National Aeronautics and Space Administration

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Use Case Scenarios – Space Based Receiver Assessment

GPS Adjacent Band Compatibility Assessment Workshop VI

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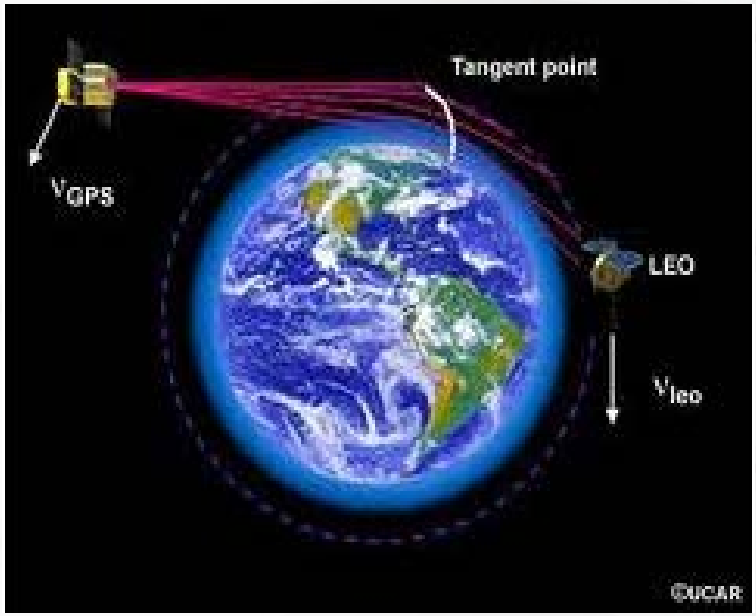
Space Based Receiver Applications

- Space vehicle navigation / Precise Orbit Determination (POD)
  - Position
  - Velocity
  - Time
  - Attitude
  - Associated scientific missions:
    - Ocean and ice altimetry
    - Synthetic Aperture Radar (SAR)
    - Interferometric SAR
    - POD and time transfer for gravity field
- Science measurements:
  - Radio occultation (GNSS-RO)
    - NOAA Operational Weather Forecasting
    - Climate change science
    - Space weather phenomenona
  - Reflectometry (GNSS-R)
    - Weather forecasting
    - Tidal surges
    - Flood plain monitoring



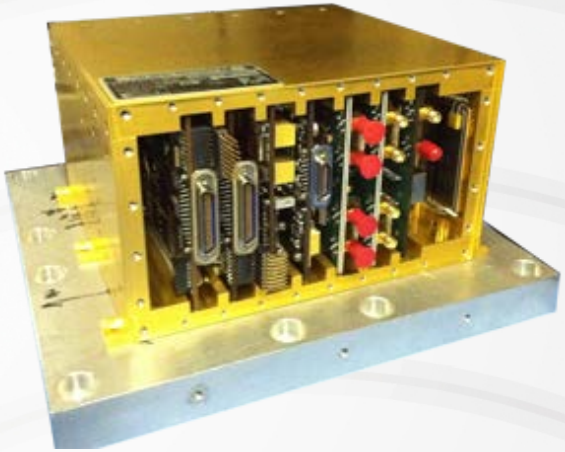
Radio Occultation CONOPS

NASA Developed Receivers

- Goddard Space Flight Center (GSFC)
  - Navigator GPS Receiver
- Jet Propulsion Laboratory (JPL)
  - Flight TurboRogue
  - BlackJack GPS Receiver
    - IGOR
    - IGOR+
  - **TriG Receiver**

