China's Constellation of Yaogan Satellites & the Anti-Ship Ballistic Missile – An Update

Authors

Professor S. Chandrashekar and Professor Soma Perumal

International Strategic & Security Studies Programme (ISSSP)

National Institute of Advanced Studies (NIAS)

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Executive Summary

With the recent launch of the Yaogan 19 satellite China has in place an advanced space capability to identify, locate and track an Aircraft Carrier Group (ACG) on the high seas. This space capability is an important component of an Anti-Ship Ballistic Missile (ASBM) System that China has set up.

The current 19 satellite constellation consists of ELINT satellites, satellites carrying Synthetic Aperture Radar (SAR) sensors as well as satellites carrying optical imaging sensors.

Based on the orbit characteristics, their local time of equatorial crossing and other related parameters, these satellites can be grouped into different categories that perform the various functions for identifying, locating and tracking the ACG.

Yaogan 9 (Yaogan 9A, 9B, 9C), Yaogan (16A, 16B, 16C) and Yaogan 17 (17A, 17B, 17C) are the three clusters that are equipped with ELINT sensors that provide broad area surveillance over the Oceans. With a coverage radius of about 3500 Km, they provide the first coarse fix for identifying and locating an ACG in the Pacific Ocean.

Yaogan 13, Yaogan 10, Yaogan 18 and Yaogan 14 are the satellites carrying a SAR sensor.

With Local times of crossing of 02 00, 06 00, 10 00 and 14 00 hours and a resolution of 1 to 3 m , they provide all weather as well as day and night imaging capabilities over the regions of interest.

Yaogan 11, Yaogan 4, Yaogan 2 and Yaogan 7 constitute the high resolution optical satellites in the current constellation. The sensors they carry may have resolutions of between 1 to 3 m.

Their local times of crossing of 09 00, 11 00, 13 30, and 15 00 hours respectively ensure favourable illumination conditions for their imaging missions.

Yaogan 19 and Yaogan 15 satellites with local times of crossing of 10 30 and 14 30 hours respectively are optical imaging satellites with medium resolution (5 to 10 m) capabilities.

They act as a broad area coverage complement for the SAR as well as the high resolution optical imaging satellites.

The Yaogan 12 which replaced the Yaogan5 has the orbital characteristics of a SAR mission but its local time of crossing is 10 30 AM. This is very close to the 10 00 hours crossing time of the Yaogan 18 SAR satellite. Having two satellites spaced so close to each other makes it unlikely that it is a SAR mission. Most probably this is a high resolution optical imaging satellite that complements the broad area coverage provided by the 1200 km orbit of the Yaogan 15 and Yaogan 19 satellites.

Using typical sensor geometries and the two line orbital elements available from public sources the ability of the current constellation to identify, locate and track the ACG was simulated.

The three ELINT clusters typically make 18 contacts in a day with the moving target. The maximum period for which the target remains outside the reach of the ELINT satellites is about 90 minutes in a day.

The SAR and the optical imaging satellites together typically provide 24 satellite passes over the target.

About 16 targeting opportunities, during which the uncertainty in the target's location is less than 10 km, are available in a day.

The analysis and the simulation results suggest that China has in place an operational ASBM system that can identify, locate, track and destroy an Aircraft Carrier in the Pacific Ocean.

This seems to be an important component of a larger Chinese Access and Area Denial Strategy focused around a conflict over Taiwan.

China's Constellation of Yaogan Satellites & the Anti-Ship Ballistic Missile

Authors: S. Chandrashekar and Soma Perumal

1. Background

A major requirement for the operation of China's Anti-Ship Ballistic (ASBM) is the identification, location and tracking of an Aircraft Carrier Group (ACG) in the western Pacific Ocean well before it reaches within striking distance of the Chinese mainland.[1]

The ASBM is a complex system with several high technology components.[2] Apart from the maneuverable missile with autonomous terminal guidance capability[3] an Over the Horizon (OTH) is an important component of the system.[4] However, to be able to locate the ACG well before it comes within the range of the OTH radar, an advanced space reconnaissance and broad area surveillance capability is needed.

