

18 and 19 SDS Small Satellite Support

Cynthia Wilson, Corey Best
U.S. Space Force, 18th Space Defense Squadron
Vandenberg Space Force Base, CA; +1-805-606-2830
18SPCS.DOO.CustomerService@us.af.mil

The views expressed herein are those of the author(s) and do not necessarily represent the official positions of the United States Space Force, the Department of Defense, or the United States Government. This publication qualifies as a work of the United States Government under 17 U.S.C. § 105 and thus is not protected under U.S. copyright law, but foreign copyright law may apply.

ABSTRACT

This paper explores the services and recommendations offered by the 18th and 19th Space Defense Squadrons (SDS) to enhance spaceflight safety and ensure mission success for satellite owners and operators.

18 SDS OVERVIEW

The United States Space Force's (USSF) 18th Space Defense Squadron (18 SDS) and 19th Space Defense Squadrons (19 SDS) are the primary organizations charged with executing the United States Space Command's (USSPACECOM) Space Domain Awareness (SDA) mission. Our mission is to provide and advance a continuous, comprehensive, and combat-relevant understanding of the space situation.

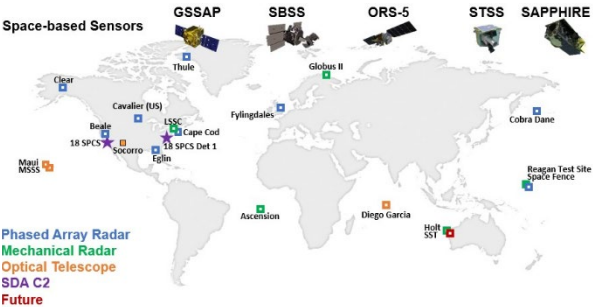


Fig. 1: U.S. Space Surveillance Network

18 SDS collects hundreds of thousands of metric observations daily from the U.S. Space Surveillance Network (SSN, shown in Fig. 1) and calculates current and predicted orbits for all artificial objects in Earth orbit. We monitor all activity to, in, and from space, and maintain custody of all resident space objects.

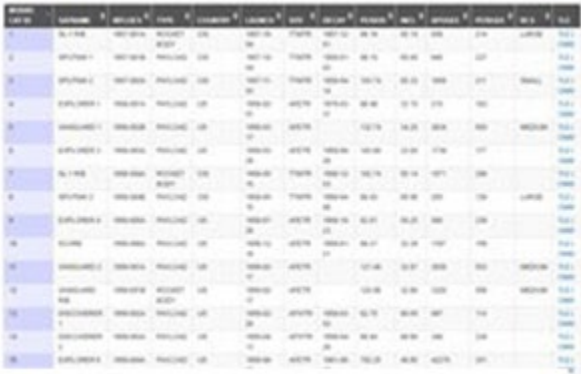


Fig 2: Satellite Catalog

Primary mission functions include launch detection and tracking, identifying potential collisions between space objects, human spaceflight support, maneuver detection, breakup identification, and reentry assessment. We maintain the most complete satellite catalog (SATCAT) of Earth-orbiting artificial objects, currently tracking more than 44,300 objects including about 8,100 active spacecraft, which is available to the public on the website www.Space-Track.org (Fig 2).

There are more than 163,000 active accounts on Space-Track, representing 205 countries.

In addition to its primary mission, the 18 SDS implements the USSPACECOM Space Situational Awareness (SSA) Sharing Program, which provides orbital data and services at no cost to satellite owners and operators worldwide in the interests of spaceflight safety. We track all artificial objects in Earth orbit, generate

orbital elements and forecast reentries, and publish the data on the website, www.Space-Track.org. In concert with our sister squadron, the 19 SDS, the data produced by the 18 SDS is used to predict close approaches between any two artificial objects in Earth orbit to support collision avoidance by satellite operators (including small satellite owners). Of note, however, neither the 18 SDS nor the 19 SDS is authorized to recommend maneuver courses of action, provide advice, or tell anyone what to do in the event of an assessed conjunction.

The SSA Sharing Program was created following the Cosmos 2251-Iridium 33 collision in 2009. This incident generated thousands of pieces of debris that would continue to pose a threat to spaceflight safety for years to come, so the decision was made to provide data and thus awareness to all satellite owners and operators. While the primary focus of 18 SDS and 19 SDS is providing comprehensive space domain awareness to enable space defense, we realize that spaceflight safety and promoting responsible behavior in space is paramount to continuing assured access to space for our partners and allies as well as for all space operators around the world.

