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Lessons Learned from Tracking and Identification for Rideshare LEOP Support

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Abstract

The growing popularity of small satellites and the demand for affordable launch services has led launch providers to rideshare missions as a cost effective solution for getting their customers to orbit. This has created a new challenge for the SSA community. With some launchers deploying over 100 satellites, cataloguing these new objects is difficult and takes time. This can cause problems for operators who need to establish reliable communications with their satellites as soon as possible to ensure mission safety and begin commissioning. Satellites can be lost if operators cannot establish communications soon enough. Even when reliably tracked and catalogued, accurate identification poses a significant problem, with some payloads never making it to the catalogue.

Neuraspace has supported operators on SpaceX Transporter and Bandwagon rideshare launches. In this paper we present an analysis of the number of rideshares and payloads to illustrate the scale of the problem facing SSA systems. We then examine the time to catalogue for these payloads under the current system.

The primary need from operators is the provision of TLEs with sufficient accuracy to establish two-way communication with the satellite. A comparison is made between initial propagations of the state vectors supplied by the launch provider, and the GNSS data obtained from the satellite, in order to analyse the size of the error that can develop over the period before cataloging. We then discuss the choice of orbit determination method, in this case the Batch Least Squares, and its application to both optical tracking and GNSS data, along with their advantages and limitations.

The next section describes some lessons learned from supporting a number of payloads launched on rideshare missions. We discuss issues with obtaining data and orbit determination, advantages and limitations of optical tracking and techniques to optimise the chances of successfully tracking a satellite. Optical tracking data was provided by Neuraspace's telescopes and we also address the advantages of multiple sensor locations and geographical considerations.

Next we examine the actions that could be taken by spacecraft manufacturers and operators to improve identification and tracking in the days after deployment. Finally we conclude with some takeaways on best practice for rideshare deployments, with a view to maximising the chances of successfully tracking the payload from deployment to its inclusion in the Space-Track catalogue.

1. Introduction

The recent trend towards cubesats and smallsats has led to many changes in the way the industry operates. A key result has been a dramatic reduction in the cost of satellites together with an increase in the number of payloads launched. This has inevitably led to a focus on reducing the cost of launch. A dedicated launch can be more than the procurement cost of many smaller satellites and could render business cases unviable.

The launch industry response to this demand to deliver large numbers of small satellites to orbit on a budget has been the rideshare launch, some of which deploy over a hundred payloads.

Another result of the push to reduce costs, together with the growth in relatively simple cubesat class architectures has been the reduction in size of satellite operations teams. Smallsat operators have found it hard to justify employing specialists in areas such as Space Surveillance and Tracking (SST) and flight dynamics. As a result there has been much more reliance on what is available "for free", predominantly from Space-Track.

The combined effect of proliferating rideshare launches together with operators who do not independently track their spacecraft has been significant difficulties in identifying and cataloging payloads launched as part of these rideshares. Increasing concern about this situation is reflected in the ESA Space Debris Mitigation Requirements [1], result of ESA's Zero Debris policy.

Having worked with a number of small satellite operators, Neuraspace has seen some of the issues, misconceptions and mistakes that have lead to problems during the Launch and Early Operations (LEOP) phase and has put together this paper to offer some guidance to smallsat operators who are planning to make use of a rideshare.

2. A Review of Rideshares

For the purposes of this paper when we refer to a rideshare launch we are referring to those missions deploying dozens of satellites from many different operators. Of course, it has long been common for multiple payloads to be launched on one launch vehicle, but Ariane launches deploying two large GEO satellites or Starlink launches do not result in quite the same issues we discuss here. In particular these examples have very experienced operational teams and much more resources than a typical smallsat operator.

Rideshare launches, like most other launches, have come to be dominated by SpaceX with their series of Transporter (and to a lesser extent Bandwagon) missions. Transporter missions deploy satellites to a Sun Synchronous orbit around 550km, something that we will return to later. Bandwagon launches deploy satellites in mid inclination orbits at around the same altitude. Advertised launch costs are $6,500/kg [2].

Other than SpaceX several other launch providers have performed rideshare missions, such as ISRO with the PSLV, Arianespace with Vega and Rocketlab with Electron. No doubt we can expect more of this from other launch vehicles and providers over the next few years.

