This version was last updated on 2021-03-10.

Introduction

This document collects a variety of potential questions and answers related to NASA's collision avoidance policies and guidance. Included below are references to the source documents, various points of contact, and the various questions and associated answers. The document may be updated periodically to add additional information.

For questions not sufficiently covered in this document, please email one of the points of contact. For questions requiring the context of a specific space flight mission, please start with the JSC Flight Operations Directorate (for human space flight missions) or Conjunction Assessment Risk Analysis (CARA) for all other space flight missions.

Document References

- NASA Interim Directive (NID) 7120.132: Collision Avoidance for Space Environment Protection https://nodis3.gsfc.nasa.gov/OPD_docs/NID_7120_132_.pdf
- NASA Spacecraft Conjunction Assessment and Collision Avoidance Best Practices Handbook (publication pending)

Points of Contact

- Overall policy, guidance, and process questions:
  - ca-policy-feedback@nasa.onmicrosoft.com

- Feedback on general technical and handbook topics:
  - ca-handbook-feedback@nasa.onmicrosoft.com

- Support to specific space flight missions:
  - Human spaceflight (HSF) missions: JSC Flight Operations Directorate (FOD)
  - Non-HSF missions: Conjunction Assessment Risk Analysis (CARA) program

Table of Contents

Background and Context

What is the problem NASA is attempting to address?

The near Earth orbit environment is becoming congested due to the success of government and commercial endeavors. More spacecraft in similar orbits naturally leads to increased conjunctions. All space operators need to be proactive in planning, coordination, and operations to protect not just their own systems, but also the space environment. We need to operate within a framework of standard practices that includes appropriate protocols for inter-operator coordination.

How big a problem is posed by on-orbit conjunctions?

On-orbit conjunctions are frequent, and as more satellites are placed in orbit, will become even more frequent. This is a natural consequence of a diverse and vibrant space enterprise. Space operators need robust processes to be proactive in predicting and mitigating close approaches. The NID establishes NASA's internal requirements, and the Handbook identifies the necessary elements of a mature set of conjunction assessment processes.

What federal agency has responsibility for space traffic management and conjunction avoidance in the U.S.? Is there a United Nations or international group that has overall responsibility?

The U.S. has promulgated Space Policy Directive 3 (SPD-3), the National Space Traffic Management Policy. Implementation of the goals associated with SPD-3 are underway, which assigns a leadership role for Space Situational Awareness (SSA) and Space Traffic Management (STM) activities to the Department of Commerce (DOC) for commercial and international entities. In August 2020, the National Academy of Public Administration issued a congressionally mandated report that concluded the DOC is "best suited to perform STM tasks in the federal government." And, in October 2020, Senator Wicker introduced legislation authorizing the DOC to perform STM and SSA functions.

What is the NASA conjunction assessment process?

At a high level, NASA uses a three step process for Conjunction Assessment (CA):

1. **Conjunction assessment** – The process of comparing trajectory data from the asset to be protected against the trajectories of the objects in the space object catalog to predict when a close approach will occur within a chosen protective volume placed about the asset.
2. **CA risk assessment** – The determination of the likelihood of two space objects colliding and the expected consequence if they collide in terms of lost spacecraft and expected debris production.
3. **Conjunction mitigation (aka collision avoidance)** – An action taken to remediate conjunction risk, including a propulsive maneuver, an attitude adjustment (e.g., for differential drag or to minimize frontal area), or providing ephemeris data to the secondary operator to enable an avoidance maneuver.

NASA Policy Information

Why was the NID issued?

NASA's interests are best served by proactively implementing protocols and best practices to minimize collision risk. We are in a position to lead by example and demonstrate an effective approach to protect the space environment.

What is fundamentally new or different in the NID?

The overall objectives and technical implementation guidance have not significantly changed from existing practice. From that perspective, the NID largely codifies existing practice and implementation in policy form. Various roles and responsibilities, largely implemented yet not documented in policy, are now defined. In order to ensure NASA is proactively managing collision risk, additional planning requirements are established to focus attention on conceptual and pre-implementation actions that will manage operational impacts. For contracts and partnerships, the NID provides additional guidance to help ensure NASA continues to lead in protecting the space environment through managing collision risk.

How will the NID transition to a permanent policy document, such as a NPR?

OCE is working on the permanent successor document to the NID in CY2021 in the form of an NPR. The timeline for the NPR is not yet final. The proposed NPR will follow the normal NPR process, with opportunity for formal comments from all Centers and Mission Directorates.

