Second fragmentation of Titan 3C Transtage SSN #3692

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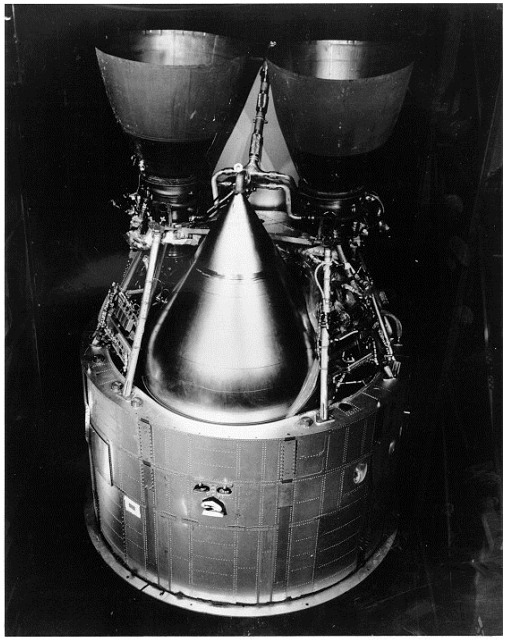
Outline

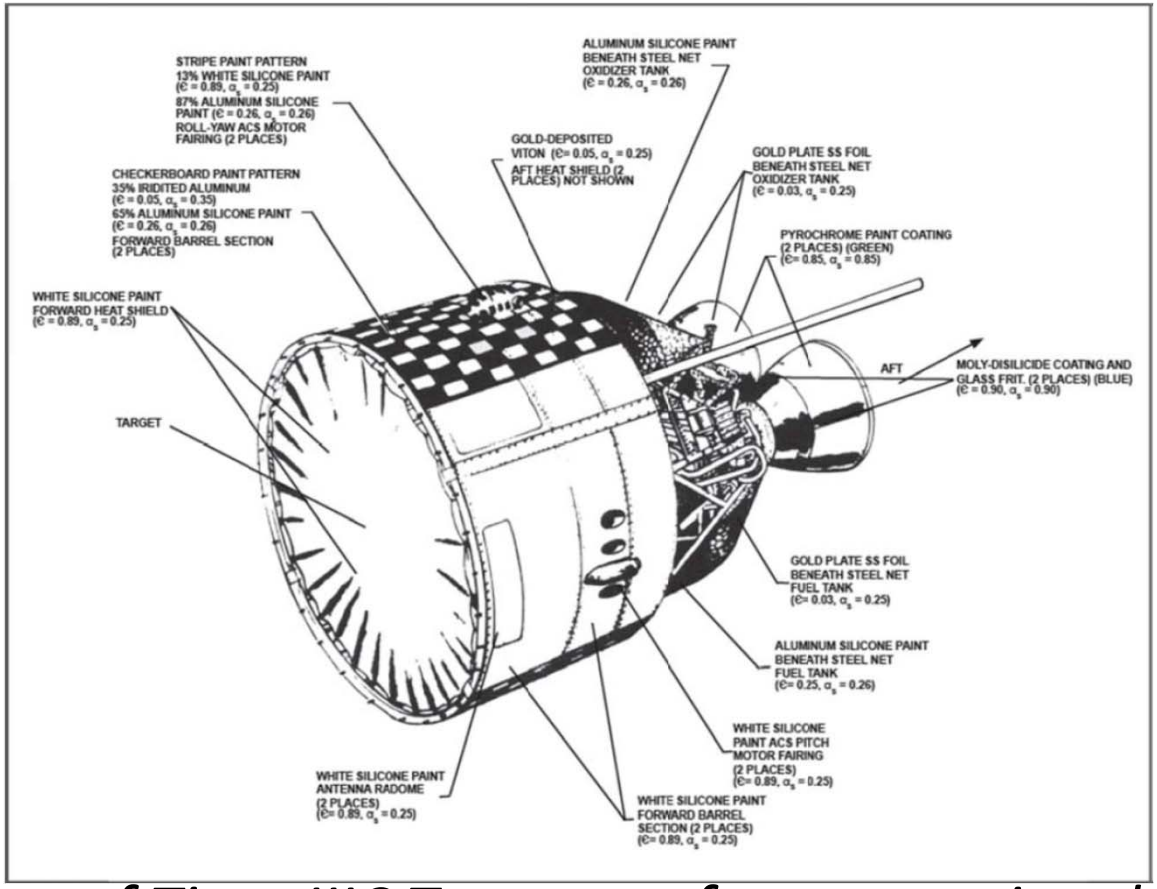
- Titan 3C Transtage overview
- Feb 2018 anomaly in orbital motion of Transtage SSN #3692
- Detection of new debris and their association with SSN #3692
- Characterization of newly detected debris
- Conclusion

Transtage SSN #3692

- Launch on Feb 9, 1969 to place TACSAT satellite in GEO
- Transtage 17 (1969-013B) was used as an upper stage
- First breakup reported to have occurred on 4 June 2014 at 02:38 UT



Titan 3C Transtage Schematic



From "Observations of Titan IIIC Transtage fragmentation debris" by H.Cowardin, P.Seitzer et al.