SERVICES FOR SATELLITE OWNERS

We support satellite owners and operators from pre-launch to re-entry. The following services are provided using high accuracy data: early engagement, launch collision avoidance, launch support and early orbit determination, early orbit conjunction assessment, on-orbit conjunction assessment, and end-of-life disposal.

Early Engagement

Prior to any launch, we make our best effort to identify and contact the owners of each of the satellites to be deployed. The owners help us to identify their satellite once it's on orbit, provide contact information in case of emergency, and share information on their spacecraft and mission plans that allow us to better track and support the spacecraft through its lifetime. During this phase, 18 SDS sets up Space-Track.org access for the satellite operator, which enables data exchange, access to conjunction data messages (CDMs) and entry to the global satellite operator directory.

Launch Collision Avoidance

Every launch provider launching from a USSF installation or licensed by the U.S. (and others upon request) receives launch conjunction assessment (LCOLA) screening. The launch provider submits trajectory data for the rocket and each piece separating

from the launch vehicle, and we screen it against our on-orbit catalog to identify any potential close encounters. The launch provider uses the results to determine the best time of launch within their window.

Launch Support and Early Orbit Determination

Launch support and early orbit determination consists of tracking and identifying new resident space objects and establishing orbital state data for them. Pre-launch coordination with the launch provider and each satellite owner is critical to expediting the tracking, cataloging and identification of each new object. Upon cataloging, element sets for each new object will be available on Space-Track.org.

Early Orbit Conjunction Assessment

Early orbit CA includes the screening of satellite operator-provided ephemeris against the catalog to facilitate the safe maneuvering of a newly launched object into its final orbit. This service covers the gap between launch and when we catalog the object and begin providing routine conjunction assessment services.

On-Orbit Conjunction Assessment

Basic conjunction assessment is provided to any satellite owner/operator (O/O) upon request at no cost via www.Space-Track.org. Should we identify a potential close approach between an active satellite and another space object, and the operator has an organization account on Space-Track.org, they will automatically get information in a Conjunction Data Message (CDM). We do three types of screenings every day: High Accuracy Catalog (HAC) vs. HAC; owner-generated ephemeris vs. HAC; owner ephemeris vs. all other owner ephemeris. This service is available to all satellite owners, regardless of your satellite's size or mission.

End-of-Life/Disposal

When a satellite operator decides to responsibly dispose of their spacecraft at the end of its lifetime by moving it to a less crowded orbit, we can provide conjunction assessment and collision avoidance support to make sure its path to its destination is safe and doesn't compromise other active spacecraft.

Deorbit and Reentry

A deorbit is the controlled reentry of a satellite into the Earth's atmosphere. If a satellite owner decides to deorbit a satellite or rocket stage through a series of maneuvers, we can provide conjunction assessment screenings, as well as coordinate with NASA to ensure the deorbiting spacecraft safely descends through the

International Space Station's (ISS) orbit. After the spacecraft completes its maneuvers, we can process it as a reentry assessment.

Reentry assessment (RA) is the process of maintaining the orbits of reentering objects, predicting the location and time of atmospheric reentry 10 km above the Earth's surface, and notifying the appropriate U.S. and international agencies, as well as the public of the predictions. RA is performed for objects (payloads, rocket bodies or platforms, and debris) equal to or larger than one square meter but may be provided for small spacecraft on a case-by-case basis through the orbital data request (ODR) process.

Orbital Data Requests

Other information, such as historical orbital data, may be requested using an Orbital Data Request (ODR). The form and description of the process are available on www.space-track.org.

DATA EXCHANGE

A critical component of spaceflight safety is data exchange, both with the 18 SDS and with other satellite operators. During the satellite registration process, 18 SDS will create private folders for you on Space-Track.org that allow you to send us predictive ephemeris for your spacecraft, submit maneuver notifications and share your contact information. The information you provide will be used to identify possible collisions, update our database, and facilitate communication with other satellite operators who use Space-Track.org. This will ensure that in any situation as much information as possible is available to prevent miscalculations and misunderstandings. While small satellites may not have the same capabilities or size as larger traditional spacecraft, small satellite operators still bear the same responsibility to follow safe and sustainable guidelines.

