Space Activities in 2014

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Definitional Challenges

Statistical reviews of space activity ask questions like 'which country has launched the most satellites into space?', in which every term (country, launch, satellite, space) is sufficiently problematic that no two analysts will get the same answer. To break with tradition, I am putting front and center what would normally be footnotes.

Challenge 1: Globalization Confusion

The tradition of characterizing space activity in terms of the nation-states performing that activity goes back to Sputnik and the Cold War; it is still the standard today, but makes less and less sense today when every aspect of each launch may involve organizations from multiple countries and globalized organizations not strongly associated with any one country.

Some of the issues are addressed in my presentation on 'the Globalization of Space' (http://planet4589.org and in my discussion of UN registration at http://planet4589.org/space/un/complicated.html

In 2014 the following specific issues are worth noting:

- The Antares 120 rocket is integrated in the USA and owned by a US company, but uses a first stage built in Ukraine with a Russian engine. It is counted as a US rocket.
- The Ariane 5 rocket is a collaborative venture of W European industry, developed by the European Space Agency and marketed by Arianespace, whose headquarters are in France. I list Ariane launches as nominally French although really they are international in nature.
- The Zenit-3SL rocket is built in Ukraine and Russia and launched from a platform in international waters. However, it is integrated in Long Beach, California and launch services are provided by a US subsidiary of the Russian 'Energiya' company. Its launches are allocated to the US despite its non-American origin. In contrast, launches of the very similar Land Launch Zenit-3SLB (not used in 2014) are allocated to Russia.
- The Soyuz ST-A and ST-B rockets are designed and manufactured in Russia but launched from French Guiana under the aegis of the French-registered company Arianespace. These launches are counted as French.
- The Tigrisat satellite was built by Iraqi students in Rome, funded by an Iraqi government grant and under the auspices of the University of Rome 'La Sapienza'. Although press reports and an official Iraqi government press release claimed this to be the first Iraqi satellite, it was registered with the UN by Italy and appears to be owned by La Sapienza. Similarly, the LambdaSat satellite built by a group of engineers of Greek heritage in the US was advertised as a Greek satellite, but appears rather to be a US one.
- Globalized commercial satcom companies include EUTELSAT, based in France; Intelsat is now formally based in Luxembourg but its satellites are registered by the US in the name of its engineering headquarters Intelsat SA (US) in Washington, D.C. The O3b company is based

in the UK Channel Islands. Optus Singtel is an Australian company which is a subsidiary of Singapore Telecom. SES is a particularly difficult case. Its headquarters are in Luxembourg; some satellites are initially launched as the property of UK (Isle of Man) based SES Satellite Leasing and transferred on orbit to SES World Skies (Netherlands) or SES World Skies (New Jersey, USA); the SES Astra satellites are more closely tied to Luxembourg and the SES Sirius AB satellites are Swedish.

- The SPOT 7 satellite was owned by France at the time of launch, but was sold to Azerbijan in 2014 Dec and renamed Azersky.
- The second Kondor-E satellite was launched in 2014 Dec; it was built by Russia but has been sold to another country, rumoured to be South Africa. In fact, it's not entirely clear if the transfer of control is the whole satellite or just its radar payload, or even just access to the data product. In practice the satellite bus is probably still operated from Russia, but the legal ownership of the satellite is unclear. For the time being I assign it to South Africa, although I expect Russia will register it with the UN.
- The Athena-Fidus military comms satellite is a joint French/Italian project, manufactured in France. I count it as French.
- The QB50 P1 and P2 satellites are registered as Belgian. They are developed by an international consortium led by the Von Karman Institute in Belgium, and were built in the Netherlands.

Challenge 2: What is Commercial?

A topic of much discussion in 2014 was the perceived move towards commercial space missions. Sometimes lost in this discussion is the fact that commercial space activity has been strong since the late 1970s, but several different standards for what is meant by 'commercial' are often conflated. We may distinguish:

- GOV: Government, Non-commercial: Activities entirely carried out by civil or military departments of a government, e.g. by a government lab or civil space agency
- CO: Commercial operation: Activities in which a private entity is paid by a government to operate government-developed hardware, such as contractors peforming launch range operations.
- CM: Commercial manufacture: Activities in which a private entity is paid by a government to manufacture space hardware to a government design, such hardware then being delivered to that government. This may or may not be done via a competitive selection process.
- CSP: Commercial (contracted) service provision: Activities in which a private entity is paid by a government to design, manufacture and operate hardware of their own design to provide a service or data needed by that government. The Dragon ISS cargo supply missions are an example of this. The US government is the only customer.
- FCS: Fully commercial service: Activities in which a private entity develops, manufactures and operates hardware and then sells the hardware or a corresponding service to other private entities as well as, possibly, to one or more governments. For example, Boeing builds communications satellites and delivers them on orbit to a variety of customers including but not limited to the US government.

