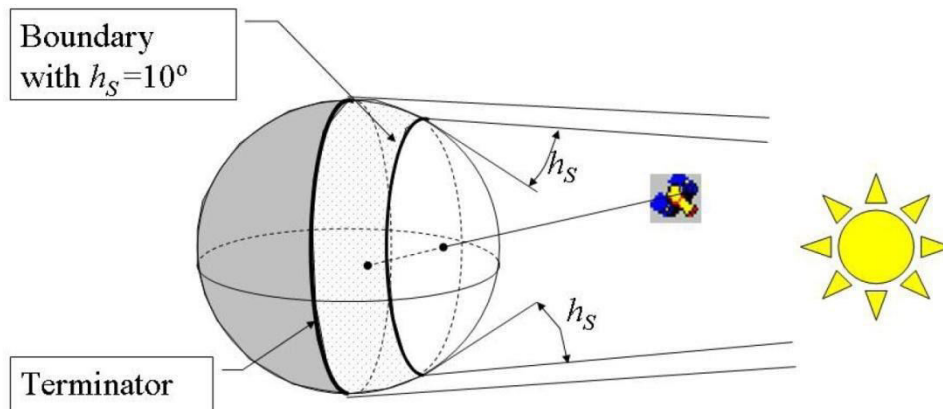


Fig. 6. Sun elevation angle boundary limitation for SC with optical payload

SAR satellites observation gaps are approximately the same over all the areas under study. For the optical payload satellites (Ofeq-7 and Ofeq-9), Figure7, Egypt shows a better observation pattern than the other smaller cities under study, it is only for the reason that Egypt’s territory is of greater area than that of Cairo and Aswan. Notice also the observation gap over Cairo is greater than that of Aswan, as Aswan is at a lower latitude, and lower latitudes for inclined orbits shows a larger number of observation accesses. An inclined orbit possesses a rate of regression of ascending node, which changes continuously the angle between the orbital plane and the sun, this change keeps on increasing until the angle is right angle between the sun and orbital plane, under this condition, the lighting condition under the satellite is of sun elevation angle lower than 10° , which makes it impossible to capture an image with an optical payload.

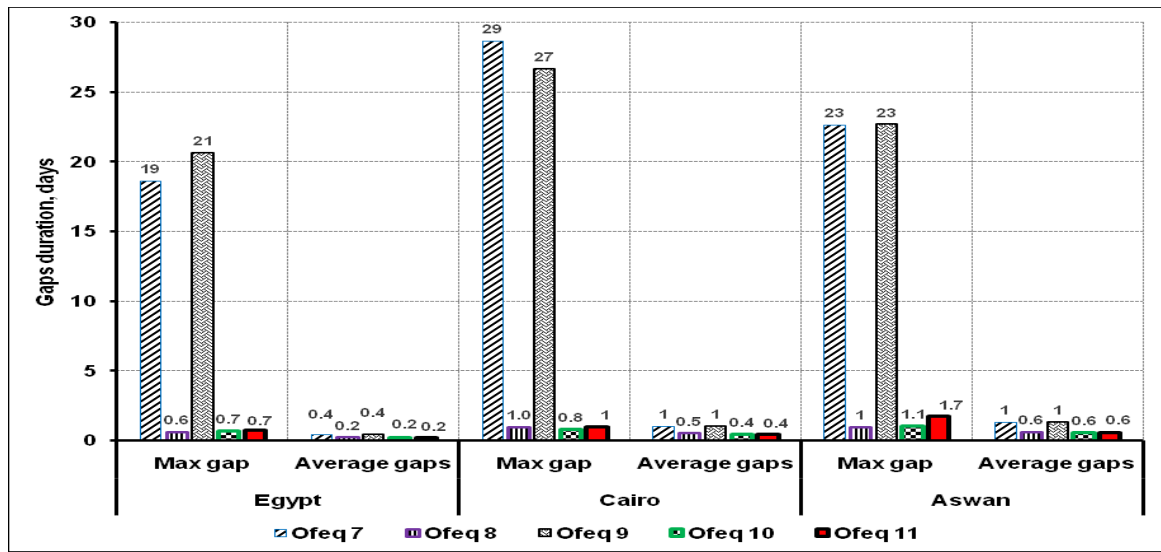


Fig. 7. Average and maximum gaps periods for the in-service Ofeq constellation

Observation coverage of the Ofeq constellation shows a high coverage pattern over the Egypt’s territory with a total number of images 3987 times, observation gaps (period between an image and the consecutive one) have an average 0.06 days (1.4 hours), Figure 8., maximum gap period is 0.24 days (5.8 hours). The mentioned observation coverage data can be simplified by stating that the Ofeq constellation approximately captures 18 images with a maximum number of daily images 25 times.

