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PERFORMANCE ASSESSMENT OF VLEO SENSORS FOR SPACE SURVEILLANCE AND TRACKING

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Over the past decade, smaller and more affordable spacecraft have driven a sharp increase in satellite launches, particularly for communications and Earth observation. This growth has crowded Low Earth Orbit, raising concerns about space traffic and debris. As a result, the Very Low Earth Orbit, below 450 kilometers, is gaining interest for its natural debris mitigation properties. Its geometry also offers unique advantages for tracking space objects, with fewer Earth obstructions and faster revisit times. This study explores the feasibility of space surveillance and tracking missions in this region through geometric analysis and sensor modeling, aiming to inform future mission designs and strategies.

INTRODUCTION

Over the past decade, advances in miniaturized components and manufacturing techniques have significantly reduced the size, cost, and complexity of designing and launching spacecraft.[1] This evolution has lowered the barrier to entry for private actors while accelerating governmental and institutional programs. Consequently, the annual satellite launch rate has surged, especially for communications and remote sensing missions.[2] Most of these missions operate in higher Low Earth Orbit (LEO), above 450 km, to minimize atmospheric drag and extend orbital lifetimes. However, this altitude range is becoming increasingly congested. The number of resident space objects (i.e., both active satellites and debris) is growing exponentially, increasing the probability of collisions and endangering the long-term sustainability of space operations.[3]

In response, attention is shifting to the lowest portion of LEO, commonly referred to as Very Low Earth Orbit (VLEO), located below 450 km, which offers several strategic advantages.[4–6] Chief among them is the natural atmospheric drag, which acts as a self-cleaning mechanism: decommissioned objects deorbit more rapidly, limiting long-term debris accumulation. Although VLEO platforms are primarily optimized for Earth Observation (EO) and telecommunications due to commercial drivers, their combination of low altitude and high relative motion also makes them well suited for Space Surveillance and Tracking (SST). From VLEO, most resident space objects lie above the observer, enabling sensors to maintain unobstructed views and perform more frequent observations without Earth occlusions. This geometric benefit has led to novel mission concepts, including the European Defence Agency's LEO-to-VLEO constellation for crisis response,[7] suggesting a growing institutional interest in leveraging VLEO for multiple types of mission. Accordingly, SST emerges as a promising complementary function in this regime, whether as an opportunistic add-on to existing EO or telecom missions, or through dedicated VLEO SST payloads designed to benchmark performance against proposed state-of-the-art LEO systems (e.g., Vyoma, NorthStar).

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Motivated by these trends, this work investigates the feasibility, challenges, and benefits of operating SST payloads in VLEO. Specifically, we evaluate whether the increased revisit rates and improved target visibility can enhance tracking performance. Our approach consists of two complementary stages, detailed in the methodology section of this paper. First, a geometric analysis explores the fundamental observability constraints across a large set of real orbital objects, establishing the key advantages of VLEO SST. Second, we conduct a detailed performance assessment that incorporates realistic sensor models and orbit determination algorithms, focusing on a subset of objects with known characteristics. Together, these analyses aim to define optimal payload configurations and provide a roadmap for deploying SST capabilities in VLEO. The results highlight not only the potential advantages, but also the design and operational challenges unique to this orbital regime. The paper begins with a detailed assessment of the benefits and limitations of VLEO, emphasizing how its expanding adoption for commercial and institutional missions motivates early-stage analysis of SST potential in this increasingly important environment.

STATE OF THE ART IN VLEO MISSIONS

Reducing orbital altitude compared to conventional LEO offers a wide range of design and operational advantages, particularly for small satellite platforms. At lower altitudes, optical payloads benefit from significantly improved ground resolution, which scales linearly with decreasing altitude.[4] Even off-nadir observations benefit from this proximity, despite the degradation introduced by Earth's curvature at higher viewing angles.[6] Radiometric performance and communications link budgets also improve, as the received signal power increases with the inverse square of distance,[4] enhancing the signal-to-noise ratio (SNR) and reducing latency.[5] However, these gains come at a cost: reduced swath widths, shorter integration times, and, in off-nadir configurations, elevated atmospheric noise due to longer path lengths through denser air layers.[6] The faster orbital periods associated with VLEO improve communication latency, but also shorten visibility windows with ground stations, which constrains data downlink capacity per pass. Furthermore, revisit times at very low altitudes ($\approx$130–175 km) tend to be poor,[6] limiting persistent coverage. Radiation effects are significantly mitigated in VLEO as illustrated in Fig. 1. Lower exposure to energetic particles reduces material degradation and the likelihood of Single Event Effects, which account for up to 40% of anomalies in LEO.[8] This radiation environment is a key reason why both the ISS and Tiangong space stations operate near the upper limits of VLEO.