- FC: Fully commercial: For-profit activity in which only private entities are involved in the financing, decision making and management activity, with no government money (except possibly for general subsidies and tax benefits available to all such private entities). Such activity may stil make use of government facilities such as launch pads. For example, the private company SES ordered a communications satellite from the private company Orbital Sciences and launched it on a rocket built and operated by the private company SpaceX; government involvement was limited to regulation and use of launch facilities. The special case of Russian commercial launch providers which are not entirely separate from the government is confusing, but I choose to count Kosmotras and ILS as fully commercial. A similar problem exists with ISRO, which is a government space agency which provides occasional commercial launch services through its subsidiary Antrix Corp. Sometimes there is a main Indian government payload with Antrix-managed small secondary payloads, so Antrix is not really a launch service provider as such but acts more like the UTIAS nanosat launch brokers

- A: Amateur, academic and non-profit: Activities in which the private entity is not seeking to make money off the services or data obtained, such as university research satellites; it's not sensible to lump these in with commercial satellites.

Challenge 3: What counts as reaching orbit?

In 2013, China's Kunpeng-7 launch reached orbital energy, but at the wrong angle for reaching orbit. It made a suborbital flight to an apogee that may have been of order 30000 km. It is not included in the table below. There have in the past been launch failures whose orbits had a positive perigee but low enough that they reentered on the first orbit; there were no such cases in 2014 but the ESA IXV in early 2015 deliberately flew such a trajectory.

A number of spacecraft included in this year's tabulations were in bound Earth orbit only briefly while still attached to their launch vehicle, and are now in interplanetary space. These are not strictly speaking 'Earth satellites', but I am including them nevertheless.

Challenge 4: What counts as a separate satellite?

When two satellites with different owners are placed in orbit at once and fail to physically separate from one another, do they count as one or two satellites? Tradition varies on this question.

What if you launch a satellite aboard a cargo ship to the ISS? If the satellite is later deployed (e.g. through the Kibo airlock) and orbits separately, it definitely counts. But that may not happen in the same year that it's launched; for example Flock 1b-11 was launched in 2014 Jul but deployed in 2015 Mar. Does it count as a 2014 or a 2015 satellite? Its sibling Flock 1b-13 was also launched in 2014 Jul, but after months aboard the ISS was returned to Earth in 2015 Feb without ever haven flown free as a satellite. Flock 1e-10, launched in 2015 Apr, is aboard the ISS at the time of writing. Will it be deployed, or eventually returned to Earth? I can't tell right now, so I can't yet know how many satellites were launched in 2015 Apr - that number will retrospectively change.

As for the ISS itself, some of its modules (e.g. Unity, Zarya, Destiny, Zvezda, Poisk) have their own catalog numbers in the US satellite catalog, while others (Harmony, Tranquility, Pirs, Rassvet) do not, for apparently arbitrary reasons. Is the ISS one satellite, or many docked together, and if the latter, how many?

One reasonable approach is to count satellite deployments rather than satellites launched, counting them towards their year of deployment. This works for counting numbers of satellites, but complicates tracking the mass of satellites launched. For the time being, I'm going to stick with

counting satellites launched, and accept that next year's report may require me to adjust the 2014 figures.

Orbital Launch Attempts

During 2014 there were 92 orbital launch attempts.

	2009-2013 Average	2014
USA	19.0	24
Russia	30.2	32
China	14.8	16
France	*11*	
Japan	*4*	
India	*4*	
Israel	*1*	
N Korea	*0*	
S Korea	*0*	
Other	15.0	20
Total	79.0	92

Notable was the first flight of Russia's heavy-lift Angara A5, and a suborbital test flight (not tabulated above) of the core stages of India's GSLV Mk III. The Antares 120 failure led to a redesign of the Antares vehicle with a new Russian main engine; it is expected to fly in 2016. Also notable was the continued failure of the new generation Chinese launch vehicles to make an appearance.

