Time, Space, and Position Information for Geosynchronous Satellites

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Abstract

A brief survey of characterizing the three dimensional radar cross section of satellites. The process of finding the optimal Fourier expression for each band is explored and different success measures are presented. `/GitHub/sharing/bibliographies/`

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†Contributed sections 1 and 2, classified as "4-o with canvas."

1 ChatGPT*

1.1 Two-Line Element Sets (TLE Data)

TLEs are a standard format for satellite position data, widely used for tracking satellites, including geosynchronous ones.

Where to Find:

- **CelesTrak:** https://celestrak.com/
  Provides up-to-date TLEs for geosynchronous satellites in various categories like communications, navigation, and weather.
- **NORAD (via Space-Track.org):** https://www.space-track.org/
  Requires registration but provides authoritative TLE data directly from the US government.

Use Cases: Input TLEs into satellite tracking software to determine positions in real time. Tools like STK, Orbitron, or Heavens-Above can visualize this data.

1.2 Satellite Databases

Comprehensive databases provide details on satellites' orbital parameters and operational details.

Key Resources:

- **Gunter's Space Page:** https://space.skyrocket.de/
  Contains detailed information about satellite launches, missions, and operators, including geostationary orbits.
- **SatNOGS Network:** https://db.satnogs.org/
  Open-source satellite database with tracking capabilities.

1.3 Real-Time Tracking Tools

Online tools provide real-time positional data for satellites.

Recommended Tools:

- **N2YO:** https://www.n2yo.com/
  Tracks geosynchronous satellites, providing real-time location, coverage maps, and pass details.
- **Heavens-Above:** https://heavens-above.com/
  Offers visualizations of satellite positions in the sky, including geostationary satellites.

1.4 Satellite Operators and Agencies

Many geosynchronous satellites are operated by private companies or government agencies that provide detailed orbital data.

Examples:

- **Intelsat and SES:** https://www.intelsat.com/, https://www.ses.com/
  Large operators of geosynchronous satellites often provide orbital and coverage information.
- **NOAA (National Oceanic and Atmospheric Administration):** https://www.noaa.gov/
  Provides data for weather satellites like GOES (Geostationary Operational Environmental Satellites).

1.5 Ephemeris Data Sources

Ephemeris data provides precise information about satellite positions and velocities.

Sources:

- **JPL Horizons System:** https://ssd.jpl.nasa.gov/horizons
  Offers high-precision ephemeris for various objects, including satellites.
- **SP3 Format Data:** Used in high-accuracy positioning and geodesy, available from providers like the International GNSS Service (IGS).

1.6 Software for Satellite Tracking and Analysis

Specialized software allows you to process satellite position data and visualize their orbits.

Popular Software:

- **STK (Systems Tool Kit):** https://www.agi.com/products/stk
  Advanced software for satellite orbit modeling and analysis.
- **GPredict:** https://gpredict.oz9aec.net/
  Free and open-source software for tracking satellites.

1.7 Research Papers and Publications

For precise and in-depth geostationary satellite data, scientific research often provides detailed information.

Sources:

- **NASA Technical Reports Server (NTRS):** https://ntrs.nasa.gov/
- **IEEE Xplore:** https://ieeexplore.ieee.org/

1.8 GNSS Augmentation Systems

For geosynchronous satellites involved in GNSS augmentation:

- **WAAS (Wide Area Augmentation System):** Covers the US; managed by the FAA.
- **EGNOS (European Geostationary Navigation Overlay Service):** Provides orbital data for geosynchronous satellites enhancing GPS accuracy.

Key Parameters to Consider:

- **Orbital Slot:** Longitude where the satellite is stationed (e.g., 119.5°W for a GOES satellite).
- **Inclination:** Near 0° for geostationary satellites.
- **Altitude:** 35,786 km for geostationary orbits.
- **Epoch Time:** Timestamp of the most recent TLE data.
- **RAAN (Right Ascension of the Ascending Node):** Orbital orientation relative to Earth's equator.

2 Using satnogs.org to Identify GEO Satellites*

Geostationary (GEO) satellites can be identified on the SatNOGS Database (https://db.satnogs.org/) by utilizing their unique orbital characteristics and the filtering tools available on the platform. Below are the steps to locate and identify GEO satellites effectively.

2.1 Understanding GEO Characteristics

Geostationary satellites have the following orbital properties:

- **Altitude:** Approximately 35,786 km above the Earth's surface.
- **Inclination:** Near 0° to remain stationary over the equator.
- **Eccentricity:** Close to 0, indicating a circular orbit.
- **Orbital Slot:** Fixed at a specific longitude (e.g., 119.5°W for GOES satellites).

