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China's Space Power & Military Strategy – The role of the Yaogan Satellites

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Executive Summary

China is now a full-fledged space power in all respects and is ready to compete with the US across the spectrum of space capabilities. Space Power seems to be critical component of its aspiration to become a global power house whose role on the regional and world stages cannot be ignored.

A new series of Yaogan satellites that have been recently launched by China clearly reinforces its pursuit of great power status. These satellites have been launched three at a time from the Xi Chang Launch complex using the CZ 2C launcher. Their altitude of 600 Km and inclination of 35 degrees are very different from the orbits of other satellites that use the Yaogan name. They are also the first Yaogan satellites to be launched from the Xi Chang Launch Centre normally used for launches to the Geostationary Orbit.

More interestingly, after launch, each triplet was maneuvered in such a way that they are equally spaced 120 degrees apart in the same orbital plane. The third and fourth triplets were also moved to occupy the same orbital plane with the six satellites being spaced 60 degrees apart. The three orbital planes occupied by the twelve satellites are also spaced equally around the earth separated by 120 degrees.

The architecture of this 12 satellite constellation suggests that the purpose is to achieve a near continuous ELINT surveillance of the regions between 35 degrees North and 35 degrees South Latitude. It is likely that two other triplets will soon be launched so that the three equally spaced orbital planes will each have six satellites apiece spaced 60 degrees apart. This will create an operational constellation of 18 satellites.

Taiwan, the Korean peninsula, the southern islands and shores of Japan, Guam, the South and East China Seas and the various access routes from the Indian to the Pacific Oceans all fall within this coverage region. These are also the sources of major security concerns for China.

China already has an operational Yaogan satellite constellation comprising ELINT, SAR and EO satellites that provide it with large area surveillance capabilities especially over the Pacific Ocean. This constellation has been in operation since 2010 and provides China with the ISR capabilities to detect adversaries at distances far away from its coastline.

The new constellation complements this large area Yaogan ISR coverage with near continuous theatre level ELINT surveillance capabilities. The idea seems to be that as the adversary comes closer to China via various access routes to its eastern seaboard it needs to be kept under constant surveillance. The two Yaogan constellations appear to be the space component needed for China's A2AD strategy for "fighting and winning local wars under conditions of informationization."

The ELINT coverage patterns of the two constellations over Taiwan were analyzed separately and together using the ISSSP developed Veni Vidi Vici orbital software module. The results suggest that the two constellations together will enable China to monitor Electronic emissions from Taiwan for about

80% of the time. When the theatre level ELINT constellation gets its full complement of 18 satellites this coverage can improve further.

In addition to this new constellation China has also launched several military satellites as a part of its space build up to “fight and win local wars under informationization conditions”. These include the TJS 1 and TJS 2 Early Warning satellites in Geo Stationary Orbit, a new triangular formation Yaogan 31 ELINT triplet for large area ocean reconnaissance, Beidou navigation satellites and other LKW EO satellites very similar to the Yaogan hi resolution EO satellites. With the launching of the two TJS satellites the major gap in China’s Early Warning capabilities for BMD has been bridged.

In addition to these visible demonstrations of its space prowess, China has also initiated major structural changes in the organization of its military industrial complex. These include the abolition of a number of middle layers between the CMC and the armed forces as well as the replacement of the seven military regions by five theatre commands.

The responsibility for fighting wars now vests with the theatre commands. They will have all the resources cutting across the Army, Navy, Air Force and Rocket Forces at their disposal. The powers of the Army, Navy, Air Force and the Rocket Forces have been reduced to their supplying the theatre commands with trained forces and equipment.

The role of information and information dominance has been explicitly recognised in this new dispensation. A Strategic Support Force (SSF) with responsibility for Space, Cyber and Electronic Warfare operates directly under the CMC. They appear to be responsible for providing the real time battlespace information needed. They are also responsible for cyber and electronic warfare measures for preserving the information dominance function cutting across all theatres. The signal that China is sending out to its adversaries is that it is not only technically ready but also has the organizational and institutional wherewithal to fight and win local wars under conditions of informationization.

China's Space Power & Military Strategy – the Role of the Yaogan Satellites

1. Background

The Yaogan series of satellites launched by China from 2006 onwards are a constellation of operational ISR satellites that provide China with a global surveillance capability. In combination with its demonstrated ASAT capabilities, the architecture of this space constellation suggests that it is a vital component of its Anti-Access Area Denial (A2AD) strategy aimed at deterring US intervention over events in China's sphere of influence.

The constellation uses three kinds of satellites:[1]

- Electronic Intelligence (ELINT) satellites that pick up the electronic emissions and locate the object of interest 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.

Till the end of April 2018, China had launched 31 Yaogan satellites.[2] Apart from catering to specific missions such as the ASBM, this constellation provides the needed large area surveillance capability for its A2AD strategy. The constellation includes six triplets of ELINT satellites (the sixth triplet has been added recently) that fly in a triangular formation in an 1100 km orbit with an inclination of 63.4 degrees.

2. Shift in Focus towards Theatre Surveillance & Military Operations

In the second half of 2017 and the first half of 2018 we see changes in the use of the Yaogan nomenclature for other military satellites launched by China.

In September 2017 it launched a new triplet of Yaogan satellites. However unlike the earlier triplets these did not fly in a triangular formation. Their altitude at 600 Km and their inclination of 35 degrees were also significantly different from the 1200 Km altitude and 63.4 degree inclination of the earlier triplets. After launch the three satellites were maneuvered and spaced 120 degrees apart in the same orbital plane.

The September 2017 launch was followed by further triplet launches in November, December 2017 and January 2018. The last two triplets after launch were also maneuvered to fly in a six satellite configuration in the same orbital plane. This would suggest that the other two planes would also soon have a complement of six satellites each making a total constellation of 18 satellites. The architecture of

[1] Though the Asia Pacific now termed the Indo=Pacific is China's main region of concern the space capabilities it has created can provide it a global surveillance capability if needed.

[2] If the ELINT triplets are considered to be separate satellites China has 40 satellites in the broad area surveillance Yaogan constellation.

this satellite configuration indicates a near constant ELINT surveillance over the land and ocean areas of the world that lie between 35 degree North Latitude and 35 degrees South Latitude.[3]

China also launched other military satellites some of which can also be seen as being very similar to the Yaogan satellites though the official designations used for them appear to be different. These are the Ludikancha Weixing (LKW) satellites that were all launched into 500 Km Sun Synchronous Orbit (SSO) using a CZ 2D launcher from the Jiaquan Space Centre. Two of them were launched in December 2017 with further launches in January and March 2018.

The first two satellites have an Equatorial Crossing Time (ECT) distributed around 10 30 hours while the other two satellites have an ECT around 13 30 hours. These satellites are very similar to some of the other Yaogan hi resolution EO satellites and are likely to perform the same or similar functions.

In addition to the above satellites meant for ISR, China also moved forward to complete its Beidou 35 satellite navigation constellation with 2 Beidou Medium Earth Orbit (MEO) satellites in 2017 and six more till the end of April 2018.

It also launched the TJS 2 satellite into GSO using the CZ 3B launcher. This satellite is very similar to the TJS 1 satellite launched in 2016. Both the satellites seem to be military satellites performing an early warning function for BMD operations.

These satellites along with China's other military satellites will provide it with a full spectrum space capability that will help it fight and deter "local war under informationized conditions".

In addition to these technical developments China has also created new organizational arrangements for integrating different domains, weapon systems and platforms to provide it with the capabilities to fight and win local wars under the new conditions of informationization.[4]

This brief will take stock of these developments in China's space capabilities and provide an assessment of its current status. It will link these space capabilities to China's strategy for war and deterrence in what it perceives to be its current region of major concern – the Asia Pacific now renamed the Indo-Pacific.

An update on the earlier large area ISR Yaogan constellation of ISR satellites is provided first. Recent launches of the LKW satellites that seem to have similar orbital characteristics and coverage patterns as the earlier Yaogan ISR satellites are also included as a part of this analysis.

[3] These would provide a constant vigil over Taiwan, the Korean peninsula, as well as the southern islands and seas of Japan. The seas and waters off China's eastern coastline including the South and East China seas as well as the Sea of Japan would also be covered. Since they do not fly in a triangular formation they will not be able to locate the position of the emission source. However since they cover the area closer to China's shoreline more intensely there will be other ways to locate their position.

[4] Kevin L. Polpetter et al, "The Creation of the PLA Strategic Support Force and Its Implications for Chinese Military Space Operations", Report by the RAND Corporation's Project Air Force, for China Aerospace Institute (CASI), at http://www.airuniversity.af.mil/Portals/10/CASI/documents/Research/PLASSF/The%20Creation%20of%20the%20PLA%20Strategic%20Support%20Force%20and%20Its%20Implications%20for%20Chinese%20Military%20Space%20Operations.pdf

This is followed by a critical review of the newer theatre level Yaogan constellation that provides near continuous ELINT coverage in the land and sea areas around China's eastern coastline. China appears to think that this will be the route through which its adversaries will achieve access. Through strong signals, cutting across different domains and platforms, China is communicating its readiness to fight a war as its adversaries approach it along the adjoining seas.

