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ITU Presentation In Bali
“AVOIDING THE ZOMBIE SATELLITE APOCALYPSE”

8 Sep 2016

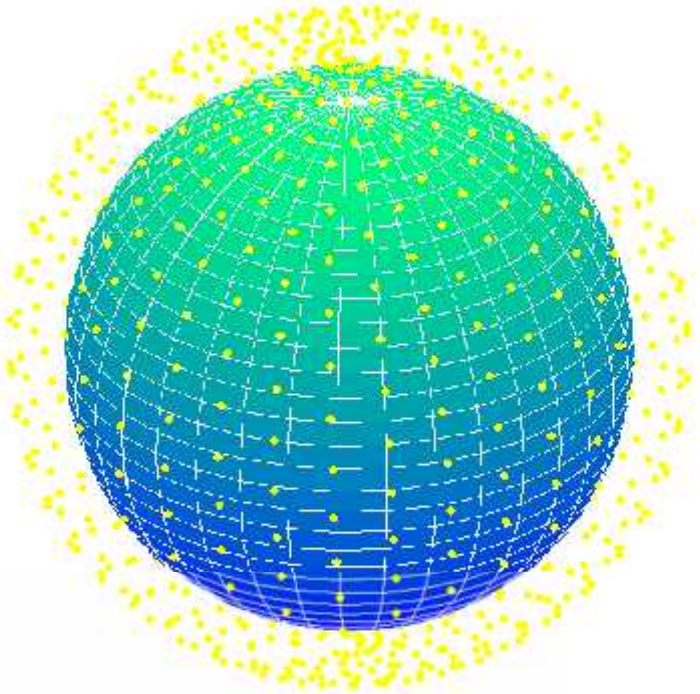
The ITU and the World Should Fear “OneWeb”

- Currently there are over 300 GEO satellites which cost over $30Billion Dollars
  - Including FSS and DTH, the annual revenue approach $100B for GEO systems
- GEO satellites cost minimum $100M USD providing 99.99% in-orbit reliability
- GEO satellite becoming uncontrollable is extremely rare event
- Build Quality of GEO satellites allow operators/nations to minimize harmful interference and quiet enjoyment of the GEO neighborhood by all participants
- This is however about to change dramatically
- Oneweb is 720 LEO Satellites in 20 Polar Orbit Planes which proposes to use the exact same Ku-band used by GEO satellites
- Oneweb will use “Progressive Pitch” to avoid harmful interference
- However: Unlike GEO satellites with 99.99% reliability, OneWeb proposes to use low cost, non-Space qualified Commercially Off The Shelf (COTS “i.e. COSTCO”) hardware for average price of $400,000 each. These satellites will have an much higher failure rate than GEO and may become uncontrollable
- **Each failed OneWeb satellite that cannot be controlled will interfere with 100% of all GEO satellites. 10% failure rate will destroy the GEO arc. It will be apocalyptic.**
- **Because LEO arc affect all GEO networks, the build quality must be the same if not higher than GEO satellites.**
- ITU member states must **STOP THE ZOMBIE SATELLITE APOCALYPSE**