Launch failures

There were three orbital launch failures during the year, tabulated below. To evaluate average launch vehicle reliability I allocate each launch a score between 0.0 (total failure) and 1.0 (success). Failures which nevertheless reach orbit get an intermediate score.

2014 Orbital Launch Failures

Designation	Date	LV State	LV	Payload	Type of failure	Launch Score
2014-F01	May 15	Russia	Proton-M/Briz-M	Ekspress AM-4R	Stage 3 underburn, impact China	0.00
2014-F02	Oct 28	USA	Antares 130	Cygnus Orb-3	Destroyed during launch	0.00
2014-050	Aug 22	Europe	Soyuz ST-B	GalileoSat 5/6	Deployed in incorrect orbit	0.40

Commercial Launches

Of the 92 orbital launch attempts, 47 were carried out by governments; 25.5 by commercial companies under contract to their host governments, and 19.5 for commercial customers, including foreign governments.

Launch provider	Launches	Type	Customers
US Launch providers			
ULA/Boeing Delta 4	4	CSP	US Gov
ULA/Boeing Delta 2	1	CSP	US Gov
ULA/LM Atlas 5	9	CSP	8 US Gov, 1 Comm
OSC Antares	3	CSP	US Gov
SpaceX Falcon 9	6	FCS	4 Comm, 2 US Gov
Sea Launch	1	FC	1 Comm
European Launch providers			
Arianespace Vega	1	FC?	1 foreign gov
Arianespace Ariane 5	6	FC	1.5 Eur gov, 4.5 comm/for.
Arianespace Soyuz	4	FC	2 Eur gov, 2 Comm
Russian Launch providers			
Kosmotras Dnepr	2	FC	2 Comm
ILS Proton	3	FC	3 Comm
Khrunichev Proton	5	GOV	3 Ru.gov, 2 semi-comm
Khrunichev Rokot	2	GOV	2 Ru.gov
Khrunichev Angara	1	GOV	1 Ru.gov
Roskosmos Soyuz	12	GOV	11 Ru.gov (civil), 1 joint project
VVKO Soyuz	6	GOV	6 Ru.gov (military)
NPOMash Strela	1	GOV	1 Ru.gov (joint w. S Africa)
Chinese Launch providers			
CASIC Kuaizhou	1	GOV	Chinese gov
CALT CZ-2C	4	GOV	Chinese gov
CALT CZ-3A/3C	2	GOV	Chinese gov
SBA CZ-2D/4B/4C	9	GOV	Chinese gov (+1 joint project)
Other Launch providers			
MHI H-IIA	4	CSP	Japan gov
ISA Shaviyt	1	GOV	Israeli gov
ISRO/Antrix PSLV/GSLV	4	GOV+FC	3 In.gov, 1 Comm

Satellite Launch Statistics

2013 and 2014 saw a dramatic increase in the numbers of satellites deployed, thanks to the launch of several clusters of cubesats. The 255 satellites include 123 with masses above 100 kg.

Failures to reach orbit are not included here.

Payloads launched			
	2012	2013	2014
USA	35	85	110
Russia	22	29	34
China	25	17	26
Other	50	75	85
Total	132	206	255

Let us break this down by class for 2014 (first the launch powers, then other countries). In 2014 the satellites launched were owned by 32 countries plus ESA.

2014 payloads launched, by owner country and class					
	A Academic/NonProfit	B Business/Commercial	C Civil	D Defense	Total
USA	5	83	7	15	110
Russia	0	6	16	12	34
China	2	3	6	15	26
Japan	16	3	5	0	24
India	0	0	4	0	4
ESA/EU	0	0	4	0	4
AR Argentina	0	2	0	0	2
AU Australia	0	1	0	0	1
AZ Azerbijan	0	1	0	0	1
B Belgium	2	1	0	0	3
BR Brazil	0	1	0	0	1
CA Canada	4	0	0	0	4
D Germany	0	0	1	0	1
DK Denmark	1	0	0	0	1
E Spain	0	2	0	0	2
EG Egypt	0	0	1	0	1
F France (+EUTELSAT)	0	1	0	1	2
I Italy	2	0	0	0	2
IL Israel	1	0	0	1	2
KZ Kazakhstan	0	0	3	0	3
L Luxembourg	0	2	0	0	2
LT Lithuania	2	0	0	0	2
MY Malaysia	0	1	0	0	1
N Norway	0	0	1	0	1
PE Peru	2	0	0	0	2
PL Poland	0	0	1	0	1
SA Saudi Ar.	0	0	1	0	1
SG Singapore	1	1	0	0	2
T Thailand	0	1	0	0	1
TR Turkey	0	0	1	0	1
UK	0	9	1	0	10
UA Ukraine	0	1	0	0	1
UY Uruguay	0	0	1	0	1
ZA South Africa	0	0	0	1	1
Total	38	119	53	45	255