For now though, we will take a look at the Transporter missions to illustrate the cataloging problems we have mentioned. Some previous analysis of identification success rates for cubesats launched on mainly PSLV rockets can be found in [3].

2.1 Transporter Launches and Payload Numbers

Since the launch of Transporter-1 in 2021, SpaceX has launched (at time of writing) 14 Transporter missions Fig. 1. These have carried from 40 to 143 payloads.

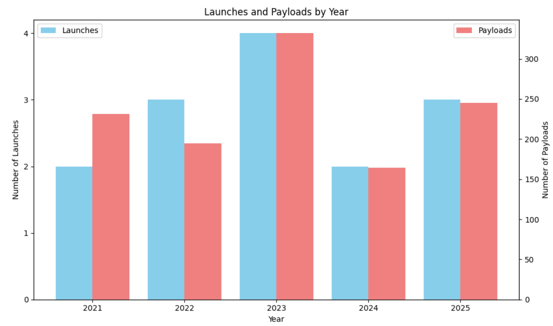

Fig. 1. Number of Transporter launches and total payloads per year.

Despite the high correlation between the number of launches and the number of payloads, the number of payloads actually varies widely, as can be seen from Table 1 in Appendix A. At the time of writing, a further launch was expected for October 2025.

We can then assess the time between the launch date and the first available TLE for these launches, and the fraction catalogued after 1, 2, 3, and 4 weeks shown in Fig. 2. This reveals a large variation in the time taken to catalogue payloads. However it is likely that operators would have to wait between 2 and 3 weeks, with a non negligible fraction not being present in the catalogue even after 4 weeks from the date of launch.

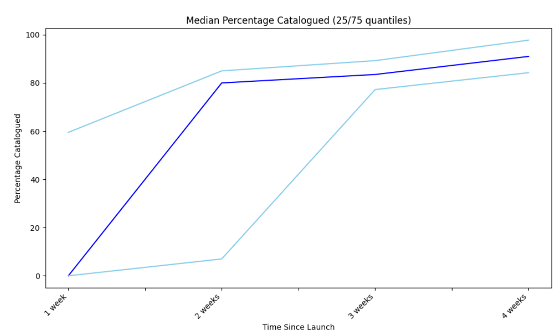

Fig. 2. Fraction of total payloads catalogued at set intervals after launch.

We note that some payloads may be deployed later from orbital transfer vehicles. We have not attempted to account for this, so these cataloging figures should be treated as indicative rather than exact.

Currently SpaceX impose a 7 day no-manoeuvre window for spacecraft deployed from its rideshare missions [4] in order to allow time for the deployed spacecraft to disperse. This directly conflicts with the requirement from ESA that a spacecraft are ready to manoeuvre within 2 days of deployment [1] for the sake of collision avoidance.

Clearly if these two are to be reconciled, it will be necessary to achieve faster identification and orbit determination to ensure that manoeuvres can be conducted safely even soon after launch. For now the launcher imposed requirements are interpreted as taking precedence over the ESA requirement, an approach the ESA's Space Debris office has accepted [5].

3. Deployment and First Signal

The first and most important step an operator takes after launch is to establish communications. Any delay is at best lost time and at worst may lead to a loss of mission.

In order to successfully communicate with the satellite, we must maintain a sufficiently accurate estimate of the orbit. The plots (Fig. 3, Fig. 4) below illustrate how the accuracy of the initial orbit prediction (from the deployment vector) degrades over time. SpaceX recommends that the initial orbit estimate is updated as soon as possible using either onboard GNSS data or ground based tracking [4]. The comparison was made against GNSS data obtained from the onboard receiver.

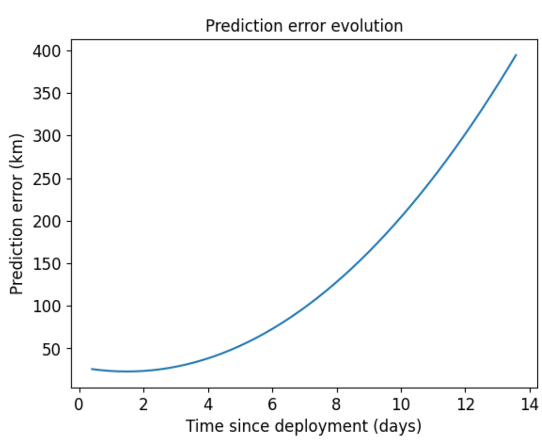

Fig. 3. Deployment state vector prediction error - Satellite 1.