A defining feature of VLEO is the increased atmospheric drag, which accelerates the deorbiting of defunct objects and offers a natural compliance mechanism with the IADC debris mitigation guidelines.[4] This self-cleaning effect significantly enhances the sustainability of operations in this regime. Moreover, drag can be exploited for functional purposes: attitude control, formation keeping, and even ground track repeatability.[10,11] However, if unmitigated, drag leads to rapid orbital decay, attitude disturbances, and structural degradation, especially from atomic oxygen, which makes up $\tilde{8}0$% of the atmosphere at these altitudes.[8,12,13] These effects require aerodynamic design optimizations and material selection to minimize drag and material wear.[13,14] To address lifetime limitations, Atmosphere-Breathing Electric Propulsion systems offer a promising solution: by harvesting atmospheric particles as propellant, they limit the need for stored fuel, reduce spacecraft mass, and enable continuous drag compensation.[14,15]

As mentioned in the introduction, VLEO also presents geometric advantages for in-space SST. Since most resident space objects lie above the observer, sensors benefit from an unobstructed line of sight, avoiding Earth occlusion within the field-of-view.[16] This geometry enables more frequent

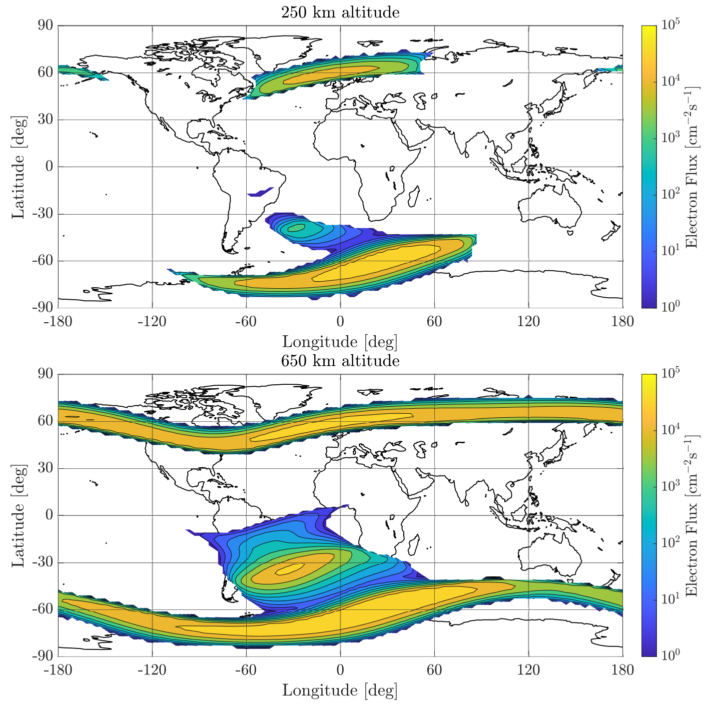

Figure 1. Distribution of electron flux at 250km (top) and 650km (bottom). Data retrieved from ESA SPENVIS[9]

tracking opportunities. However, the high relative velocities between observer and target in VLEO can challenge sensor tracking performance and place greater demands on onboard processing.

From a launch and integration standpoint, VLEO's compatibility with small, lightweight satellites aligns well with the broader New Space economy.[1,17] Reduced spacecraft mass enables cost-effective production, simplified development, and greater access to launch services as rideshare opportunities and through smaller launchers.[5,6,18] As a result, small satellite deployments have skyrocketed, comprising 97% of orbital launches in 2023 alone,[19] reflecting a rapidly growing market for commercial and institutional actors alike. Historically, VLEO has been targeted both by civil and military missions. Notably, in the Cold War era, the CORONA program leveraged these altitudes for reconnaissance,[20] while a range of scientific missions have explored atmospheric properties (e.g., Atmosphere Explorer,[21] CHAMP,[22] SLATS,[23] CASPA-ADM[24]), material interactions (e.g., SOAR[25]), and geophysical phenomena (e.g., GOCE[26]). The QB50 mission stands out for deploying a large constellation that demonstrated formation flying, drag compensation, material science experiments, and novel green propellants, all while probing the lower thermosphere.[27] Today, VLEO is increasingly central to commercial EO and telecom strategies. The EO market alone is expected to reach $3 billion by 2025,[19] with constellations like Satellogic's Adelph-1 and PlanetLab's Dove leveraging the resolution and latency advantages of lower altitudes. This commercial momentum, driven by both demand and accessibility, is reshaping the space industry as shown by the trend in Fig. 2*, with the small satellite market projected to grow from $2.8 billion in 2020 to $7.1 billion by 2025.[1,2,17]

This anticipated expansion of VLEO infrastructure presents a timely opportunity to evaluate SST

*https://brycetech.com/reports/report-documents/smallsats-2025/

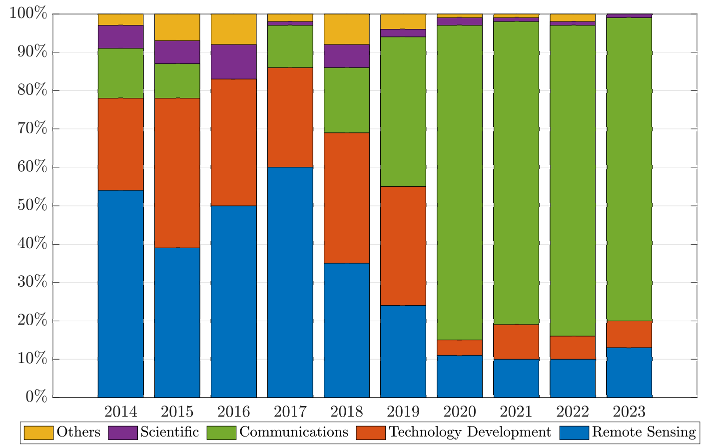

Figure 2. Evolution of the operations of launched smallsats between 2014 and 2023: remote sensing and telecommunications appear to be the most requested operation.

capabilities in this regime, not only as a dedicated mission objective, but also as an opportunistic addition to EO or telecom payloads. The following section presents the setup of a case study incorporating both simulated and real-world analyses to assess the feasibility and performance of SST operations in VLEO.