SSN #3692 observations

- Performed by ASPOS OKP and ISON on a regular basis (nearly every night) in a survey mode
- Last observation prior to the full Moon (Mar 2nd 00:51 UT, 2018) obtained on Feb 27 at 1638 UT
- OD fit span which included the last observation was equal to 58.5 days
- 1647 measured positions from 34 telescopes were used for the OD

SSN #3692 orbital motion anomaly detection

- First observation after the full Moon obtained on Mar 3 at 1528 UT
- Large residuals of new measurements with respect to the propagated orbit from the last OD revealed:
  -2910 arcsec along track (equivalent to -199.6 sec of time) – compare to expected 1.1 arcsec calculated from the last OD covariance
  +128 arcsec cross-track
- Additional observations were used to determine new orbit and estimate time when anomaly in the orbital motion have occurred
- Following estimations obtained:
  time: Feb 28 between 20:45 and 21:15 UT
  dV: 1.7 m/s with components dVr -0.7 m/s, dVt +0.7 m/s, dVz -1.4 m/s

SSN #3692 orbital motion anomaly assesment

- Following estimations obtained for the equivalent impulse:

  Time: Feb 28 between 20:45 and 21:15 UT

  dV: 1.7 m/s with components dVr -0.7 m/s, dVt +0.7 m/s, dVz -1.4 m/s

- Following estimations obtained for orbital parameters changes:

  Semimajor axis: +21.4 km
  Inclination: -0.0115 deg
  RAAN: +0.225 deg
  Apogee radius: +0.9 km
  Perigee radius: +41.8 km
  Eccentricity: -0.00048

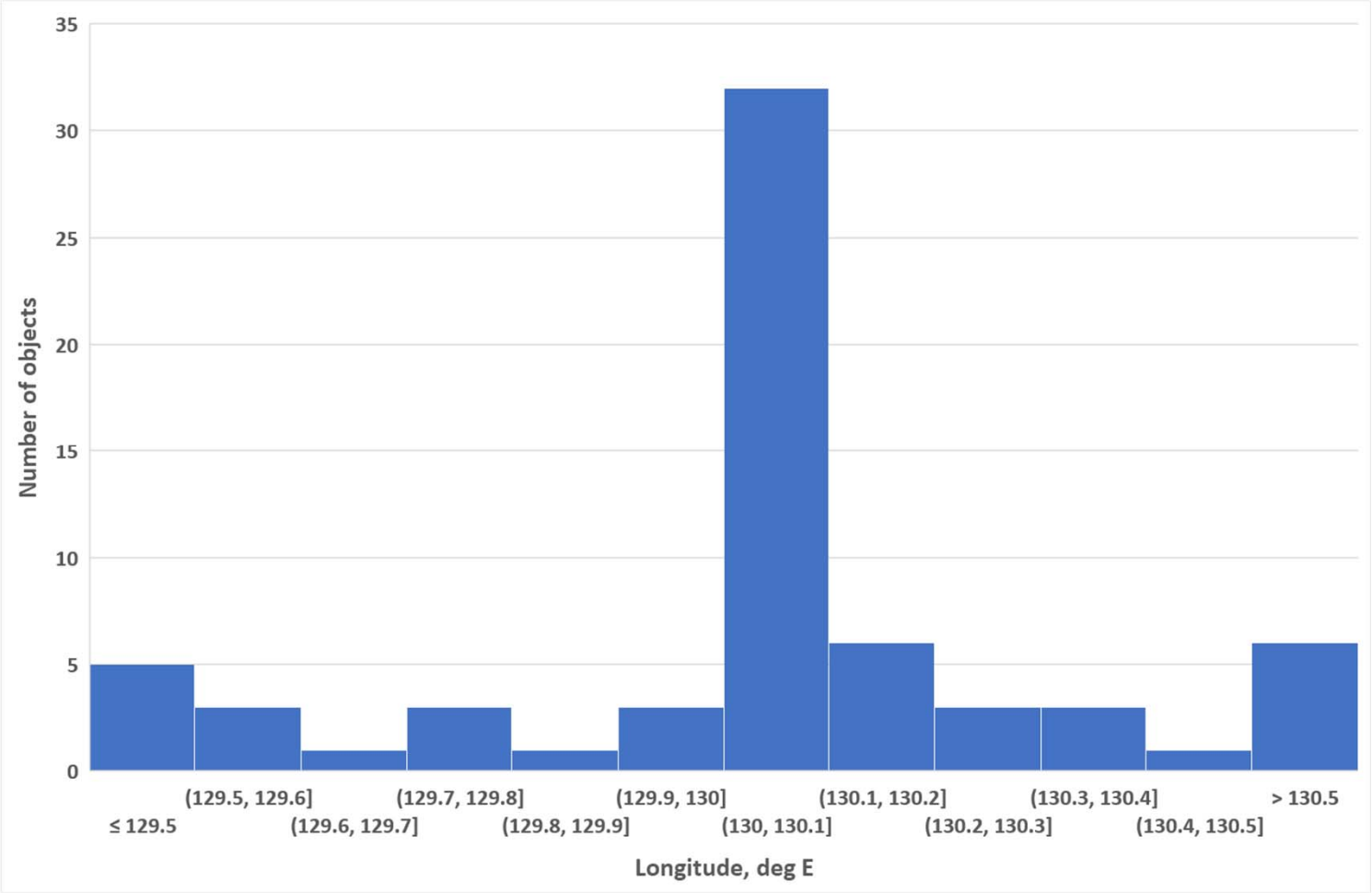
Search for possible fragments of SSN #3692