However, most countries built only very small (cubesat) satellites or purchased their satellites from one of the main space powers. Here I tabulate the manufacturers of 2014 satellites with masses of 100 kg or more. HSF is 'Human spaceflight', including related robotic missions such as cargo ships to support ISS. 'Surv.' is surveillance, including early warning and space debris surveillance; visible and radar imaging recon satellites and weather sats are under 'Imaging'. Microgravity research and planetary probes are included under Sci (Science). Satellites built in the UK, France, Germany, Italy, Spain and the Netherlands are lumped together as 'Europe' to reflect the integration of the western European aerospace industry.

2014 payloads by manufacturer country - 100 kg and up only									
	HSF	Comms	Imaging	Nav	SIGINT	Surv.	Sci	Tech	Total
USA	5	16	2	4	3	2	2	0	34
Russia	8	14	5	3	1	0	2	1	34
Europe	1	13	5	2	0	0	0	1	22
China	0	1	9	0	6	3	2	0	21
Japan	0	1	3	0	0	0	1	0	5
India	0	2	0	2	0	0	0	0	4
Israel	0	0	1	0	0	0	0	0	1
Saudi Ar.	0	0	0	0	0	0	0	1	1
Argentina	0	1	0	0	0	0	0	0	1

Scientific Space Programs

Two major scientific satellites were launched in 2014: the Global Precipitation Mission GPM-Core spacecraft, a joint US/Japanese climate research project to study rain and snow, and Russia's Foton-M No. 4 recoverable life sciences mission, which suffered failures in the onboard systems. NASA's OCO-2, the Orbiting Carbon Observatory, reached orbit for another climate research mission to measure atmospheric carbon dioxide (OCO-1 failed to reach orbit in 2009.) Two more small astronomy satellites in the BRITE constellation, BRITE-Toronto and Poland's Heweliusz, began their astroseismological observations, but their sibling BRITE-Montreal failed to separate from its launch vehicle. Japan's Tsubame small satellite will test an X-ray Compton polarimeter for and measure gamma ray bursts.

Military Space Activities

Military satellites include navigation, communications, and technology development missions in addition to the intelligence gathering activities that I report here.

Editorial comment: GSSAP and transparency

In my opinion, the most significant development in 2014 was the first operational deployment of spacecraft intended to make close approaches to the spacecraft of other nations without their approval. The two GSSAP satellites launched to near-geosynchronous orbit by the USA are intended to perform space surveillance, at least partly to monitor sources of space debris.

From a USAF statement:

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... will have the capability to perform Rendezvous and Proximity
Operations (RPO). RPO allows for the space vehicle to maneuver near a
resident space object of interest, enabling characterization for anomaly
resolution and enhanced surveillance...
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However, the fact that the USA is refusing to release orbital elements for the satellites, so that other satellite operators won't know when their own vehicles are being approached, is likely to be seen as provocative and indeed destabilizing.

When other countries have carried out proximity operations with their own satellites, US sources have often characterized such behaviour as ASAT (antisatellite weapon) related, and secretive close approaches to US spacecraft by a non-US satellite would certainly trigger adverse comment in US defense circles. It is to be hoped that the DoD will decide to declassify the GSSAP orbital data in the interests of transparency.

Reconnaissance

US and European intelligence organizations continue to supplement military spy satellites with data from commercial imaging satellites, while Russia and China probably rely mostly on their dedicated intelligence systems.

The NRO imaging constellation consists of four CRYSTAL (KH-11 derivative) type imaging satellites and five radar satellites - two of the older LACROSSE/ONYX type and three of the new type rumoured to be called TOPAZ, whic fly in 1100 km retrograde orbits. In addition, the small US Air Force ORS-1 imaging satellite continues to provide tactical imaging.