These strands will then be linked together along with the changes in the organization structure within the National Security Complex to understand the role of space in China's war and war deterrence strategy.

3. The Large Area Yaogan ISR Constellation

ISSSP (NIAS) had provided an update of the status of this constellation in its brief of May 16 2016.[5]

Since that time China launched one additional ELINT triplet for large area surveillance in April 2018. Though China did not launch any other SAR or EO satellite using the Yaogan name since the time of our last brief, it did launch a new series of LKW satellites that seem to have similar orbital and coverage characteristics as the earlier Yaogan satellites. Table 1 provides a complete list of all these military ISR satellites along with orbital and other details that help in characterizing the function of the satellite.

We can easily see from Table 1 that apart from the ELINT triangular triplets, all the other satellites are in near polar Sun Synchronous Orbits (SSO) at different altitudes. Such orbits ensure global coverage over a certain period. It will also make sure that imagery acquired over any point or area on the ground on different days will have near identical illumination conditions. The orbital planes of these SSO orbits are also likely to be chosen in such a way that objects of interest can be kept under constant or near constant surveillance.[6]

These satellites carry both Electro-Optical (EO) as well as SAR sensors which can be tilted appropriately across the track of the satellite to cover the area of interest. In the normal course of events the ELINT satellites first get a coarse fix on the location of the object. This is then used to cue the EO and SAR satellites in the constellation to further locate and continuously keep track of the object.

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 large area space based surveillance system. It could also help us understand how some of its weapon systems such as the ASBM may be deployed for operations. 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.

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[5] S. Chandrashekar and Soma Perumal, "*China's Constellation of Yaogan Satellites & the ASBM: May 2016 Update*" ISSSP Report No. 03-2016, Bangalore, International Strategic and Security Studies Programme, National Institute of Advanced Studies, May 2016, available at http://isssp.in/chinas-constellation-of-yaogan-satellites-the-asbm-may-2016-update/

[6] The frequency of the updates should depend on the situation. As the enemy approaches closer in the theatre area one would expect the degree of surveillance to increase appreciably.

Table 1
Characteristics of the Yaogan Large Area Surveillance 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	06.48 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
Yaogan 20 ABC	Jiuquan	05 45 UT	13 45 CST	1104	1086	63.4	107.16	August 9 2014	NA	CZ 4C
Yaogan 21	Taiyuan	10 22 UT	18 22 CST	494	480	97.42	94.35	September 8 2014	17 30	CZ 4B
Yaogan 22	Taiyuan	06 31 UT	14 31 CST	1209	1196	100.32	109.48	October 20 2014	13 30	CZ 4C
Yaogan 23	Taiyuan	18 53 UT	02 53 CST	513	492	97.33	94.67	November 14 2014	02 00	CZ 2C
Yaogan 24	Jiuquan	07 12 UT	15.12 CST	653	630	97.91	97.55	November 20 2014	13 30	CZ 2D
Yaogan 25 ABC	Jiuquan	19 33 UT	03 33 CST	1097	1089	63.41	107.12	December 10 2014	NA	CZ 4C
Yaogan 26	Taiyuan	03 22 UT	11 22 CST	491	484	97.44	93.46	December 27 2014	10 30	CZ 4B
Yaogan 27	Taiyuan	02 31 UT	10 31 CST	1206	1194	100.46	109.39	August 27 2015	09 29	CZ 4C
Yaogan-28	Taiyuan	07.06 UT	15 06 CTC	482	460	97.24	94.02	November 8 2015	14.14	CZ 4B
Yaogan-29	Taiyuan	21.24 UT	07 24 CTC	619	615	97.84	97.04	November 26 2015	04 30	CZ 4C
Yaogan 30	Jiuquan	02 43 UT	10 43 CST	655	626	98.07	97.6	May 15 2016	09 01	CZ 2D
Yaogan 31 ABC	Jiuquan	04 25 UT	12 25 CST	1100	1090	63.4	107.1	April 10 2018	NA	CZ 4C
LKW 1	Jiaquan	04 11 UT	12 11 CST	512	494	97.4	94.5	Dec 3 2017	10 30	CZ 2D
LKW 2	Jiaquan	04 14 UT	12 14 CST	511	496	97.4	94.5	Dec 23 2017	10 30	CZ 2D
LKW 3	Jiaquan	07 10 UT	15 10 CST	507	498	97.3	94.5	Jan 13 2018	13 30	CZ 2D
LKW 4	Jiaquan	07 10 UT	15 10 CST	511	495	97.3	94.5	March 17 2018	13 30	CZ 2D

4. 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 electrical power and larger solar arrays for their operations. Sensors may also have to be tilted either by moving the sensor or by tilting the satellite itself. All of these factors will have an impact on the mass of the satellite as well as the life of the satellite.[7]

Keeping in mind these considerations knowing the launcher that puts the satellite into orbit and the launch site location provide additional information that helps categorize the sensors on the various Yaogan satellites.

[7] Achieving a higher orbit may also require a bigger launcher.

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.[8] A new set of launchers are being introduced by China. Future satellites may be launched by them as they enter service.

5. The Large Area Surveillance – Composition & Architecture

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

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 20 ABC	Jiuquan	05 45 UT	13 45 CST	1104	1086	63.4	107.16	August 9 2014	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 25 ABC	Jiuquan	19 33 UT	03 33 CST	1097	1089	63.41	107.12	December 10 2014	NA	CZ 4C
Yaogan 31 ABC	Jiuquan	04 25 UT	12 25 CST	1100	1090	63.41	107.1	April 10 2018	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 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-28	Taiyuan	07.06 UT	15 06 CTC	482	460	97.24	94.02	November 8 2015	14.14	CZ 4B
LKW 3	Jiaquan	07 10 UT	15 10 CST	507	498	97.30	94.5	Jan 13 2018	13 30	CZ 2D
LKW 4	Jiaquan	07 10 UT	15 10 CST	511	495	97.30	94.5	March 17 2018	13 30	CZ 2D
Yaogan 23	Taiyuan	18 53 UT	02 53 CST	513	492	97.33	94.67	November 14 2014	02 00	CZ 2C
LKW 1	Jiaquan	04 11 UT	12 11 CST	512	494	97.40	94.5	Dec 3 2017	10 30	CZ 2D
LKW 2	Jiaquan	04 14 UT	12 14 CST	511	496	97.40	94.5	Dec 23 2017	10 30	CZ 2D
Yaogan 5	Taiyuan	03.22 UT	11.22 CST	492	481	97.40	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 21	Taiyuan	10 22 UT	18 22 CST	494	480	97.42	94.35	September 8 2014	17 30	CZ 4B
Yaogan 26	Taiyuan	03 22 UT	11 22 CST	491	484	97.44	93.46	December 27 2014	10 30	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	97.80	96.99	April 26 2006	06 00	CZ 4C
Yaogan 3	Taiyuan	22 48 UT	06.48 CST	624	613	97.80	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-29	Taiyuan	21 24 UT	07 24 CTC	619	615	97.84	97.04	November 26 2015	04 30	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 24	Jiuquan	07 12 UT	15.12 CST	653	630	97.91	97.55	November 20 2014	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	98.00	97.53	September 22 2010	09 00	CZ 2D
Yaogan 30	Jiuquan	02 43 UT	10 43 CST	655	626	98.07	97.6	May 15 2016	09 01	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 22	Taiyuan	06 31 UT	14 31 CST	1209	1196	100.32	109.48	October 20 2014	13 30	CZ 4C
Yaogan 27	Taiyuan	02 31 UT	10 31 CST	1206	1194	100.46	109.39	August 27 2015	09 29	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	100.50	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.**

[8] China Academy of Launch Vehicle Technology (CALT) et al, "LM 3A Series Launch Vehicle User's Manual, Issue 2011, p 1-2.

5.1 The ELINT Satellite Cluster

Six 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), the Yaogan 17 (17 A, 17 B and 17 C), the Yaogan 20 (20A, 20B and 20 C), the Yaogan 25 (25A, 25B and 25C) and the most recently launched Yaogan 31 (31A, 31B and 31C) form an Electronic Intelligence (ELINT) Satellite cluster.

These are the satellites that enable the identification and coarse tracking of objects of interest such as an aircraft carrier strike force.[9] The Yaogan 17, the Yaogan 20, the Yaogan 25 and the Yaogan 31 are likely to be the current operational satellites.

5.2 Broad Area Coverage Electro-Optical Imaging Satellite Cluster

Yaogan 8, Yaogan 15, Yaogan 19, Yaogan 22 and Yaogan 27 all exhibit a common pattern. They are all in near circular 1200 km SSO orbits, their inclinations are very close to each other and they are all launched from Taiyuan with the same CZ 4C launcher.

