Tracking and Identifying Anonymous ISON Satellites

By Brad Young

Amateur satellite observers, including myself, rely on symbiotic relationships that involve observations based on predictions, followed by predictions based on observations, as derived by analysis with standard models. The key data derived in this process is the 3-line element set (TLE). The TLE describes, at a certain point in time (epoch) the orbit of a satellite such that its state (position and velocity vector) at any other time can be estimated within limits of accuracy. A satellite position can then be predicted at a specific time of interest if the observer's location is known. [(1)]

The Russian based ISON (International Scientific Optical Network) provides a weekly update of a catalog listing manmade objects in Earth orbit. The ISON Catalog is maintained at http://spacedata.vimpel.ru/ including geostationary space objects and objects with large eccentricity orbits. [(2)] Using this resource, the services of remote telescopes, and the assistance of other amateurs involved in data analysis, and predictive methods, I have been working to identify the "anonymous" objects of this catalog. In doing so, 107 orbiting objects have been identified beyond those previously matched with other sources, and there are five interesting objects that though regularly trackable remain unidentified.

Satellite Tracking and Reporting by ISON and Others

Earth orbiting satellites are tracked by entities the world over. Perhaps the best known is the U.S. Joint Space Operations Center (JSpOC) that provides a wealth of technical information at its data portal https://www.space-track.org/ about most objects on orbit. Its primary mission is Space Situational Awareness (SSA), a slate of products published to inform spacecraft operators of any collision dangers or other unforeseen problems. [(3)] However, there are some satellites that are considered classified, and all or part of their data is not made public.

One of the other main entities that track satellites is ISON, which publishes data via the data portal OJSC Vimpel, which states "Hundreds of previously unknown space debris objects were found, including substantially large objects, that formed over decades of space activity, but which were not duly tracked by ground-based monitoring stations and as a result have been lost." [(4)]

Challenges Involved with Cataloging Earth Orbiting Objects

Besides the ever-growing number of satellites, spent rocket bodies, fairings, etc. that is expected from space exploration and use, there is an ever-growing amount of debris. Unplanned debris is caused by collisions between spacecraft, both accidental and purposeful, explosions or other violent disintegration of existing objects, and the occasional strange mishap such as the tool kit once lost by a spacewalking astronaut. Since even the smallest debris can cause catastrophic damage to operational satellites or manned missions, it is imperative that spacecraft operators are aware of any objects that may threaten their assets (Space Situational Awareness). [(5)]

In addition, although the optical imaging equipment, radio signal receivers, and radar now used for tracking these objects are extremely sensitive, all have limits of resolution. Small objects, especially as orbital height increases, are, as one would expect, more difficult to track.

The Seeds of This Project

In the end, there are a large, ever-growing number of objects that appear in the ISON catalog as published by JSC Vimpel. Most of the objects have been identified with either unclassified targets that are already reported by JSpOC at the Space-Track data portal, or classified missions. ISON reports its matches via the *datefirst.txt* file, updated regularly at the JSC Vimpel data site.

Many previously unidentified objects in the ISON catalog were matched with objects tracked by hobbyists. But, as is often seen with large repositories of data, there were many remaining objects regularly followed by ISON but not identified with any known satellite.

Beginning in 2018, I set out to try to identify more objects by imaging these objects myself. The purpose was to determine if any of the remaining catalog objects would be candidates for tracking by the amateur community. I also hoped to match some of these objects with either known unclassified or classified objects already appearing in the amateur list of targets.

This proved to be as rewarding and demanding a project as I have enjoyed in forty years as an amateur astronomer. I had no experience with imaging until 2016, when I began citizen science efforts such as Target Asteroids and variable star photometry (AAVSO). By building on those experiences, using remote telescopes, and the feedback other amateurs, I began addressing a set of goals.