China has in place a constellation of dedicated Yaogan Satellites that performs the identification, location and tracking function for the ASBM mission.[5] Together with the OTH radar they provide the vital C4ISR inputs necessary for a successful missile strike on a moving Aircraft Carrier Group.

This note provides an update on China's current constellation of Yaogan satellites for the ASBM mission.

2. The Current Constellation of Yaogan Satellites

China currently has 19 Yaogan satellites in orbit. Table 1[6] lists all the 19 satellites along with other relevant parameters.[7]

To keep the entire area of interest (in this case the western Pacific Ocean) under surveillance the constellation will need three kinds of satellites:

[1] For a detailed description of the ASBM system please see S. Chandrashekar et al "China's Anti-Ship Ballistic Missile – Game Changer in the Pacific Ocean", National Institute of Advance Studies (NIAS) Report R5-11, November 2001 available at http://isssp.in/wp-content/uploads/2013/01/2011-november-r-5-chinas-anti-ship-ballistic-missile-report2.pdf
[2] Figure 8, Reference 1, p 17.
[3] See Reference 1 pp 16-29 and Annexure 2 pp 38–44 for details of the maneuver requirements and its implications for the warhead.
[4] For a description of the OTH radar please see Reference 1 pp 7-9 and Annexure 1 pp 34-37.
[5] For an earlier description of the space constellation that covered it to the launch of Yaogan 11 see Reference 1 pp 9-14.
[6] The Table provides the launch time in both Universal Time (UT) as well as China Standard Time (CST)
[7] http://www.zarya.info/Diaries/China/Yaogan/Yaoganprog.php

- Electronic Intelligence (ELINT) satellites that pick up the electronic emissions from the Aircraft Carrier Group and locate it in the Ocean with a relatively coarser spatial resolution;
- Synthetic Aperture Radar carrying satellites that are cued by the ELINT satellites or by other satellites in the constellation that have located the object of interest;
- Electro-optical satellites that are cued by the ELINT satellites or by other satellites in the constellation that had located the aircraft carrier earlier.

The ELINT satellites have certain unique orbital characteristics. In one configuration they consist of three satellites that fly in a triangular formation in a 63.4 degree inclined orbit.

Table 1

Parameters of the Yaogan Satellite Series

Satellite	Launch site	Launch Time	Launch Time	Apogee Km	Perigee Km	Inclination °	Period (Min)	Launch date	Image Time	Launcher
Yaogan 1	Taiyuan	22.48 UT	06.48 CST	626	624	97.8	96.99	April 26 2006	06 00	CZ 4C
Yaogan 2	Jiuquan	07.12 UT	15.12 CST	655	630	97.85	97.59	May 25 2007	13 30	CZ 2D
Yaogan 3	Taiyuan	22.48 UT	6.48 CST	624	613	97.8	97.07	November 11 2007	06 00	CZ 4C
Yaogan 4	Jiuquan	04.42 UT	12.42 CST	652	634	97.92	97.58	December 1 2008	11 00	CZ 2D
Yaogan 5	Taiyuan	03.22 UT	11.22 CST	492	481	97.4	94.34	December 15 2008	10 30	CZ 4B
Yaogan 6	Taiyuan	02.55 UT	10.55 CST	521	486	97.63	94.7	April 22 2009	10 01	CZ 2C
Yaogan 7	Jiuquan	08.42 UT	16.42 CST	659	623	97.84	97.54	December 9 2009	15 00	CZ 2D
Yaogan 8	Taiyuan	02.31 UT	10.31 CST	1204	1193	100.5	109.39	December 15 2009	09 29	CZ 4C
Yaogan 9 ABC	Jiuquan	04.55 UT	12.55 CST	1099	1083	63.41	107.06	March 5 2010	NA	CZ 4C
Yaogan 10	Taiyuan	22.48 UT	06.48 CST	632	624	97.82	96.99	August 9 2010	06 00	CZ 4C
Yaogan 11	Jiuquan	02.42 UT	10.42 CST	657	624	98	97.53	September 22 2010	09 00	CZ 2D
Yaogan 12	Taiyuan	03.21 UT	11.21 CST	491	484	97.41	94.36	November 9 2011	10 29	CZ 4B
Yaogan 13	Taiyuan	18.50 UT	02.50 CST	511	505	97.11	94.78	November 29 2011	01 56	CZ 2C
Yaogan 14	Taiyuan	07.06 UT	15.06 CST	474	470	97.24	94.04	May 10 2012	14 14	CZ 4B
Yaogan 15	Taiyuan	07 31 UT	15 31 CST	1206	1202	100.13	109.51	May 29 2012	14 30	CZ 4C
Yaogan 16 ABC	Jiuquan	04 06 UT	12 06 CST	1105	1085	63.39	107.15	November 25 2012	NA	CZ 4C
Yaogan 17 ABC	Jiuquan	19 16 UT	03 16 CST	1111	1076	63.41	107.12	September 1 2013	NA	CZ 4C
Yaogan 18	Taiyuan	02 50 UT	10 50 CST	511	492	97.55	94.65	October 29 2013	09 56	CZ 2C
Yaogan 19	Taiyuan	03 31 UT	11 31 CST	1207	1201	100.48	109.51	November 20 2013	10 29	CZ 4C

