**Earth Orbiting Satellites**

By Daniel Brenners, December 2014.

**Overview**. Twenty two thousand miles above our heads, a global race for orbital real estate is underway. A single circular orbit around the Earth, called the geostationary Earth orbit (GEO), is the only area in space that allows a satellite to remain in a fixed point in the sky above Earth's surface while it rotates.1 This prime location allows satellites to have consistent communication with the ground below. Satellite television, a $100 billion industry worldwide, relies on satellites within the GEO to broadcast signals to homes across the world. Global positioning systems (GPS) and military applications also depend on satellites within this thin ring around the Earth. Unfortunately, space is severely limited in the GEO, and tension is growing over who gets to send their satellites to this valuable parking lot in the sky. The principles used to organize which satellites get to be placed in the GEO have many unforeseen legal and sociopolitical complications. As room becomes limited, it is, and will be, increasingly important to find a solution to the problem of multiple organizing agents competing to organize this system to support varying interactions.

**What is being organized?** The scope of resources being organized are the satellites deployed to the GEO. These are physical objects that have been launched into orbit. The satellites are each unique and are able to provide a variety of interactions. The only unifying attribute that they share is that they are computers that are able to send and receive radio signals to and from Earth. To stay in orbit, they must be able to adjust their position with propulsion systems. This organizing system is designed to manage a collection in which resources are continually added and removed. The International Telecommunications Union (ITU) records which portions of the orbit are already occupied.2 Satellites cannot stay in the orbit forever, as they expend lots of energy performing computational processes and maintaining orbit, and eventually run out of power. The resources follow a lifecycle that is unique to each individual resource, but the timescale is typically one to fifteen years.3

**Why is it being organized?** Satellites are being organized in the GEO to support several interactions. The GEO allows satellites to move at the same rate as the Earth, giving them a stationary view of more than 40 percent of the Earth's surface. This view is ideal for broadcasting signals to large regions and performing remote sensing, such as weather forecasting. These satellites also serve as crucial relay points to transfer telecommunications across the globe. Other interactions that these satellites provide include surveillance, scientific research, global positioning, navigation, and military reconnaissance.3 Longitudinal positioning along the GEO shapes which interactions can occur and which users can interact with the satellite. For instance, a satellite directly over the Atlantic Ocean may not be well suited to broadcast a television signal, but may be positioned to relay signals from North America to Europe.

The users are practically everyone on Earth. Civilians use geostationary satellites directly when they use GPS or need to have a call relayed to distant regions of the world. Commercial organizations, such as television providers, use these satellites to broadcast signals down to viewers. Geostationary satellites are also particularly useful for early warning systems used by the military to detect ballistic events around the globe.

**How much is it being organized?** If resources are able to be placed in the GEO, they are placed in a vacant slot that the applicant chooses, based on what types of interactions they want to support and what users they want interacting with the satellite. To prevent signal interference and collision, satellites need to be placed very far apart, leaving only 2,000 total orbital slots where satellites can be placed in the GEO.4 The ITU uses a first-come, first-served organizing principle to decide which resources are placed into orbital slots, provided the applicant completes the lengthy application process.

The organization applying for the slot chooses where to place its satellite. The ITU catalogs these slots as degrees longitude, and includes other resource descriptions such as the name of the satellite, country of operator, types of users, mass, expected lifetime, and contractor.3 Organizations choose to place satellites around the longitude of the Earth that the satellite is supposed to interact with. Since the latitude is fixed at zero degrees, countries with the same longitude but different latitudes (countries directly north or south of each other) must vie for the same slots.

**When is it being organized?** Satellites are added as soon as they can be approved by the ITU and launched into orbit. At the end of their life cycle, the Federal Communications Commission mandates that U.S. satellites are pushed into what is called the graveyard orbit, which is a few hundred kilometers outside of the GEO.5 At this point, another satellite can be added to the vacant slot via the ITU application process.

**How or by whom is it being organized?** Many organizing agents are competing with each other to organize this system according to their own needs. Applications to occupy the GEO come from countries, scientific organizations, companies, and civilians. Satellite TV companies such as DirecTV, Dish Network, and Intelsat own a large number of the slots across the western hemisphere. Countries such as the United States, Russia, and the United Kingdom own a majority of the military satellites, and multinational European organizations own a large share of orbital slots as well.3

**Other considerations.** Although the ITU serves as an authoritative entity for this organizing system, the reality is that the ambiguous legality of ownership in outer space means that anyone can attempt to organize this system. The ITU is in place to perform the useful task of cataloging occupied slots and facilitating the filling of vacancies, but it has no way of enforcing these guidelines.

This organizing system is interesting because many agents are attempting to organize the same system. There are also interesting social implications that stem from the system’s principles of organization. The first-come, first-served system of the ITU has the effect of allowing only technologically-advanced organizations to manage the collection. It does not take into consideration that, by the time many countries are finally ready to use this type of technology, there will be no more room in the GEO belt.