METHODOLOGY DESCRIPTION

This section presents a feasibility analysis of using a VLEO asset for SST application while comparing it to a more standard LEO counterpart, on the same orbit but at a higher altitude. The analysis follows a two-step approach. First, a purely geometrical analysis is conducted, considering only the visibility constraints of a population of Resident Space Objects (RSOs) relative to the observer. This includes eclipse conditions for optical payloads, but ignores other sensor limitations. This simplified approach allows for the analysis of a large RSO population while capturing the most impactful geometric constraints. Second, a more refined analysis which incorporates sensor constraints, such as maximum magnitude limits for optical sensors and minimum detectable SNR for radars is conducted. To accommodate these additional factors it is necessary to adopt a smaller but more realistic RSO population, with representative mass and size distributions. The analyses are structured to enable conclusions about achievable performance in LEO and VLEO. Additionally, to provide an upper-bound estimate of observational capability, no specific pointing strategy is assigned to the satellite. This ensures that every visible satellite is observed when it is in view, even though simultaneous observations of all targets are not feasible. A more detailed study of specific applications would require the definition of a pointing strategy and observation scheduling policy to ensure feasible observations and assess SST performances. However, such an approach would make the results less generalizable than they are in this paper. VLEO objects are also subject to attitude constraints, either absent or less stringent for LEO satellites, that may limit certain target observations. As a result, the assumptions in the following section may be overly optimistic when applied to VLEO observers. Furthermore, the study focuses on a single satellite rather than an entire constellation. This choice was made because the preliminary results clearly indicated that analyzing full constellations is unnecessary: key insights emerged from examining individual satellites in each orbital regime.

For both simplified and realistic scenarios, observers in LEO and VLEO are simulated with various payload types, resulting in ten distinct analyses.

Preliminary analysis

The population of objects adopted for this analysis is taken from spacetrack.com at the first date of the analysis (23 November 2024). On this date, 26320 RSOs were tracked. The TLEs for each object were processed so that objects destined to re-enter with a month could be excluded from the analysis. Moreover, the population was filtered to retain a statistically representative sample while guaranteeing more efficient computations. The total residual population was composed of 13044 objects. The population is reported in the following Fig. 3, where it is divided by orbital regime according to Table 1.2 of[3] ESA classification.

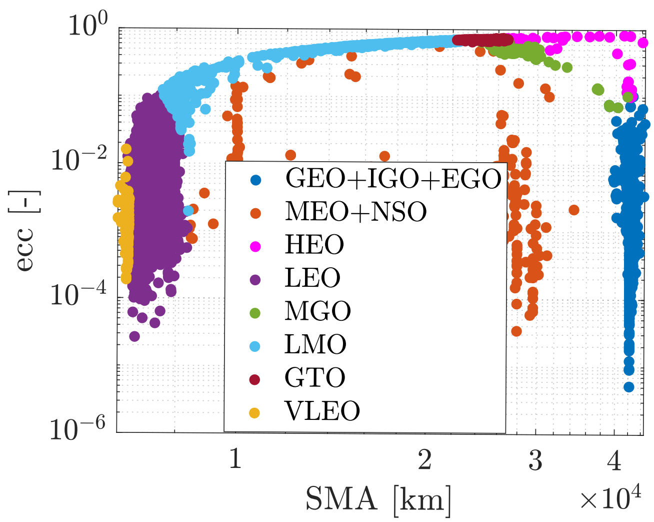

Figure 3. Total population of the simplified analysis.

Three different SSO observer orbits are considered (VLEO@250km, mid-LEO@500km, and high-LEO@800km). For each orbit (LEO and VLEO) and each sensor type (Optical and Radar) an analysis of 1 month from the reference date of the population is carried out. The propagation is performed using SGP4 model, a standard approach for orbit determination practices which strikes a good balance between accuracy and computational cost of the propagations. Visibility conditions are verified for each target using the constraints from[28] represented schematically in Fig. 4:

- Earth and Sun exclusion angles: to avoid images with Earth or Sun in the background which are unusable for SST purposes (or may even damage the sensor).
- Earth occulsion: the target must be above the local horizon.
- Illumination: for optical payloads only, the target must not be in eclipse.
- Tracking speed: the relative angular velocity of the target in the observer's frame must not exceed $1°/s$.

When a target is observed, the minimum observation window to consider the target as detectable is set to 1 minute. In the preliminary analysis, a simplified catalog maintenance policy is also

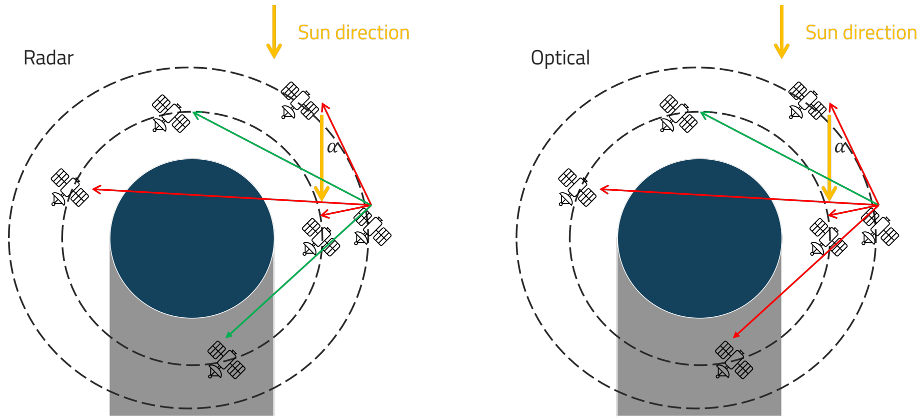

Figure 4. Geometrical constraints for radar (left) and optical (right) payloads.

implemented. In case a target is observed for 1 minute or more over a single visibility window, the satellite is considered tracked (i.e., Orbit Determination is taken for granted). Then, if the next valid visibility window falls within one orbital period of the target, the target is considered maintained, otherwise it falls out of the catalog. This approach is simple yet representative of realistic scenarios for Orbit Determination practices, and it is based on expertise on orbit determination campaigns carried out for EUSST.