Targeted observation analysis is more difficult than a large area under analysis, as the frequency of reaching a certain target (as the Cairo stadium in Cairo) is less frequently reached. Figure 9. shows the pattern of observation of Cairo, total number of images over the six months’ period is 1805 times, maximum gaps duration is 0.52 days (12.5 hours), while most of the images are taken in the gaps range less than 0.2 days (5 hours). Average daily observations are 8 images with a 12-maximum number of daily images.

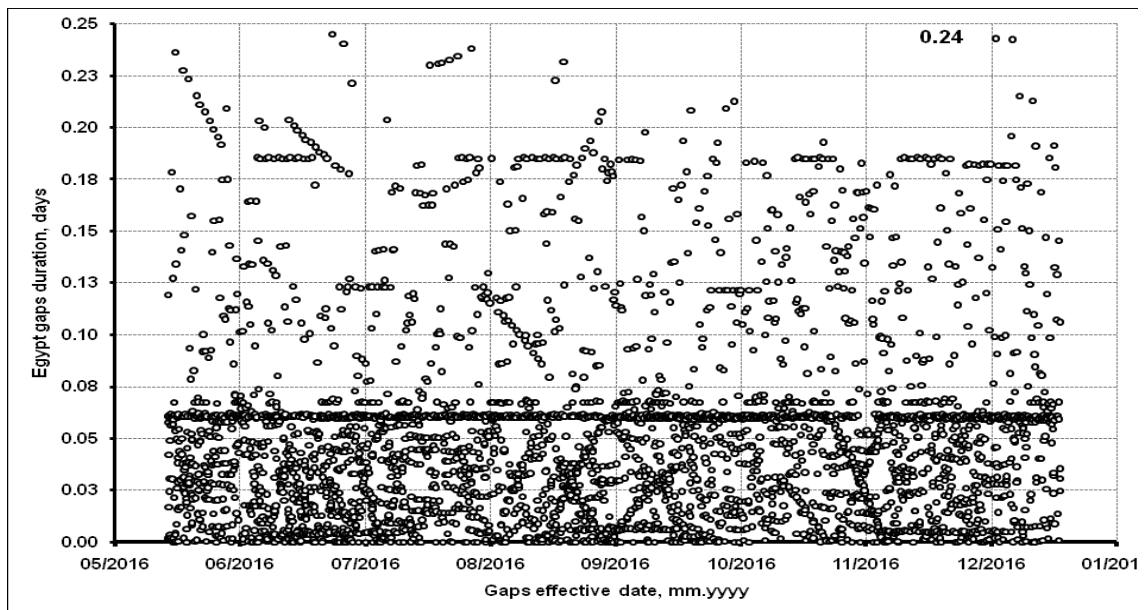


Fig. 8. Egypt’s imaging pattern by Ofeq constellation

Aswan dam is selected as a target spot for observation, as it is at a lower latitude, to show also whether changing latitude will affect the observation pattern or not. In Figure 10., total number of observations are 1430 times, maximum



observation gap is 0.7 days (17 hours), this maximum gap takes place only one time over the whole observation period, followed by five large gaps with a duration 0.6 days (14 hours), the average observation gap is 0.15 days (3.5 hours). Average daily observations are 6 images with a 9-maximum number of daily images.

Aswan observation pattern at a lower latitude shows an overall less observation pattern than observation of a higher latitude target, a fact that shows the importance of analyzing pattern of any satellite or a constellation on all the areas and targets of interest.