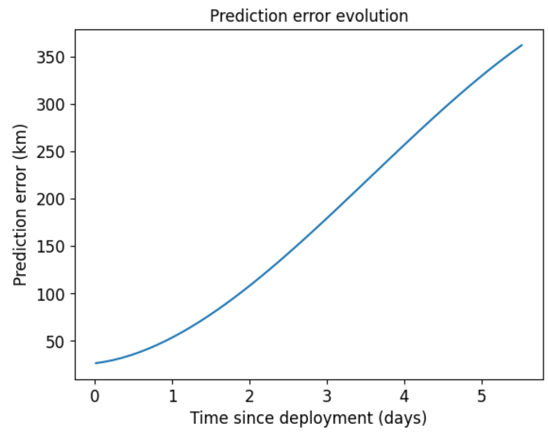

Fig. 4. Deployment state vector prediction error - Satellite 2.

While working with several operators, Neuraspace has observed significant variation with the time to, and reliability of, acquisition of signal. This suggests that there is significant room for improvement in the industry via sharing of best practices for satellite design and sequencing of commands to be executed upon deployment.

Priority should be given to establishing communications as soon as possible, even if the satellite is tumbling as a result of deployment, and to achieving a sustainable power budget to avoid a race against time. Given that a number of operators reliably achieve acquisition of signal on first pass, this is an achievable goal with preparation and application of best practices.

4. Space-Track

Space-Track forms the backbone of global space situational awareness (in fact Space-Track is dependent on 18th Space Defence Squadron for its data and capabilities, but we will just refer to Space-Track here for simplicity). It provides the only publicly available large scale catalogue of space objects, a catalogue maintained by its network of ground based radars. It also provides all-vs-all conjunction screening services, along with screening for operator specified manoeuvres and ephemeris [6].

A certain amount of information is available on how Space-Track processes data, but given that the analysis is provided by a military unit, there will always be a limit on transparency and data sharing. Additionally, the Space-Track service was built at a time when LEO in particular was far less congested. The new TraCSS platform may provide a significant step forward, but it is still in the development phase.

Nevertheless, Space-Track is a free and enormously valuable resource that many satellite operators rely on.

The main disadvantage of relying solely on Space-Track is highlighted in the earlier section describing the time to catalogue. Cataloguing and identifying 100 small satellites is a difficult task and may not be their highest priority.

The key point we want to highlight here is that it is mutually beneficial to share as much data as possible. TLEs for objects that have been tracked but not yet catalogued are available, and this can provide valuable cues for ground based tracking and signal acquisition. In Neuraspace's experience, whenever an object has been tracked from launch and/or GNSS data is available it has been relatively straightforward to correlate that object with the TLEs that Space-Track is tracking.

5. Orbit Determination

Over the next two sections we will mention the need for orbit determination methods to be applied. While supporting LEOP operations, Neuraspace's flight dynamics team has preferred to use a Batch Least Squares algorithm for orbit determination. The principal alternative would be one of the many flavours of Kalman filter such as EKF or UKF. These have the advantage of potentially producing a realistic covariance as well as the state vector. However we have opted for the more basic BLS for the following reasons.

- Simplicity - a BLS algorithm requires only an initial state estimate to initialise the orbit determination process. By contrast a Kalman filter requires a covariance estimate as well as a process noise model
- Robustness - a batch algorithm can converge even from a poor initial estimate. It is also less sensitive to configuration errors. A sequential filter on the other hand can produce very poor results with an inappropriate configuration of process noise
- Data availability - during LEOP, measurement data may be sparse and irregular. Batch methods are well suited to fitting small volumes of data or data with large gaps.
- Outlier rejection - outlier rejection is simple to implement on a batch method
- Consistency metric - the reduced chi-square can be used as a sanity check in the fit obtained, whereas no such simple metric is available for a Kalman filter. If using outlier rejection however it is important to interpret this alongside the number of observations accepted or rejected
- Drag fitting - since the drag force is the largest source of error in LEO, it is desirable once sufficient tracking data has been obtained to fit the drag coefficient and obtain a more realistic value. The BLS is ideally suited to fitting an unobservable parameter such as drag or SRP effects.