- Bright Moon and unstable weather prevented possible faint fragments search in the close vicinity of SSN #3692
- First unknown quite bright fragment detected on Mar 4 at 0643 UT very far from SSN #3692 (106 deg to the East of the SSN #3692 location). Orbital parameters were quite different
- Second unknown quite bright fragment detected on Mar 4 at 1711 UT not far from SSN #3692 (12 deg to the West)
- New fragments began to appear as the phase of the Moon decreased
- Dedicated search scenario was used

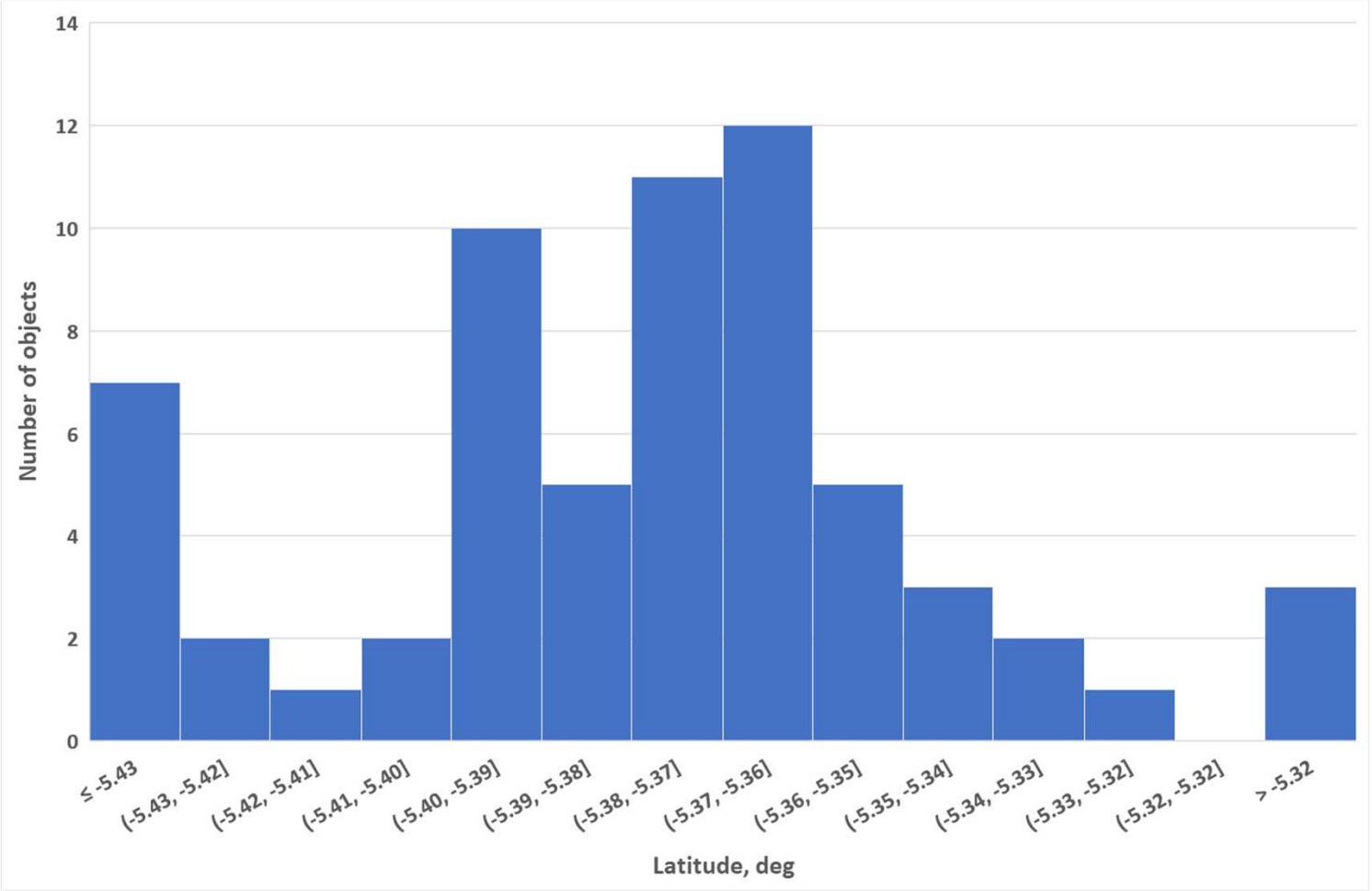
Association of newly detected debris with the event of fragmentation of SSN #3692

- More than 100 objects of nearly 200 ones detected to the date by ASPOS OKP and ISON since Mar 4 were selected as possible candidates for the SSN #3692 fragmentation debris
- Selection was based just on inclination and RAAN values allowing any orbital period larger than 1000 min
- 78 fragments declared as having well established orbit
- Other fragments are still in the ‘analyst’ category
- All determined trajectories propagated back to the estimated event time interval
- Longitude, latitude and height above Earth for each fragment compared to the values of the same parameters of SSN #3692
- Nearly two dozens of selected objects were rejected as having no relation to the event (probably, they appeared in orbit at the first fragmentation of SSN #3692)