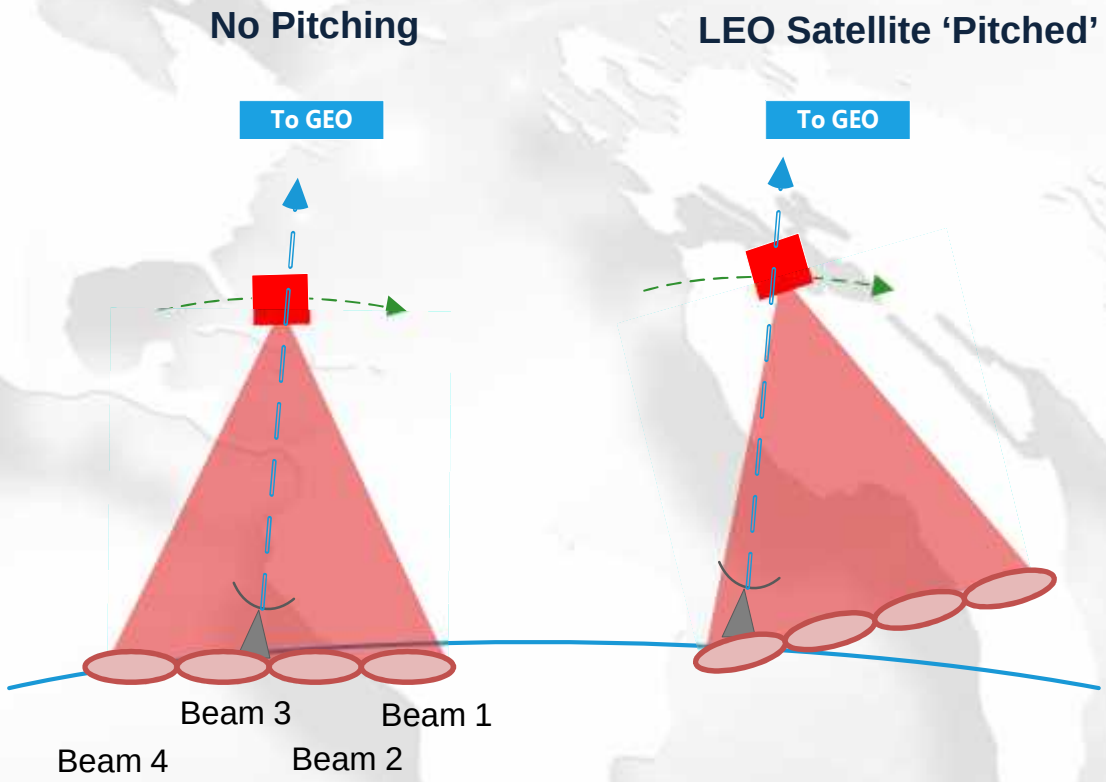
OneWeb LEO Parameters

1200 km Altitude
720 Satellites
Ku Bands: Standard FSS and Plan, **Ka Band**

LEO Parameters		
LEO Satellite Altitude	1,200	km
LEO Satellite Period	110	min
LEO Satellite Speed	7.21	km/sec
LEO Orbit Circumference	47,570	km
LEO Fleet Size	720	satellites
No. of LEOs in 1 plane	40	
No. of LEOs planes	18	
Distance between 2 LEOs in 1 plane	1,189.2	km
Time between 2 LEOs in 1 plane	165	sec
LEO Satellite Beam Diameter	~ 20	degrees
Number of beams per LEO Satellite	16	



“Progressive Pitch”

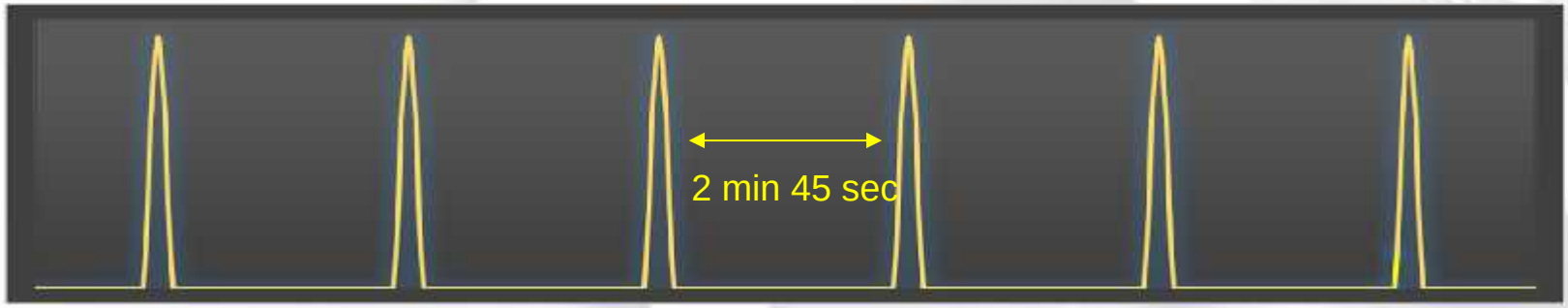


- How feasible is large “Progressive Pitch” at low latitudes to provide acceptable levels of isolation with GEO satellites?
- What if LEO satellite fails to control the pitch?