Overall the objective of orbit determination straight after launch is to obtain a "good enough" solution in order to maintain custody of the object and allow communication, despite the low volume of tracking data available and a lack of calibrated propagation parameters. As a very rough guide errors of 20km after 3 days should keep a satellite in a telescope's field of view long enough allow more than one visible pass, though this will clearly depend on the sensors being used and the observability of the orbit. This can favour different orbit determination methods from those planned for the routine phase of a mission.

5.1 Drag and Atmospheric Models

Incorrect modeling of the effects of drag on the spacecraft is the next biggest concern after obtaining a reasonable state vector. Even with a highly accurate state vector, a modest error on the drag force can easily accumulate 10's of km of error over a few days. It is therefore important to configure the drag model correctly. Based on the expected behaviour of the satellite it should be possible to calculate the expected cross sectional area in the velocity direction, and the launch mass will be known accurately. It is also possible to estimate the drag coefficient, otherwise a default of 2.1 is generally recommended. In this case we strongly recommend using an atmospheric model such as NRLMSISE-00 which takes into account the most up to date space weather (as opposed to a model such as Harris-Priester which does not). This gives the best chance of realistic modelling. Once sufficient orbit data is accumulated, the drag coefficient can be estimated from the long term behaviour of the spacecraft.

An alternative if the spacecraft is a "twin" of one already in orbit is to use the calibrated drag coefficient for the first spacecraft as a starting point. Obviously in this case the coefficient should be used with the same atmospheric model and configuration for which it was fitted in order to provide a good estimate.

Changes in configuration or behaviour such as deployment of solar panels or detumbling will alter the drag effect and should be reflecting in the configuration used.

6. GNSS

Most smallsats now have onboard GNSS receivers, such as those from SkyFox Labs and NovAtel. These receivers process the signals from GNSS satellites in order to obtain positions and velocities in ITRF. These may be logged in the NMEA format, although it is simpler to use the custom lines giving accurate times, positions and velocities (in some cases other data about the reliability of the signal is provided).

It is important to understand that the data obtained from these receivers suffers from noise as well as sections of the orbit where signal may be lost. Additionally, orbital states are very sensitive to changes in velocity and it is generally we have observed significant noise in the velocity measurements. Therefore it is important that these measurements are not treated as spacecraft state vectors.

To illustrate the danger, we took a typical segment of GNSS data and selected states at approximately 1 minute intervals to propagate. We compared the results to the orbit obtained from propagating the deployment state. The results are plotted below, and clearly indicate that arbitrarily selecting measurements to propagate can lead to very significant position errors after only a couple of days.

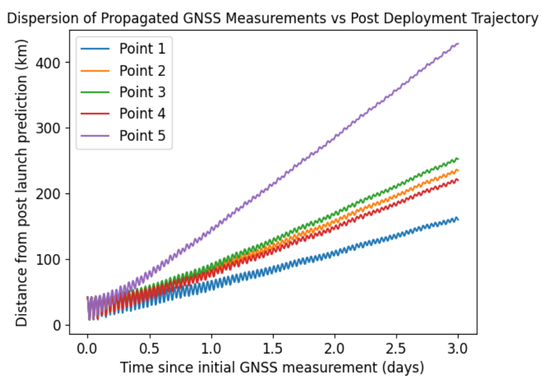

Fig. 5. Position differences for propagated GPS states vs post deployment state vector.

Fig. 5 demonstrates that the noise from the GNSS data can actually be more impactful than the advantage of having more recent data than the deployment state vector. Simply put, propagating GNSS measurements directly can just as easily make the prediction worse rather than better.

In order to avoid mistakes such as these it is recommended to:

- filter GNSS data to remove highly anomalous measurements
- use an orbit determination method such a batch least squares (BLS) on data that spans at least one orbit (gaps are acceptable - see below)
- once 3-4 days have elapsed, a drag coefficient can be fitted over the complete data span to improve future predictions

Despite the fact that most smallsats carry GNSS receivers, they are often not turned on at deployment. The most common reason given for this is power constraints. This is obviously a valid concern, however we believe that the advantages of obtaining GNSS data are such that activating the receivers from deployment should be foreseen. In order to reduce the power consumption it is recommended to reduce the logging frequency. Orbit determination algorithms can easily cope with ”sparse” data and obtaining datapoints consistently every 10 minutes would easily give enough data for a BLS orbit determination after a couple of orbits. Indeed orbit determination based on sparse measurements over a longer span will be much more robust than if a short but dense segment of measurements was used.