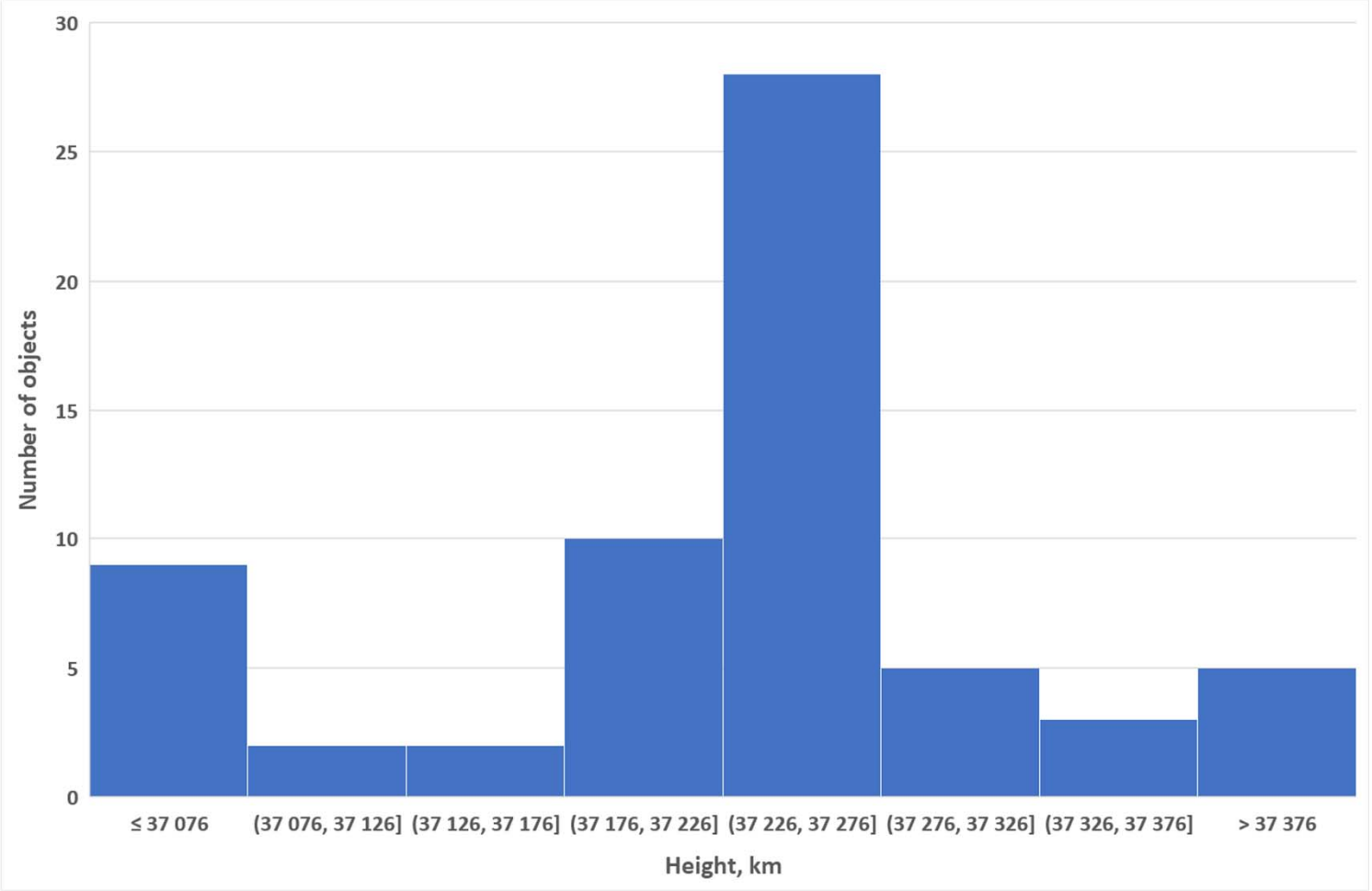
Fragment's propagated longitude distribution at 21:00 UT on Feb 28, 2018