Potential Interference Duration

- Highest risk of interference is when LEO Satellites crosses the GEO Ground Antenna Beam
- Duration of such events depends on ground antenna size and its location (Latitude)
- Probability of interference higher at lower latitude
- Duration of the interference higher at higher latitude

Percentage of time 40 LEO Satellites are in -5 dB contour			
Ground Antenna Diameter	**60 cm**	**1 m**	**3m**
At 5° Latitude	7%	4%	2%
At 25° Latitude	8%	5%	2%
At 50° Latitude	14%	8%	4%



- If “Progressive Pitch” capability fails and cannot improve isolation, Interference may spike every 2 min 45 sec

Potential Risk for GEO Service Interruption with Various LEO Fleet Failure Rate

- Table below demonstrates scenarios if 1 or more LEO satellites cannot control "progressive pitch" while transmission is not ceased
- **Service in every ground GEO antenna may be interrupted while failed LEO satellite crosses its beam**

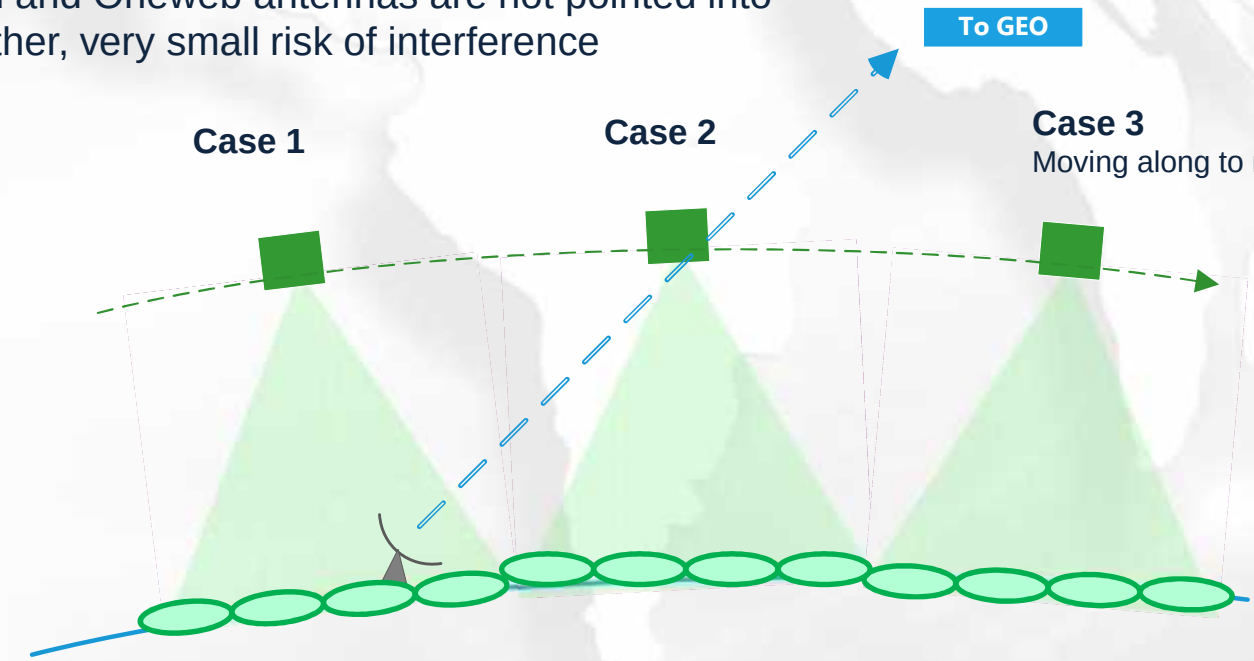
LEO Failure rate		Potential Service Interruption Duration for 60 cm Antenna at 25° Latitude based on - 5 dB contour			
Q-ty Uncontrolled Satellites	% of Fleet	per day	per week	per month	per year
1 satellite per orbital plane	0.14%	3.05 min	21.4 min	1.55 hours	18.6 hours
2 satellites per orbital plane	0.28%	6.1 min	42.8 min	3.1 hours	1.55 days
5 satellites per orbital plane	0.70%	15.3 min	1.8 hours	7.5 hours	7.7 days

- **If only one LEO satellite fails to control pitch and transmission, a 60 cm GEO Ground antenna at 25 deg Latitude may not exceed maximum theoretical service availability of 99.79% (based on -5 dB contour),**
  - **with 2 failed satellites, service availability will drop to 99.57%**
  - **with 5 failed satellites, service availability will drop to 98.93%**