These properties can help filter and identify GEO satellites in the SatNOGS database.

2.2 Using the SatNOGS Search and Filters

1. Navigate to SatNOGS Database.
2. Use the search bar to look for:
   - Keywords such as `GEO` or `Geostationary`.
   - Known GEO satellite names or operators (e.g., GOES, Intelsat, SES).
3. Click on a satellite's entry to view its details and orbital parameters.
4. Look for the following key parameters:
   - **Inclination:** Near 0°.
   - **Altitude:** Approximately 35,786 km.
   - **Eccentricity:** Close to 0.
5. Use category tags (e.g., communication, weather, navigation) to narrow down the results.

2.3 Cross-Verification Using External Tools

If GEO satellites are not explicitly labeled in SatNOGS, the following tools can provide additional verification:

- **CelesTrak GEO Catalog:**
  Access the TLE catalog for GEO satellites at https://celestrak.org/NORAD/elements/geo.txt and cross-reference satellite names or NORAD IDs with SatNOGS entries.
- **Heavens-Above:**
  Use https://www.heavens-above.com/ to visualize GEO satellite positions and compare their orbital parameters.

2.4 Examples of GEO Satellites

Examples of well-known GEO satellites to search for:

- **Weather Satellites:** GOES (NOAA), Meteosat (EUMETSAT).
- **Communications Satellites:** Intelsat, SES satellites.
- **Navigation Satellites:** WAAS (USA), EGNOS (Europe).

2.5 Automating Identification (Optional)

For advanced users, you can programmatically compare TLE data from CelesTrak GEO Catalog with SatNOGS records using tools like Python (e.g., with the `PyEphem` library).

3 Conclusion

Using SatNOGS, along with external tools like CelesTrak and Heavens-Above, enables efficient identification and tracking of geostationary satellites.

4 Geo TLE

Sample file https://celestrak.org/NORAD/elements/geo.txt

```
TDRS 3
1 19548U 88091B   24325.92885469 -.00000302  00000+0  00000+0 0  9994
2 19548  13.0423 344.8375 0040075 335.1643  25.8602  1.00266141119620
FLTSATCOM 8 (USA 46)
1 20253U 89077A   24325.77379124 -.00000369  00000+0  00000+0 0  9996
2 20253  12.5869 354.5997 0006168 257.7869 212.2336  1.00276169254813
SKYNET 4C
1 20776U 90079A   24325.76378818  .00000123  00000+0  00000+0 0  9995
2 20776  13.5248 353.7193 0003851 254.3871 120.4274  1.00272744125145
```

5 Alphabetical Listing of 565 Open Source Geo Satellites

1. ABS
   - 1.1 ABS-2
   - 1.2 ABS-2A (MONGOLSAT-1)
   - 1.3 ABS-3A
   - 1.4 ABS-4 (MOBISAT-1)
   - 1.5 ABS-6
2. AEHF
   - 2.1 AEHF-1 (USA 214)
   - 2.2 AEHF-2 (USA 235)
   - 2.3 AEHF-3 (USA 246)
   - 2.4 AEHF-4 (USA 288)
   - 2.5 AEHF-5 (USA 292)
   - 2.6 AEHF-6 (USA 298)
3. AL YAH
   - 3.1 AL YAH 3
4. ALCOMSAT
   - 4.1 ALCOMSAT 1
5. ALPHASAT
   - 5.1 ALPHASAT
6. AMAZONAS
   - 6.1 AMAZONAS 2
   - 6.2 AMAZONAS 3
   - 6.3 AMAZONAS 4A
   - 6.4 AMAZONAS 5
7. AMAZONAS NEXUS
   - 7.1 AMAZONAS NEXUS
8. AMC
   - 8.1 AMC-11
   - 8.2 AMC-14
   - 8.3 AMC-15
   - 8.4 AMC-21
   - 8.5 AMC-3
   - 8.6 AMC-6
9. AMOS
   - 9.1 AMOS-17
   - 9.2 AMOS-3
   - 9.3 AMOS-4
10. ANGOSAT
    - 10.1 ANGOSAT 2
11. ANIK F
    - 11.1 ANIK F1
    - 11.2 ANIK F1R
    - 11.3 ANIK F2
    - 11.4 ANIK F3
12. ANIK G
    - 12.1 ANIK G1
13. APSTAR
    - 13.1 APSTAR-6C
    - 13.2 APSTAR-6D
    - 13.3 APSTAR-6E
    - 13.4 APSTAR-7
    - 13.5 APSTAR-9
14. ARABSAT
    - 14.1 ARABSAT-5A
    - 14.2 ARABSAT-5C
    - 14.3 ARABSAT-6A
    - 14.4 ARABSAT-7B (BADR-8)
15. ARCTURUS
    - 15.1 ARCTURUS
16. ARSAT
    - 16.1 ARSAT 1
    - 16.2 ARSAT 2
17. ASIASAT
    - 17.1 ASIASAT 4