To illustrate the improvement in prediction accuracy achieved with an orbit determination soon (24 hours) after launch we present data (Fig. 7, Fig. 9) from the two satellites mentioned above. We have added the error of the GNSS based prediction alongside the deployment state propagation. Both comparisons are made to the same set of GNSS measurements which represents an effective ground truth. We also present the residuals for each fit (Fig. 6, Fig. 8). Extreme outliers have been removed by an outlier rejection process in the BLS algorithm, but some noise remains.

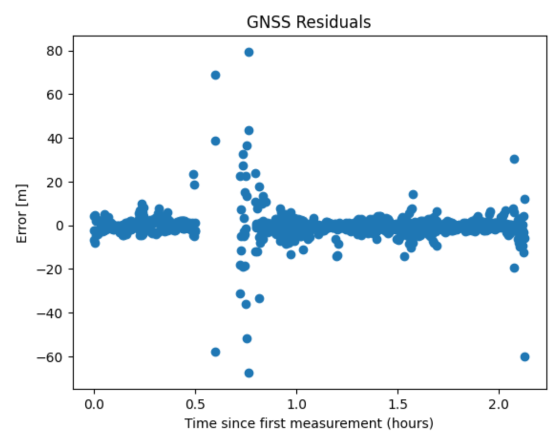

Fig. 6. Residuals resulting from BLS orbit determination process - Satellite 1.

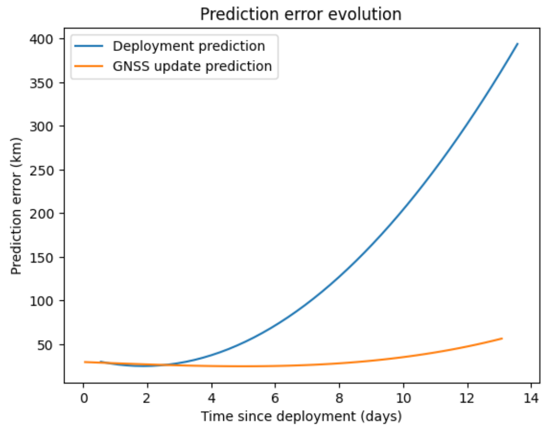

Fig. 7. Deployment & GNSS based OD prediction error - Satellite 1.

And the same plots for satellite 2.

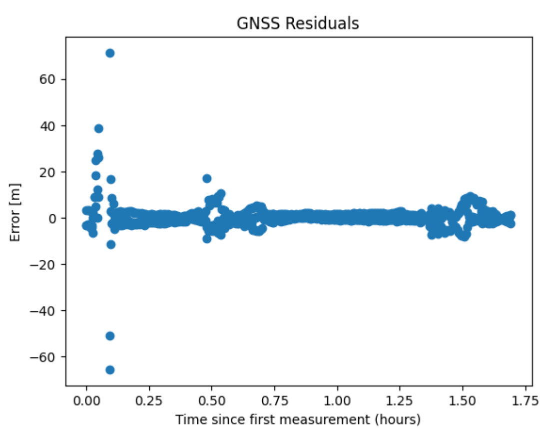

Fig. 8. Residuals resulting from BLS orbit determination process - Satellite 2.

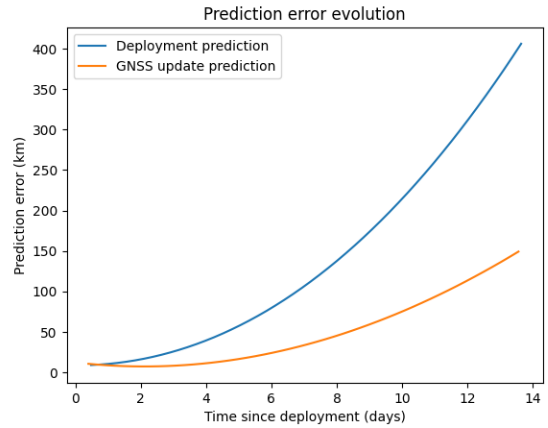

Fig. 9. Deployment & GNSS based OD prediction error - Satellite 2.