It is important to note that we can only provide data. We are not authorized to recommend maneuver courses of action, provide advice, or tell anyone what to do.

SSA SHARING AGREEMENTS

Advanced services such as expanded CA screenings or access to our higher accuracy catalog, are available to all entities who sign an SSA Sharing Agreement with USSPACECOM. USSPACECOM currently has agreements with 133 commercial companies, more than 30 countries, and 7 universities. There is no cost for the agreement. More information about the services available to agreement holders and how to pursue an

agreement is at <https://www.Space-Track.org/documentation#/odr>.

As an example, basic CA services report conjunction events according to these criteria: Time of Close Approach (TCA) within 3 days, miss distance ≤ 1 km, and Probability of Collision (P_c) $\geq e^{-4}$. For an agreement holder with advanced CA services, the criteria are: TCA within 5 days and $P_c \geq e^{-7}$. Advanced CA will provide much more data to enable risk analysis and maneuver planning.

MULTI-MISSION/MULTI-PAYLOAD LAUNCHES

The 18 SDS "Space Domain Awareness (SDA) Partnership and Coalition Engagement" (SPACE) Office, also known as the SSA Sharing Office, makes every effort to contact all of the satellite owners on each launch. We invite you to register on www.Space-Track.org and then contact us at 18SPCS.DOO.CustomerService@us.af.mil. A satellite registration form is available on the Space-Track.org home page. It's short and easy and will tell us everything we need to know to create an organization account for you on Space-Track.org.

SATELLITE REGISTRATION	
To: 18 th Space Defense Squadron (18 SDS), Vandenberg SFB, CA	
Step Zero: REGISTER THE SATELLITE OPERATORS ON WWW.SPACETRACK.ORG	
1. FROM: <small>(Select Owner/Operator Company Name and Location)</small> United Federation of Planets Country San Francisco, CA, U.S. Primary Contact Person(s) <small>(Please email; phone optional)</small> Capt James I. KVA, james.kva@ufp.org +1-415-123-456	2. SATELLITE NAME(S) AND TRACKING <small>(Optional)</small> 2a. Have you checked the satellite catalog to make sure there is not already a satellite with this name on orbit? <input type="checkbox"/> 2b. Does the satellite have GPS or any other means of determining the orbit independently? YES <input type="checkbox"/> NO <input type="checkbox"/>
3. LAUNCH DATA 3a. Launch Provider Space Crazy Launchers, Ltd 3b. Launch Vehicle Elementary Particle 3c. Launch Date 2-2-2022 3d. Primary Payload or Launch Name SDSD 3e. Planned Orbit (initial and final if there will be an orbit change) 525 x 525 km	SMALL SATELLITE DATA (up to 600 kg) 4. International Space Station (ISS) or Cygnus Deployments, if applicable a. Method/Identifier of Deployment <input type="checkbox"/> 4b. Deployment Date <input type="checkbox"/> 5. If NASA supported, Educational Launch of Nanosatellites (ELaNa) Number <input type="checkbox"/> 6. Name of launch facilitator/broker if applicable <input type="checkbox"/>
SATELLITE & ORBIT INFORMATION	
7a. Size of the satellite (L x W for CubeSats, or mass in kg for larger satellites) 6U 7b. Will anything will be deployed from it? (anything to change its shape) 2 1U Sun Shields 7c. Type of propulsion, if any None 7d. Expected mission lifetime 6 months 7e. Will you be providing predicted ephemeris data to 18 SDS? YES <input type="checkbox"/> NO <input type="checkbox"/> If yes, please provide emails for the people/groups who will need to be able to upload the files: mr.spock@ufp.org, scott@ufp.org	
WWW.SPACETRACK.ORG: ORGANIZATION ACCOUNT DATA <small>(If you already have an organization account, just enter the name and skip the rest of this section)</small> Note: once operators have registered on Space-Track, an account will be created using the name of the organization. People and satellites are added via this account. Please see instructions for more details.	
8a. Organization name for account United Federation of Planets 8b. Primary representative(s): name and email address as registered on Space-Track (these can determine who gets conjunction notices and manage orbital information - see instructions) MUST BE REGISTERED ON Space-Track james.kva@ufp.org 8c. Close Approach Notifications (CANs) (REQUIREMENTS MUST BE REGISTERED ON Space-Track) <small>Email addresses to receive notification messages and access the data</small> dr.spock@ufp.org, scott@ufp.org 8d. Emergency notification phone number(s) (for someone who speaks English, please) +1-415-123-456	

Fig. 3: Satellite Registration Form

We'll link the appropriate people to that account, and once the satellite has been launched and identified, we'll link it to the account, too: this is how the conjunction data will automatically be routed to you. Today we have more than 700 organization/CDM accounts on Space-Track.org; many of these represent small and CubeSat owners, and about one third of them are academic institutions.