How were the technical elements of the NID reviewed?

The technical components of the NID were peer reviewed by a group of inter-agency experts in conjunction assessment.

Is there overlap between NPR 8517.6 and the NID?

There is a small amount of overlap between the two documents, and they do not conflict. NPR 8715.6 includes a description of the Conjunction Assessment Risk Analysis (CARA) program and the key CA roles for human space flight that are based in the JSC Flight Operations Directorate (FOD), as well as certain coordination requirements for spacecraft maneuvers. The NID provides an increased level of detail for these topics, as well as other essential considerations. These overlaps will be reconciled when the NID is succeeded by a permanent policy document.

Is there overlap between the OCAP (from the NID) and the ODAR or EOMP (from NPR 8715.6)?

The Orbit Collision Avoidance Plan (OCAP), Orbital Debris Assessment Reports (ODAR), and End of Mission Plans (EOMP) are distinct documents addressing different perspectives with the overall goal of protecting the space environment. The ODAR and EOMP work to reduce the potential for unmanaged introduction of new or enduring orbital debris from space flight missions (including launch). The OCAP is a new required plan that applies to the early design phase of a space flight mission, documenting study and analysis tasks and design considerations that affect how the mission's operations phase appropriately mitigates conjunctions.

How should NASA levy the requirements in the NID on contractors or partnerships?

For contracts that will result in the implementation of a spaceflight mission, the appropriate requirements from the NID should be included. The specific approach should be tailored to the contract and its objectives. Incorporating the requirements in a planned contract modification, as opposed to initiating a new modification solely to incorporate the NID's requirements, is generally sufficient.

For partnerships and other agreements, the specific agreement goal and structure should guide the involved NASA organization(s). Agreement goals and structure tend to vary widely across NASA. Agreements that do not involve the development or operation of a space flight mission generally do not require attention. For agreements involving a space flight mission, the NASA organization(s) should consider the nature of the agreement in context with overall risk to the space environment from collision risk. Where appropriate and possible, the NASA organization should invite the partner to adopt the technical requirements from the NID, and possibly update the agreement to reflect this.

Are templates available for the NID-required OCAP and CAOIA documents?

Non-human space flight missions should contact CARA for a copy of the latest baseline template for the CAOIA, and a general template for the OCAP (based on the NID's Appendix C).

Is there an altitude below which the NID requirements do not apply?

No. Operational spacecraft traverse all orbital altitudes, and space safety is important everywhere. The NID currently focuses on GEO and below, and the future NPR may address additional orbits and trajectories. NPR 8715.6 requires CA for non-Earth-orbiting spacecraft. Space flight missions should contact CARA to arrange CA services for non-Earth-orbiting spacecraft.

Does the NID apply to all classes of space flight missions? What about smallsats and cubesats?

Yes, the NID applies to all classes and sizes of space flight missions. Any collision affects the involved objects, and likely will generate risk to other objects through new debris. While NASA can accept risk to our own assets, we will not attempt to impose risk on other operators. All space operators need to be proactive in identifying and mitigating close approaches.

What if the miss distance is low but the *Pc* is also low?

If the predicted Euclidean miss distance is smaller than the hard-body radius for the conjunction, then the NID requirements mandate a mitigation action, regardless of *Pc* value. If the *Pc* is lower than the mitigation requirement of 1E-04 and in the opinion of the mission, the miss distance is disturbingly small, the mission may elect to pursue a mitigation action. As with any mitigation maneuver (see NID 4.3.2), a planned maneuver must be screened and analyzed by CARA to ensure risk to other objects can be identified.

Why are the requirements for producing and furnishing ephemerides more demanding than past practice?

The CA community, including activities at the 18th Space Control Squadron, and more broadly in industry, is moving to a more ephemeris-based methodology for protecting active payloads. The methodology is the best way to represent planned trajectory changes and produce durable future predictions that include uncertainty estimates. NASA wishes to emphasize the responsibility that owners/operators must assume to produce and distribute ephemerides that enable actionable CA decisions. Based on interagency experience

with using ephemerides for conjunction assessment, the requirements specify the ephemeris generation frequency, density, length, covariance realism, and format needed for use in the CA enterprise.

NASA Conjunction Assessment and Collision Avoidance Best Practices Handbook Information

Who should use the Handbook?

The Handbook has two distinct audiences. First, for NASA program and project managers as a consolidated reference and aid during the development of future space flight missions. The Handbook provides context and support for the NID's implementation requirements. Second, for any other space operator that might benefit from understanding the technical basis for our conjunction assessment processes. NASA's conjunction assessment processes have been developed over the past 30 years, and may serve to help other space operators in developing their own mature approach.