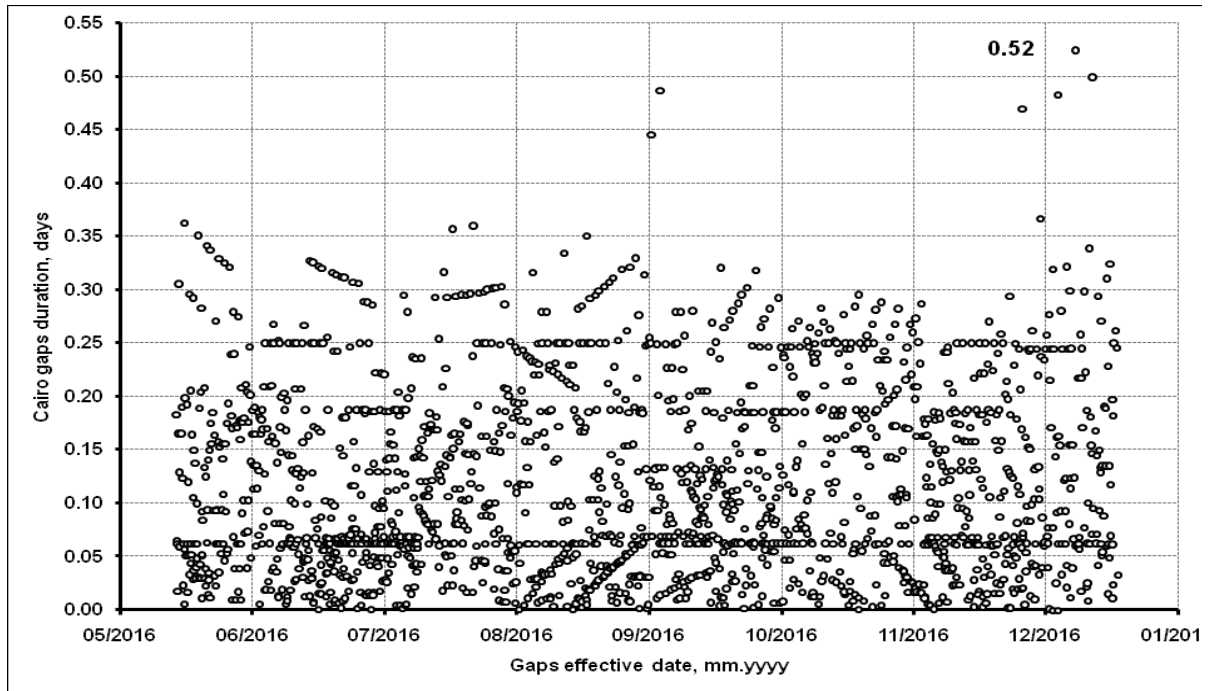


Fig. 9. Cairo’s imaging pattern by Ofeq constellation

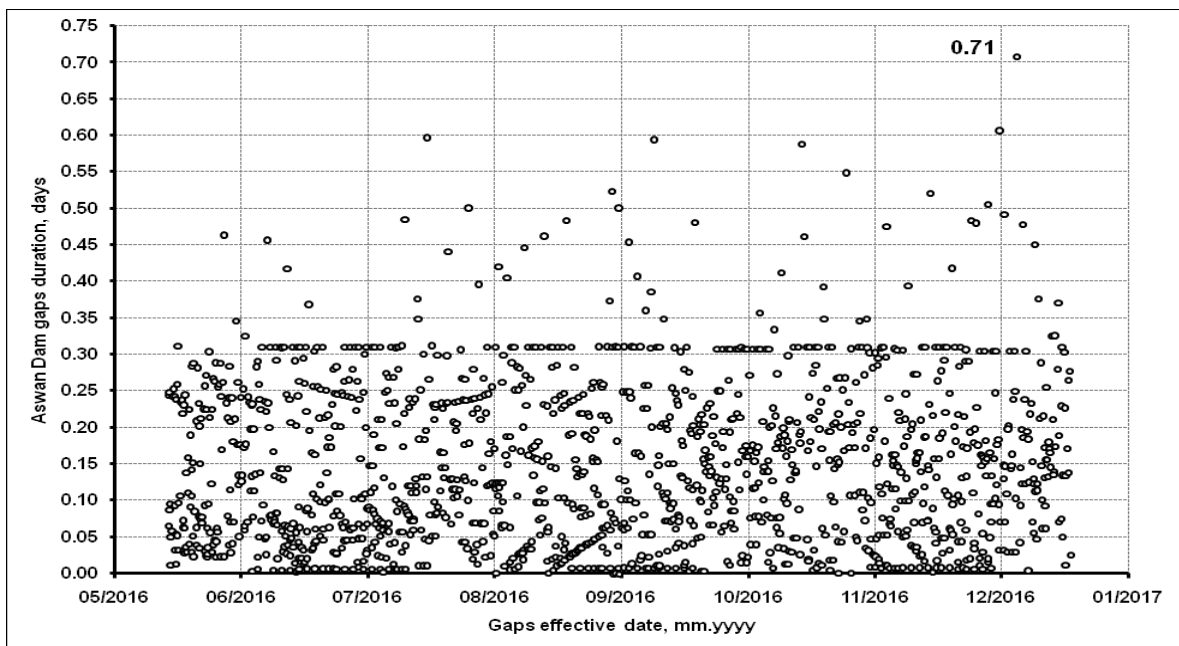


Fig. 10. Aswan dam’s imaging pattern by Ofeq constellation



VII. CONCLUSION

In September 1988, the first reconnaissance satellite (Ofek-1) was launched by Israeli Shavit launcher, making Israel the eighth country in international space club.

Up till now, Israel had successfully launched eight military reconnaissance satellites (Ofeq series) in LEO with high observation reaches 0.5m (optical and SAR), from Israeli Palmachim launch site. Israeli Shavit launcher has been launched 10 times with reliability reaches 80%, presenting it for commercial launches in the near future.

According to an official statement analysis, 7 to 11 Ofeq-series satellites are a three-axes stabilized, lightweight satellite platform, adapted for high-resolution observation technological payloads (optical or SAR) reaches less than 0.5 m.

The Ofeq-series satellites mass is 189 to 370 kg. The satellites spanning in an ellipse orbit around the Earth from 387 to 610 km, with inclination coverage earth area between ± 40 degrees north and south latitudes.

The next-generation satellite will feature an advanced panchromatic camera and possibly a multispectral imaging payload. As Israel is searching cooperation with an unnamed Asian country, probably India, it has not yet decided, to which inclination the satellite will be launched.

to reach polar orbit as soon as possible, to satisfy that, the Israeli Shavit-2 LV must be presented by high performed parameters or launched by other countries or launch Shavit-2 in the east direction over Arab countries.

