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Eavesdropping from Space[1]

Pat NORRIS
Adviser to Vice-President Space, CGI IT UK Ltd., Leatherhead, UK

United States satellites that intercept communications have so far avoided the full weight of the media scrutiny that the Edward Snowden revelations have brought on other parts of the intelligence world. This paper outlines the activities of the National Reconnaissance Office that supplies the satellites and its relationship to the rest of the U.S. intelligence community.

1. The World's Largest Satellite

The satellite launched on 21st November 2010, NROL-32, was "the largest satellite in the world" according to public remarks by the then Director of the U.S. National Reconnaissance Office (NRO), General Bruce Carlson[2]. He did not elaborate on this remark but in the media "largest" is generally taken to mean "widest once deployed in space". He seems to be suggesting that it is bigger than the football-pitch-sized International Space Station (109m x 73m).

From information supplied by former intelligence analyst Edward Snowden we can deduce that NROL-32 was a satellite called ORION-7 in the "signals intelligence (SIGINT) (high)" category where "high" means geostationary orbit 36,000 km up or some other orbit >10,000 km high.

2. National Reconnaissance Office

The NRO public website describes its activities as follows:

- "When the United States needs eyes and ears in critical places where no human can reach – be it over the most rugged terrain or through the most hostile territory – it turns to the National Reconnaissance Office (NRO).
- The NRO is the U.S. Government agency in charge of designing, building, launching, and maintaining America's intelligence satellites."

The mission patch for the NROL-49 satellite launched in early 2011[3] summarises the NRO's raison d'être as "*melior diabolus quem scies*" – "better the devil you know".

NRO has three main customers, each of which requires somewhat different information: the Department of Defense (DOD), the Central Intelligence Agency (CIA) and the National Security Agency (NSA).

The first of these customers, DOD, wants information about enemy armed forces. This might be strategic and long term, for example the number and location of missile silos, bombers, nuclear submarines or tanks. Or the information required might be tactical and short-term (perhaps even

[1] This paper is based on research for the chapter on "Military Radio Surveillance from Space" in the author's book Watching Earth from Space (Springer-Praxis, 2010) and the author's chapters on "Eavesdropping" and "Satellite Programs in the United States" in Schrogl KU, Hays PL, Robinson J, Moura D, Giannopapa C (Eds) Handbook of Space Security. Policies, Applications and Programs, Vol 2, pp 631 – 643 and Vol 3, pp 743 - 774. Springer (2015) New York Heidelberg Dordrecht London. The views expressed in this paper are those of the author and are not those of CGI IT UK Ltd

[2] Carlson B, "National Reconnaissance Office Update", Air Force Association conference, Oxon Hill, MD, 13 Sept. 2010, available online at http://www.nro.gov/news/speeches/2010/2010-02.pdf

[3] http://www.nro.gov/images/launches/nrol-49/NROL-49-patch.jpg

immediate) in order to support on-going military operations. In both cases the coverage required is potentially anywhere in the world.

The second customer, the CIA, has subtly different requirements. Its public website declares that its mission is to "pre-empt threats and further U.S. national security objectives by collecting intelligence that matters, producing objective all-source analysis, conducting effective covert action as directed by the President, and safeguarding the secrets that help keep our Nation safe". The CIA therefore wants information on people who pose a threat to U.S. interests. This includes determining the location of terrorists and other people of interest. It also includes analysing the activities of terrorists, such as to whom they speak, who they visit or visits them, what vehicles they use, what they purchase and so on. It may even extend to researching the background of terrorists, including what training they have had, and what links they have to relevant groups.

The third of the NRO's main customers, NSA, has been most in the limelight due to the Edward Snowden revelations. NSA's public website defines its two missions as:

1. Information assurance, i.e.: to keep U.S. secrets safe
2. Signals intelligence, in which the NSA "collects, processes and disseminates intelligence information from foreign signals for intelligence and counter-intelligence purposes and to support military operations"

3. SIGINT from Space

The principles by which NRO satellites pick up radio signals that can be turned into useful intelligence were first illustrated less than 3 years after Sputnik-1 kicked-off the space age. On 22nd June 1960 the tiny GRAB spacecraft was launched by the U.S. DOD and became the first satellite designed to "observe" the Earth on an operational basis. GRAB didn't observe the Earth in the conventional sense (by taking pictures), instead it detected radio signals from below and relayed them to ground terminals thousands of miles away. GRAB provided the U.S. with unprecedented information about the signals emitted by Soviet radars at a time when those two super-powers were Cold War adversaries and when information about activities inside the Soviet Union was almost impossible to obtain. The information collected by GRAB was sufficiently useful to justify the launch of more such satellites.

The value of these satellites is that some of the information of interest to DOD, CIA and NSA is carried on radio waves and can in principle be picked up by sufficiently powerful receivers in space. The information broadly can be considered as either military or civilian (although the boundary lines are blurred). Military information includes voice and data traffic between military bases and units, data from weapons and their "platforms" (ships, planes, helicopters, tanks, jeeps, missiles, submarines, etc.) and radar transmissions. The civilian information could include voice, messaging and other data via satellites (since often satellites are the only form of telephony in remote areas), communications to and from mobile phone towers and communications between microwave towers.

