"Small Satellite Technology and Space Capability"

Christopher Johnson, *Secure World Foundation*

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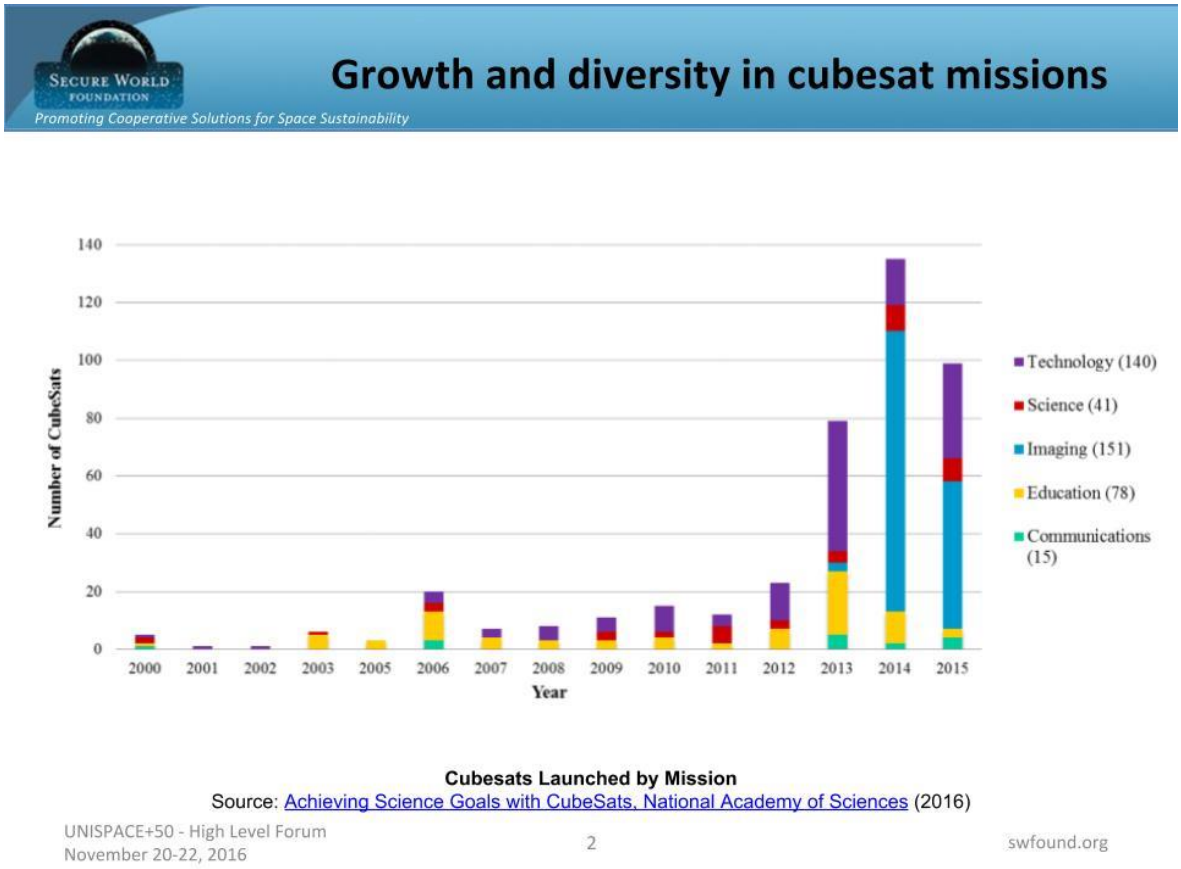
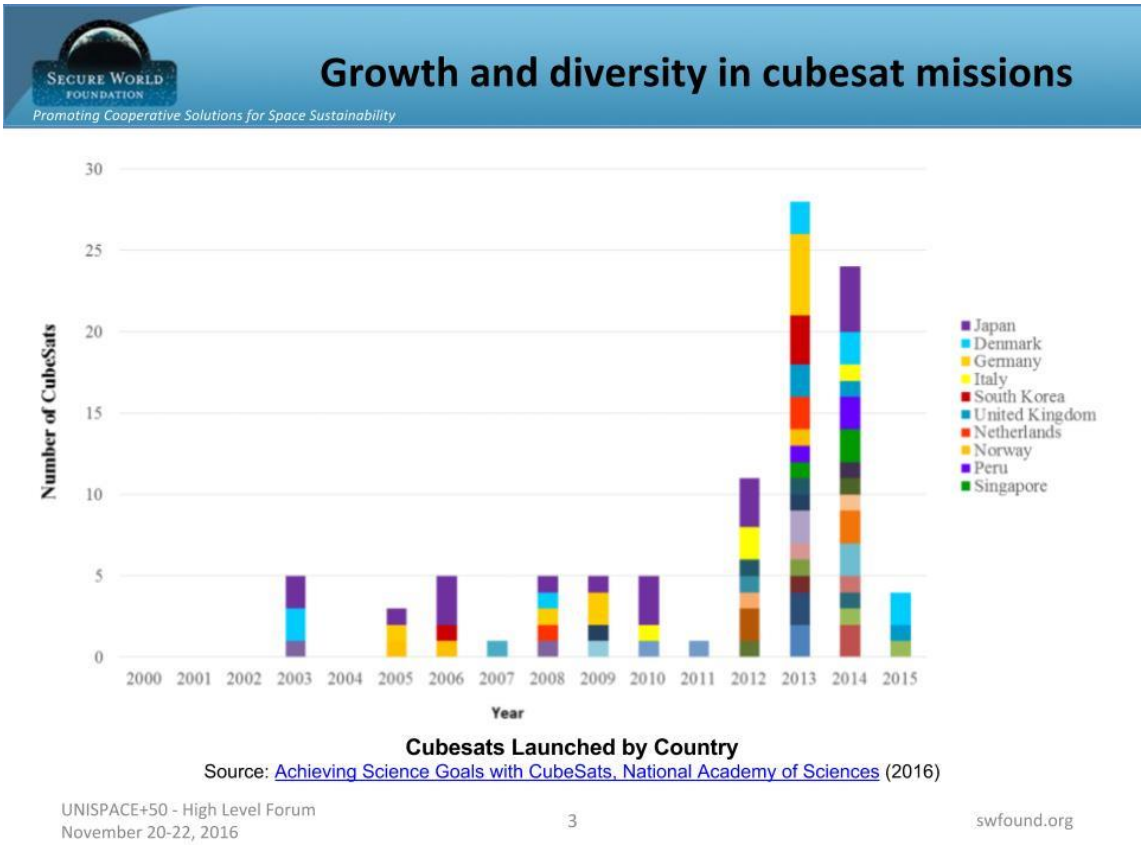
Humanity has been launching satellites into orbit and conducting space activities for a wide variety of reasons over the last sixty years. Over that same time period, many aspects of our daily lives have been altered, often for the better, as a result of the benefits space capabilities provide on Earth. Yet for much of this period, there were still limits - while many could benefit indirectly from space activities, direct participation was largely limited to large governments or organizations that had access to the sophisticated technology and could afford the significant costs.