We track only what our Space Surveillance Network sees, and do not send commands to nor get telemetry from any satellite. If a satellite has a way of calling attention to itself, for example, using GPS data or a beacon signal, we do not process that information. However, we do work closely with the satellite owner to receive and understand that information which we leverage for tracking and identification. We can determine the size of the objects we are tracking, but when there are multiple satellites of the same size, size alone cannot be used to identify a specific spacecraft.

As an example of a multi-mission/multi-payload rideshare launch, Figure 4 shows a graph of tracking data for SpaceX's first Transporter mission, with 148 objects deployed.

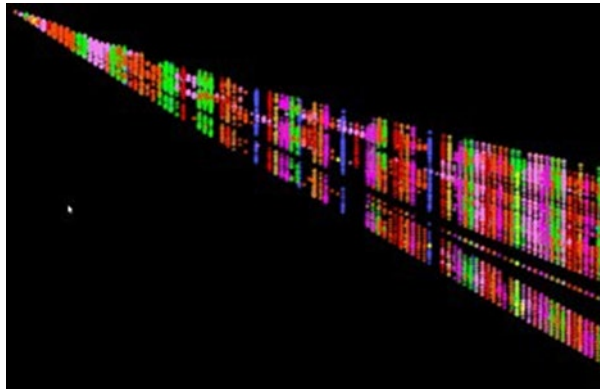


Fig. 4: Transporter 1 Launch Tracking Data

Each of the vertical lines of dots is a set of observations when a tracking site senses the objects going by, and the time span of the entire graph is from a 7 day period. You can see that all of the satellites are together in a bunch to begin with, and gradually move away from each other. After a while the dots start to line up horizontally and we can make out separate tracks for each object.

Once we separate out the different objects and we're confident in the quality of the orbital data, Two Line Element sets (TLEs) are published in the satellite catalog. To begin with, each object is assigned a number and catalogued as Object A, B, C and so on.

If there's only one satellite on a launch, the tracking, cataloging and identification can all happen in a matter of hours, but for the huge rideshare launches, it can take several days. While tracking and establishing custody of objects occurs soon after launch, giving official names to the objects can take weeks – the last satellite on Transporter 1 was identified a couple of months later.

This is why your cooperation is so important: we rely on you to review the TLE's or use any of your own data to tell us which one of these objects is your satellite.

We in the 18 SDS SPACE Office will work with you before, during, and after launch. We'll do our best to let you know how we're doing with tracking and creating orbits, and we can usually send you a preliminary TLE before objects are

SPACEFLIGHT SAFETY RECOMMENDATIONS

Although we're not able to tell anyone what to do, we do have a few suggestions when you're designing your missions:

1. Consider the safety of humans; anytime your spacecraft transits through the orbits of a space station or vehicle visiting to a space station you may pose additional risk to human spaceflight. You can mitigate some of this risk by sharing your contact and spacecraft's positional information through Space-Track.org and keeping 18 SDS updated on your mission activities.
2. Make sure your satellite is big enough for 18 SDS to track easily: at least 1U in low Earth orbit is best. If you're not sure, we highly recommend using one of the many tracking enhancement devices available.
3. It's best to use a unique satellite name. You can see what satellite names have already been used by checking Space-Track.org.
4. Register on www.Space-Track.org and contact 18 SDS at 18SPCS.DOO.CustomerService@us.af.mil

CONCLUSIONS

As space congestion and competition increase, it is crucial for space actors to collaborate, share operational data, and exchange best practices to ensure safe, secure, and sustainable space operations. While there is no legal obligation for satellite owners to collaborate with 18 SDS and 19 SDS, early communication and coordination with these organizations enhance mission success through accurate tracking, early identification, and collision warnings. The value and importance of spaceflight safety services provided by 18 and 19 SDS are recognized by U.S. government licensing agencies. The goal is to preserve the space domain for future operators, be it university students or military personnel. For inquiries or questions, please contact 18SPCS.DOO.CustomerService@us.af.mil