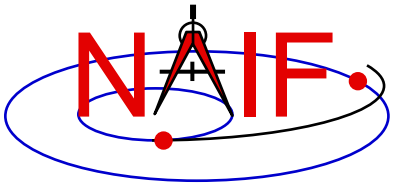


Navigation and Ancillary Information Facility

SPICE Geometry Finder (GF) Subsystem

Searching for times when specified geometric conditions occur

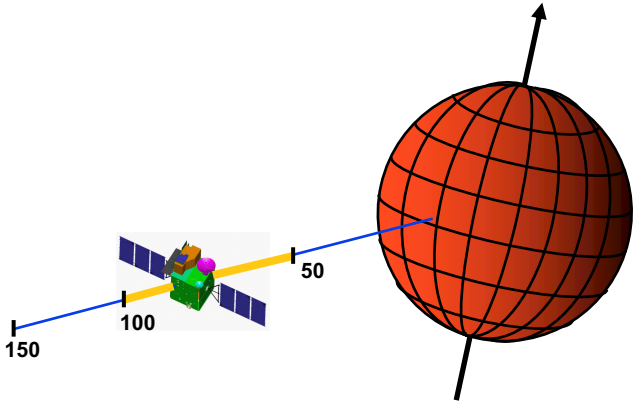
June 2019

(Class version)

Purpose

- **Much SPICE software computes a geometry parameter at a given time, t, i.e. *x = f(t)*.**
  - **Example: on 2011 MAR 30 14:57:08, what is the spacecraft's altitude above Mars?**

- **The Geometry Finder subsystem does the inverse.**
  - **Example: within some time bounds, when is the spacecraft's altitude between 50 and 100 km?**

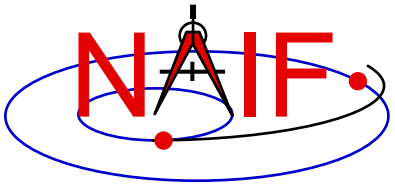


Some Examples

- **The SPICE Geometry Finder (GF) subsystem finds times when specified geometric events occur.**
  - **A "geometric event" is an occurrence of a given geometric quantity satisfying a specified condition. For example:**
    - » **Mars Express distance from Mars is at a local minimum (periapse)**
    - » **Elevation of the Cassini orbiter as seen from Deep Space Station-14 is above a given threshold angle**
    - » **Titan is completely occulted by Saturn**
    - » **The Saturn phase angle as seen by the Cassini orbiter is 60 degrees**
  - **Each GF search is conducted over a user-specified confinement window.**
  - **The result of a GF search is the time window over which the specified condition is met.**

Types of GF APIs

- **GF provides two primary types of event-finding APIs**
  - **Boolean: a geometric condition (an event) is true or false**
    - » **Example: Phobos is occulted by Mars**
    - » **Example: Vesta is not in the OSIRIS instrument's field of view**
  - **Sometimes we call these binary conditions**
  - **Numeric: a geometric quantity has a given value, is within a given range or has achieved a local or global maximum or minimum**
    - » **Example: spacecraft altitude is between X and Y km above the surface**
    - » **Example: angular separation of Titan from Saturn has reached the maximum (within the search window being used)**



GF High-Level API Routines

- **The GF subsystem provides the following high-level API routines; these search for events involving the respective geometric quantities listed below**
  - **GFDIST: observer-target distance**
  - **GFILUM: illumination angles**
  - **GFOCLT: occultations or transits**
  - **GFPA: phase angle**
  - **GFPOSC: position vector coordinates**
  - **GFRFOV: ray is contained in an instrument's field of view**
  - **GFRR: observer-target range rate**
  - **GFSEP: target body angular separation**
  - **GFSNTC: ray-body surface intercept coordinates**
  - **GFSUBC: sub-observer point coordinates**
  - **GFTFOV: target body appears in an instrument's field of view**
  - **GFUDB: user-defined boolean quantity (only Fortran and C)**
  - **GFUDS: user-defined scalar quantity (only Fortran and C)**

The SPICE Window

- **The high-level GF routines return a search result as a SPICE window. This window specifies intervals of time when the user's constraints are satisfied.**

- **A SPICE window is:**
  - **a span of time defined by a start time and an end time;**
  - **within that time span, a time-ordered sequence of zero or more time intervals each having zero or non-zero length.**