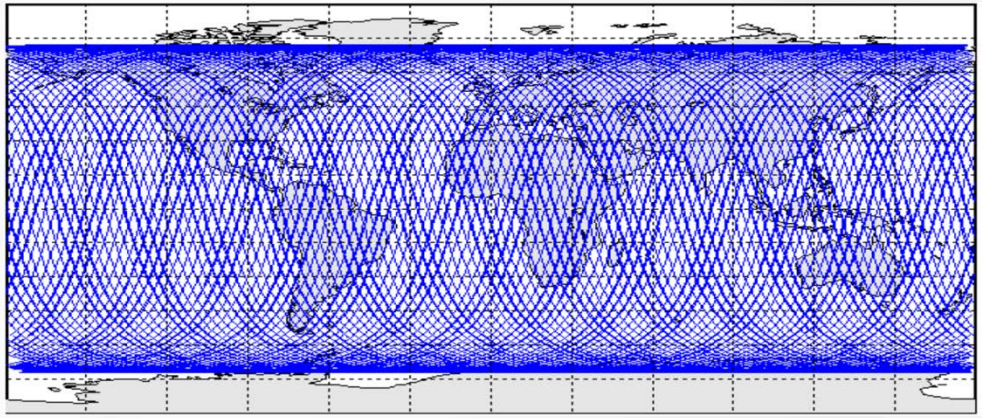
Focus on TRIG

- Applications:
  - Navigation/POD/sub-nanosecond time transfer
  - Radio Occultation
- Upcoming Missions:
  - Deep Space Atomic Clock (DSAC)
  - COSMIC-2 Equatorial (6 satellites)
  - COSMIC-2 Polar (6 satellites)
  - GRACE-Follow-On
  - Sentinel-6
  - Surface Water and Ocean Topography (SWOT)
  - NASA-ISRO Synthetic Aperture Radar (NISAR)
  - Other missions in development



On-Orbit Assessment Parameters

- Assessment based on the aggregate received interference from terrestrial interferer network
- Computation Method:
  - MATLAB time simulation
    - 10-day orbit simulation period @ 1-sec time steps
- System on-orbit specifications:
  - Altitude
  - Inclination angle
- Receiver specifications:
  - Antenna type
  - Antenna pointing azimuth
  - Antenna pattern
  - Polarization
  - Interference threshold*
- Propagation Loss
- Cross-polar antenna loss