Today, the space world is currently experiencing rapid growth in new entrants and innovation. Much of this growth is being driven by the emergence of small satellites as a capable platform for space activities. Small satellites in turn are enabled by a potent combination of Moore's Law, spin-in technologies from the computer and information technology sector, and cloud computing. This combination has driven down the barriers to entry for the space world. It is now cheaper and easier than ever before to design, build, launch, and operate a satellite, or to purchase satellite applications and new excitement in the space world. As the barriers to entry fall, more countries, international such as remote sensing imagery.

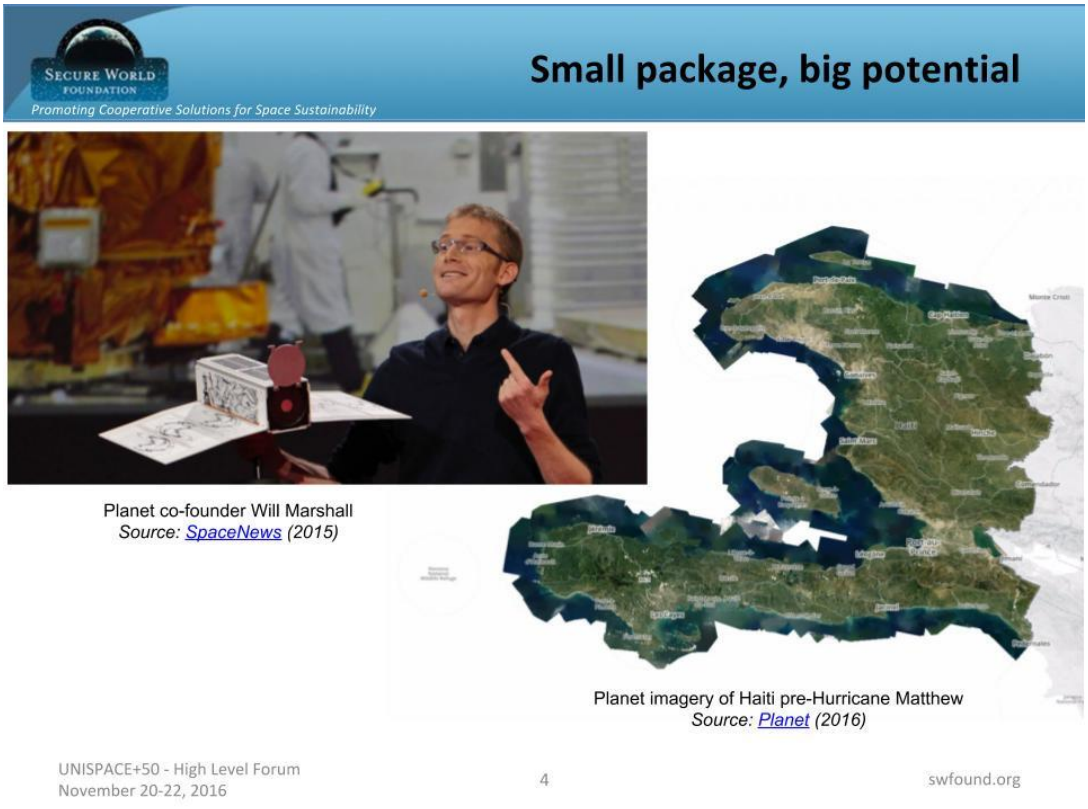
The positive effects of this trend are an infusion of fresh ideas, new approaches, increased innovation, organizations, companies, universities, and even individuals are able to directly participate in space activities. Each are able to bring their own desire to solve a particular problem, and their own ideas on how to do so, and this drives innovation. Increased competition and innovation are creating more services and more data products than ever before, and widening global accessibility.



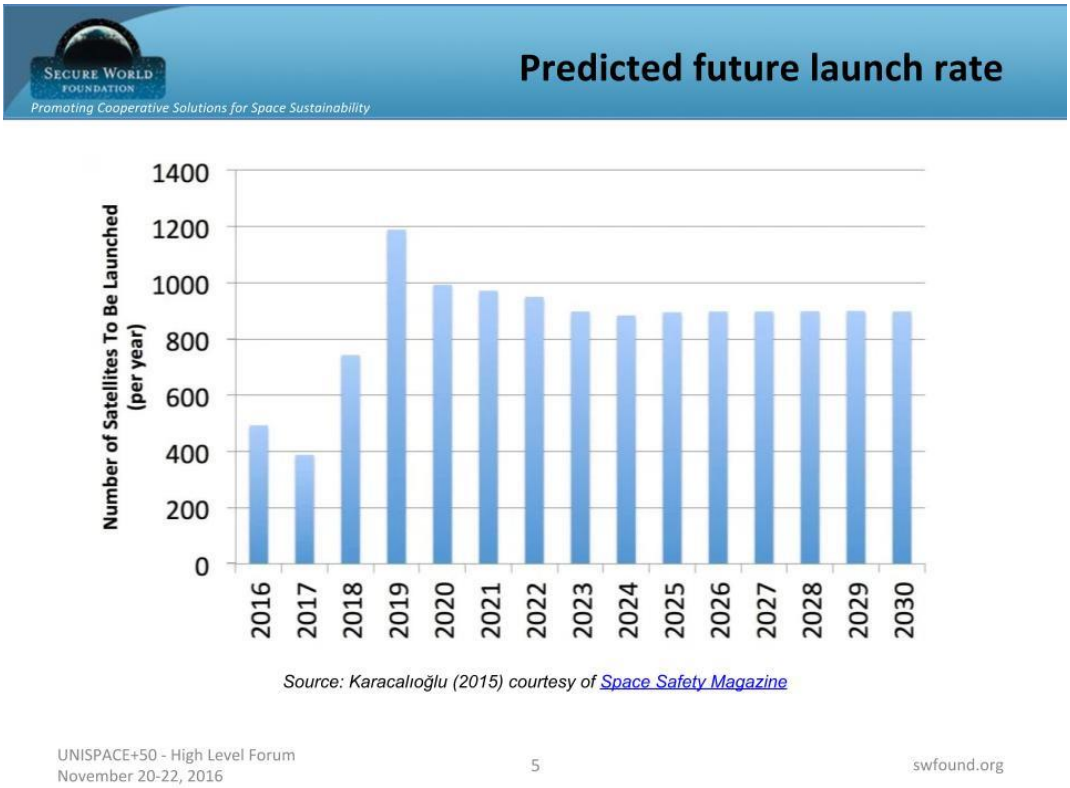
Slide 2 provides some data on these trends. This chart shows the total number of cubesats launched into Earth orbit, broken down by application, including technology, science, imaging, education, and communications. Cubesats are contributing to a diverse range of missions, including technology development, science, education, and remote sensing applications.