Russia's reconnaissance satellite system is depleted; two Kondor radar satellites are in orbit, one of which is thought to have been sold to South Africa. One Kobal't-M recoverable spy satellite flew from May to Sep 2014.

In contrast, China's imaging satellite constellation is strong. Four optical and one radar imaging satellites in the Yaogan series were launched during 2014 to join up to six optical and five radar Yaogans and one ZY-3 satellite already operating. Two low orbit Kuiazhou satellites were launched in 2013 and 2014 by the new rapid-response Kuaizhou launch vehicle; they make regular orbit maintenance manuevers.

Signals Intelligence

Signials intelligence satellites are the least known and probably most numerous type of spy satellite. The NRO's US Navy component operates low orbit satellites (analysts refer to these using their old name of NOSS, for Naval Ocean Surveillance System). The NOSS satellites operate in pairs

(previous generations used triplets) to locate radio signals from ships by the difference in their arrival time at the different satellites. As many as 16 NOSS satellites may currently be in operation, although some of these are probably retired or in reserve.

Six satellites in Molniya orbits (12 hour period, 63 deg inclination) host signals intelligence, communications and infrared early warning payloads. Three of these, launched in 1994-1997, may be retired or in reserve; a replenishment constellation launched in 2006-2014 is thought to be fully operational.

A variety of NRO signals intelligence platforms are in geostationary orbit, with large dish antennae possibly in the 30 metre class. Five satellites were launched in the 2003-2014 period; six older satellites are thought to be still possibly operational, including one launched in 1989 which was reported to be active at the end of 2012.

Russia has one older generation Tselina-2 signals intelligence satellite and two newer Lotos satellites, all in low orbit. In addition, the Luch/Olimp geostationary tracking and communications satellite launched in 2014 is rumoured to host a signals intelligence payload.

China appears to have two dedicated LEO signals intelligence programs, both involving multiple satellites. The Shi Jian 6 system operates in pairs; its last launch was in 2010. The Yaogan triplet series (Yaogan 9, 16, 17, 20 and 25) appears to be a direct analog of the older triplet US Navy NOSS system and operates in the same 1100 km, 63 degree orbit.

Space Surveillance and Early Warning

The US Air Force legacy geostationary missile early warning system, DSP, has 7 satellites, the last orbited in 2007. The successor system, SBIRS, has two dedicated geostationary satellites in orbit as well as three payloads hosted on elliptical orbit satellites. The two GSSAP satellites mentioned above were launched in 2014 Jul along with an experimental satellite, ANGELS, which is also conducting proximity surveillance experiments at GEO altitudes, mainly in conjunction with ts upper stage rocket.

In low orbit, three USAF STSS (Space Surveillance and Tracking System) satellites carry out experiments to track ballistic missiles. while one SBSS (Space Based Surveillance System) is performing tracking of satellites and debris,

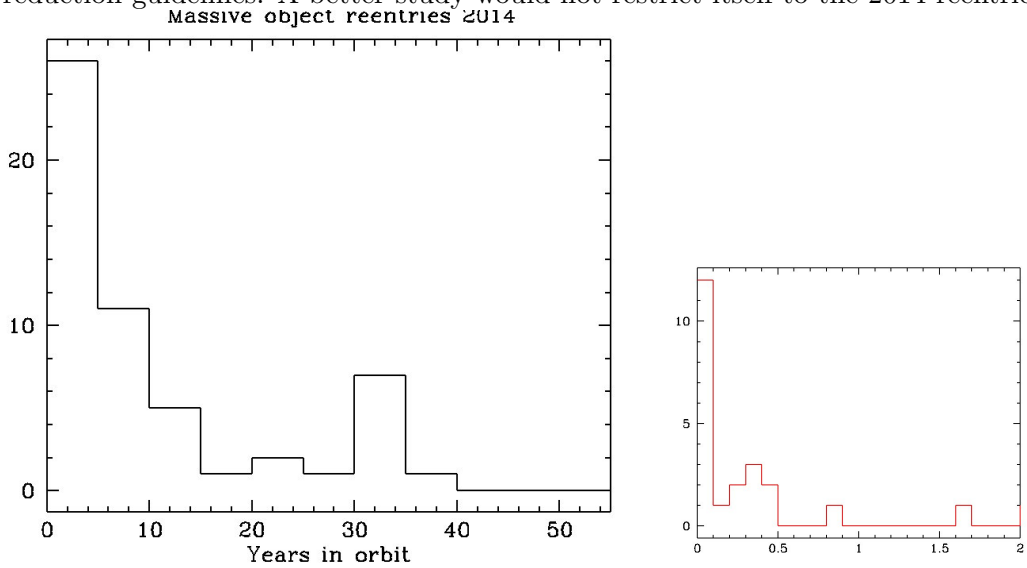
Six Chinese SJ-11 satellites in LEO are possible early warning or surveillance satellites. The last three satellites in the series were launched in 2014.