High Latitudes:
No interference, no progressive pitch needed

- At high latitudes, geo antenna elevation angle to the GEO satellite is relatively low as shown by blue arrow in the picture below
- LEO satellite beam (~ +/- 20 deg) is shown by green color
- As LEO satellite approaches geo antenna, it becomes exposed to radiation from Oneweb satellite (case 1). However, because LEO satellite is not in the main beam of geo antenna, interference risk is low
- When LEO satellite passes through the geo antenna main beam (case 2), the geo antenna is already outside of the LEO satellite beam coverage, so interference risk is low
- However, the interference duration would be high

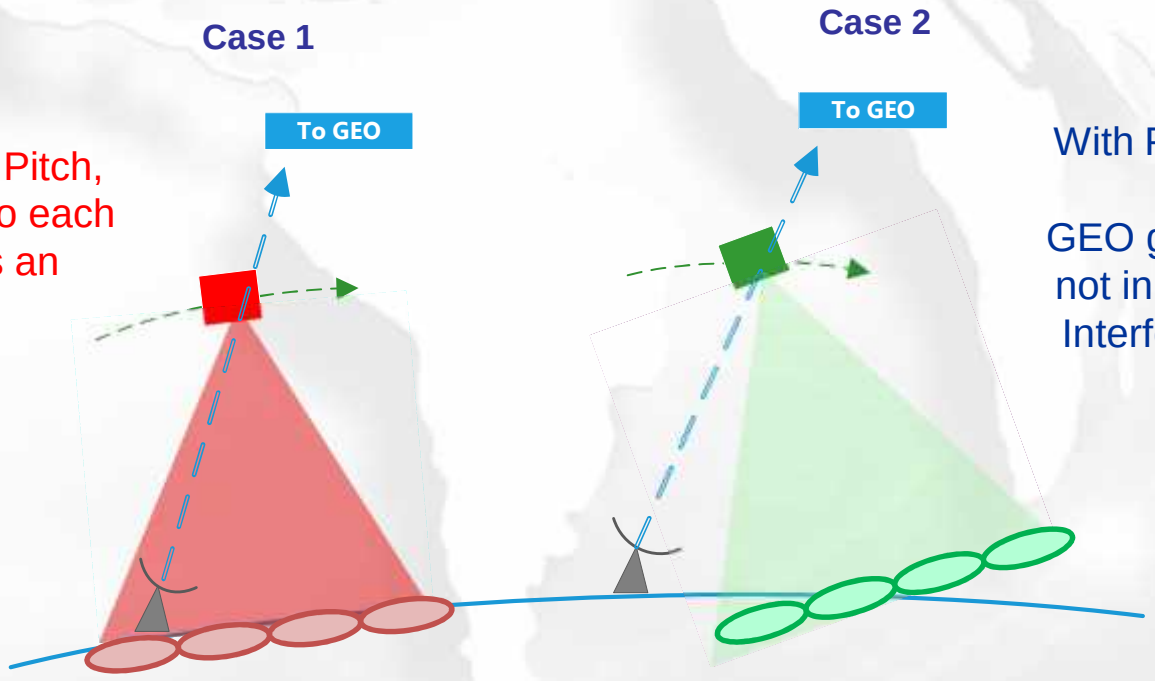
Ground and Oneweb antennas are not pointed into each other, very small risk of interference



Mid Latitudes:
Interference, progressive pitch is needed

- At mid latitudes, geo antenna elevation angle to the GEO satellite is not so low any more
- When LEO satellite passes through the geo antenna main beam (case 1), the geo antenna is still inside LEO satellite beam coverage, and there is a high interference
- However, Oneweb claims to implement “Progressive Pitch” and tilt the satellite (case 2) and therefore move its beam so that the geo antenna is outside the LEO beam coverage area

If no Progressive Pitch, antennas look into each other and there is an interference