Scope of the Study

Among the hundreds of ISON objects are most of the classified satellites tracked by hobbyists. Through the arduous efforts of many observers and analysts, most of the classified objects were correlated with ISON objects prior to this study. However, there remained a fair number of objects being routinely tracked by ISON that were reported to have standard magnitudes of 7.5 or brighter. This indicated these objects might be independently monitored by hobbyists, and perhaps identified. I had been observing ISON objects but had not systematically approached tracking them. I developed an unidentified ISON target list, widened my approach with global remote imaging, and set these goals:

1. *Identify more of these anonymous ISON objects using the Space-Track and hobbyist TLE files*
2. *Determine which objects are consistently trackable using equipment available to amateurs*
3. *Identify origin of objects that are trackable but do not directly correlate with known objects*

Methods

Objects were selected based on several factors:

- Standard magnitude of 7.5 or brighter
- Consistently reported by ISON
- My observations before this study were discarded

Predictions were made using the weekly updates provided at the JSC Vimpel data portal, and all observations via remote imaging using equipment available to amateurs. Positional reports were made using Astronomica and converted to the format used by satellite analysts.

Results

1. *Identify more of these anonymous ISON objects using the Space-Track TLE files*

The process consisted of the following steps:

- Check objects against the datefirst.txt file from ISON that lists items matched to JSpOC objects
- If the item has not been matched, consider it an anonymous ISON target
- Where one of the anonymous ISON targets appears to be a known JSpOC object, use the TLE of the known object at the epoch closest to the ISON report and compare.
- If the anonymous ISON target does not appear to be a known JSpOC object, either by matching it with datefirst.txt or comparison to JSpOC elements, it remains a target.

2. *Determine which unmatched anonymous objects are consistently trackable using equipment available to amateurs*

Several of the brighter objects have proven to be trackable, using commercially available remote imaging and other resources available to the amateur community. There are five relatively bright, consistently trackable objects, as shown on Table 1:

TABLE 1

Consistently Trackable Objects

Orbit details based on latest (May 2022) elements

ISON Catalog Number	Duration (days) of Tracking	Standard Magnitude (per ISON)	Inclination (ι) °	Mean Daily Motion (n)	Implied Type of Orbit	Possible Type of Object
52400	401	6.5	63	3.14	Molniya	Debris
62800	1,331	4.5	6	2.32	Geo Transfer	Rocket Body
105100	473	6.5	2	1.37	Geo Transfer	Debris
141410	864	4.5	19	1.02	Retired Geosynchronous	Payload or Rocket Body
142403	813	5.5	4	1.01	Geosynchronous	Payload or Rocket Body

3. *Identify origin of objects that are trackable but do not directly correlate with known objects*

Common methods used to identify the origin of tracked orbiting objects include estimation of orbit evolution, visual characteristics, and historical launch and maneuver data (where available)

Only the five objects above were found to be reasonably trackable, and not currently included in the JSPOC or hobbyist file for classified objects *classfd.tle.* Long-term study may lead to positive identification; however, orbital characteristics and brightness do suggest the type of object listed.

Results

Over the course of the effort, 852 objects from the ISON catalog were observed or analyzed to determine ones that were trackable and potentially identifiable. 468 objects were reported with at least one set of positional data. Most of the observed objects were matched with known debris. However, 107 of the objects identified as JSpOC objects are not tracked by ISON.

Most interesting is that about 25 ISON objects have been tracked occasionally, and five tracked consistently and over several years, that can't be matched to any of the 52,000+ JSPOC objects.

From Here

There is potential for amateur satellite observers to act in an important citizen science role to provide a niche service to increase the level of Space Situation Awareness. This can be achieved both by observation and data mining between sources of orbital data. Identification of unknown objects is an exciting and challenging effort; the reward may be as much in approaching the problem and executing the plan as in the specific results. My hope is that this type of approach will foster open exchange of data, encourage amateur satellite tracking, and provide in some small way, an increase in our scientific knowledge. This project has been enlightening for me, as I had the opportunity to work with some great people whose proficiency in a very narrow field is astounding.

Acknowledgements

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References

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