The data also suggest that the Yaogan 27 launched in August 2015 is a replacement for the Yaogan 8 launched in December 2009 that may be nearing the end of its life

Therefore we can surmise from this analysis that Yaogan 27, 19, 15 and 22 currently provide large area optical coverage needed for performing the ISR functions.[10]

Their orbit characteristics in conjunction with their equatorial crossing times of 09 30 hours, 10 30 hours, 13 30 hours and 14 30 hours suggest that these satellites carry Optical Imaging sensors with a broad swath and with medium resolution of 3 to 10 m.[11]

5.3 The SAR Cluster

Table 3 provides details of the remaining satellites of the Yaogan constellation after taking out the satellites categorized in Sections 5.1 and 5.2.

These are presented after being sorted by the launcher used followed by the local time of equatorial crossing within each launcher group.

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[9] 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.

[10] Based on comparisons with other satellites in similar orbits, the imaging sensors may have resolutions of 3 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.

[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.

Table 3
The SAR & High Resolution Optical Imaging Clusters

Satellite	Launch site	Launch time	Launch Time	Apogee Km	Perigee Km	Inclination °	Period (Min)	Launch date	Image Time	Launcher
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 13	Taiyuan	18.50 UT	02 50 CST	511	505	97.11	94.78	November 29 2011	01 56	CZ 2C
Yaogan 23	Taiyuan	18 53 UT	02 53 CST	513	492	97.33	94.67	November 14 2014	02 00	CZ 2C
Yaogan-29	Taiyuan	21.24 UT	07 24 CTC	619	615	97.84	97.04	November 26 2015	04 30	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 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	06.48 CST	624	613	97.8	97.07	November 11 2007	06 00	CZ 4C
Yaogan 12	Taiyuan	03.21 UT	11 21 CST	491	484	97.41	94.36	November 9 2011	10 29	CZ 4B
Yaogan 26	Taiyuan	03 22 UT	11 22 CST	491	484	97.44	93.46	December 27 2014	10 30	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
Yaogan-28	Taiyuan	07.06 UT	15 06 CTC	482	460	97.24	94.02	November 8 2015	14 14	CZ 4B
Yaogan 21	Taiyuan	10 22 UT	18 22 CST	494	480	97.42	94.35	September 8 2014	17 30	CZ 4B
Yaogan 30	Jiuquan	02 43 UT	10 43 CST	655	626	98.07	97.6	May 15 2016	09 01	CZ 2D
Yaogan 11	Jiuquan	02.42 UT	10 42 CST	657	624	98	97.53	September 22 2010	09 00	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 24	Jiuquan	07 12 UT	15.12 CST	653	630	97.91	97.55	November 20 2014	13 30	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 7	Jiuquan	08.42 UT	16 42 CST	659	623	97.84	97.54	December 9 2009	15 00	CZ 2D
LKW 1	Jiaquan	04 11 UT	12 11 CST	512	494	97.4	94.5	Dec 3 2017	10 30	CZ 2D
LKW 2	Jiaquan	04 14 UT	12 14 CST	511	496	97.4	94.5	Dec 23 2017	10 30	CZ 2D
LKW 3	Jiaquan	07 10 UT	15 10 CST	507	498	97.3	94.5	Jan 13 2018	13 30	CZ 2D
LKW 4	Jiaquan	07 10 UT	15 10 CST	511	495	97.3	94.5	March 17 2018	13 30	CZ 2D

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 hours), have similar orbits and are launched by the same CZ 4 C launcher. This suggests that the Yaogan 3 is a replacement for the Yaogan 1 and that the Yaogan 10 is a replacement for the Yaogan 3. From the equatorial crossing time of 06.00 hours we can infer that it is a SAR satellite that is likely to be heavy and requires the use of the larger capacity CZ 4C launcher.

Yaogan 29 is launched from Taiyuan using the heaviest launcher the CZ 4C. This along with the equatorial crossing time of 04 30 hours suggests that this is also a SAR satellite. Its orbital parameters are very similar to the first generation Yaogan satellites such as Yaogan, 1, 3 and 10. It therefore has to be categorized as a SAR satellite.

The other two satellites that stand out are Yaogan 13 and Yaogan 23. Both have equatorial crossing times of 02.00 hours (night time crossing). This would suggest that both of them are also SAR satellites with the Yaogan 23 serving as a replacement for the Yaogan 13. Their lower orbit (511 x 500 km) as compared to the Yaogan 1, 3, 10 and 29 SAR launches (630 x 620 Km orbits) and its launch by a lower capacity CZ 2C launcher suggests that this satellite carries a more optimized SAR payload into a lower orbit.[12]

The Table also reveals that Yaogan 18 and Yaogan 6 have orbital characteristics very similar to Yaogan 13 and Yaogan 23. They are also launched by the same CZ 2 C launcher from Taiyuan. These may also carry the same SAR sensor carried by the Yaogan 13 and Yaogan 23 satellites. Their near identical equatorial crossing times of 09.56 AM and 10.01 AM shows that the Yaogan 18 is a replacement for the Yaogan 6 satellite.

We can also see from the Table that the Yaogan 12, 26, 5, 14, 28 and 21 are in very similar 490 Km orbits. All these satellites are launched from Taiyuan, the launch site that is optimized for delivery into sun synchronous orbits. All of them are also launched by the CZ 4B which can deliver a slightly larger payload into sun synchronous orbit as compared to the CZ 2C launcher. Taken together all these factors indicate that these are all SAR satellites.

The Yaogan 26 appears to be a replacement satellite for the Yaogan 12 and Yaogan 5 satellites. The Yaogan 28 satellite is a replacement for the Yaogan 14 satellite.

From the above we can make the reasonable inference that the Yaogan 18, Yaogan 23, Yaogan 21 Yaogan 26, Yaogan 28 and Yaogan 29 represent the current operational SAR satellites.

5.4 High Resolution Electro-Optical Imaging Satellite Cluster

From Table 3 we can also see that Yaogan 11, Yaogan 4, Yaogan 24, Yaogan 2, Yaogan 7 and the Yaogan 30 have similar orbits and are all launched from Jiaquan with the same CZ 2D launcher.[13] All of them are in orbits of 630 Km x 650 km. Their equatorial crossing times are 09.00, 11.00, 13.30, 13 30, 15.00 and 09 01 hours respectively. Taken together these appear to be electro-optical imaging satellites that carry a high resolution sensor.[14] From the identical equatorial crossing times of 13 30 hours it is also clear that the Yaogan 24 is a replacement for the Yaogan 2. By the same logic Yaogan 30 is a replacement for the Yaogan 11 with both having an Equatorial Crossing Time (ECT) of 09 00 hours.

These satellites form a part of the high resolution optical satellite cluster of the Yaogan ISR series with the Yaogan 4, Yaogan 20, Yaogan 24 and Yaogan 7 representing the current operational satellites.[15]

[12] It is possible that Yaogan 1, 3 and 10 may have also carried an optical payload in addition to the SAR payload. This may account for the use of the very large CZ 4 C launcher.

[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.

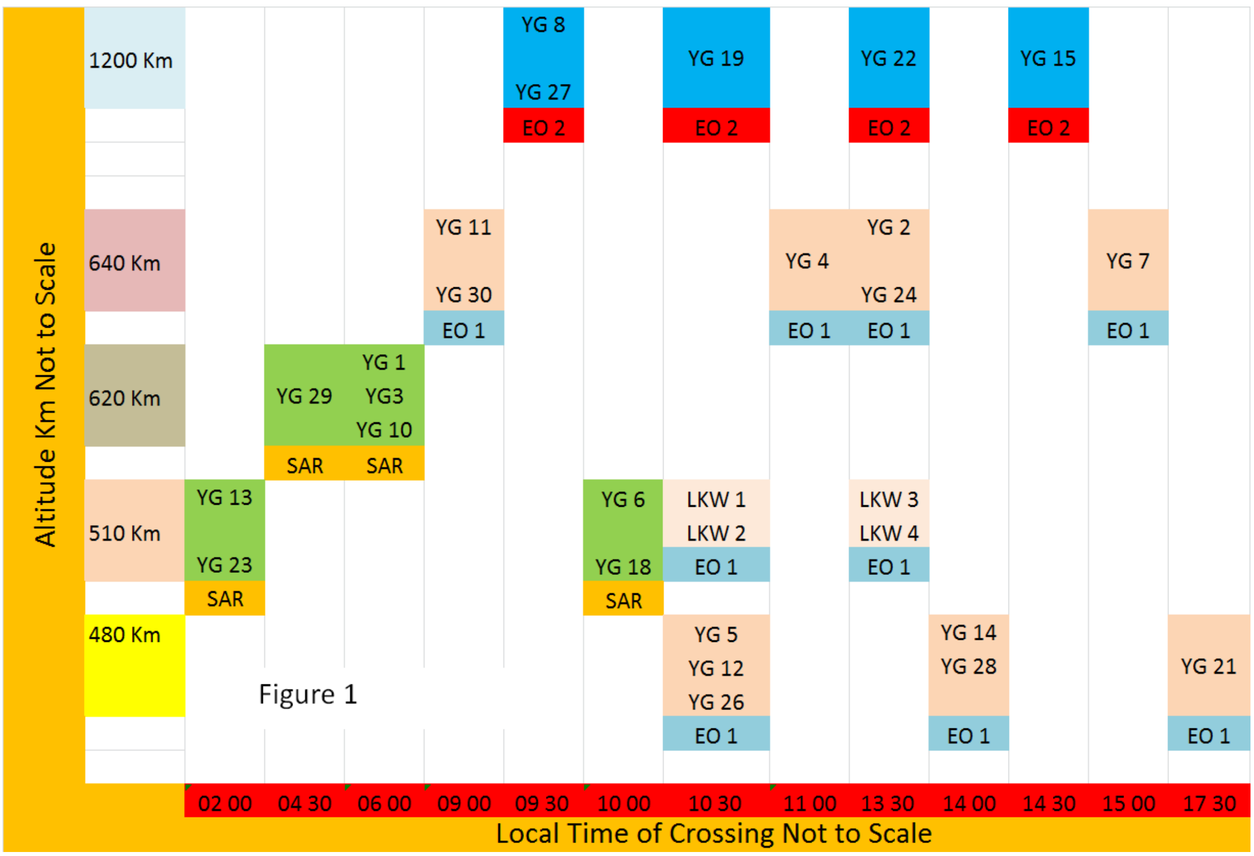
[14] A typical sensor would be able to be tilted to cover about 300 km on either side of the ground trace of the satellite. Within this area of possible coverage the sensor would have a swath of about 25 to 30 km with a resolution of about 1 to 3 metres.