The Shavit launcher is operational for 25 years with the record of inserting the Ofeq satellites series into orbit from Israeli launch site. SHAVIT utilizes a unique set of launch preparation equipment. It is largely independent of the launch site and provides the full testing capability of the launcher on the launch pad. This configuration enables satellite launch from different launch sites, according to customer requirements

From the constellation observation analysis, constellation imaging over the Egyptian territory guarantees at least four (4) images on a daily basis, and on a targeted area at the capital (Cairo), there is also a daily revisit with a minimum of two images with an average five images, this revisit number changes for the lower latitudes areas as at Aswan with at least one image daily and an average three daily images.

Remark: The analysis and/or conclusions expressed in this paper are only the author's point of view and it does not reflect the official policy of the Arab Republic of Egypt or the Egyptian Armed Forces.

REFERENCES

- [1] . S. E. The Columbia Electronic Encyclopedia, "Reconnaissance satellite," Columbia University Press., 2012. [Online]. Available: <https://www.infoplease.com/encyclopedia/science/space/exploration/reconnaissance-satellite>. [Accessed 01 09 2020].
- [2] . V. A. Chobotov, Orbital Mechanics Third Edition, Virginia: American Institute of Aeronautics and Astronautics (AIAA), 2002.
- [3] . H. Curtis, Orbital Mechanics for Engineering Students, Florida: ELSEVIER, 2005.
- [4] . "Celestrak," Analytical graphics INC., 26 1 2016. [Online]. Available: <http://celestrak.com/SpaceData/SpaceWx-format.asp>. [Accessed 26 1 2016].
- [5] . G. S. A. Theresa W. Beech, "A STUDY OF THREE SATELLITE CONSTELLATION DESIGN ALGORITHMS," Madrid.
- [6]. L. S. V. L. Moshe Bar-Lev, "EROS SYSTEM - SATELLITE ORBIT AND CONSTELLATION DESIGN," in 22nd Asian conference on remote sensing, Singapore, 2001.



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