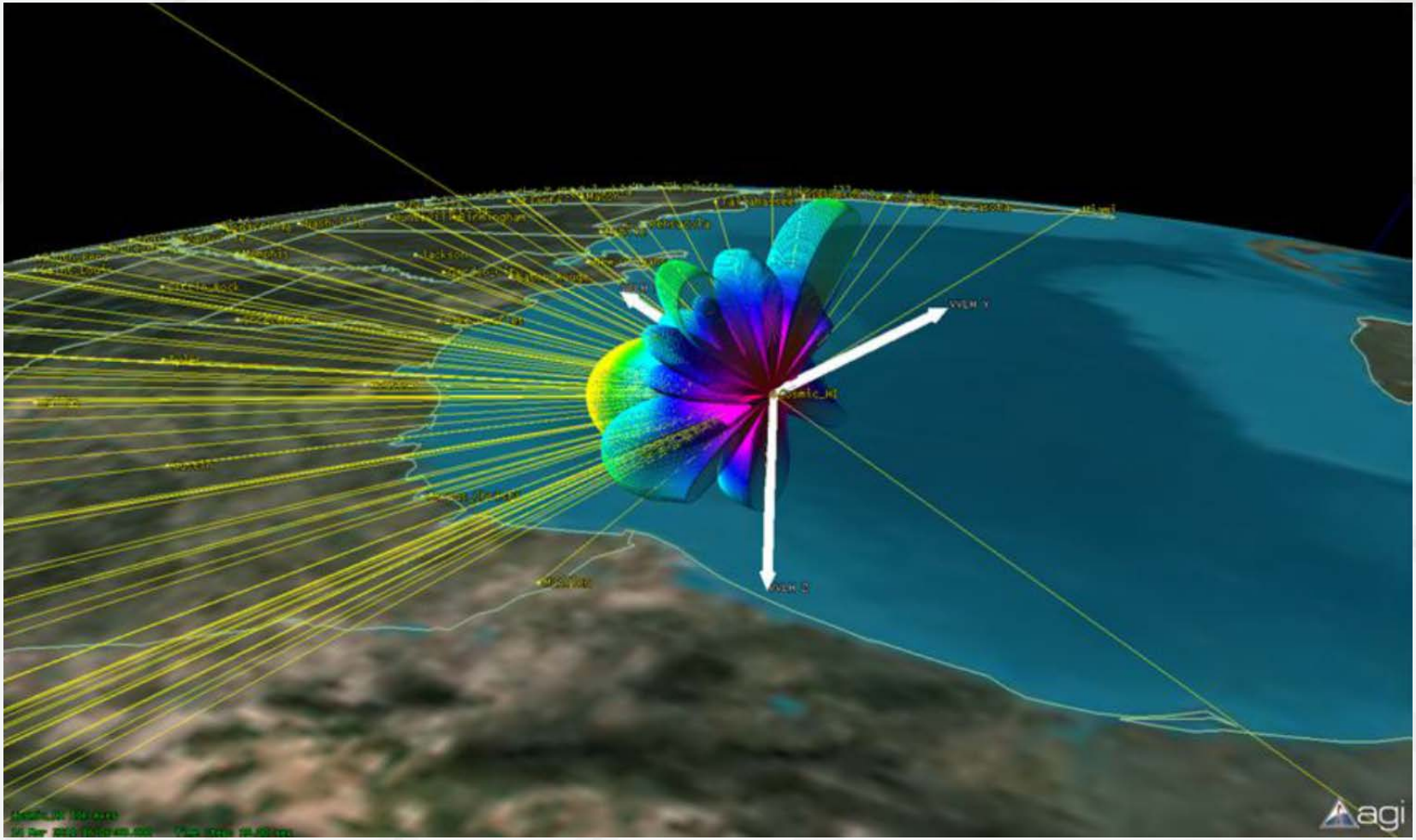


Cosmic-2 Satellite 800 km/72° inclination orbit (1 of 6 Constellation Satellites) over 10 day period

* Obtained from results of DOT ABC Radiated Chamber Testing (April-2016)

TRIG GNSS-RO Antenna Gain Pattern

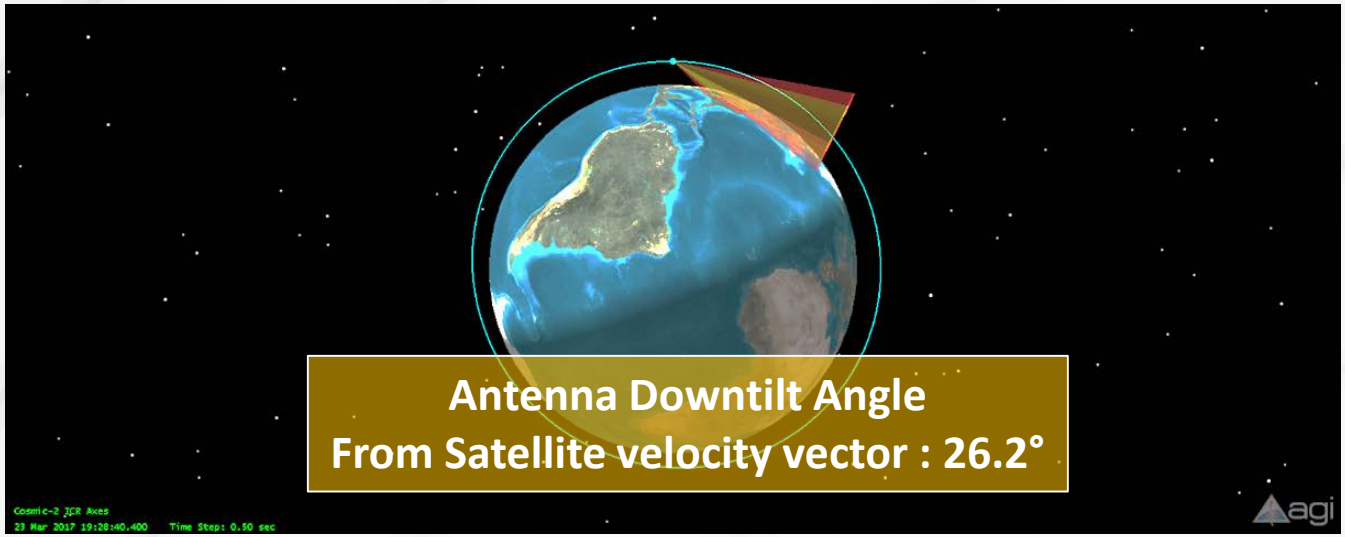
12-Element Array Antenna (Main beam pointing toward Earth limb)