4. Current Status

Following the launch of ORION-7 (NROL-32 - "the largest satellite in the world") in 2010, ORION-8 (NROL-15) followed in mid-2012. ORION-8 required an especially improved version of the Delta 4H launcher which suggests that it was heavier than its predecessors – but NRO hasn't told us if it was "larger" than ORION-7.

ORION-8 is said by civilian analysts to be the third satellite in a series that started with NROL-26 in 2009. Jonathan McDowell, a well-known U.S. chronicler of space activities, has identified 9 previous satellites that he considers fit into this series starting in 1970.

Launch date	Launcher	Notes
19 June 1970	Atlas Agena	
6 March 1973	Atlas Agena	
11 Dec. 1977	Atlas Agena	
7 April 1978	Atlas Agena	
24 Jan. 1985	Space Shuttle Discovery /IUS	
23 Nov. 1989	Space Shuttle Discovery /IUS	
14 May 1995	Titan-Centaur	
9 May 1998	Titan-Centaur	
9 Sept. 2003	Titan-Centaur	
18 Jan. 2009	Delta 4H	NROL-26
21 Nov. 2010	Delta 4H	NROL-32, ORION-7
29 June 2012	Delta 4H (enhanced engine)	NROL-15, ORION-8

Satellites in the series leading to NROL-15 as identified by Jonathan McDowell[4]

Looking to the future, papers released by Edward Snowden identify an NRO program called "SIGINT High Altitude Replenishment Program" (SHARP) which received more than $2.5 billion funding in the 2011-2013 period. General Carlson's successor as NRO Director, Ms Betty Sapp, touched on this

[4] http://planet4589.org/space/jsr/back/news.661

in public evidence to a Congressional Committee in 2013 when she said that "Over the coming years, the National Reconnaissance Office will incorporate revolutionary new technologies into our architecture that will provide enhanced support to the war fighter while also improving the resiliency of our systems."[5] This lavishly funded program will presumably result in new satellites soon, but to what extent they will be "sharper" than ORION-7 and -8 has not been revealed.

The giant antennas that these eavesdropping satellites deploy when in geostationary or other very high altitude orbit represent a highly sophisticated technology. We can get a feeling for the difficulty of the technology by comparing them with the largest civilian space antennas.

Satellite	Antenna size	Launch
ACeS/Garuda	12m	2000
Thuraya	12 x 16m	2003-08
MBSAT	12m	2004
Inmarsat-4	9m	2004-08
ETS-8/Kiku-8	19m	2006
TerraStar-1	18m	2009
SkyTerra-1	22m	2010
MUOS	14m	2012-13
Alphasat	11m	2013

The table above lists most of those launched since the turn of the century. The website of one of the two main U.S. manufacturers, Harris Corporation, claims to have supplied the "world's largest unfurlable reflector" on orbit[6]. Its competitor, Northrop Grumman, claimed in mid-2014 that it had 8 such units deployed in orbit with two more due to be launched in 2014[7]. The satellites carrying these antennas typically weigh 5 tons or more when launched, of which the antenna weighs of the order of 100kg of which the actual antenna surface (often referred to as the reflector) is about half, with the structure and deployment mechanism making up the rest. If the NRO's ORION-7 is 100m or so in size as implied by General Carlson (see above), they are significantly more advanced than anything in the civilian world.

5. Low SIGINT satellites

Besides the ultra-large satellites in geostationary or other "high" orbits, NRO also builds "low" SIGINT satellites, typically in near-polar orbits about 1,000km high. They are thought to primarily address military targets especially maritime ones. Many deploy 1 or 2 sub-satellites (officially described as "debris") which would allow them to triangulate radio or radar emissions. Their orbit results in them traversing a roughly north-south path that gradually covers the whole globe as the Earth turns below.

About 20 of these Naval Ocean Surveillance Satellites (NOSS) are thought to be in orbit. Edward Snowden's leaks revealed that their official name is INTRUDER and their 2011-2013 3-year budget was $2B, which is about half that of the "high" variety. Furthermore they lack a future development programme similar to the SHARP programme for the high satellites.

In addition to using special satellites for eavesdropping, another approach is to have antennas on the ground that intercept conversations, messages and data that are routed through commercial satellites. Since the 1980s most long distance communications are carried by cable – on land or under the sea. However, certain types of communication tend to go by satellite, for example where one of the parties is on a ship or an airplane, and eavesdropping of these calls is viable.

6. Information Can Lead to Action

Several examples of the use of intercepted conversations by anti-terrorist agencies have been reported. In November 2002, the NSA detected a phone call coming from Qaed Salim Sinan al-Harethi considered to be the al-Qaeda operative who planned the attack on the *USS Cole* in a Yemeni harbour in 2000 that killed 17 U.S. sailors. The satnav chip in Al-Harethi's phone gave his exact location in rural Yemen. A CIA Predator unmanned aircraft was dispatched from across the Red Sea in Djibouti and was directed by its operators to fire a Hellfire missile at al-Harethi's car, destroying the vehicle and killing all of its occupants.