Detailed analysis

This section introduces the simulation setup and results of the advanced analysis with additional payload constraints. The population of objects adopted for this analysis is taken from space-track.com. The reference population is frozen on 22 May 2023. This date differs from the one adopted for the simplified analysis because it is the last date when physical objects' characteristics were provided by spacetrack.com: Radar Cross Section (RCS) and brightness. These physical quantities are necessary to introduce detectability limits in the sensors. The total population of objects with physical properties was composed of 3349 objects. The distributions is similar to the one adopted in the simplified analysis and is reported in Fig. 5, where a representation of the distribution of number of objects and sizes is reported.

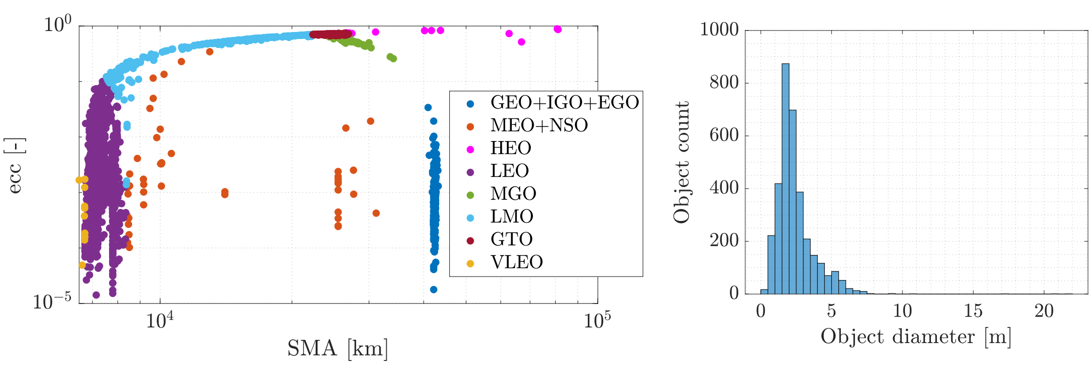

Figure 5. Total population of the detailed analysis (left) together with the distribution of ROS size (right).

Property	Value
Sampling rate [Hz]	1.0
Angular accuracy [deg]	$1e-3$
Maximum detectable magnitude [-]	10.0

Table 1. Optical sensor properties. Angular accuracy is given for 1σ level of uncertainty.

Property	Value
Sampling rate [Hz]	1.0
Angular accuracy [deg]	$1e-1$
Range accuracy [km]	$1e-1$
Minimum detectable SNR [dB]	6.0
Reference Emitter temperature [K]	100.0
Bandwidth [Hz]	100.0
Carrier frequency [GHz]	1.0
Emitter power [W]	1000
Antenna gain [dB]	33.7

Table 2. Radar sensor properties. Sensor accuracy is given for 1σ level of uncertainty.

The simulation setup is identical to the simplified analysis but only VLEO and high-LEO observers are investigated. Besides the visibility constraints, real sensor limitations have been introduced in the form of:

- Maximum observable brightness for the optical payload.
- Minimum SNR for the radar payload.

The payload characteristics were chosen according to ref.[28] The optical payload properties are reported in Table 1 and the radar sensor properties are reported in Table 2.

The value of sensor accuracy is used only during the catalog maintenance simulation. During this simulation a real Orbit Determination process is carried out. Each object is assigned a realistic covariance typical of TLE data. Then, at each observation time, measurements are simulated with added noise (taken from sensor accuracy) and fed to a real Orbit Determination algorithm. If the algorithm succeeds, the covariance is updated and propagated until the next measurement, where a refinement of the orbit determination can be carried out. When the propagated covariance grows too large, the object exits the catalog, and an initial orbit determination algorithm needs to be performed at the next measure time. All the passage times, observation windows, and constraint checking have been obtained with the help of the SENSIT software.[29] At this stage, it must be highlighted that the proposed radar limits constitute a rather optimistic assumption. Indeed, no additional source of noise was added, allowing larger antenna gains to be used. These parameters are used to compute the SNR using the standard radar equation. With the assumed parameters of the payload, the radar setup allows the smallest object in the catalog (around 0.02 m^2 of RCS) to be observed at 100 km of distance, whereas the median object of the catalog (around 5 m^2 of RCS) would be visible at 1200 km. This approach, although optimistic, was deemed acceptable to avoid unnecessary penalties on radar performances, which are quite poor (as it will be illustrated in the remainder of this paper) even in this favorable scenario.

NUMERICAL RESULTS

The results of the simulation in both the preliminary and detailed analyses are presented in this section.

Results of the preliminary analysis

This section reports the main results for detection statistics in terms of number of observation windows, total observable population, and length of the observation windows. The results are presented for each orbital regime of the target, as this structure provide additional insights on the problem. First, it must be noticed that the absence of payload limitations provides an extremely optimistic view of the achievable performances for higher orbits. The following Fig. 6 gives an overview of the percentage of objects that enters the catalog at least once over 1 month for each specific sensor, orbit, and orbital regime.