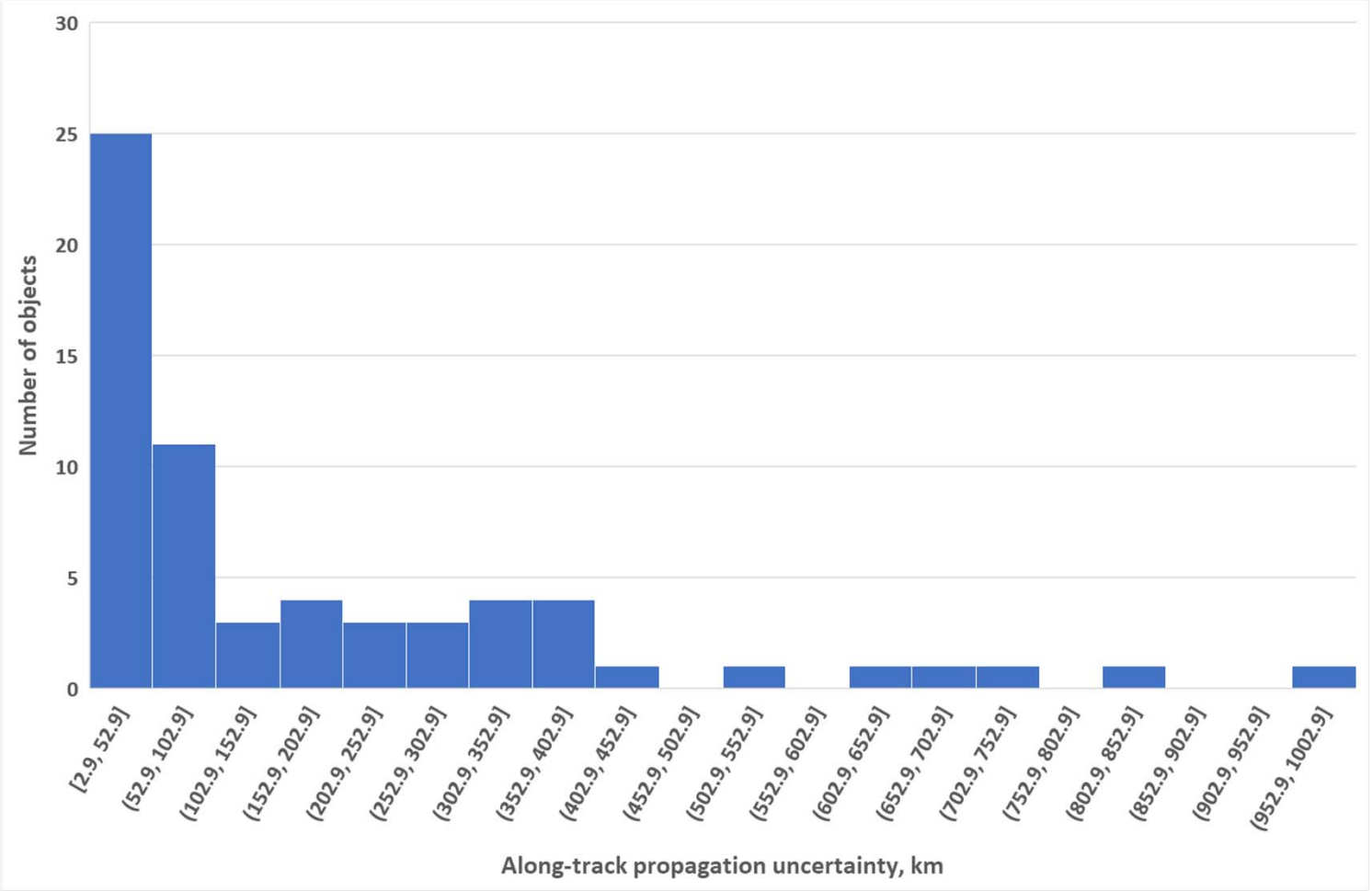
Fragment's propagated latitude distribution at 21:00 UT on Feb 28, 2018



Fragment's propagated height distribution at 21:00 UT on Feb 28, 2018



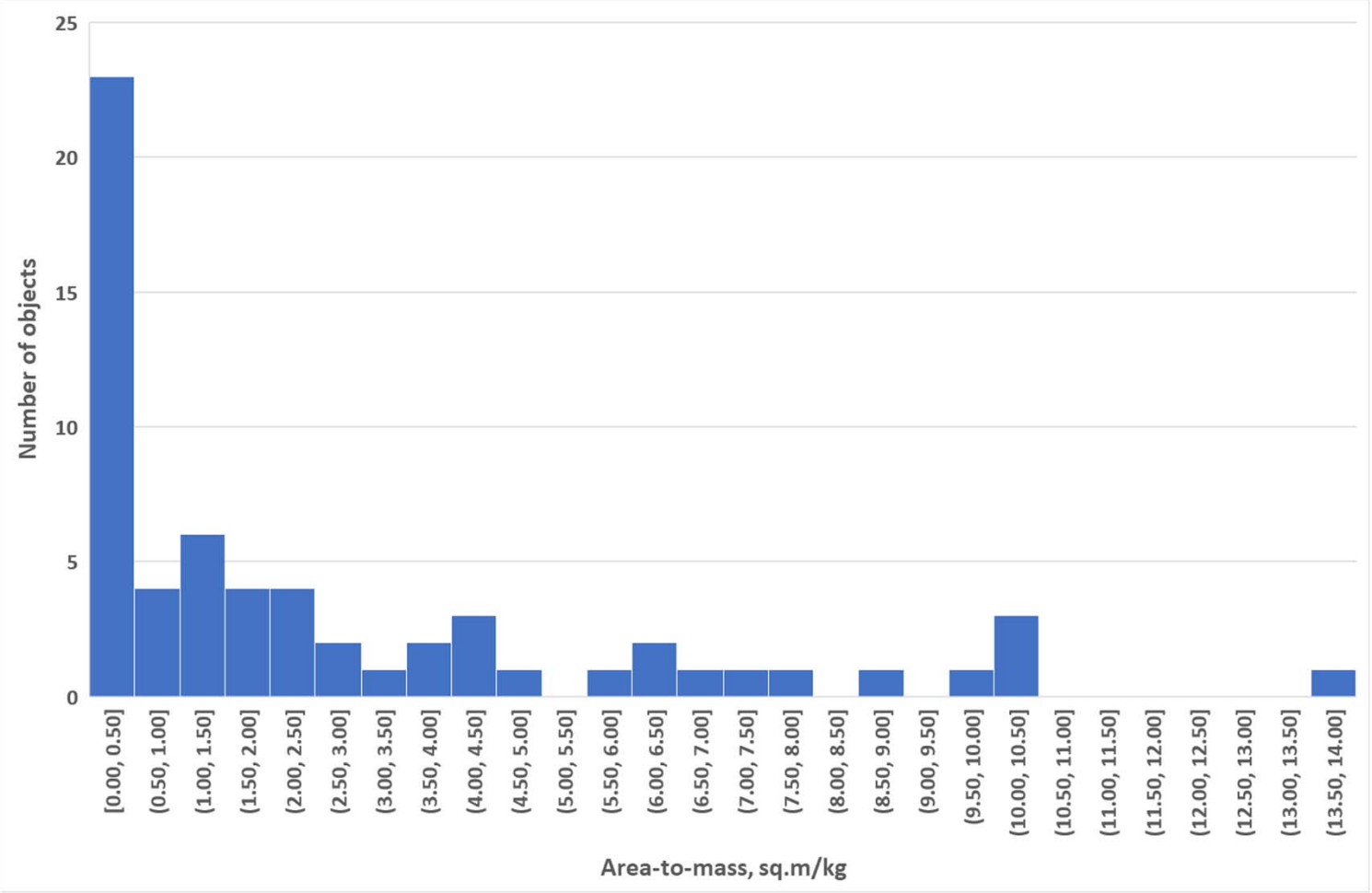
Fragment's along-track propagation uncertainty at 21:00 UT on Feb 28, 2018