[15] The Yaogan 4 launched in 2008 and the Yaogan 7 launched in 2009 may have already reached their end of life. The four LKW satellites launched in 2018 will complement the other Yaogan EO satellites.

The four LKW satellites listed in Table 3 were all launched from the Jiaquan Space Centre using the same CZ 2D launcher. However they are in a lower 500 Km orbit as compared to Yaogan high resolution EO satellites that were launched up to 2016 that occupied a 630 Km orbit. These satellites, two of which have an Equatorial Crossing Time (ECT) around 10 30 hours and the two others having an ECT of about 13 30 hours are therefore high resolution EO satellites.[16] They may be the second generation of high resolution EO satellites that cater to China's needs for ISR.

5.5 Operational Large Area Surveillance Constellation

Figure 1 provides an overview of the current Yaogan ISR constellation without the ELINT satellites. This figure provides an overview of all the EO and SAR satellites that use the Yaogan and LKW nomenclature.



We can see from the above analysis that out of a total of 28 satellites, 24 are high resolution SAR and EO satellites launched as a part of the Yaogan and LKW military series of satellites. Fourteen of them are SAR satellites and ten of them are high resolution optical imaging satellites.

Out of these about 6 SAR and 8 EO satellites may be currently operational.

[16] The first two satellites with an ECT around 10 30 hours are in the same orbital plane and seem to follow each other in quick succession. The same pattern is seen in the other pair of satellites that have an ECT around 13 30 hours

After taking into account the replacements of satellites at the end of their lives, the current SAR complement of the Yaogan ISR constellation consists of six satellites. These are the Yaogan 23 (02 00 hours), Yaogan 29 (04 30 hours), Yaogan 18 (10 00 hours), Yaogan 26 (10 30 hours), Yaogan 23 (14 00 hours) and the Yaogan 21 (17 30 hours).

The high resolution EO complement of the constellation consists of the Yaogan 30 (09 00 hours), Yaogan 4 (11 00 hours), Yaogan 24 (13 30 hours) and the Yaogan 7 (15 00 hours). In addition to these first generation satellites in orbits of around 630 Km there are four LKW second generation satellites that also provide high resolution optical imagery. They orbit in SSO at altitudes of around 500 Km. Two of them are in the same orbital plane providing coverage around 10 30 hours. The other two provide coverage around 13 30 hours. They may be substitutes for the Yaogan 4 and Yaogan 7 satellites.

Apart from the Yaogan and LKW satellites covered here China also has a number of hi resolution SAR and EO satellites that ostensibly support a civilian function. There are a large number of these dual use satellites that could provide additional SAR or optical coverage.

The data on the large area surveillance constellation also shows that China is now into its third generation of Yaogan SAR satellites. The first-generation SAR satellites were heavy (launched by the CZ 4C) and operated at altitudes of around 620 Km. They continue to be used even as recently as 2015 as is evidenced by the launch of Yaogan 29.

The second-generation SAR satellites appear to be lighter and launched by the CZ 2C into a lower 500 Km SSO.

The 3rd generation SAR satellites may be a little heavier and are placed in orbit by the CZ 4B which can place a slightly heavier payload than the CZ 2C in SSO.

As far as the high resolution EO satellites are concerned the first-generation satellites which are in a 630 Km orbit are being replaced by the second-generation satellites which are in a 500 Km SSO. Both generations use the CZ 2D launcher to achieve orbit.

These high-resolution SAR and EO capabilities are complemented by at least a pair of medium resolution EO satellites that are in a 1200 Km SSO.

At least three to four triplets of ELINT satellites flying in a triangular formation provide the coarse fix to the SAR and EO satellites for locating and continuously track the objects of interest.

The constellation build up started in 2006 and entered the initial operational phase with the launch of the Yaogan 9A, 9B, 9C ELINT triplet in 2010. It has been in operation since then.

China seems to have in place the capacities for both satellite and launcher manufacture. There are also multiple entities that can supply the required numbers of satellites and rockets.

Different launch sites (Taiyuan, Jiuquan) as well as different launchers with different capacities have been used for placing them in orbit. The achieved orbits may reflect both improvements in capabilities as well operational improvements deriving from the experience of the earlier missions.

6. ELINT Large Area Coverage

For the Large Area Satellite Surveillance system to work the coverage of the ELINT part of the system is most important since it provides the initial cues for the other satellites. In order to understand this coverage the ISSSP Group carried out a study using the two line element orbital data put out by NORAD and the in-house developed Veni Vidi Vici orbit propagation software. Five of the ELINT constellations were taken and their coverage of Taiwan analyzed for a period of 26 hours.[17] The ELINT satellites chosen were the Yaogan 16 ABC, Yaogan 17 ABC, Yaogan 20 ABC, Yaogan 25 ABC and the Yaogan 31 ABC satellites.[18] The ability of these satellites to monitor electronic emissions emanating from Taiwan was studied.

There are 29 passes during the 26 hour period (a little over one pass every hour) that can monitor electronic emissions over Taiwan. This location information can then cue the SAR and EO satellites for a more precise location of the object of interest such as an Aircraft Carrier Group (ACG).[19]

There are also about 30 periods between the passes during which emissions cannot be detected. Of these 30 gap periods there are six periods where the gaps between passes exceeds 60 minutes. The average gap between passes is about 36 minutes with a maximum gap of 92 minutes and a minimum gap of 5 minutes.

The target is visible for 495 minutes out of the total time period of 1560 minutes which translates into a 32% emission monitoring capability.

While this monitoring capability may be good enough for long range surveillance of the ocean areas around China’s eastern coastline extending into the northern Pacific Ocean it may not be adequate as the adversary comes closer to its coastline. A continuing surveillance capability may be needed to deal with such eventualities. Chinese launches of a new series of Yaogan 30 satellites promise to provide this near constant surveillance capability.

7. The New Yaogan Theatre ELINT Constellation

On the 25th of January 2018 China launched a new Yaogan 30 satellite from Xi Chang. The same name – Yaogan 30 – had been used earlier by China for a hi-resolution EO satellite launched in May 2016.

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[17] The choice of Taiwan was based on the view that it is the most likely venue for a future conflict given China’s vulnerabilities and its security priorities. Taiwan provides only a static target whereas the threat is posed by a mobile Aircraft Carrier Group (ACG). A similar analysis is needed for a moving target. This will be addressed in a subsequent paper.

[18] The Yaogan 9 triplet was launched in 2010. This has not been taken into the exercise since it may have reached its end of life.

[19] Ideally this exercise must be carried out for a moving object like an Aircraft Carrier. Such an exercise is currently underway using the Veni Vidi Vici software tool developed by ISSSP, NIAS.