The other satellites in the constellation are remote sensing satellites that use a sun synchronous orbit which ensures that they pass over the regions of interest at the same local time of day providing identical illumination conditions.

The orbital planes of these remote sensing satellites also have to be spread out in time in such a way that within a reasonable time after an ELINT location of the carrier one or the other of the satellites in the constellation are able to fix and pinpoint the geographic

location of the carrier. Their local time of crossing the equator is an important parameter that provides information on the sensor as well as the coverage of the satellite.

SAR sensors have the advantage that they can see through clouds and can also image objects during night passes. Imaging satellites on the other hand operate only during daylight conditions and would not be able to function under cloudy conditions.

The ELINT satellites provide the coarse location of the carrier that is used to cue the following imaging and SAR satellites to precisely locate and track the target in geographic space.

Identifying the different kinds of satellites that make up the constellation and the coverage pattern they provide gives us insights into the operational timeline of the space component of China's ASBM system.

The current constellation will also include replacement satellites for some of the earlier satellites that might have stopped working or completed their life in orbit.

3. Chinese Launch Vehicle Performance Capabilities

The weights of the sensors to be carried on the satellite as well as the lifetime of the satellite are the major determinants of the mass of the satellite. SAR sensors are in general heavier than optical sensors and may also require more power for their operations. Sensors may also have to be tilted either by moving the sensor or by tilting the satellite itself. These will also have an impact on the mass of the satellite as well as the life of the satellite.[8]

Keeping in mind these considerations knowing the launcher that puts the satellite into orbit provides additional information that helps categorise the sensors on the various Yaogan satellites.

The capabilities of the CZ 2C, CZ 2D, CZ 4B and CZ 4C launchers that have been used for placing the various Yaogan satellites in sun synchronous orbits are 2100 Kg, 1150 Kg, 2230 Kg and 2950 Kg respectively.[9]

4. Patterns in Coverage

Table 2 provides the same data as in Table 1 but sorted in terms of increasing inclination

[8] Achieving a higher orbit may also require a bigger launcher.
[9] China Academy of Launch Vehicle Technology (CALT) et al, "LM 3A Series Launch Vehicle User's Manual, Issue 2011, p 1-2.