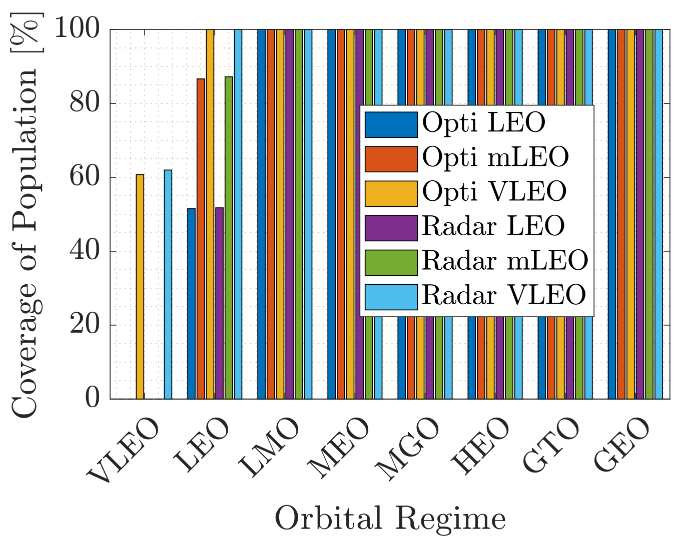

Figure 6. Total population entering the catalog at least once in the simplified analysis.

As it appears clear, having no limit on the maximum range and magnitude of observations, all the targets above LMO orbital regime are observed at least once. It must be noted that with these assumptions, only 60% of the VLEO population is observed and is only visible from VLEO (regardless of payload type). Moreover, also the LEO population coverage shows a clear improvement from lower orbits. This trend is explained by the geometry of the Earth exclusion angle constraint, which is more taxing for higher orbits that need to point down to observe lower satellites and consequently have higher chances of having the Earth in the FOV of the sensor. This behavior can be observed in Fig. 7. Also, it is possible to see that for the higher LEO orbit another constraint comes into play. Indeed, there is a large population of objects close to the altitude of the observer at 800 km that are never seen. This is due to the fact that those that they have similar orbital periods, therefore, if they are not visible in the beginning, they will never be visible due to their synced relative motion.

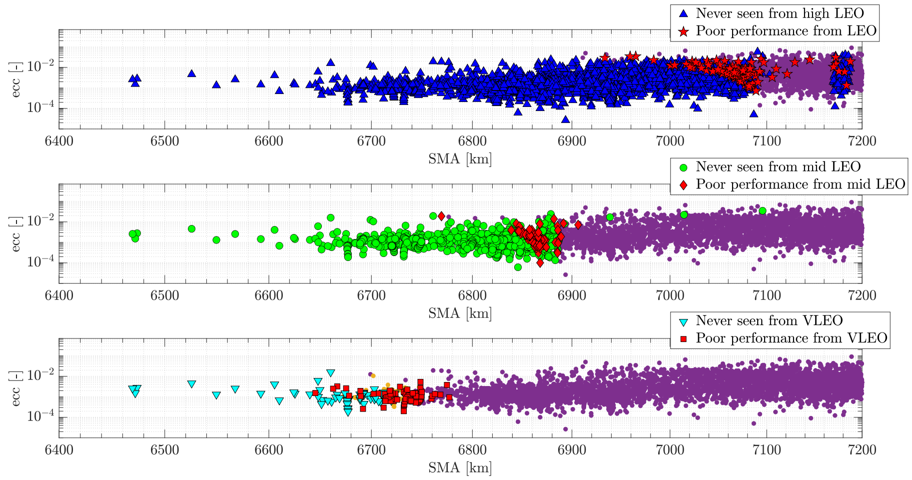

Figure 7. Effects of the observer altitude on the activation of the Earth exclusion angle constraint.

Some statistics are reported concerning the typical length of observation windows and the number of observations per period of the target. Longer windows entail a higher number of measurements and, consequently, higher probability of Orbit Determination success, and is therefore considered a metric of merit. Higher orbital regimes all behave similarly and the number of observations for each period of the observed target is on average the same across different orbits of the observer regardless of the payload type.

First, the GEO orbit results are reported in Fig. 8.

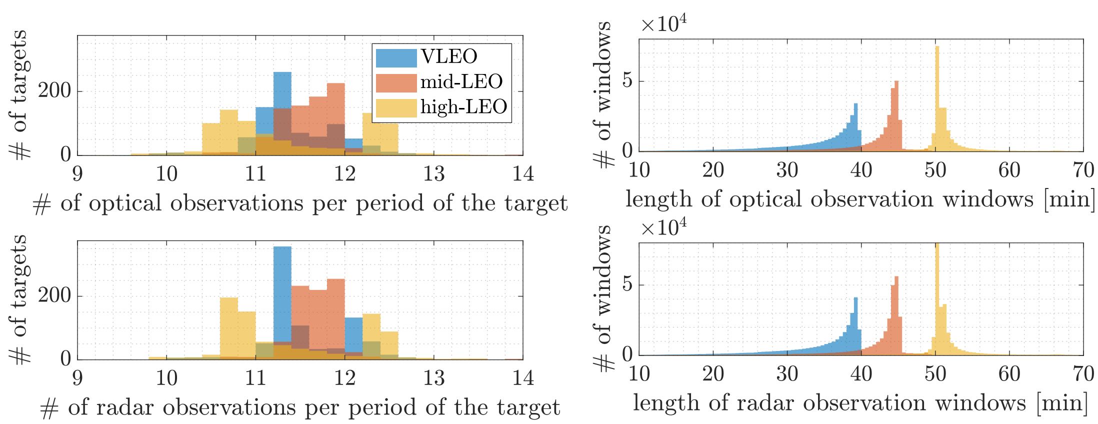

Figure 8. Distribution of observation windows per period of the target (left) and their length (right) for the GEO population of targets. Optical and Radar payloads are reported at the top and bottom of the figure, respectively.