T_{start} T_{stop}

A SPICE Window

SPICE Windows Operations

- SPICE provides routines to:
  - compute unions, intersections, and differences of windows
  - contract each interval within a window …
    - » by increasing the left endpoint and decreasing the right endpoint
- These functions allow one to search for multi-condition events
- See the next page for an example

Example of Window Operations

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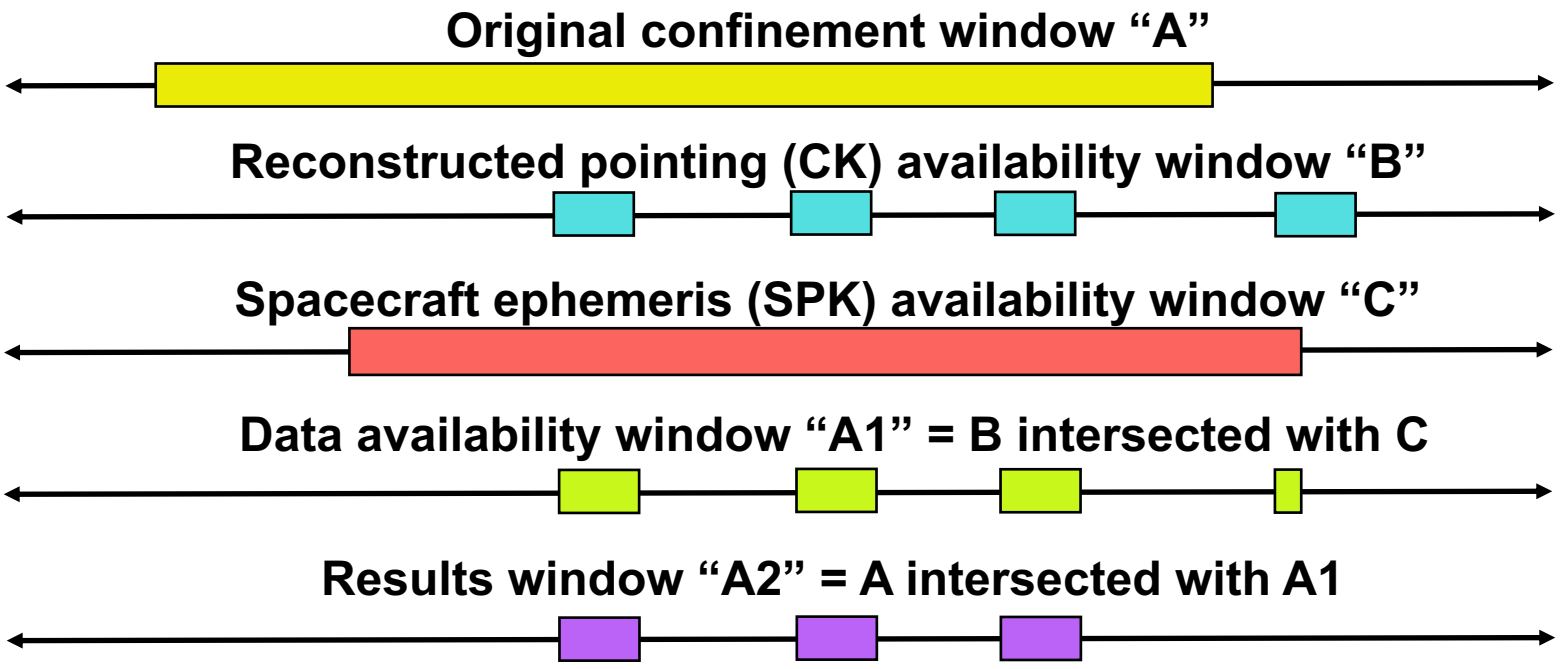
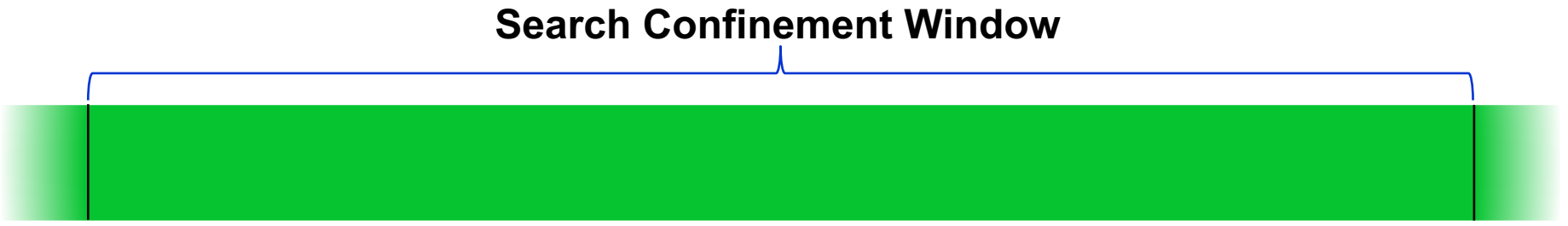
Given an initial confinement window, restrict that window to times when required CK and SPK data are available.