Table 2

Yaogan Satellites - Orbit Inclination Based Sorting

Satellite	Launch site	Launch time	Launch Time	Apogee Km	Perigee Km	Inclination °	Period (Min)	Launch date	Image Time	Launcher
Yaogan 16 ABC	Jiuquan	04 06 UT	12 06 CST	1105	1085	63.39	107.15	November 25 2012	NA	CZ 4C
Yaogan 9 ABC	Jiuquan	04.55 UT	12.55 CST	1099	1083	63.41	107.06	March 5 2010	NA	CZ 4C
Yaogan 17 ABC	Jiuquan	19 16 UT	03 16 CST	1111	1076	63.41	107.12	September 1 2013	NA	CZ 4C
Yaogan 13	Taiyuan	18.50 UT	02.50 CST	511	505	97.11	94.78	November 29 2011	01 56	CZ 2C
Yaogan 14	Taiyuan	07.06 UT	15.06 CST	474	470	97.24	94.04	May 10 2012	14 14	CZ 4B
Yaogan 5	Taiyuan	03.22 UT	11.22 CST	492	481	97.4	94.34	December 15 2008	10 30	CZ 4B
Yaogan 12	Taiyuan	03.21 UT	11.21 CST	491	484	97.41	94.36	November 9 2011	10 29	CZ 4B
Yaogan 18	Taiyuan	02 50 UT	10 50 CST	511	492	97.55	94.65	October 29 2013	09 56	CZ 2C
Yaogan 6	Taiyuan	02.55 UT	10.55 CST	521	486	97.63	94.7	April 22 2009	10 01	CZ 2C
Yaogan 1	Taiyuan	22.48 UT	06.48 CST	626	624	97.8	96.99	April 26 2006	06 00	CZ 4C
Yaogan 3	Taiyuan	22.48 UT	6.48 CST	624	613	97.8	97.07	November 11 2007	06 00	CZ 4C
Yaogan 10	Taiyuan	22.48 UT	06.48 CST	632	624	97.82	96.99	August 9 2010	06 00	CZ 4C
Yaogan 7	Jiuquan	08.42 UT	16.42 CST	659	623	97.84	97.54	December 9 2009	15 00	CZ 2D
Yaogan 2	Jiuquan	07.12 UT	15.12 CST	655	630	97.85	97.59	May 25 2007	13 30	CZ 2D
Yaogan 4	Jiuquan	04.42 UT	12.42 CST	652	634	97.92	97.58	December 1 2008	11 00	CZ 2D
Yaogan 11	Jiuquan	02.42 UT	10.42 CST	657	624	98	97.53	September 22 2010	09 00	CZ 2D
Yaogan 15	Taiyuan	07 31 UT	15 31 CST	1206	1202	100.13	109.51	May 29 2012	14 30	CZ 4C
Yaogan 19	Taiyuan	03 31 UT	11 31 CST	1207	1201	100.48	109.51	November 20 2013	10 29	CZ 4C
Yaogan 8	Taiyuan	02.31 UT	10.31 CST	1204	1193	100.5	109.39	December 15 2009	09 29	CZ 4C

Even such a simple re-arrangement provides us with a fair amount of information on the nature and composition of the various satellites in the Yaogan constellation. Three clear clusters can be identified from **Table 2**

4.1 The ELINT Satellite Cluster

Three of the satellites the Yaogan 9 made up of three co-launched satellites (9 A, 9 B, 9 C), the Yaogan 16 (16 A, 16 B 16 C) and the Yaogan 17 (17 A, 17 B and 17 C), form an Electronic Intelligence (ELINT) Satellite cluster. These are the ones that enable the identification and coarse tracking of an aircraft carrier strike force.[10]

Apart from the three ELINT constellations (Yaogan 9, Yaogan 16 and Yaogan 17) the remaining 16 satellites are all in sun-synchronous orbit with altitudes ranging from about 470 km to 1200 km. There are also clear patterns among these 16 satellites that are evident from **Table 2**.

[10] The orbit of these satellite clusters are so chosen that they fly in a stable configuration with known separation distances. The ELINT sensors on these three satellites receive electronic transmissions from objects of interest on the earth's surface and by triangulation are able to fix the position of the object of interest. The ELINT sensors cover an area on the earth's surface with a radius of about 3500 km. For more details see Reference 1 pp 10-13.