The number of observations for each period of the observed target is on average the same across different orbits of the observer regardless of the payload type. Both VLEO and LEO observers show a bimodal distribution, which is the clear sign of the coexistence of distinct families of objects inside the same population (i.e., EGO, IGO, and GEO are all lumped together in this analysis). Conversely, a clear trend emerges in terms of length of the observation windows: the higher the observer, the higher the observation times. These changes cause improved orbit determination performances and more available measurements. In intermediate orbital regimes such as MGO, MEO, and HEO, performances are very similar without a clear trend in number of observations per period of the target and a uniform distribution of targets. This result can be explained thanks to the variability of periods present within this population. However, the same trends of length of observation windows emerge as in GEO. For conciseness, only HEO results are reported in Fig. 9 but MGO and MEO all behave similarly.

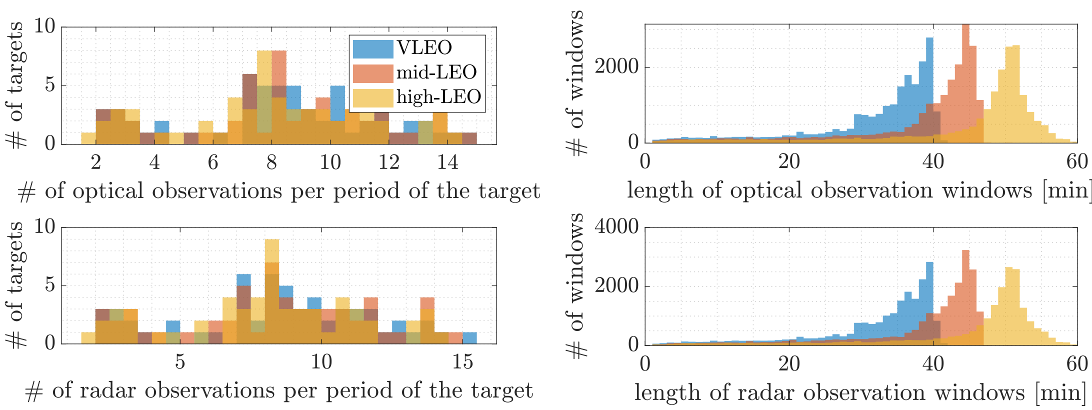

Figure 9. Distribution of observation windows per period of the target (left) and their length (right) for the HEO population of targets. Optical and Radar payloads are reported at the top and bottom of the figure, respectively.

The most interesting things for this analysis start to happen around the orbits of the observers. In LMO regime, a vast population of objects is close to the higher observers in LEO. Therefore, there is a peak of shorter observation windows but with higher frequency. Conversely, higher RSOs in LMO will behave similarly to higher orbital regimes already presented and therefore will be better for LEO observers. In terms of number of observation windows per period of the target, there is no significant variation between observers with different payloads. Then, LEO results are reported in Fig. 10. The number of observation windows per period of the targets are impacted due to the presence of RSOs with lower orbits which are not observable from higher orbits. This is also reflected in the distribution of observation windows lengths, which are on average higher for higher orbits of the observers but are reduced (almost halved) in absolute numbers. Another interesting thing to observe is that the eclipse now plays a major role in number of observations per period for particularly low targets as observed on the left side of Fig. 10. To conclude, VLEO satellites are only visible from VLEO observers and this is the most important take away message of this analysis.

Finally, the performance of the simplified catalog maintenance analysis for different payload types and different observers is reported in Fig. 11.

With this simplified approach, it appears that a VLEO orbit has the greatest advantage in terms of population coverage and catalog maintenance capabilities. The difference between sensors is not significant, demonstrating that the impact of the eclipses is not meaningful over one month. However, the performance increase with lower orbital radius can be completely imputed to the different observer performances presented in the previous section on the LEO population, which occupies almost 80% of the entire catalog.

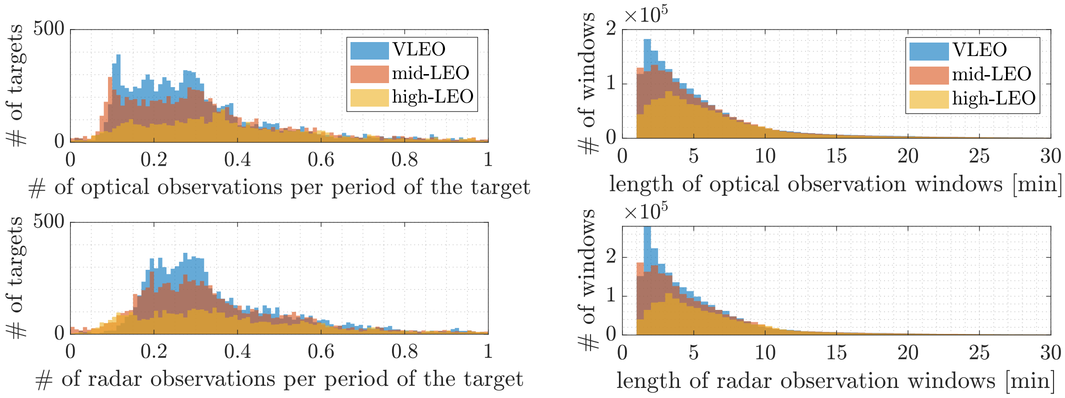

Figure 10. Distribution of observation windows per period of the target (left) and their length (right). Optical and Radar payloads are reported at the top and bottom of the figure, respectively.