This next chart shows the number of cubesats launched by countries other than the United States. Here, too, there is a growing diversity and number of countries that are able to directly engage in space activities as a result of small satellite technology.

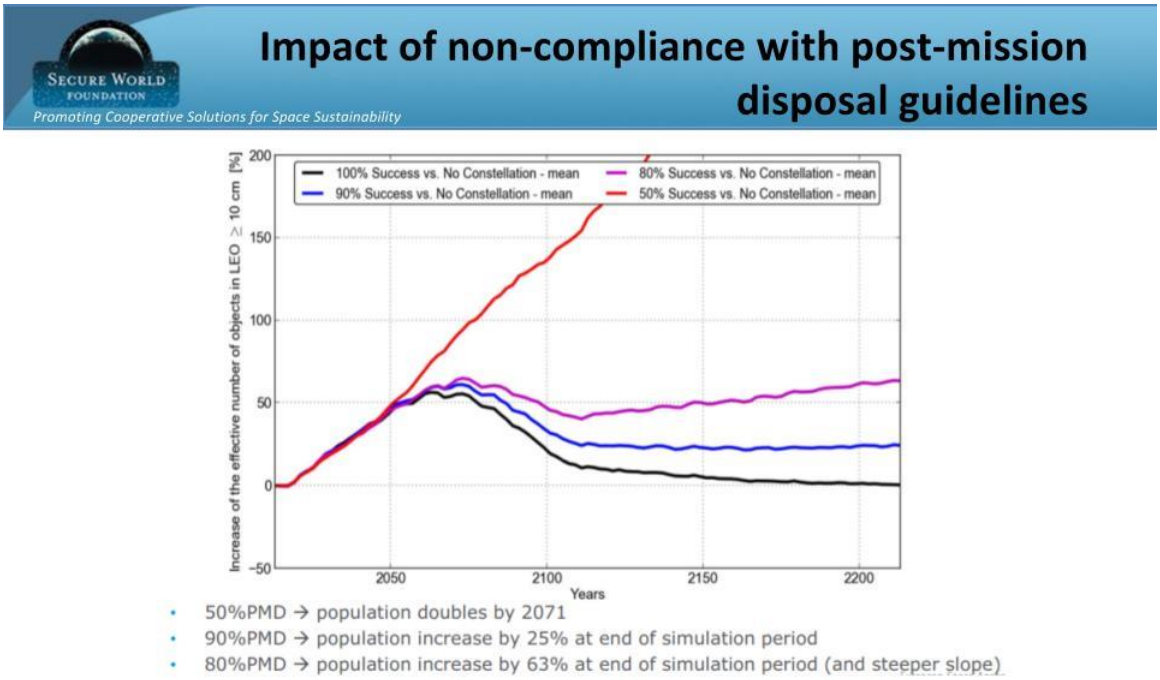


Small satellites and cubesats are also demonstrating the ability to help address real-world challenges. The dozens of cubesats launched by Planet, a small satellite company founded in the US, is a great example of this. On the top left of Slide 4, we see Planet's co-founder Will Marshall holding one of their Dove cubesats. The bottom right shows imagery that Planet's current constellation of satellites took of Haiti, less than a month before the island was devastated by Hurricane Matthew. The imagery was provided to aid agencies to help plan a humanitarian response.