In both cases the error is dramatically reduced, even though only 2 hours of GNSS data are available and there has been no calibration of the drag coefficient.

7. Ground Based Tracking

Although we recommend a strong emphasis on obtaining immediate communication with the satellite and obtaining GNSS data as soon as possible, this is not guaranteed and ground-based tracking options can enable you to maintain custody of your satellite even when it is not possible to download GNSS tracks.

This section reviews some of the available ground sensors and identifies their characteristics along with strengths and weaknesses.

It is better to plan ground based observations before launch rather than waiting to see if things go as planned for a couple of reasons.

1. it will generally be cheaper and more responsive as sensor operators can plan the observation campaign in advance

2. the chance of success is much greater if the tracking begins immediately the separation vector is received. The longer you wait the further your satellite is likely to be from the propagated trajectory. Since there has been no opportunity to calibrate things like the drag coefficient, this propagation is unlikely to be a good one, and so it may only take a couple of days for the satellite to be far enough away from the predicted trajectory that it falls outside the field of regard of the sensor. Although it is possible to attempt search patterns, the chance of successfully detecting an object decreases rapidly with time.

Neuraspace has successfully used search patterns to find a satellite that went missing for a couple of days, but has not been successful when contacted by customers that have waited a week or more. However there are various sensor related considerations here and these are outlined below.

Another thing to note is that without other information, ground based sensors generally can't confirm whether an object is yours or someone else's, from 1200km most smallsats look pretty much the same. Although there are some exquisite imaging capabilities available they are not common, and will require highly accurate trajectories before images can be obtained. This is another reason to begin tracking as soon as possible and ideally obtain at least some GNSS tracking data to confirm the identification.

7.1 Radar

Radar is a very effective tracking method, with a significant advantage over laser or passive optical in that it can operate day or night in any weather conditions. However, this capability does not come cheap, and obtaining radar tracking for your mission may result in a non negligible cost increase.

If, however you are prepared to pay for the reliability then it is a good choice. Radars can also be good for finding lost satellites as many operate in a surveillance mode to which they are well suited. There is a good reason why USSF rely on radar as a primary means for keeping track of objects in orbit.

7.2 Laser

Laser ranging of spacecraft fitted with retroreflectors is the gold standard for ground based tracking, providing centimetre level accuracy. It does require onboard hardware in the form of a retroreflector, but this is small, lightweight, and entirely passive. Additionally some companies are developing uniquely identifiable retroreflectors, which would help identify satellites in a situation where multiple reflectors where present.

It is also possible for some sensors to range objects that do not carry a retroreflector although the accuracy is reduced. Daylight tracking may also be possible in some cases.

To use laser ranging a reasonably accurate trajectory estimate is required. Therefore it is best deployed as soon as possible after launch.

The exact restrictions on tracking conditions for laser ranging vary between providers, but they will not be able to track given cloudy weather. Additionally retroreflectors have limited field of reflection, so a tumbling satellite may prove difficult to track. This could be mitigated with reflectors on multiple faces or the use of a number of ground stations.

7.3 Passive Optical

Passive optical tracking (telescopes) is popular as a cost effective method of tracking. Accuracy can vary a lot depending on the sensors used.

Sensors can broadly be divided into surveillance and tracking.

- Surveillance telescopes will have a wide field of view and will stare at a certain point in the sky and wait for satellites to pass overhead. They will then collect a brief track with relatively low accuracy. Surveillance systems are good for keeping track of a large number of objects or for finding lost satellites.
- Tracking telescopes will have a narrower field of view and will track an object across the sky using its expected trajectory. Since they move to "keep up" with an object the tracks can be much longer and of higher accuracy. On the other hand, if the object falls outside the narrow field of view because it is too far from the prediction then no data will be obtained.

Neuraspace's telescopes (see Fig. 10) are tracking telescopes, allowing accurate orbit determination with only a couple of tracking passes [7], but requiring a moderately accurate orbit estimate.

7.3.1 Limitations

Passive optical sensors have one particularly important limitations relating to Transporter launches in particular. It was mentioned earlier that Transporter launches deploy satellites to SSO, an orbit which is popular for remote sensing missions in particular. Unfortunately, SSOs are difficult to observe, particularly at certain times of the year.