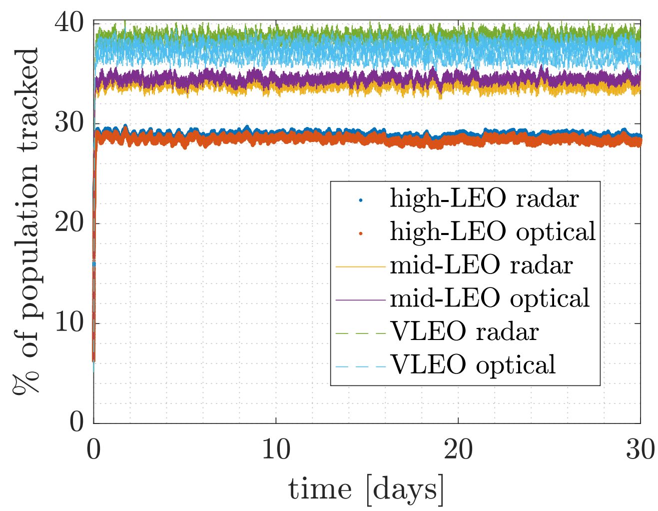

Figure 11. Tracked population for different sensors and observers in the simplified analysis.

This means that in practice when considering constellations in LEO for SSA/SST applications it is advisable to use an orbit below the most densely populated regions. Finally, VLEO satellites are only observable from VLEO exactly for this reason, which makes a strong argument in favor of adopting VLEO for SST applications using this simplified analysis. However, this view is partial to the limits of the sensor performances. Moreover, it is an extremely optimistic assumption to state that the satellite in VLEO could point the instrument at will. Indeed, for the drag and corrosion environment, more sophisticated geometric constraint such as an exclusion zone around the velocity direction of the satellite should be excluded. In addition, the attitude of the VLEO satellite is constrained by propulsion and drag requirements which are far more stringent than those related to SST performance. Consequently, it is unlikely that the performances illustrated in this section would be attainable in VLEO. Conversely, these problems do not impact LEO observers.

Results of the detailed analysis

The introduction of sensor limits in the detailed analysis drastically changes the performances of the different sensors as can be seen in Fig. 12.

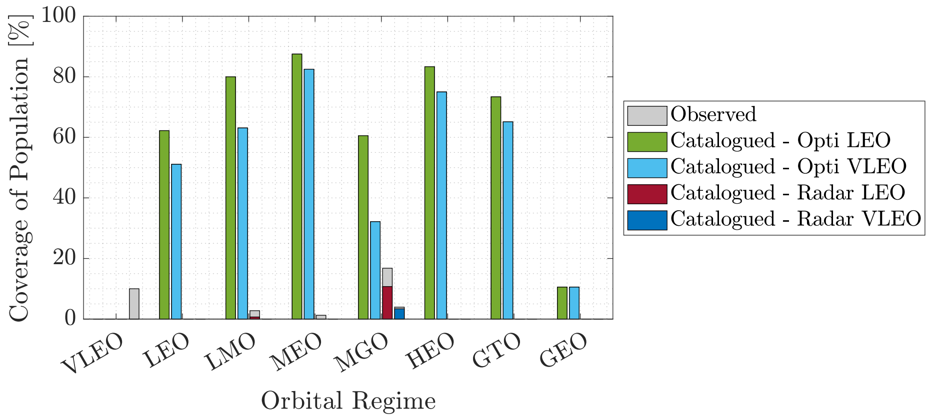

Figure 12. Total population detected and entering the catalog at least once in the detailed analysis.

Indeed, the Radar sensors are strongly hindered by the limited detection range which allows to observe only objects in neighboring orbital regions. Conversely, optical sensors perform best: a result in line with latest developments on in orbit SST. Moreover, the advanced analysis confirms that VLEO objects are only visible from VLEO orbit. Nonetheless, the VLEO population is often disregarded from the analyses as it is extremely reduced (10 satellites only) and only one of them is observable by the radar payload from the VLEO observer.

The distributions of detections per period of the target and the duration of observation windows are only reported for the LEO population. Indeed, the general trends behave similarly to the results presented in the preliminary analysis and are therefore not interesting. As before, all higher orbital regimes behave similarly, and no significant difference between observers' altitudes can be detected. Contrarily to the preliminary analysis, the LEO observer has more observations of the targets. However, from the distribution of length of observation windows reported in Fig. 13, it can also be noted that the windows for the additional satellites seen from LEO are quite short, with a peak duration around 1 minute. Therefore, when dealing with realistic sensor performances, it is advisable to use passive payloads such as optical sensors and to park in LEO orbit.

To conclude this investigation, the performance of the realistic catalog maintenance analysis for different payload types and different observers is presented. The impact of the observation performances also reflects on the cataloging. The results of the detailed analysis with the simulated Orbit Determination process are reported in Fig. 14.