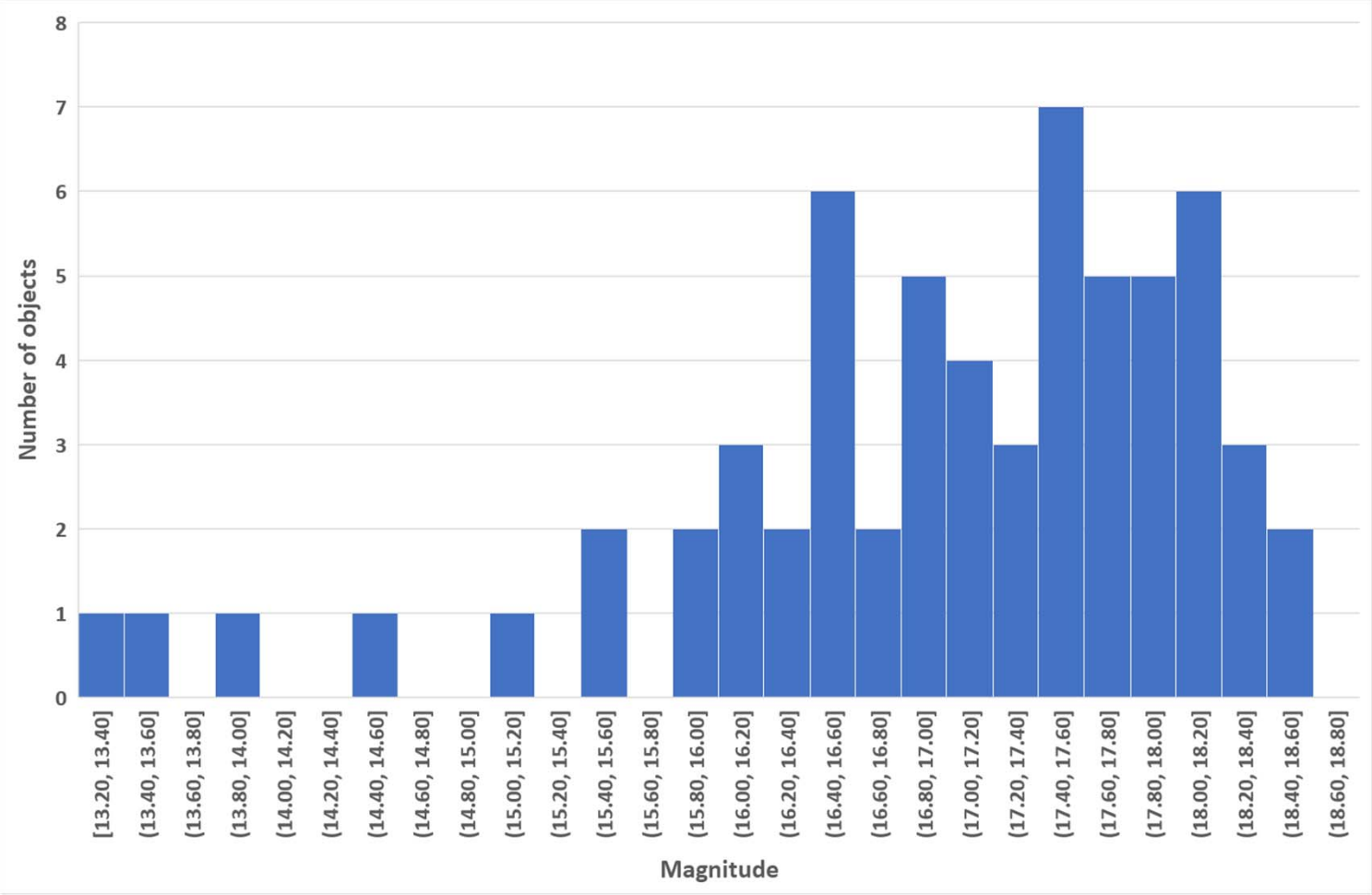
Characterization of the SSN #3692 fragments