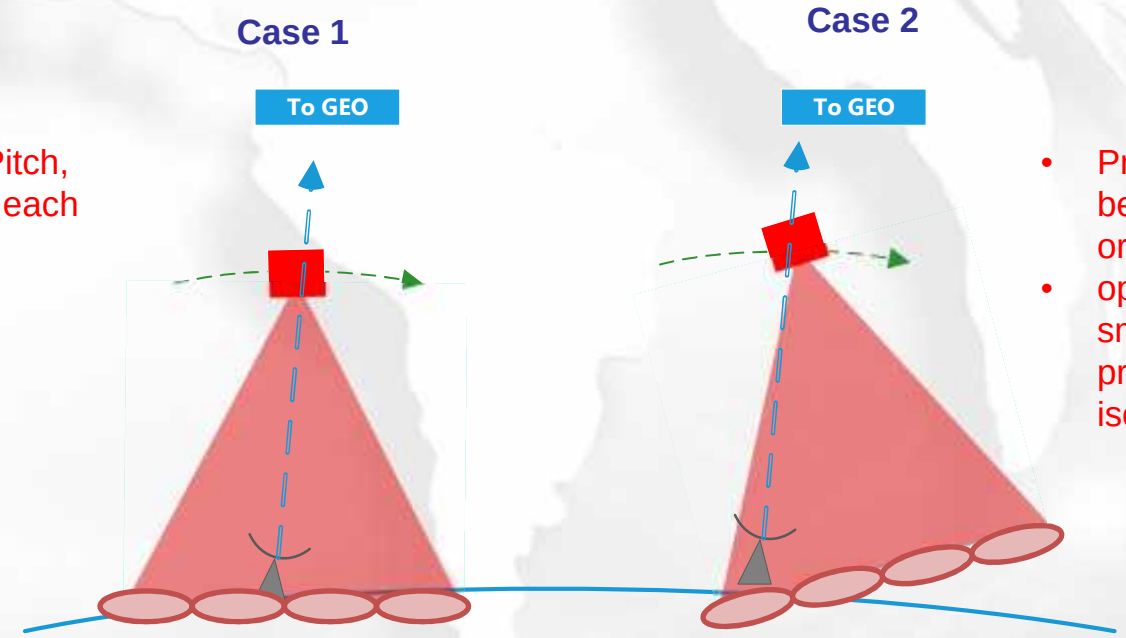


With Progressive Pitch, (satellite tilt) GEO ground antenna is not in the beam of OW: Interference minimized

Low Latitudes:
Interference, progressive pitch does not work always

- At low latitudes, geo antenna elevation angle to the GEO satellite is close to 90 degrees
- When LEO satellite passes through the geo antenna main beam (case 1), the geo antenna is in the middle of LEO satellite beam coverage, and there is a high interference
- "Progressive Pitch" should be very large, more than 30-40 degrees provided that the beam coverage of Oneweb is +/-20 degrees, and its pattern does not roll off quickly. So, the progressive pitch should be too large to be practical, or if it will not resolve interference (case 2)
- For GEO antennas located in low latitudes, the chance of interference is very high, although its duration is lower

If no Progressive Pitch, antennas look into each other and there is interference



- Progressive Pitch should be unpractically large in order to work;
- operationally reasonable small pitch does not provide sufficient antenna isolation

What Can ITU Member States Do

- EPFD levels of NGSO systems towards GEO IS NOT SUFFICIENT based on “theoretical” levels of performance. We must take into account the Quality of the Satellite Network being proposed at the NGSO. If the satellites fail, the EPFD protections will not maintained
- Introduce in the ITU regulations satellite build quality requirements such that all LEO, MEO and GEO systems use heritage based Space Qualified Components to insure 99.99% quality that is being used in GEO
- Set new rules which makes launching nations of low-cost, low-quality NGSO satellites which fail, liabilities to compensate all GEO satellite operators and customers. The liabilities should cover $100B of potential annual revenue lost at GEO
- Adopt local in-country licensing schemes to make sure that NGSO networks building satellite systems with non-space qualified COTS components DO NOT RECEIVE LANDING RIGHTS!
- Speak as one voice to the future investors of OneWeb or any other NGSO system that is not planning to build with Space-Qualified hardware that they will neither receive commercial licenses and will suffer massive liabilities for damaging the current harmonious operations of GEO networks
- ITU Nations should not stand in the way of innovation but we must demand that new entrants build their systems to protect the integrity of existing GEO networks that have a higher priority and significant revenue base
- **Zombie satellites must not be launched to harm Humanity’s Quiet Enjoyment of Space**