MADCAP FAQs

Does MADCAP report Pc for conjunctions?

Yes, MADCAP will calculate and report Pc when there is covariance data available for both objects involved in a close conjunction. If covariance data is only available for one object, then a worst-case Pc is calculated and reported. The worst-case Pc assumes the unknown covariance is that which maximizes the Pc. If covariance data is not available for either object, then no Pc is reported.

Why doesn't MADCAP use Pc as the primary risk assessment metric?

Passive ground-based tracking of objects in most deep-space environments is not currently possible, so deep-space conjunction assessment is reliant on ephemeris information provided by owner/operators. Covariance data has historically not been provided for most spacecraft operating in these environments, and MADCAP cannot compute Pc without this data. As more spacecraft begin to report covariance data, Pc will become an increasingly important metric for deep-space conjunctions.

How are MADCAP thresholds determined?

The MADCAP thresholds used to categorize conjunctions as High Interest Events (HIE) or "Red" are intended to reflect the 3-sigma orbit position uncertainties. This method is more conservative than the CARA standard mitigation threshold of 1E-04 Pc. There are much fewer conjunction events in deep space environments than in Earth orbits and therefore less uncertainty information is available. Thus, extra conservatism in flagging HIEs is warranted. Additionally, not all HIEs result in mitigation actions. MADCAP HIE thresholds are intended to enable initiation of further investigation into whether mitigation may be needed. These thresholds are derived from trajectory covariance data, if available. In the absence of covariance data, missions should work with the MADCAP team to develop estimates of the typical expected 3-sigma spacecraft position uncertainties during each mission phase. More details on the derivation and use of MADCAP thresholds, as well as information on how close approaches are calculated, can be found in the papers listed on the MADCAP website (https://www.nasa.gov/cara/madcap/)

What is the recommended MADCAP threshold for performing a Risk Mitigation Maneuver (RMM)?

When a High Interest Event (HIE) or "Red" conjunction is discovered, the MADCAP team will promptly reach out to the missions involved to gain further knowledge to assess conjunction risk. Such information would include estimates of uncertainty (if not provided via covariance data), upcoming trajectory altering events (maneuver, momentum wheel unload), and other operational considerations. This data, along with the Pc (if available), will be used by the teams to come to a decision on any action that may be required to mitigate conjunction risk. When Pc is available, MADCAP follows the CARA guidelines of recommending an RMM when Pc is above 1e-4. Missions are free to consider RMMs for cases with Pc below 1e-4 based on other mitigating circumstances.

What types of Ephemeris files are accepted by MADCAP?

MADCAP accepts trajectory information in two ephemeris formats:

1) SPICE (Spacecraft Planet Instrument C-matrix Event) SPK (Spacecraft and Planet Kernel)
2) CCSDS (Consultative Committee for Space Data Systems) OEM (Orbit Ephemeris Message)

Trajectory uncertainty information can be delivered via covariance data in the OEM format only.

How often should Ephemeris files be updated and how far into the future should they predict?

Ephemeris files should be updated as frequently as is needed to capture significant changes to the spacecraft trajectory. This cadence will depend on the orbital regime and mission operations of each

spacecraft. Highly dynamic orbits with frequent spacecraft activities may need to update as often as daily (or more), while those in more stable environments could be refreshed as infrequently as weekly. Accurate and timely MADCAP analysis is dependent on ephemeris files which predict out at least 14 days into the future from the MADCAP run time. Thus, the frequency of deliveries and timespan of the predicted trajectory should be sufficient to cover this requirement. For missions updating ephemeris data weekly, the minimum requested predict span would be 21 days.

How are Ephemeris files sent to MADCAP?

Ephemeris files can be sent to MADCAP in three ways:

1) MADCAP can automatically download and use the ephemeris files uploaded to the Deep Space Network (DSN) Service Preparation Subsystem (SPS). Many spacecraft operating in shared deep-space environments are already tracked by the DSN, so this provides a convenient repository for the exchange of ephemeris files.
2) The MADCAP Deep-space Ephemeris eXchange (MDEX) is an S3 bucket system where missions not using the DSN can upload ephemeris files.
3) Files can also be emailed to the MADCAP team, though this process is usually reserved for testing or emergency cases.

Which environments are analyzed by MADCAP?

MADCAP is tasked with performing conjunction analysis for all shared deep-space environments. These currently include the orbit regimes around Mars, Earth's moon, Cislunar space, Sun-Earth L1, and Sun-Earth L2. MADCAP analysis is performed daily for Mars and the Moon, and weekly for the Cislunar, L1, and L2 environments. MADCAP analyses are expected to be initiated at Venus and Jupiter in the near future.