The January 2018 launch saw three satellites placed into a 600 Km orbit with an inclination of 35 degrees. This was the fourth such triplet that China had launched with earlier launches in September, November and December 2017. **Table 4** provides relevant details of the orbital parameters of these Yaogan 30 satellites.[20]

Table 4

Yaogan 30 ELINT Theatre Constellation Details

Satellite	Launch site	Launch Time	Launch Time	Apogee Km	Perigee Km	Inclination °	Period (Min)	RA °	Launch date	Launcher
Yaogan 30 A	Xi Chang	04:21 UT	12:21 CST	609	604	35	96.7	260.491	Sep 29 2017	CZ 2C
Yaogan 30 B	Xi Chang	04:21 UT	12:21 CST	609	605	35	96.7	260.725	Sep 29 2017	CZ 2C
Yaogan 30 C	Xi Chang	04:21 UT	12:21 CST	602	611	35	96.7	261.251	Sep 29 2017	CZ 2C
Yaogan 30 D	Xi Chang	18:10 UT	02:10 CST	611	602	35	96.7	139.612	Nov 24 2017	CZ 2C
Yaogan 30 E	Xi Chang	18:10 UT	02:10 CST	610	604	35	96.7	139.820	Nov 24 2017	CZ 2C
Yaogan 30 F	Xi Chang	18:10 UT	02:10 CST	610	604	35	96.7	139.260	Nov 24 2017	CZ 2C
Yaogan 30 G	Xi Chang	19:44 UT	03:44 CST	610	603	35	96.7	18.6986	Dec 25 2017	CZ 2C
Yaogan 30 H	Xi Chang	19:44 UT	03:44 CST	611	603	35	96.7	19.2722	Dec 25 2017	CZ 2C
Yaogan 30 J	Xi Chang	19:44 UT	03:44 CST	610	603	35	96.7	19.4547	Dec 25 2017	CZ 2C
Yaogan 30 K	Xi Chang	05:39 UT	13:39 CST	611	603	35	96.7	19.8513	Jan 25 2017	CZ 2C
Yaogan 30 L	Xi Chang	05:39 UT	13:39 CST	609	604	35	96.7	19.8040	Jan 25 2017	CZ 2C
Yaogan 30 M	Xi Chang	05:39 UT	13:39 CST	610	603	35	96.7	20.9685	Jan 25 2017	CZ 2C

There are several firsts associated with this series of launches that indicate that these satellites are the early launches of a new constellation of Yaogan satellites.

All the four triplets were launched from the Xi Chang Space Launch Complex usually used for reaching the Geostationary Orbit. These satellites were the first Yaogan satellites launched from this complex.

The launching of a triplet of satellites is usually associated with ELINT missions. However the altitude (600 Km) and inclination (35 degrees) of these triplets were different from the other ELINT triplets launched by China which had altitudes of 1200 Km and inclinations of 63.4 degrees. (See Section 5.1 for details of China's earlier ELINT launches)

The other major difference was that after the launch the satellites were maneuvered in such a way that instead of flying in a triangular formation they were equally spaced at intervals of 120 degrees within the same orbital plane. Such a configuration would suggest a mission focused on maintaining constant surveillance over a given area – which in this case would be the region between 35 degrees North latitude and 35 degrees South Latitude.

The logical inference one can make from this architecture would be that these Yaogan 30 satellites are ELINT satellites that are meant to provide constant electronic surveillance over the land and sea areas

[20] Data in the Table compiled from a number of open sources and NORAD two line element data as of June 17, 2018 at 11 00 hours.

bordering China's eastern seaboard which includes Taiwan, the Korean peninsula, key parts of Japan's southern waters, Guam, the ASEAN countries as well as all parts of the Indian Ocean.

From **Table 4** we can easily see that the orbital plane separation between the first two triplets (Yaogan 30ABC and Yaogan DEF) is close to 120 degrees.[21]

The orbital plane separation between the second and third triplet is also close to 120 degrees.[22]

The three groups are thus equally spaced 120 degrees apart.

Figure 2 provides a simple overview of the orbital plane separation between these satellite groups.

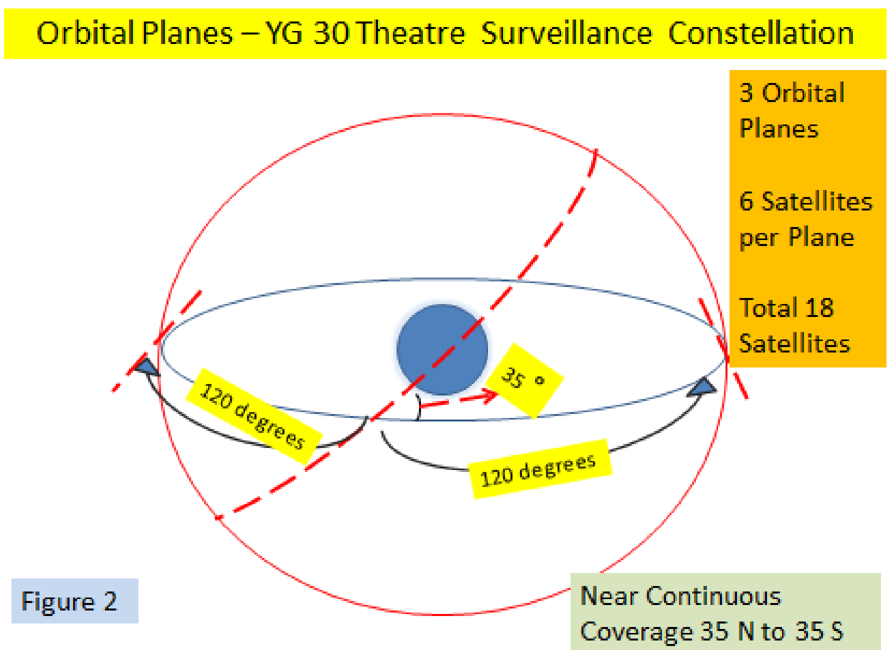


Figure 2

We can also see from the data in Table 4 that the satellites constituting the third triplet (Yaogan GHJ) and the fourth triplet (Yaogan KLM) are all coplanar and spaced nearly equally in the same orbital plane.[23]

Figure 3 provides a pictorial representation of this spacing within the same orbital plane of the Yaogan GHJ and Yaogan KLM satellites.

It is likely that the other two orbital planes will also have a complement of six satellites each making a total constellation size of 18 satellites that are dedicated to the theatre ELINT surveillance function.

[21] The difference in the Right Ascension (RA in the Table) between the triplets provides the information on orbital planes separation.

[22] The Right Ascension of the first triplet is close to 260 degrees and that of the second close to 140 degrees giving a separation close to 120 degrees. The separation between the second and third triplets is also close to 120 degrees.

[23] An equal spacing of six satellites in the same orbital plane implies a separation between satellites of 60 degrees.

The architecture of this new constellation suggests that its coverage of the land and sea areas between 35 degrees N and 35 degrees South Latitudes would be much better than what it can achieve only with its large area ocean ELINT surveillance system.

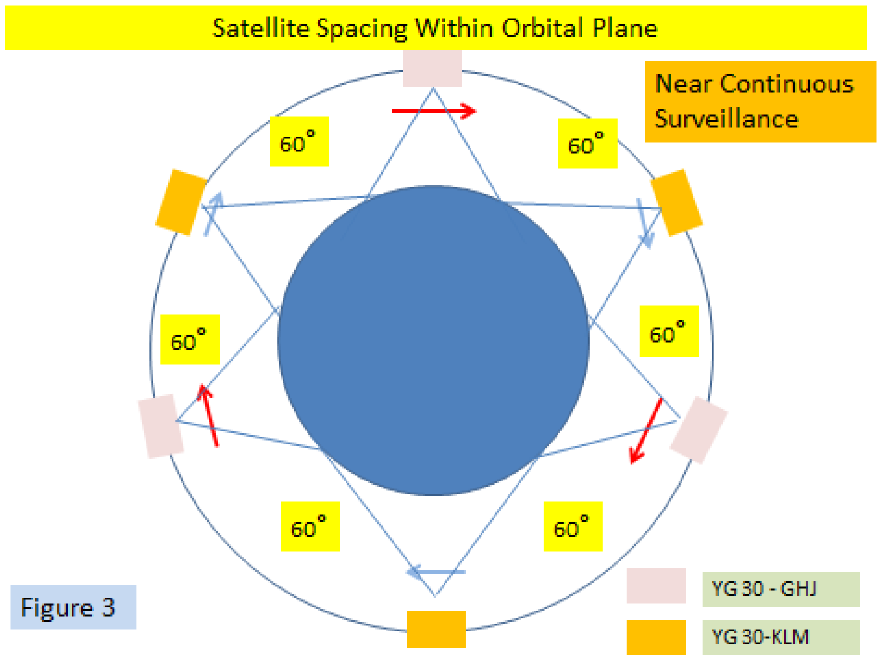


Figure 3

8. The Yaogan Theatre ELINT Coverage

To investigate this improved coverage achieved with the new system we once again looked at the constellation's ability to monitor electronic emissions over Taiwan. We choose the same 26 hour period that we had used for the earlier large area ELINT surveillance study and used the in-house developed Veni Vidi Vici software along with the NORAD supplied two line element data for carrying out the study.[24]

The major findings are summarized below. There are a total of 103 orbital passes during a period of 26 hours during which electronic emissions from Taiwan can be monitored by the Yaogan theatre level ELINT constellation.