In order for a passive optical telescopes to successfully track an object, the object must be illuminated while the telescope is not. In practice this means that for LEO satellites, tracking opportunities will occur close to dawn and dusk (i.e. close to the terminator). During the middle of the night, the spacecraft will also be in the Earth's shadow. For Transporter launches the LTAN/LTDN is relatively close to midday/midnight, meaning that the Sun is not far outside the orbital plane. By definition the time at which the SSO crosses various latitudes is consistent.

For a midday/midnight SSO then, it would cross the terminator close to the poles, making it very hard to observe from lower latitudes where optical tracking systems tend to be placed.

The Earth's tilt adds a further effect, and means that SSO's can most easily be observed during local summer, and not during local winter. The result is reasonable trackability close to the solstices (assuming sensors in both

Fig. 10. Neuraspace's optical tracking telescope

North and South Hemispheres) and a lack of tracking close to the equinoxes.

The following two plots illustrate the difference in trackability between similar satellites, one of which is in SSO (Fig. 11) and the other in a mid-inclination orbit (Fig. 12. Neuraspace's two telescopes in Portugal (NOWL) and Chile (SOWL) were used for this tracking campaign.

By contrast a mid inclination orbit is much more trackable.

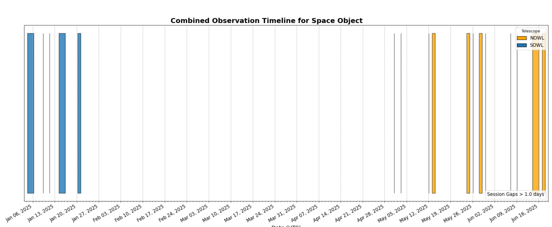

Fig. 11. Tracking for SSO satellite over a period of 6 months

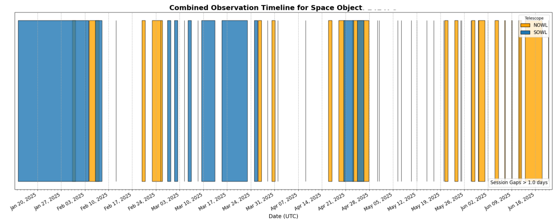

Fig. 12. Tracking for mid-inclincation satellite over a period of 6 months

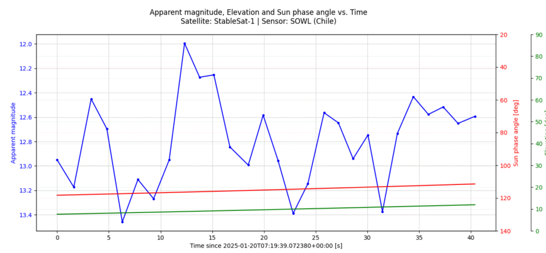

Fig. 13. Apparent magnitude plot for a stable satellite.

7.3.2 Understanding Anomalies

One capability of optical tracking telescopes is their ability to produce photometeric data (data on the brightness of the object observed). For a horizon to horizon tracking telescope like those operated by Neuraspace, it is possible that during a good pass measurements can be collected every couple of seconds for a minute or so.

Of course the observed brightness of the satellite depends on a number of factors such as the materials, range, sun phase angle, satellite attitude relative to the sun and observer, atmospheric conditions, etc. However, it is possible to infer from the change in brightness over the pass something about the behaviour of the satellite. A strong periodic pattern with large changes in the brightness likely indicates a rotating satellite for example. Examples of these apparent magnitude plots are given in Fig. 13 (stable) and Fig. 14 (tumbling).

Consequently, this can be a useful technique to use

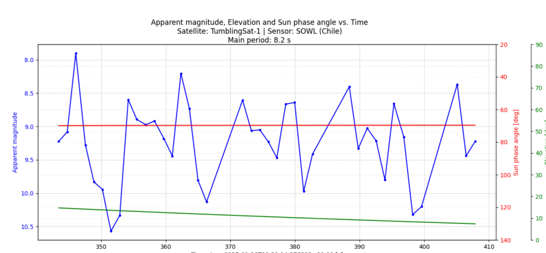

Fig. 14. Apparent magnitude plot for a tumbling satellite.

when a satellite is not contacted during an expected ground pass. Obtaining some optical tracking data can confirm two useful things about your satellite:

1. is it where you think it is?
2. is it stable or tumbling?