4.2 Broad Area Coverage Electro-Optical Imaging Satellite Cluster

Yaogan 8, Yaogan 15 and Yaogan 19 (the latest in the Yaogan series) all fall within a common pattern. They are all in near circular 1200 km orbits, their inclinations are very close to each other and they are all launched from Taiyuan with the same CZ 4C launcher.

Their orbit characteristics in conjunction with their equatorial crossing times suggest that these satellites carry Optical Imaging sensors with a broad swath and with medium resolution of 5 to 10 m.[11]

The launch sequence of Yaogan 8 (December 2009), Yaogan 15 (May 2012) and Yaogan 19 (November 2013) viewed together with their equatorial crossing times of 9.30 AM, 14.30 PM and 10.30 AM respectively suggest that the Yaogan 19 is a replacement for the Yaogan 8.

Therefore we can surmise from this analysis that Yaogan 15 and Yaogan 19 currently provide large area optical coverage for the ASBM mission.[12]

4.3 High Resolution Electro-Optical Imaging Satellite Cluster

From Table 2 we can also see that Yaogan 2, Yaogan 4, Yaogan 7 and Yaogan 11 have similar orbits and are all launched from Jiaquan with the same CZ 2D launcher.[13] Their equatorial crossing times are 13.30 PM, 11.00 AM, 15.00 PM and 09.00 AM respectively. Taken together this suggests that these are electro-optical imaging satellites that carry a high resolution sensor.[14]

It is clear that these satellites form the high resolution optical satellite cluster of the Yaogan series for the ASBM mission.

4.4 The SAR Cluster

Table 3 provides details of the rest of the current constellation of Yaogan satellites sorted by the local time of equatorial crossing.

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[11] There are suggestions that these could also carry some kind of a SAR sensor. Though the launcher used can launch a big satellite (2950 kg) into a sun synchronous orbit, these satellites orbit at a much higher altitude than normal sun synchronous orbits. Reaching these orbits will reduce the mass of the satellite that can be placed in such an orbit. In the absence of any better information our view is that a meaningful SAR payload in a 1200 km orbit may be difficult to achieve even with the use of the CZ 4 C.

[12] Based on comparisons with other satellites in similar orbits, the imaging sensors may have resolutions of 5 to 10 metres. The sensor may have a swath of about 100 km. By tilting the sensor suitably an area of 500 km on either side of the ground track may be reachable. Thus the satellite could image any 100 km swath within a 1000 km width.

[13] The mass of these satellites based on the CZ 2D capabilities would be about 1200 Kg – a useful payload for a complement of optical sensors.

[14] A typical sensor would be able to be tilted to cover about 300 km on either side of the ground trace of the satellite. Within this area of possible coverage the sensor would have a swath of about 25 to 30 km with a resolution of about 1 to 3 metres.

We can see from **Table 3** that Yaogan 1, Yaogan 3 and Yaogan 10 are very similar. They all have the same time of equatorial crossing (06.00 AM), have similar orbits and are launched by the same CZ 4 C launcher. This suggests that the Yaogan 3 is a replacement for the Yaogan1 and that the Yaogan 10 is a replacement for the Yaogan 3. The equatorial crossing time suggests that it is probably a SAR satellite that is likely to be heavy and requires the use of the heavy launcher the CZ 4 C.

We can also see from Table 3 that that Yaogan 6 and Yaogan 18 are in similar orbits, launched by the same CZ 2 C launcher and have an equatorial crossing time of 10.00 AM. This suggests that they are substitutes for each other and that Yaogan 18 is a replacement for Yaogan 6.