- 61 objects having well established orbits were identified as the SSN #3692 fragmentation debris appeared in orbit on Feb 28, 2018
- 23 analyst objects have yet to be observed additionally in order to get sufficiently reliable orbits for analysis
- 26 of identified fragmentation debris have area-to-mass ratio less or equal to 1 sq.m/kg, all others – more than 1 sq.m/kg
- Standard magnitude (observed visual magnitude adjusted to 40000 km range and 0 deg phase angle for the diffuse sphere model) is dispersed between 13.2 and 18.6

Area-to-mass distribution for identified fragments of SSN #3692



Standard magnitude distribution for identified fragments of SSN #3692



Characterization of the SSN #3692 fragments

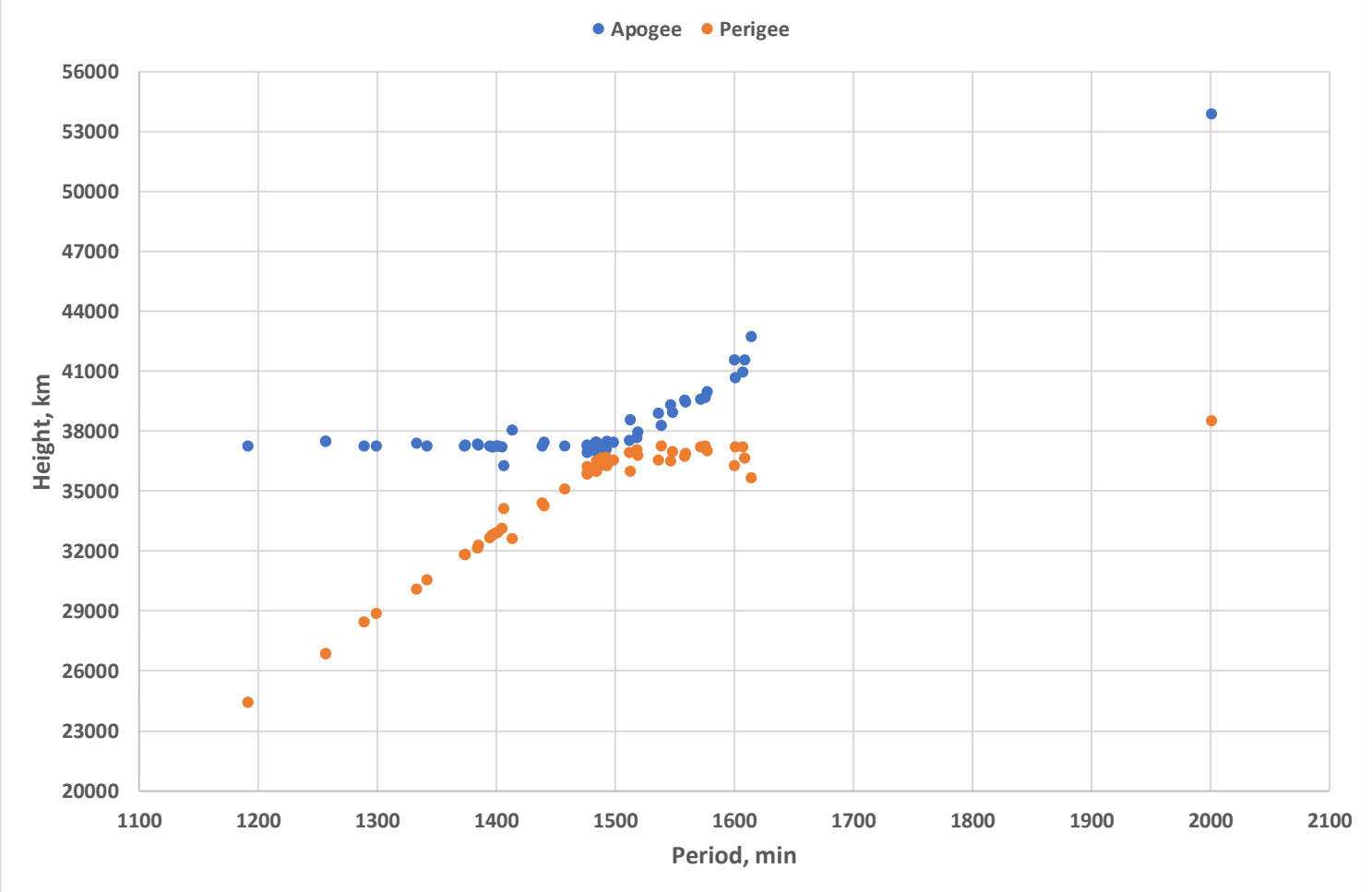
- Orbital period of all but one identified debris dispersed between 1190.7 and 1614.3 min (SSN #3692 – 1476.4 min)