Orbital Debris and Orbital Decay

At the end of 2014 there were 17106 cataloged objects in orbit. This is down slightly from 2013 because high solar activity caused accelerated orbital decay and the reentry of 570 objects, compensating for the addition of new objects. The total known mass in orbit increased slightly to around 8200 tonnes.

Debris in orbit 2013-2014 [Corrected 2015 Jul 6]						
	Debris 2013		Debris 2014		Reentries 2014	
	Number	Mass (t)	Number	Mass (t)	Number	Mass(t)
Active Payloads	1200	1527	1324	1567	56	0.3
Dead Payloads	2613	3508	2637	3530	15	19.8
Rocket bodies	1893	3079	1922	3102	47	89.7
Operational debris	1658	-	1690	-	70	3.0?
PRC ASAT/FY-1C debris	3026	-	2932	-	94	-
Strela/Iridium debris	1764	-	1610	-	155	-
Other fragment debris	5034	-	4990	-	132	-
Spurious catalog entry	1	-	1	-		
Total cataloged	17189	8114	17106	8199	570	

54 of the reentering objects had mass more than 500 kg. The figure shows the distribution of years spent in orbit for these objects. The inset shows on a finer scale the objects which reentered in less than two years; most of these reentered during the first month, including many launch vehicle rocket bodies left in very low orbit. It is not clear whether the second peak at around 30 years is significant; the drop in long lived objects at shorter lifetimes might concievably reflect the adoption of debris reduction guidelines. A better study would not restrict itself to the 2014 reentries.



Controlled deorbits and landings

In addition to natural reentries, there were 10 controlled landings and 9 controlled deorbitings of spacecraft during 2014, representing the safe removal of around 83 tonnes from the orbital environment. 4 Russian Soyuz ships landed in Kazakhstan and Foton-M landed in Russia; the X-37B landed at Vandenberg Air Force Base in California, and two Dragon and one Orion spacecraft splashed down in the Pacific near California. The Kosmos-2495 spy satellite is believed to have landed in Russia on Sep 3; however, associated debris was observed burning up over Colorado.

The USA 129 spy satellite was deorbited on May 1 after 17 years in space, probably over the Pacific Ocean. The Delta stage from the Orion test flight was deorbited over the Pacific at an unspecified location. Two Cygnus and five Progress cargo ships were deorbited over the South Pacific east of New Zealand.

Retirements in the GEO belt

During 2014, 15 satellites were retired to the graveyard above the GEO belt, including the dummy Angara payload. 4 upper stage rockets were also moved there after delivering their payloads, and one was lowered out of the region.

Three GEO satellites failed without being moved to a safe orbt. The Yamal-201 satellite, launched in 2003, failed in June 2014 and has drifted off station. Insat 3E seems to have been retired in Apr 2014 and moved to a slightly lower orbit, following an earlier failure in 2011. The Oko-1 No. 7128 early warning satellite, codenamed Kosmos-2479, also failed in Apr 2014.

Acknowledgements

The data presented here are extracted from my satellite and launch database, generated from open source media reports combined with analysis of US Space-Track orbital elements. The analysis has benefited from the opinions of many colleagues. I acknowledge in particular conversations with Dwayne Day, Brian Weeden, Jeffrey Lewis, Gregory Kulacki, Alanna Krolikowski, Laura Grego, David Wright, Igor Lissov, Phillip Clark, Wang Ting, Rui Barbosa and posters on the forums at nasaspaceflight.com.

The author is an employee of the Smithsonian Institution, but the work reported here was performed independently and does not represent the views of the Smithsonian.