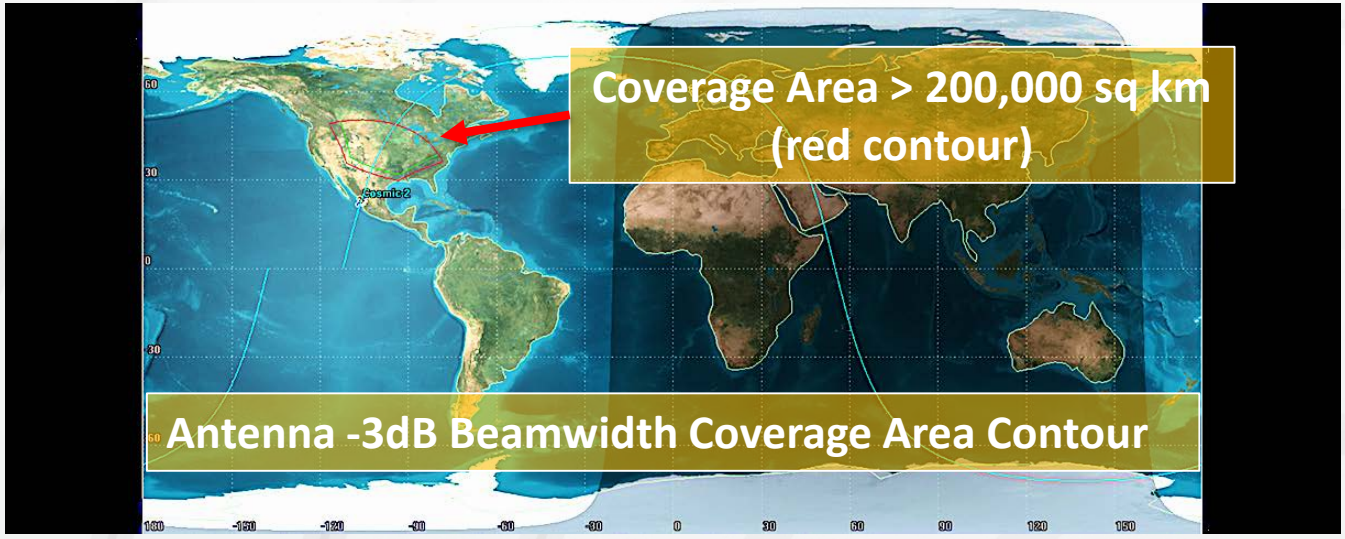


[NOTE: A 2nd 12-element array antenna exists on the reverse side of the satellite. The 2nd array antenna has been omitted from this pictorial for graphical simplicity.]