But while smallsat and cubesat technology brings with it great potential benefits, it also brings potential challenges to the long-term sustainability of space that must also be dealt with. Between 3,800 and 9,000 new satellites are projected to be launched over the next decade. A recent study attempted to catalog all the proposed new satellites, and predicted that the annual rates of new satellites being launched will jump from a historical average of 100 to 150 per year, to more than 900 per year, as shown in Slide 5. Even if the lower end of that range of future satellites came true, it would almost triple the current population of roughly 1,500 active satellites. Many of the projected new satellites are small satellites that will be launched into large constellations of hundreds or thousands of satellites.

The growth in small satellites creates challenges for space sustainability. The first challenge is in greatly increasing the number of close approaches between space objects. A recent European Space Agency (ESA) study estimated that just one large constellation of small satellites could increase the number of predicted close approaches (also known as conjunctions) by a factor of 70 compared to today. Another study estimated that the new population of Cubesats alone will generate millions of conjunction warnings each year. This does not necessarily mean that there will be more actual collisions on orbit as a result, but it will make it much harder to detect the potential collisions from the mere close approaches. The end result will be increased operational costs for satellite operators from managing the warnings, and potentially increased risk of a catastrophic event.



Relative increase in LEO population as as result of PMD success rate for large constellations
Source: Bastida Virgili, Dolado, Lewis, Radtke, Krag, Revelin, Cazaux, Colombo, Crowther, and Metz (2016)

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The second space sustainability challenge is with the potential growth in the population of space debris from improper end-of-life disposal of large constellations of small satellites. The existing international space debris mitigation guidelines recommend taking steps to ensure that space objects do not remain on orbit longer than 25 years. In many cases, this is accomplished by changing the satellite's orbital trajectory at the end of its useful life so that it will naturally decay within 25 years. Slide 6 shows the result of a 2016 ESA study, which indicated that if the large constellations have a compliance rate of less than 95% with the 25-year guideline, there is likely to be significant growth in the space debris population. Given that the current rate of compliance is between forty to sixty percent, a dramatic improvement is needed to avoid increasing the rates of future on-orbit collisions.

There are other challenges that result from the rapid growth in space activities. Along with the physical congestion mentioned above, there is also increased competition for the radio frequency portion of the electromagnetic spectrum among satellite services, and also between space and terrestrial services. New actors entering the space domain will also need to become familiarized with existing principles and norms of responsible space activities. States will need to put in place the national legal, policy, and regulatory framework to provide oversight of governmental and non-governmental space activities, and some existing governance frameworks may need to be modernized to handle the innovative new activities.

These challenges are not insurmountable, and there are efforts underway that are beginning to address them. We at The Secure World Foundation (SWF) are doing our own small part. We organized events in 2016 to help increase the dialogue between the small satellite and space situational awareness (SSA) communities, including discussions of best practices for small satellite operators, and identifying steps that both small satellite operators and SSA providers can take to improve detection, tracking, identification, and conjunction assessment for small satellites. We also are in the final stages of developing our *Handbook for New Actors in Space*, the outline of which is shown here. The SWF *Handbook for New Actors* is meant to be a provide both new governmental and non-governmental space actors with a broad overview of the fundamental principles, laws, norms, and best operational practices for peaceful, safe, and responsible activities in space.

There are also multilateral efforts underway that are proving effective as well. The work by UNCOPUOS on developing guidelines for the long-term sustainability of space activities is proving to be an effective tool for increasing awareness of the issue, and building consensus on positive steps that can be taken to address the challenges. The end goal of all of these efforts should be to maximize the positive benefits, and minimize the potential negative consequences, of the rapid growth and innovation in space activities. This will help ensure the long-term sustainable use of space so that humanity can continue to derive the many benefits space activities have to offer for the foreseeable future.

Thank you. Questions?

cjohnson@swfound.org

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Thank you for your time.