The U.S. is not alone in targeting enemies by listening to their satellite phone calls. Russia killed Chechen rebel leader Dzhokar Dudayev in 1996 by using such a call to pinpoint his position.

The information hoovered up by these satellites is radioed to ground stations around the world and then sent across secure networks to the U.S. The satellites are developed and launched by the NRO, but once in orbit they are used by the NSA to intercept radio traffic. The U.S.-UK special relationship plays its part in this. The public website of the Royal Air Force Menwith Hill base [near Harrogate, Yorkshire] in the UK says it "functions primarily as a field station of the NSA …. and is an integral part of the U.S. [Department of

[5] Sapp B, Director, National Reconnaissance Office, "Statement for the Record", House Armed Services Committee, Subcommittee on Strategic Forces, 25 April 2013; online at http://www.nro.gov/news/testimony/2013/2013-01.pdf

[6] http://download.harris.com/app/public_download.asp?fid=463

[7] http://www.northropgrumman.com/BusinessVentures/AstroAerospace/Products/Documents/pageDocs/Flight_Heritage.pdf

Defence] world-wide defence communications network"[8]. Facilities in Australia, Canada and perhaps New Zealand[9] also play a role.

7. Budgets Show the Large Scale of Activities

NSA and its British counterpart, Government Communications HQ (GCHQ), have been much in the news since the Snowden leaks first emerged in the summer of 2013. In contrast the National Reconnaissance Office has largely escaped the limelight despite its budget being revealed to be about the same as that of the NSA – each funded at slightly more than $32 billion for the 2011-2013 period.

NRO	SIGINT high	3.8
	SIGINT low	2.0
	Launchers	3.1
	Imaging satellites	6.4
	Relay satellites	1.4
	Ground engineering & operations	7.7
	Other costs	7.6
	NRO Total	**32**
CIA		**45**
NSA		**32**
Defense Intelligence		**14**
National Geospatial Intelligence Agency		**15**
9 other agencies		**23**
TOTAL		**161**

3-year budget figures (2011 to 2013, $ billions) for U.S. Intelligence Agencies[10]

The National Reconnaissance Office's roughly $10 billion per annum buys more than just eavesdropping satellites. Director Betty Sapp says that its mission is "to provide Innovative Overhead Intelligence Systems for National Security" and that it "remains the premier space reconnaissance organization in the world". Much of that is in the form spy satellites of the more conventional kind using both optical and radar sensors[11].

About $1 billion of the NRO budget goes each year to launchers to place its various satellites in orbit. This figure reflects the need to buy large rockets to launch large satellites. But it also reflects a decision some years ago to buy all military launchers from a single supplier – United Launch Alliance. The successful launch of commercial satellites into geostationary orbit by Space-X's Falcon-9 rocket is likely to lower future launch costs as Space-X becomes accepted as a viable supplier to the military community.

The cumulative budget for the years 2011 through 2013 for the NRO and the other main U.S. intelligence agencies are listed above in billions of U.S. dollars. The CIA, NSA and NRO consume over two thirds of the total between them. Of those three, the NSA and the CIA have been subjected to intense media and political scrutiny since the Snowden leaks began, but little attention has been paid to the NRO which supplies intercept tools and services to the other agencies.

8. Other Countries

The U.S. is the only country that deploys technology in space on the scale of the giant "SIGINT high" satellites. Britain cancelled the development of its Zircon "SIGINT high" satellite in the 1980s and instead joined in the U.S. program as indicated above. Russia has had electronic intelligence satellites in low orbits (about 1,000km altitude) since the 1960s and in recent years China has too. France has been experimenting with the low orbit type of surveillance from space for about a decade but has not yet made a commitment to full operation. The main targets of such satellites are probably military signals and communications, similar to the U.S. "SIGINT low" satellites.

9. Concluding Remarks

Future revelations by Edward Snowden might focus the media spotlight on the NRO, but for the moment, the role of satellites in the communications intercept activities of the U.S. government has escaped detailed media or political scrutiny.

[8] http://www.raf.mod.uk/organisation/rafmenwithhillmission.cfm

[9] Which together with the U.S. and the UK make up the "five eyes" nations that collaborate on intelligence matters

[10] Gellman B, Miller G "'Black budget' summary details U.S. spy network's successes, failures and objectives", *Washington Post,* 29 Aug 2013; online at http://www.washingtonpost.com/world/national-security/black-budget-summary-details-us-spy-networks-successes-failures-and-objectives/2013/08/29/7e57bb78-10ab-11e3-8cdd-bcdc09410972_story.html detailed budget figures available online at https://s3.amazonaws.com/s3.documentcloud.org/documents/781719/tables.pdf

[11] See for example Norris P, "Spies in the sky", *Aerospace International*, December 2010, pp26-29 and Norris P, "Watching Earth from Space", Springer-Praxis (2010), pp189-197, 214-218

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http://www.espi.or.at
Tel: +43 1 7181118-0 / Fax: -99
Email: office@espi.or.at

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