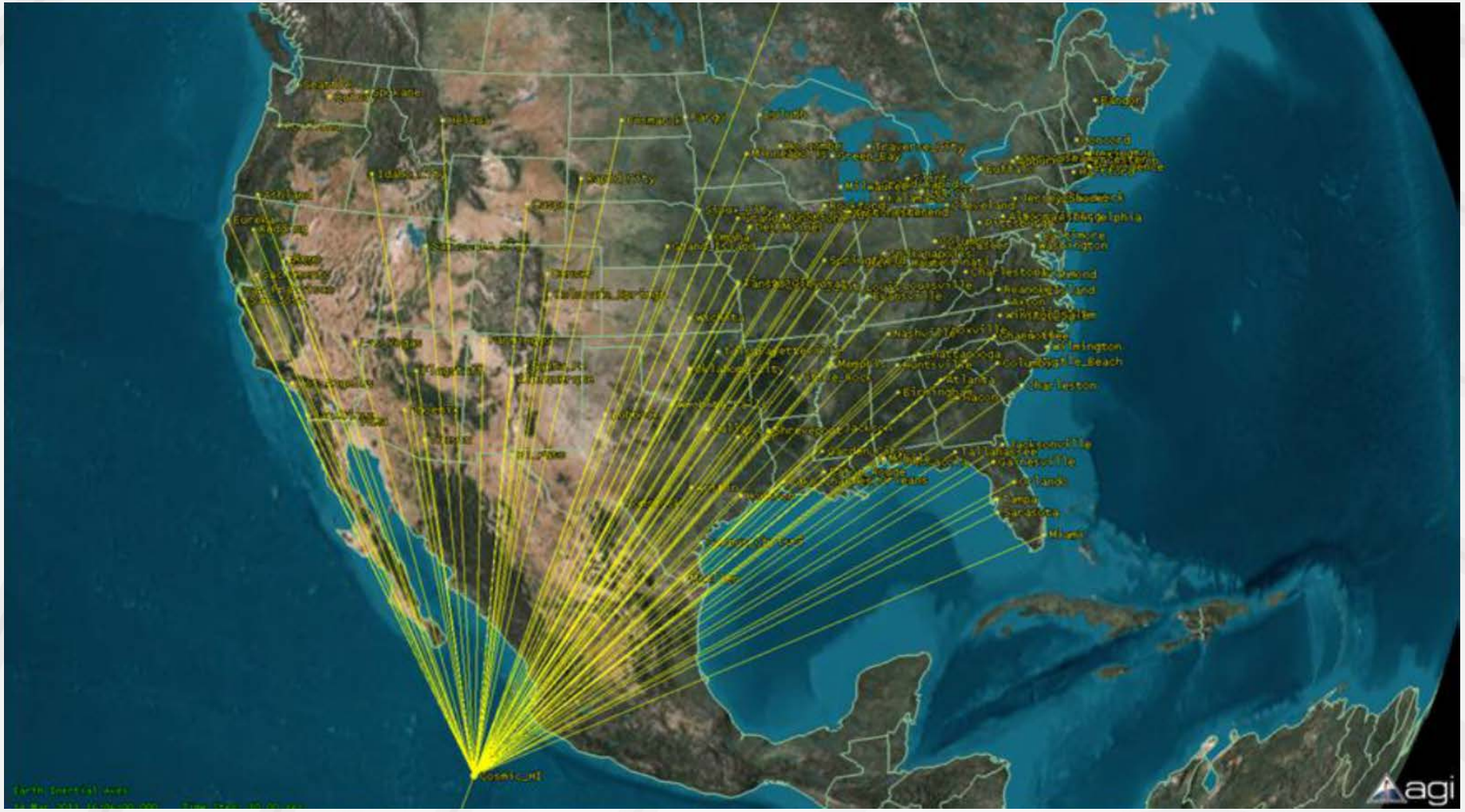
GNSS-RO Antenna Beam Earth Grazing Coverage Area

TRIG RO Antenna -3dB Beamwidth earth grazing coverage





On-Orbit View of US Major Cities



Assessment Challenges

- Unknowns of interferer network deployment
  - User target basis
    - Broadband mobile, IoT, Public Service Utility, etc.
  - Mixture of macro-/micro-cells* in a given environment
    - Urban vs rural
    - City-by-city
  - Maximum EiRP per sector per channel
- Any combination of the unknowns may affect:
  - Antenna orientation
  - Antenna vertical down-tilt/up-tilt angles
  - Density of base-stations (urban vs rural)

* Macro-/micro-cell specifications defined in ITU-R M.2292

Next Steps

- Continuation of collaboration with DOT
  - Ensure succinct assumptions for base-station macro-/micro-cell specifications
- Methodology of analysis
  - Development of generic terrestrial network deployment scenario(s)
- Documentation of assumptions
- Modeling and simulation analysis
- Provide results to DOT within a timeframe correlated with DOT's other use-case scenario assessments

POC Information

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