  One object has period of 1999.7 min

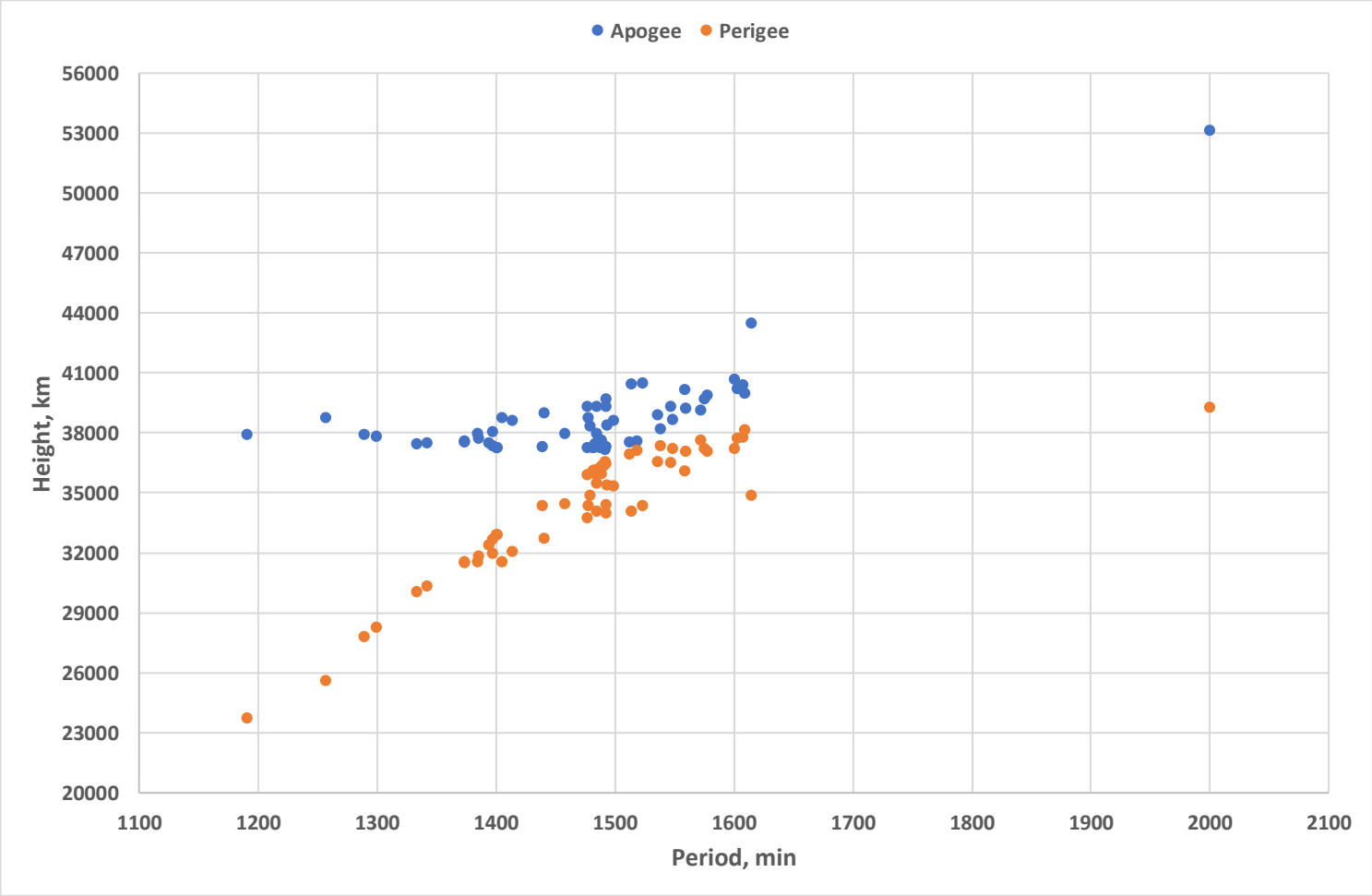
- Inclination at the moment of fragmentation was dispersed between 5.45 and 7.40 deg (SSN #3692 – 6.15 deg)

- RAAN at the moment of fragmentation was dispersed between 288.16 and 316.86 deg (SSN #3692 – 301.3 deg)

Gabbard diagram based on orbits propagated at 21:00 UT on Feb 28, 2018



Gabbard diagram based on current orbits



Conclusion

- Transtage SSN #3692 have experienced the fragmentation on Feb 28, 2018
- This is the second fragmentation of the SSN #3692
- 61 objects were identified as debris appeared in orbit due to this event
- 23 more objects do not have sufficient amount of observations yet for making definitive conclusion regarding their origin, orbital and physical properties
- Majority of discovered debris are quite faint therefore large aperture telescopes (preferably 1 m and more) are required for their regular observation
- Identified debris of the fragmentation dispersed in a very wide range of altitudes (23000-44000 km, possibly up to 53000 km)
- Due to significant difference in orbital period and eccentricity debris of the fragmentation have already dispersed across entire GEO belt

Thank you for your attention!