69.25 INTELSAT 40E (IS-40E)
69.26 INTELSAT 9 (IS-9)
69.27 INTELSAT 901 (IS-901)
69.28 INTELSAT 902 (IS-902)
69.29 INTELSAT 904 (IS-904)
69.30 INTELSAT 905 (IS-905)
69.31 INTELSAT 906 (IS-906)
70. IRNSS
70.1 IRNSS-1A
70.2 IRNSS-1B
70.3 IRNSS-1C
70.4 IRNSS-1D
70.5 IRNSS-1E
70.6 IRNSS-1F
70.7 IRNSS-1G
70.8 IRNSS-1I
70.9 IRNSS-1J (NVS-01)
71. JCSAT
71.1 JCSAT-110A (JCSAT-15)
71.2 JCSAT-12 (JCSAT-RA)
71.3 JCSAT-13
71.4 JCSAT-16
71.5 JCSAT-17
71.6 JCSAT-18 (KACIFIC 1)
71.7 JCSAT-2B
71.8 JCSAT-3A
71.9 JCSAT-5A
72. JUPITER
72.1 JUPITER 3 (ECHOSTAR 24)
73. KAZSAT
73.1 KAZSAT-2
73.2 KAZSAT-3
74. KOREASAT
74.1 KOREASAT 116
74.2 KOREASAT 5 (MUGUNGWHA 5)
74.3 KOREASAT 5A
74.4 KOREASAT 6
74.5 KOREASAT 7
75. LAOSAT
75.1 LAOSAT 1
76. LDPE
76.1 LDPE-1
76.2 LDPE-2
76.3 LDPE-3A
77. LUCAS
77.1 LUCAS (JDRS-1)
78. LUCH
78.1 LUCH (OLYMP-K 1)
78.2 LUCH-5A
78.3 LUCH-5B
78.4 LUCH-5V
78.5 LUCH-5X (OLYMP-K 2)
79. LUDI TANCE
79.1 LUDI TANCE-4 01A
80. MEASAT
80.1 MEASAT 3D
80.2 MEASAT-3A
80.3 MEASAT-3B
81. MERAH PUTIH
81.1 MERAH PUTIH 2
82. METEOSAT
82.1 METEOSAT-10 (MSG-3)
82.2 METEOSAT-11 (MSG-4)
82.3 METEOSAT-12 (MTG-I1)
82.4 METEOSAT-9 (MSG-2)
83. MEV
83.1 MEV-1
83.2 MEV-2
84. MEXSAT
84.1 MEXSAT 3
85. MORELOS
85.1 MORELOS 3
86. MUOS
86.1 MUOS-1
86.2 MUOS-2
86.3 MUOS-3
86.4 MUOS-4
86.5 MUOS-5
87. NIGCOMSAT
87.1 NIGCOMSAT 1R
88. NILESAT
88.1 NILESAT 201
88.2 NILESAT 301
89. NIMIQ
89.1 NIMIQ 2
89.2 NIMIQ 4
89.3 NIMIQ 5
89.4 NIMIQ 6
90. NSS
90.1 NSS-10
90.2 NSS-11
90.3 NSS-12
90.4 NSS-9
91. NUSANTARA SATU
91.1 NUSANTARA SATU
92. NUSANTARA TIGA
92.1 NUSANTARA TIGA (SATRIA)
93. OPTUS
93.1 OPTUS 10
94. OPTUS C

6 More on Geosynchronous Orbits

The Geosynchronous Platform Definition Study, consisting of several volumes (e.g., Myers 1973a; Myers 1973b), provides comprehensive insights into geosynchronous mission characteristics, traffic analysis, and platform synthesis.

References

1. Myers, H. L. (June 1973a). *Geosynchronous Platform Definition Study: Executive Summary*. Tech. rep. SD 73-SA-0036-1. Downey, California, USA: Rockwell International, Space Division. URL: https://ntrs.nasa.gov/search?q=Geosynchronous%20platform%20definit
2. — (June 1973b). *Geosynchronous Platform Definition Study: Geosynchronous Transportation Requirements*. Tech. rep. SD 73-SA-0036-7. Downey, California, USA: Rockwell International, Space Division. URL: https://ntrs.nasa.gov/search?q=Geosynchronous%20p