Out of a total duration of 1560 minutes (26 hours) electronic emissions emanating from Taiwan can be monitored for 1091 minutes for an overall efficiency of 70%. There are a total of 58 gaps during this period. The maximum gap between emission monitoring passes is 22 minutes with the minimum being 1 minute. The average gap is 8 minutes. The Surveillance has improved considerably. There are also

[24] The orbit propagation was for a period of 26 hours starting from June 17 2018 11 00 hours to June 18 2018 13 00 hours.

overlaps in coverage amongst the satellites in the constellation. This means that electronic emissions can be monitored at the same time by more than one satellite. The total coverage during the 26 hour period is 1340 minutes though because of overlaps in coverage this translates only into 1091 minutes of actual coverage. This overlap provides some kind of resilience to the system in case of satellite failures or some other operational problems.[25] It is also possible that with improved orbit management practices the coverage efficiency can also be improved beyond the current level of 70%.

The analysis so far has treated the large area surveillance system and the theatre level surveillance system as two separate systems. In practice they are complements to each other with one looking farther away and the other becoming more dominant as the threat comes closer to the Chinese mainland. How does the coverage change if the two systems function in tandem?

9. Combining Large Area and Theater Level Surveillance Systems

The coverage of both the large area and the theatre level ELINT surveillance systems over Taiwan for a 26 hour period was also analyzed.[26] **Table 5** provides a summary overview of the combined coverage of the two Yaogan ELINT constellations.

Table 5

Yaogan ELINT Coverage – Large Area & Theatre Surveillance Constellations

Time (Min)	Interval (Min)	Cum Time (Min)	Gaps No	Cum Gaps No	Gap time (Min)	Cum Gap (Min)	Max Gap (Min)	Min Gap (Min)	Interval Efficiency (%)	Dynamic Efficiency (%)
1 to 66	66	66	1	1	3	3	3	0	95%	95%
67-120	54	120	3	4	5	8	3	1	91%	93%
121-184	64	184	1	5	6	14	6	0	91%	92%
185-239	55	239	3	8	33	47	20	2	40%	80%
240-299	60	299	2	10	21	68	12	9	65%	77%
300-358	59	358	2	12	22	90	20	2	63%	75%
359-439	81	439	2	14	10	100	6	4	88%	77%
440-508	69	508	4	18	11	111	5	1	84%	78%
509-581	73	581	3	21	11	122	5	2	85%	79%
582-644	63	644	3	24	13	135	6	3	79%	79%
645-713	69	713	2	26	28	163	21	7	59%	77%
714-782	69	782	2	28	38	201	21	17	45%	74%
783-837	55	837	3	31	12	213	10	1	78%	75%
838-900	63	900	0	31	0	213	0	0	100%	76%
901-1002	102	1002	1	32	2	215	2	0	98%	79%
1003-1056	54	1056	3	35	12	227	6	2	78%	79%
1057-1112	56	1112	1	36	7	234	7	0	88%	79%
1113-1208	96	1208	1	37	20	254	20	0	79%	79%
1209-1311	103	1311	2	39	33	287	20	13	68%	78%
1312-1414	102	1414	4	43	14	301	6	1	86%	79%
1415-1515	101	1515	3	46	7	308	3	1	93%	80%
1516-1560	45	1560	2	48	14	322	12	2	69%	79%

[25] The resilience factor can be estimated as 1.23 which is 1340 divided by 1091. There is nearly a 25 % redundancy in the achieved coverage.

[26] The coverage is from 17 June 2018 11 00 hours to 18 June 2018 1300 hours

Figure 4 provides one snapshot of such coverage. As we can see from the Figure as one satellite moves away another satellite takes over.

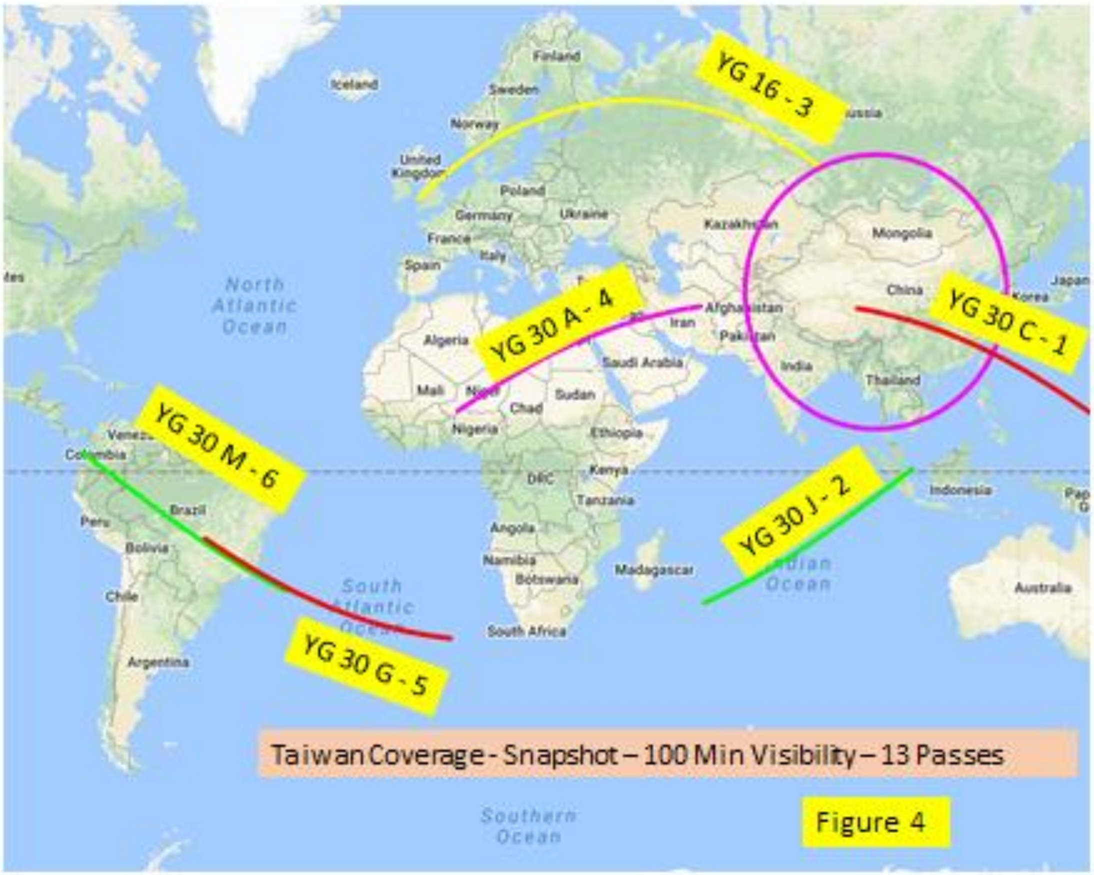


Figure 4 is just one part of a 100-minute continuous surveillance period. As the theatre ELINT constellation gets completed with the addition of six more satellites to make a constellation of 18 the gaps in coverage are likely to get further reduced. As expected the combination of the two systems provide significant improvement in the overall coverage efficiency from 70% to 79%. There is also a reduction in the average gap period from 8 minutes to 6.7 minutes.

The large values for the resilience or redundancy factor implies that there is some scope for improving the overall coverage efficiency.

10. Space – A Major Constituent in China's Military Power

The critical role of the space and cyber domains along with the nuclear and more traditional modes of war is a reality today.[27] China has for a very long time recognized the importance of military space

[27] S.Chandrashekar, "Space, War & Security – A Strategy for India", International Strategic & Security Studies Programme (ISSSP) National Institute of Advanced Studies (NIAS), Report No R36-2015, December 2015, pp 6-20.

capabilities to prevent or delay US intervention over the military actions it may take in its region of interest. The formulation of its A2AD strategy is an asymmetric response to a dominant adversary.[28] Whilst the strengthening of its other more conventional military assets is also a high priority, Chinese investments in space and cyber assets are clearly on a steep upward trend.

The pace of launching military satellites by China has significantly increased over the last several years. The programme covers the full spectrum of space capabilities from manned flight and space stations to advanced quantum communications and X ray pulsar observation satellites that are oriented towards the advancement of basic science and technology knowledge. Whilst China is striving to use its space assets for both economic and political ends, the fundamental driver of the programme has always been dictated by military needs. **Figure 5** provides an overview of Chinese military capabilities.