Table 3
The SAR and other High Resolution Optical Imaging Clusters

Satellite	Launch site	Launch time	Launch Time	Apogee Km	Perigee Km	Inclination °	Period (Min)	Launch date	Local time	Launcher
Yaogan 13	Taiyuan	18.50 UT	02.50 CST	511	505	97.11	94.78	November 29 2011	01 56	CZ 2C
Yaogan 1	Taiyuan	22.48 UT	06.48 CST	626	624	97.8	96.99	April 26 2006	06 00	CZ 4C
Yaogan 10	Taiyuan	22.48 UT	06.48 CST	632	624	97.82	96.99	August 9 2010	06 00	CZ 4C
Yaogan 3	Taiyuan	22.48 UT	06.48 CST	624	613	97.8	97.07	November 11 2007	06 00	CZ 4C
Yaogan 18	Taiyuan	02 50 UT	10 50 CST	511	492	97.55	94.65	October 29 2013	09 56	CZ 2C
Yaogan 6	Taiyuan	02.55 UT	10.55 CST	521	486	97.63	94.7	April 22 2009	10 01	CZ 2C
Yaogan 12	Taiyuan	03.21 UT	11.21 CST	491	484	97.41	94.36	November 9 2011	10 29	CZ 4B
Yaogan 5	Taiyuan	03.22 UT	11.22 CST	492	481	97.4	94.34	December 15 2008	10 30	CZ 4B
Yaogan 14	Taiyuan	07.06 UT	15.06 CST	474	470	97.24	94.04	May 10 2012	14 14	CZ 4B

From **Table 3** we can also see that Yaogan 5 and Yaogan 12 are substitutes for each other.

Taking into account the replacement of some of the earlier Yaogan satellites with the more recent ones we can make the inference that **Yaogan 13 with equatorial crossing time of 02.00 hours, Yaogan 10 with equatorial crossing time of 06 00 hours, Yaogan 18 with an equatorial crossing time of 10 00 hours and Yaogan 14 with an equatorial crossing time of 14 00 hours together comprise a cluster of SAR satellites.** Their equatorial crossing times are spaced four hours apart and this is consistent with the near continuous coverage requirements of an ASBM kind of use.

The data also suggests significant modifications to the sensor complement from the first generation of SAR satellites to the subsequent generation.

Yaogan 1, Yaogan 3 and Yaogan 10 (the first generation SAR satellites from the data) are all launched by the CZ 4C launcher which has a capacity to launch about 2950 Kg into a sun

synchronous orbit. The subsequent launches show lighter satellites. Yaogan 13 and Yaogan 18 have been launched by the CZ 2C while Yaogan14 has been launched by the CZ 4 B. The CZ 2C has a capability to place a 2100 Kg payload in sun synchronous orbit whereas the CZ 4 B can place a slightly higher 2230 Kg payload in a similar orbit.

This suggests that the Chinese have either reduced the weight of the SAR payload significantly in the later Yaogan satellites or that they have dropped some sensors from the complement of sensors carried on the Yaogan 1, Yaogan 3 and Yaogan 10 satellites.[15]

There are no major differences between the launch capabilities of the CZ 2 C and the CZ 4 B launchers and the Chinese maybe using them interchangeably for their various sun synchronous orbit missions.

The data suggests that Yaogan 10, Yaogan 13 Yaogan 14 and Yaogan 18 are the current set of satellites that provide SAR coverage for the ASBM mission.

4.5 Yaogan 5 and Yaogan 12 – What are they?

These two satellites are clearly substitutes for each other with the Yaogan 12 being the later addition. The equatorial crossing time of 10 30 AM makes it unlikely that it is a SAR satellite since it does not make much sense from the coverage point of view to have two such satellites (Yaogan 18 being the other satellite with the SAR sensor) with equatorial crossing times of 10.00 AM and 10.30 AM.

We can see from the data of Table 2 that Yaogan 19 also has an equatorial crossing time of 10.30 AM though it is in a higher 1200 Km orbit.

It is possible that the Yaogan 12 (a replacement for the earlier Yaogan 5) is a high resolution optical imaging satellite that complements the medium resolution optical imaging capabilities of the Yaogan 15 and Yaogan 19 cluster.