It appears clear from this analysis that a VLEO orbit performs worse than its LEO counterpart assuming the same optical instrument. Moreover, introducing realistic sensor performances substantially reduced the maximum percentage of cataloged population for the optical sensor, while the radar sensor turns out to be completely useless regardless of the orbit of the observer. The catalog reconstruction following realistic orbit determination is also much slower for the LEO case which does not reach steady state within 1 month with a possible 3-5% further improvement. This further motivates the selection of LEO orbit with a passive optical payload for this kind of applica-

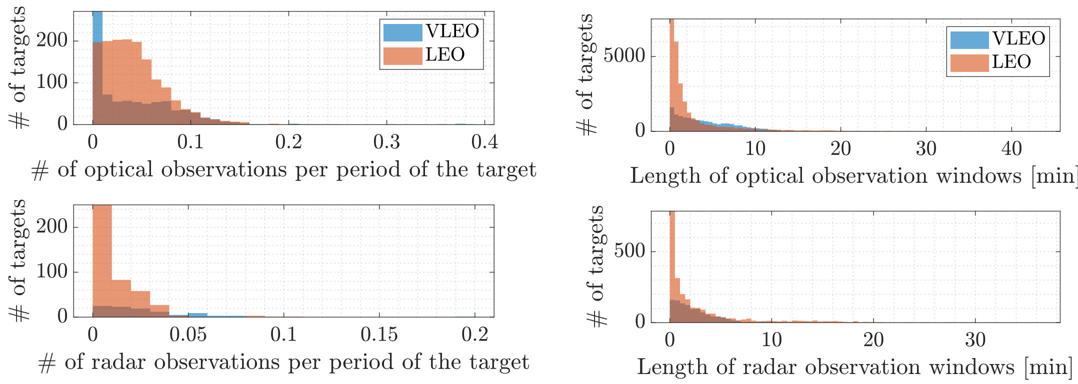

Figure 13. Distribution of observation windows per period of the target (left) and their length (right). Optical and Radar payloads are reported at the top and bottom of the figure, respectively.

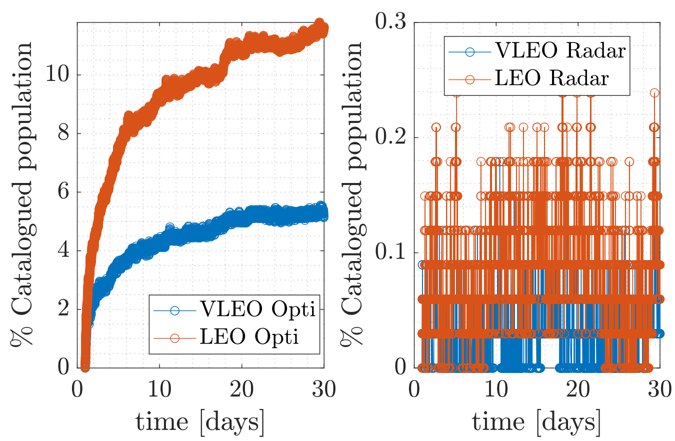

Figure 14. Tracked population for different sensors and observers in the detailed analysis. For visualization purposes, the graph is broken down in two subsets showing optical and radar performances separately.

tions. The percentage of the population for each regime that is cataloged after observation can be observed in Fig. 12. This analysis confirms that objects in VLEO, despite being observed, never achieve a successful orbit determination for any sensor within a month. This appears to be due to the performance of the radar sensor, which consistently shows the largest discrepancy between the percentage of the population observed and the percentage cataloged. Conversely, all optical payloads accurately capture the observed population, meaning that if an object is detected, its orbit will eventually be determined.

CONCLUSIONS

This paper presents a detailed assessment of the performance of LEO and VLEO platforms for SST using both simplified and realistic scenarios. The study is motivated by the increasing interest in exploiting VLEO for space operations and it yields several important conclusions regarding the viability and performance trade-offs of such assets.

For SST applications, optical sensors emerge as the more favorable choice thanks to their less stringent physical constraints compared to active radar systems. Active sensors showed a limited detection range, making them ineffective for monitoring other orbital regimes or distant objects. This finding reinforces the broader shift within the space situational awareness community toward passive optical payloads, which continue to demonstrate superior performance across a wide range of tracking scenarios.

The analysis reveals that VLEO observers perform most effectively when tracking objects in the same low-altitude regime. Both the simplified and the detailed analyses show that VLEO satellites are primarily visible to observers within VLEO, while higher-altitude targets remain outside the detection capabilities of active sensors due to their limited range. Although LEO satellites equipped with the same payloads tend to have fewer observation opportunities, these tend to be longer and more stable. In contrast, VLEO platforms benefit from more frequent access to targets at similar altitudes and offer significantly reduced latency between successive observations.

Despite these advantages, the current population of VLEO objects remains too sparse to justify the deployment of a dedicated SST mission. The low number of observable targets, coupled with infrequent passes and brief observation windows, limits the effectiveness of catalog maintenance from this regime. Additionally, many of the analyses rely on optimistic assumptions regarding spacecraft pointing capabilities. In reality, operational survival in VLEO requires spacecraft to prioritize attitude control for aerodynamic drag reduction, which significantly constrains sensor orientation and flexibility.

As a result, an optical-only payload in VLEO is not a practical solution, as it would offer worse performance than a comparable system in LEO and would be effectively incapable of observing other VLEO satellites. An active-only payload may become justifiable in the future, but only if the VLEO object population grows substantially. Finally, although standard assumptions regarding Earth exclusion from the field of view have been applied, it is possible that with optimized data processing, some useful measurements, such as observations of high-altitude aircraft or atmospheric objects, could still be obtained, even with fixed pointing configurations.

In conclusion, while VLEO platforms offer some theoretical advantages for SST, current orbital dynamics, spacecraft constraints, and the sparse target environment limit their near-term practicality for dedicated surveillance missions.

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