Did NASA work with any other agencies on the development of the handbook?

While the Handbook outlines NASA's current practices, it was developed with the help of several U.S. agencies including the Department of Defense.

What is the difference between the Handbook and DOD's 18th Space Control Squadron (18th SPCS) *Space Safety Handbook*?

The 18th Space Control Squadron (SPCS) is responsible for maintaining the space object catalog for the U.S., and for performing the first step of the process: conjunction assessment, also referred to as "screening".

The *Space Safety Handbook* available on 18th SPCS's website, Space-Track.org, describes how to receive support from 18th SPCS, including CA screening data. 18th SPCS does not perform CA risk assessment, and this must be performed by the Owner/Operator once the screening data is received.

The NASA Handbook describes NASA's best practices for risk assessment, and partly overlaps with the Space Safety Handbook as appropriate to fully describe the end-to-end CA process. NASA missions receive CA services directly from CARA or FOD and do not need to use the 18th SPCS *Space Safety Handbook* for CA purposes.

NASA Technical Standards Information

Is NASA developing a technical standard for conjunction assessment?

Yes, there is ongoing work to develop a technical standard. A very early draft was distributed for targeted stakeholder comments in early CY2020. The work to develop the standard continues, with the next draft expected sometime in CY2021. A projected timeline for when the standard will be complete is not yet available. Some of the technical support material, including some distributed with the early draft standard, is published in the appendices of the Handbook.

Is the devolution paradigm mentioned in the draft standard still an option?

The devolution paradigm is still in testing. Once an Agency decision is made regarding the acceptability of devolution, further details will be captured in the future NPR. Missions that have completed a pilot will continue in their current state until a determination is made on whether to offer this option to other missions.

NASA Conjunction Assessment Risk Analysis (CARA) Information

What is CARA's baseline support and how is it funded?

The support that CARA provides to mission customers in terms of mitigation thresholds and products exchanged is defined by the NID and documented in the CAOIA between CARA and the mission. Support at this level is included in the staffing levels that CARA is funded for through the Agency. Missions desiring support beyond the baseline should contact CARA to make a request and determine whether additional resources would be required to provide the requested support. In order to ensure the availability of CARA staff to support high interest events for all missions, additional requests may require dedicated staff.

The NID defines a threshold for maneuvering — what is the threshold for planning support from CARA?

The NID documents the threshold at which mitigation is required. CARA understands that in order to be prepared to act at that time, planning is sometimes necessary in advance of achieving that threshold. CARA recommends planning at 3-4 days before Time of Closest Approach (TCA) for LEO and 4-5 days before TCA for Non-LEO. Therefore, CARA will support event analysis and mitigation maneuver planning beginning at a threshold of 3.2E-05. Requests beyond that level are at CARA discretion and may require additional resources.

Additional Technical Information

Why was the Pc chosen as the risk assessment metric?

As a collision likelihood metric, the *Pc* presents a number of advantages. The metric considers the miss distance, the two satellites' positional uncertainties, and the combined object sizes, all within the same calculation. The result is formulated probabilistically, which makes it contextually appropriate for a risk assessment. Issues of "probability dilution," which have been raised as a criticism of the *Pc*, are minimized by the way that CARA sets the null hypothesis for risk assessment (this issue is treated at some length in the Handbook). Finally, *Pc* is the standard collision likelihood calculation within the CA community, thus aligning the Agency with this emerging industry standard.

Can a space flight mission use a different collision likelihood metric?

Yes, but the *Pc* calculation is that which will be used to assess when mitigation actions are required by the NID. Missions are free to employ a different risk assessment methodology to identify situations that, although not high-risk according to a *Pc* calculation, may be of concern to the mission and therefore candidates for mitigation.

Why was the Pc threshold of 1E-04 selected?

NASA Office the Chief Engineer considered a number of different possible thresholds and concluded that the 1E-04 value provided the desirable balance between safety and mission facilitation/enablement. This threshold also aligns with the level that most space safety organizations have embraced as a collision likelihood threshold for requiring mitigation (1 in 10,000 chance of collision).

Why was the *Pc* mitigation threshold of 1.5 orders of magnitude lower than the 1E-04 high-risk threshold, which equates to a conjunction Pc reduction to 3.1E-06, selected?

A CARA study concluded that, by reducing high-risk events to this *Pc* level, they no longer contribute appreciably to the satellite's cumulative lifetime risk of collision.