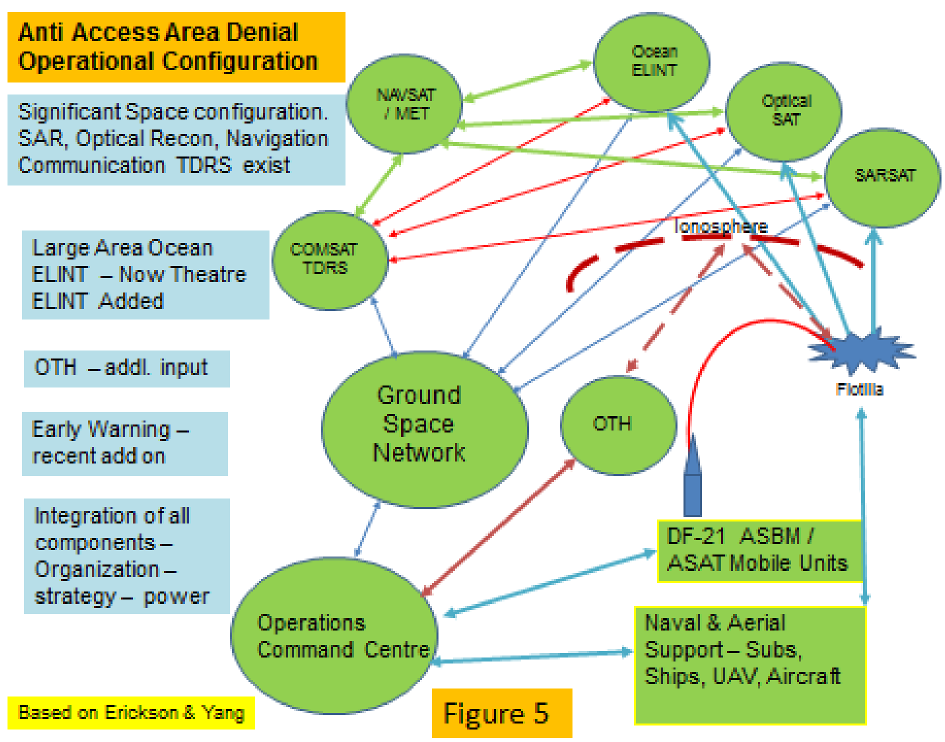


Figure 5

Apart from the C4ISR capabilities that include communications and data relay satellites in GSO, China has also invested in both ground based and space based ASAT capabilities that can extend to the GSO and maybe even beyond it. It has also demonstrated BMD capabilities.[29] More recently as mentioned earlier in this brief it has launched two satellites the TJS 1 and TJS 2 satellites located at 155 degrees E and 107.5 degrees East that are possibly Early Warning Satellites for BMD.

[28] S.Chandrashekar, "China's Anti-Access Area Denial (A2AD) Strategy", India's National Security Annual Review 2016-17, Edited by Satish Kumar, Foundation for National Security Research, New Delhi, Routledge Taylor & Francis Group, 2018, pp 381-392

[29] S.Chandrashekar, "China's Space Programme – A Critical Evaluation", Internal Report, International Strategic & Security Studies Programme (ISSSP), National Institute of Advanced Studies (NIAS) January 2017.

The creation of the new theatre-oriented Yaogan 30 constellation provides a significantly improved surveillance capability.

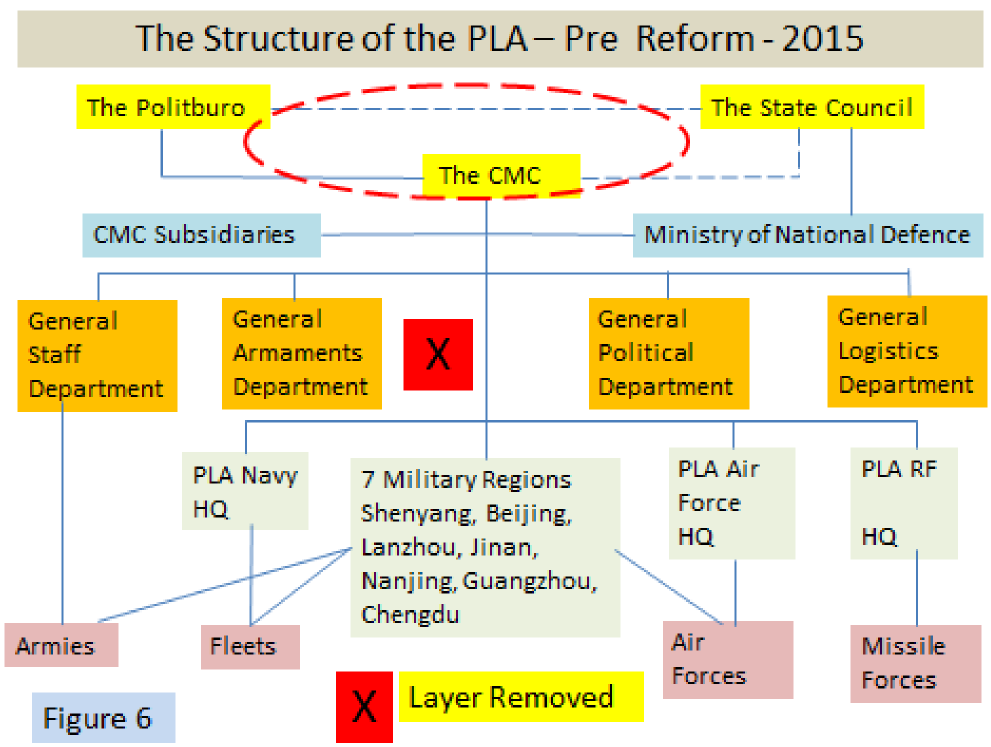
In combination with the large area Yaogan ELINT constellation described earlier China has in place a robust ELINT capability that can be effectively used along with other C4ISR and conventional military assets to provide the real time data needed to "deter, fight and win local wars under informationized conditions".

11. Organization Changes Lend Teeth to China's Military Strategy

The creation of these space capabilities has also gone hand in hand with the restructuring of the organization and institutions of the PLA.

Figure 6 provides an overview of the organization structure before the reforms of 2015 were undertaken.

Figure 7 provides the new organization structure for the PLA. [30]



[30] This section is based on Anthony H Cordesman, Joseph Kendall, "Chinese Strategy and Military Modernization in 2016 - A Comparative Analysis", Centre for Strategic & International Studies (CSIS), December 5, 2016, pp 182-210.

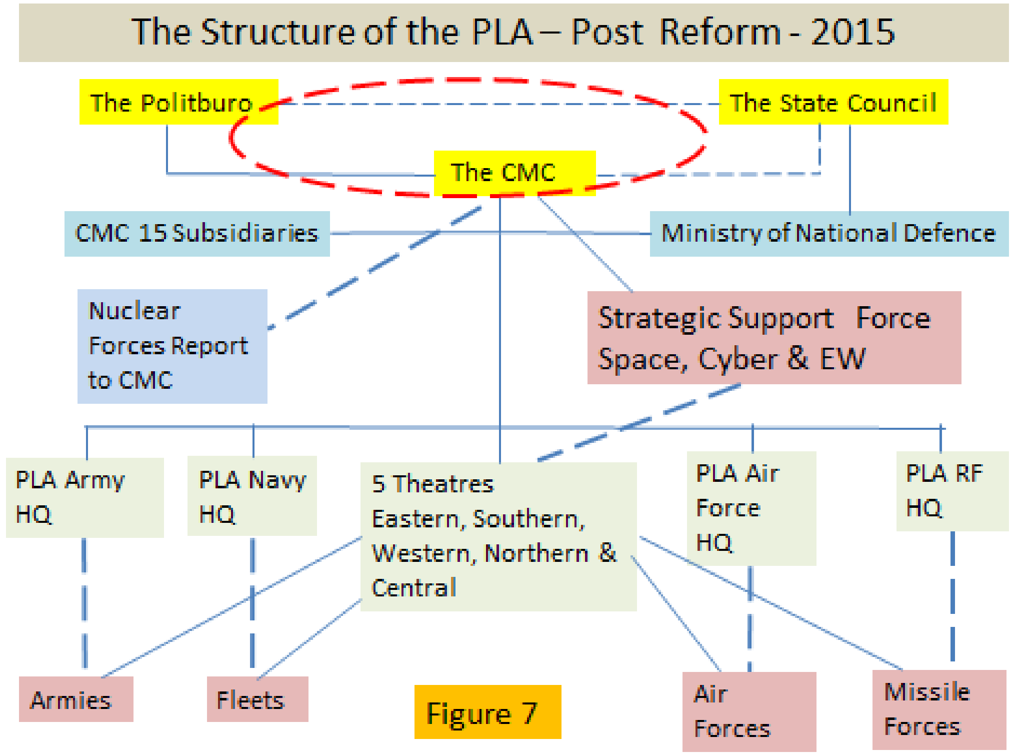


Figure 7

The first major change has been the elimination of the four General Departments. The General Staff Department, the General Political Department, the General Logistics Department and the General Armaments Department that function directly under the Central Military Commission (CMC) with oversight functions over the Armed Forces were abolished. Fifteen smaller entities based on their functions have been created. These smaller mainly oversight, staff and support groups report directly to the CMC.

In the earlier pre-reform structure, the PLA Navy, the PLA Air Force and the Second Artillery Corps had a HQ that assumed overall responsibility. The Army however did not have such a HQ and was directly controlled by the four staff departments. A new Army HQ has been created that will come directly under the CMC. The HQ of the other services also report directly to the CMC as do the theatre commands.

The seven Military Regions that were responsible for coordination with the individual services for operations have been replaced by five theatre commands in the recent re-organization. Unlike the Military Regions who merely served as coordination nodes for operations by the individual services the theatre commands will be directly responsible for operations within their theatre. This is major shift in power away from the individual services commands to command of a joint force under a theatre commander.