5. Assessment of the Capabilities of the Yaogan Constellation

Based on the analysis we can make the following inferences:

Yaogan 9, Yaogan 16 and Yaogan 17 form the ELINT cluster for the ASBM mission;

Yaogan 15 and Yaogan 19 (replacement for the Yaogan 8) form a complement of Optical imaging satellites with medium resolution (5 to 10 m) capabilities for the ASBM mission;

Yaogan 2, Yaogan 4, Yaogan 7 and Yaogan 11 form a cluster of high resolution optical imaging satellites (1 to 3 m);

[15] It is possible that the early Yaogan SAR satellites also carried some optical sensors and this could have resulted in a heavier satellite.

Yaogan 10 (replacement for the Yaogan 3 which replaced the Yaogan 1), Yaogan 13, Yaogan 14 and Yaogan 18 (replacement for the Yaogan6) are the current SAR satellites for the ASBM mission.

The Yaogan 12 which replaced the Yaogan5 seems to be some kind of an anomaly. It has the characteristics of the SAR missions but its equatorial crossing time of 10 30 AM makes it unlikely that it is a SAR mission.

Most probably this is a high resolution optical imaging satellite that complements the broad area coverage provided by the 1200 km orbit of the Yaogan 15 and Yaogan 19 satellites.

6. Simulation Results

In order to provide a more nuanced understanding of the coverage pattern and the gaps in the coverage of the current Yaogan constellation of satellites a simulation of the coverage pattern for identifying, locating and tracking a ship approaching the Chinese mainland from the Pacific Ocean was carried out. Using typical sensor geometries extrapolated from current civilian satellites and the two line orbital elements available in the public domain the capabilities of the current Yaogan constellation for identifying, locating and tracking of an aircraft carrier in the Pacific Ocean were evaluated.[16]

A brief summary of these preliminary simulation results are provided below.

- The orbital planes of three ELINT satellite clusters (Yaogan 9, Yaogan 16 and Yaogan 17) are well spaced out and typically make 18 contacts with the moving target in a day.
- The ELINT satellite pass durations vary, with the maximum pass duration being about 23 minutes.
- The maximum period of non-coverage by an ELINT cluster for a typical target is about 90 minutes.
- These results indicate that the three ELINT clusters ensure persistent detection, coarse location and coarse tracking of the Aircraft Carrier over the high seas. The current ELINT clusters therefore provide China with a strong and robust ocean surveillance capability over all ocean regions of the world including the Pacific.
- The SAR and Optical Imaging satellites provide 24 satellite passes during which the target can be imaged. When these imaging opportunities are successful the target can be located with an accuracy of about 100 metres.[17]

[16] The two line orbital elements can be obtained from www.spacetrack.com

[17] This assumes that cloud cover does not come in the way of optical imaging. In reality cloud cover could be a serious factor that may reduce this number. Future simulations will take this into account. However even with only ELINT and SAR coverage it may be possible to identify, locate and track an ACG with sufficient accuracy for realizing the ASBM mission.

- The current Yaogan constellation provides about 16 targeting opportunities for a ballistic missile launch during which the uncertainty in the location of the carrier is less than 10 Km.

These preliminary results suggest that China has in place a space-based surveillance system that can identify, locate and track an Aircraft Carrier in the Pacific Ocean.

7. Conclusions

It appears from the above analysis that the Chinese have in place a robust space based system that performs the location and tracking functions for the ASBM system.

Figure 1 provides a time line of the equatorial crossing times for the Optical and SAR satellites of this constellation.