Having these two critical pieces of information will inform recovery plans. Neuraspace has used astrometric data on multiple occasions to help diagnose anomalies.

Note that it is very difficult to answer specific questions like "did all my solar arrays deploy properly?" from this sort of data.

7.4 Trackability Augmentation

Ideas put forward for improving small satellite trackability include radio beacons, LED arrays and laser retroreflectors. Here we very briefly discuss the features of each of these methods, a slightly more in depth discussion is provided by [3, 8].

- Radio beacons - provide a simple method to identify a satellite that is passing overhead, but they are unlikely to provide sufficient accuracy to uniquely identify a specific satellite immediately after a rideshare deployment. They should however prevent a satellite from becoming entirely lost and eventually allow it to be identified.
- LED arrays - as discussed in [9], LED arrays could provide positive identification and assist optical tracking (e.g. allowing tracking when the satellite is in eclipse). However they will increase the power consumption of the satellite and may also violate dark sky guidelines.
- Retroreflectors - can help provide very accurate orbit determination, however they have a limited field of reflection (potentially an issue if the satellite is tumbling), and may not provide unique identification if they become a popular option. Some companies are looking at making retroreflectors that have a unique signature, and this would be a significant help in this regard.

8. Conclusion

In order to allow all parties to continue to use space safely it is vital that the space community tracks, identifies and catalogues objects as soon as possible after launch. Unlike other areas of space traffic management this is one situation where operators have a strong incentive to invest in better solutions.

There is however a steep learning curve to space operations, and the difficult LEOP phase most of all. We worked with several operators to successfully track and identify their spacecraft soon after launch, and in this paper we have presented a few lessons learned along the way. With careful application of best practices, a rapid acquisition of signal and effective orbit determination are achievable. Although others are better place to comment on best practice around spacecraft deployment routines and communications, our recommendations are:

- Start planning early
- Carefully plan acquisition of signal and download of GNSS data
- Minimise GNSS receiver power consumption by reducing logging frequency
- Use appropriate orbit determination techniques rather than propagating single GNSS measurements
- Work as closely as possible with Space-Track
- Consider ground based tracking - but understand what is achievable
- Calibrate drag coefficients, but take care not to overfit with short fit spans. Alternatively use a coefficient calibrated from a existing but identical satellite.
- If things go wrong, get support sooner rather than later

Neuraspace is pursuing several improvements to its LEOP services including automated, end-to-end tracking, identification and orbit determination, GNSS measurement integration and AI/ML based approaches to cleaning outliers from datasets, making orbit determination from sparse data more reliable.

Acknowledgments

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Appendix A - Transporter Rideshare Data

Table 1. Payloads launched and catalogued on Transporter Rideshare missions

Transporter	Payloads Launched	Objects Catalogued	Payloads Catalogued	Launch Date	Earliest TLE	Latest TLE	1 week (%)	2 weeks (%)	3 weeks (%)	4 weeks (%)
1	143	148	139	2021-01-24	2021-01-24	2021-05-19	79	85	87	90
2	88	88	88	2021-06-03	2021-06-30	2021-07-28	0	0	0	1
3	105	106	99	2022-01-13	2022-01-18	2022-02-10	90	90	90	99
4	40	38	38	2022-04-01	2022-04-03	2022-05-16	81	84	92	94
5	59	51	48	2022-05-25	2022-06-01	2022-12-29	0	82	82	84
6	114	104	99	2023-01-03	2023-01-13	2024-01-17	0	28	91	94
7	51	48	48	2023-04-15	2023-04-15	2023-06-26	81	85	85	85
8	72	73	66	2023-06-12	2023-06-20	2024-08-12	0	78	78	90
9	90	107	95	2023-11-11	2023-11-28	2024-04-08	0	0	81	81
10	53	51	40	2024-03-04	2024-03-13	2024-03-13	0	100	100	100
11	42	113	108	2024-08-16	2024-08-28	2024-09-12	0	77	77	100
12	101	112	97	2025-01-14	2025-02-10	2025-04-08	0	0	0	0
13	74	66	48	2025-03-15	2025-03-18	2025-05-13	1	86	86	92
14	70	67	19	2025-06-23	2025-07-17	2025-07-17	0	0	0	100