The reforms make clear that the theatre commands are directly responsible for the operations in their theatres. They will exercise direct control over various service units in their theatre of operations. This is significantly different from the earlier system where the individual services were responsible directly for the operations in various regions under the coordination of the regional commands.

In the new dispensation the Army, the Navy, the Air Force and the Rocket Forces serve as suppliers to the theatre commands. Their main task is to organize, equip and train the military units required by the theatre commands.

This is a major change that takes power away from the various services towards a more functional and integrated theatre command-based structure. Overall it dilutes to a large extent the power of the middle level General Department / Services HQ and puts it more directly under the CMC and the theatre commands.

One of the major highlights of the reforms is the importance assigned to the role of information in the war fighting and war deterring strategies of China.

The CPC / CMC have created an entirely new entity that it calls the Strategic Support Force (SSF). The SSF operates directly under the CMC and is responsible for Space, Cyber and Electronic Warfare. This arrangement seems to be directed towards meeting the need for real time information dominance that is common to and cuts across all theatres of military operations.

Nuclear Forces irrespective of where they are located come directly under CMC command only.

By eliminating a lot of unnecessary middle level military bureaucracy, transferring integrated military operations to the theatre commands, creating an SSF and by redefining the role of the four traditional services to that of a supplier of equipment and trained military units, China is creating the organizational and institutional competencies for fighting, winning and deterring local wars under conditions of informationization.

As we can see from the creation of the SSF, Space Capabilities are given a central role in providing the basic shared battlefield and warfighting information that cuts across functional and geographic domains. Associated with space and closely related to it are the Cyber and Electronic Warfare functions.

By linking all these closely coupled functions under the umbrella of the SSF the restructuring exercise has put in place the necessary organization infrastructure for achieving information dominance that is so crucial for fighting and winning wars in the world of today.[31]

12 China & Space Power

It is obvious from this that China has in place the full spectrum of space military capabilities to fight and win local wars under informationization conditions as enunciated by its leader.

Figure 8 provides an overview of the satellites launched by different countries at the end of 2016.[32]

[31] There could be some ambiguities still. The Kinetic Kill ASAT capability for example could still vest with the PLA Rocket Forces whereas satellite based counterforce capabilities and other ground based ASAT assets may be with the SSF.

As we can see from the Figure, though the US is still ahead China appears to be the only country that could pose a challenge to the US across the military, economic, political and knowledge dimensions of space use.

Its Beidou navigation system that will soon be operational could leverage its large domestic market to challenge the US GPS navigation gold standard.

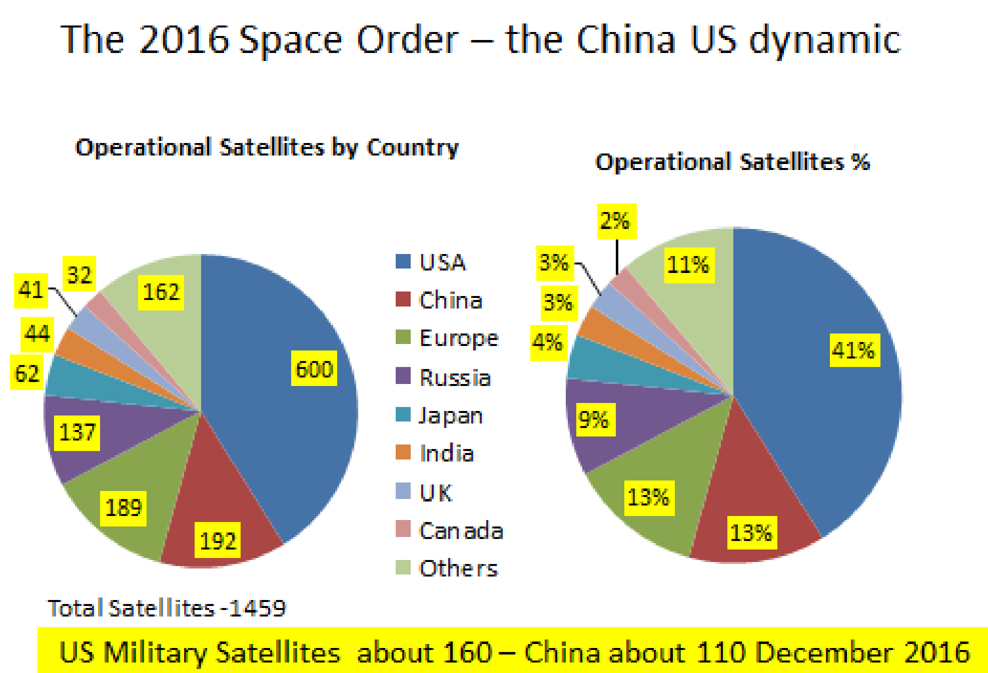


Figure 8

China is already delivering large indigenously built and launched communication satellites in-orbit to many countries across the world bypassing US regulations such as ITAR.[33]

Telecom and remote sensing data-based service companies are springing up across China. There is a burgeoning market for small satellite constellation applications pushed by the state.

There are a several companies and government entities offering launcher and satellite services comparable to the competitive space ecosystem in the US.

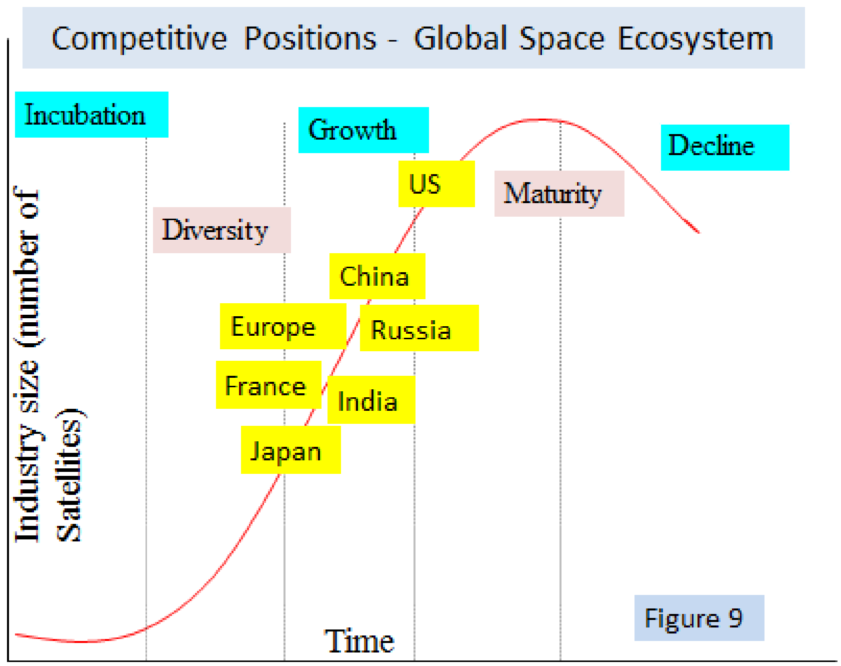
China's Quantum satellite and its X ray Pulsar satellite are the first offerings of their kind in the world. China is offering opportunities to all countries through the UN Office of Outer Space Affairs (OOSA) for

[32] In 2017 the US had 29 rocket launches as compared to China's 19 launches. Elon Musk alone had about 19 launches.

[33] International Traffic in Arms Regulations

use of its space station. Its Belt and Road Initiative will also use space capabilities for pushing its global power aspirations.[34]

Figure 9 provides the relative competitive positions of the countries that make up the current world space order.[35] The US China competition in space is likely to have a major impact on how these power games play out. It is possible that out of the current fragmented structure two networks of power and influence may emerge – one led by the US and the other led by China.[36]



China is now clearly poised to use its space capabilities not only as a key component of its military strategy but also as an instrument to build up its Comprehensive National Power (CNP) that includes the economic, political and knowledge dimensions. It has clearly identified Space as a critical component of its geopolitical power architecture.

Whether it is hard power revealed through its increasingly sophisticated military space systems or commercial communications satellites or soft power as shown by the diffusion of its emerging Beidou

[34] A more detailed view is available in Reference 28.

[35] The figure is based on the spectrum of space activities carried out by these countries and not so much based on the scale of operations. If scale of operations is included the gaps between countries like India and Japan with respect to China are likely to be greater.

[36] However under the Trump administration the prospects of such a US led network emerging in the next few years appear to have diminished. His current moves towards US allies in the region may strengthen China's influence. China's aggressive posturing in the South China Sea and its claims to large stretches of the seas around its coastline has also created problems for many of the countries in the Asia Pacific Region.

navigation system into global commercial products and services China is emerging as the only country that can challenge the dominant position of the US as the most powerful space faring nation in the world.

What we are witnessing in the space domain is one facet of the larger geopolitical rivalry between the US and China. Though the Indo-Pacific region represents the current focus area of this rivalry one can expect it to expand into the larger global stage.