Ironically, the only legal claim to sovereignty that has been made of this organizing system has been from countries that, generally speaking, have no means of organizing it themselves. In 1976 eight equatorial countries, which lie directly below the GEO belt, stated that they had exclusive rights over these slots in a document known as the Bogotá Declaration.6 The tenuous claim was that the orbit is not a part of outer space, because its existence is solely dependent on Earth's gravity, and that the earth within the borders of the equatorial countries creates GEO with its gravitational pull. Many experts disagree, stating that the gravitational pull from the moon and other celestial bodies defines the GEO, and state that the orbit does indeed lie in outer space because it is further than 100 kilometers from Earth. This demarcation, known as the Kármán line, is a widely accepted definition of when space begins.7 This would then make the GEO fall within the 1967 Outer Space Treaty, effectively leaving no possibility for ownership of the orbit.

Finding a dividing line between space and Earth’s atmosphere is an interesting topic, especially considering that ownership of valuable resources may be decided based on what is included in the category of space versus the category of atmosphere. In this case, the Kármán line roughly represents the altitude at which an aircraft would have to propel itself faster than the speed at which the Earth rotates to establish enough lift to keep itself up. While this is not intuitive (hardly carving nature at its joints), it does serve as a useful demarcation that is not completely arbitrary. It can be seen as a goal-based category, where the goal is using traditional means of traveling through the air with aeronautics. It makes sense that this is the line the Fédération Aéronautique Internationale uses to divide astronautics and aeronautics.

The limited availability of spots in the GEO, along with the relatively small number of countries able to launch satellites, has the potential to further divide countries. By the time most countries will be able to launch satellites, there will likely not be any room left. Although there are only around 400 satellites currently in geostationary orbit, there are already more filings for ITU applications than there are spots available.4 Only a select few countries will be able to take advantage of the GEO, leaving others to depend on these countries for communication, scientific research, and surveillance. Furthermore, this could limit the interactions of less developed countries to those interactions dictated by the countries with geostationary satellites. In particular, developed countries can greatly influence the information that citizens in other countries can receive via satellite.

But even within the technologically-advanced countries, competition for orbital slots may be heating up. In early 2014, the U.S. unveiled its Geosynchronous Space Situational Awareness Program (GSSAP), which aims to create maneuverable satellites that monitor and protect the precious GEO belt.8 This reveal came only months after China was seen practicing its anti-satellite missile capabilities. 9 In Russia, $300 million is being spent to construct a craft that would act as a “space broom” to push satellites out of geostationary orbit. The U.S. has a similar program under DARPA, named the Phoenix project ,. The aim of this project is to develop a robotic device that can help maintain satellites and possibly dismantle others without causing excess space debris.

Although this might simply be countries attempting to flex their military muscles, these technologies represent a newfound ability for countries to organize resources in the GEO to fit their own agenda. Years ago, the countries that were able to get satellites into orbit were the ones that could reap the benefits. Now, it seems that we may be entering an age where a country’s ability to make room for itself, possibly by force, will determine if it can make use of precious interactions created by these limited resources.

**Notes**: The following notes relate to this case study.

1. NASA Jet Propulsion Laboratory Basics of Space Flight Section 1 Chapter 5: Planetary Orbits http://www2.jpl.nasa.gov/basics/bsf5-1.php

2. ITU Space Services Department (SSD) 2014 http://www.itu.int/ITU-R/go/ space/en

3. Union of Concerned Scientists Satellite Database http://www.ucsusa.org/ nuclear\_weapons\_and\_global\_security/solutions/space-weapons/ucs-satellitedatabase. html#.VJKNXmTF-5I

4. Posen M., Have We Got a Slot? RPC Telecommunications Ltd. World Space Forum Dubai March 2010 http://www.rpctelecom.com/files/Have We Got A Slot.pdf

5. De Selding P., FCC Enters Orbital Debris Debate. Space News, 28 Jun. 2004

6. Finch M., Limited Space: Allocating the Geostationary Orbit. Northwestern Journal of International Law Vol 7 Issue 4 Fall 1986

7. Haraszti G., Questions of International Law Volume 2. Akademiai Kiado Budapest 1981

8. Hsu J., Global Conflict Could Threaten Geostationary Satellites: China, Russia and the U.S. have the ability to destroy one another’s eyes in the sky. Scientific American March 31, 2014 http://www.scientificamerican.com/article/global-conflict-could-threaten-geostationary-satellites/

9. Shalal-Esa A. U.S. sees China launch as test of anti-satellite muscle. Reuters May 2013 http://www.reuters.com/article/2013/05/15/us-china-launchidUSBRE94E07D20130515