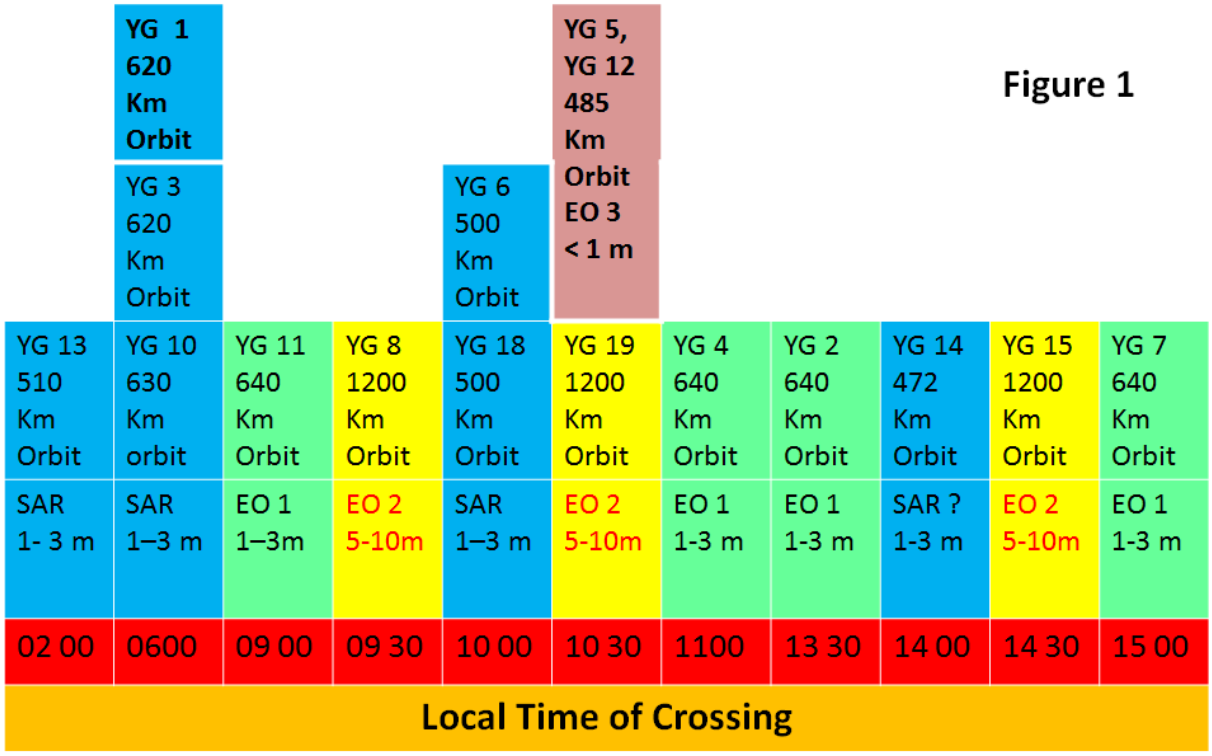

Figure 1

The Local Time of Crossing the equator is the horizontal coordinate. The vertical coordinate first shows the sensor and above the sensor the various satellites (with orbit details) that carry that sensor and which provide coverage at that local time.

As we can seem from Figure 1 there is SAR coverage at 02 00, 06 00, 10 00 and 14 00 hours.

High resolution optical imaging takes place at 09 00, 11 00, 13 30 and 15 00 hours.

To complement this high resolution capability of SAR and the optical sensors there is also coverage with medium resolution optical imaging sensors at 10 30 and 14 30 hours.

Along with the very wide area coverage provided by the ELINT satellites, this analysis and the simulation results provide substantive evidence that the Chinese would be able to locate and track an aircraft carrier in the Pacific Ocean.

We can state with confidence that t**he Yaogan satellite constellation and its associated ASBM system provide visible proof of Chinese intentions and capabilities to keep ACG strike groups well away from the Chinese mainland.**

Though the immediate purpose of the system is to deter the entry of a hostile aircraft carrier fleet into waters that directly threatens its security interests especially during a possible conflict over Taiwan, the same approach can be adopted to deter entry into other areas of strategic interest.

Viewed from this perspective the Chinese do seem to have in place an operational capability for denying or deterring access into areas which it sees as crucial for preserving its sovereignty and security.