Use CKCOV and SPKCOV to find CK and SPK availability windows B and C.



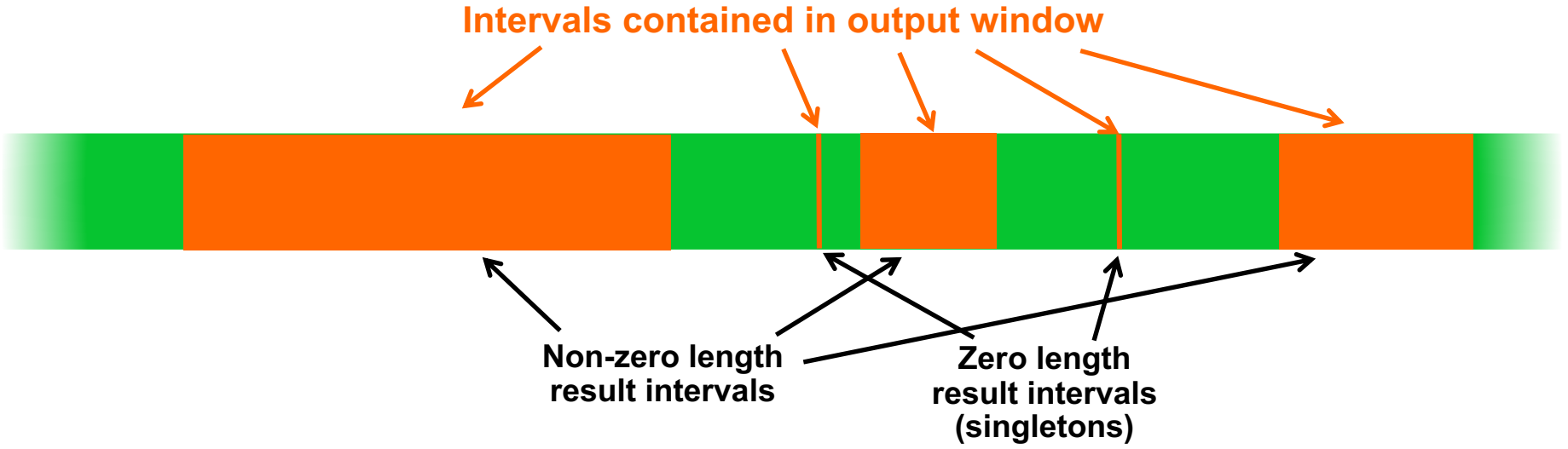
Using Time Windows in GF

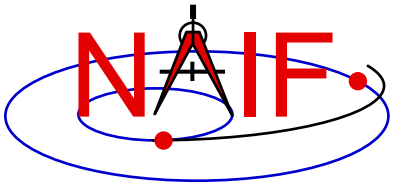
- **GF uses a SPICE window to:**
  - **confine the time bounds over which your search is to take place**



Using Time Windows in GF

- **GF uses SPICE windows for input and output**
  - **Input: confine the time bounds over which your search is to take place**
  - **Output: the time intervals that meet the search criteria**
    - » **There may be none, one or multiple result intervals**
    - » **The result intervals can be of non-zero or zero length**
      - **A zero-length interval is simply an epoch–an instant in time**





Cascading Search Using Multiple SPICE Windows

- **The result window (the output) from one search can be used as the confinement window (the input) for a subsequent search.**
  - **This is often a convenient and efficient way of performing searches for times when multiple constraints are met.**
  - **This technique can be used to accelerate searches in cases where an initial, fast search can be performed to produce a small confinement window for a second, slower search.**
    - » **See the next chart and the example program "CASCADE" in the Geometry Finder Required Reading document**

Cascading Search Example

Example: accelerate a solar occultation search.

First search for times when the angular separation of the Sun and Moon, as seen from DSS-14, is less than 3 degrees.

Use the result window of the angular separation search as the confinement window of an occultation search.

Because the angular separation search is much faster than would be the occultation search on the original confinement window, the total search time is greatly reduced.

Original confinement window (“A”)

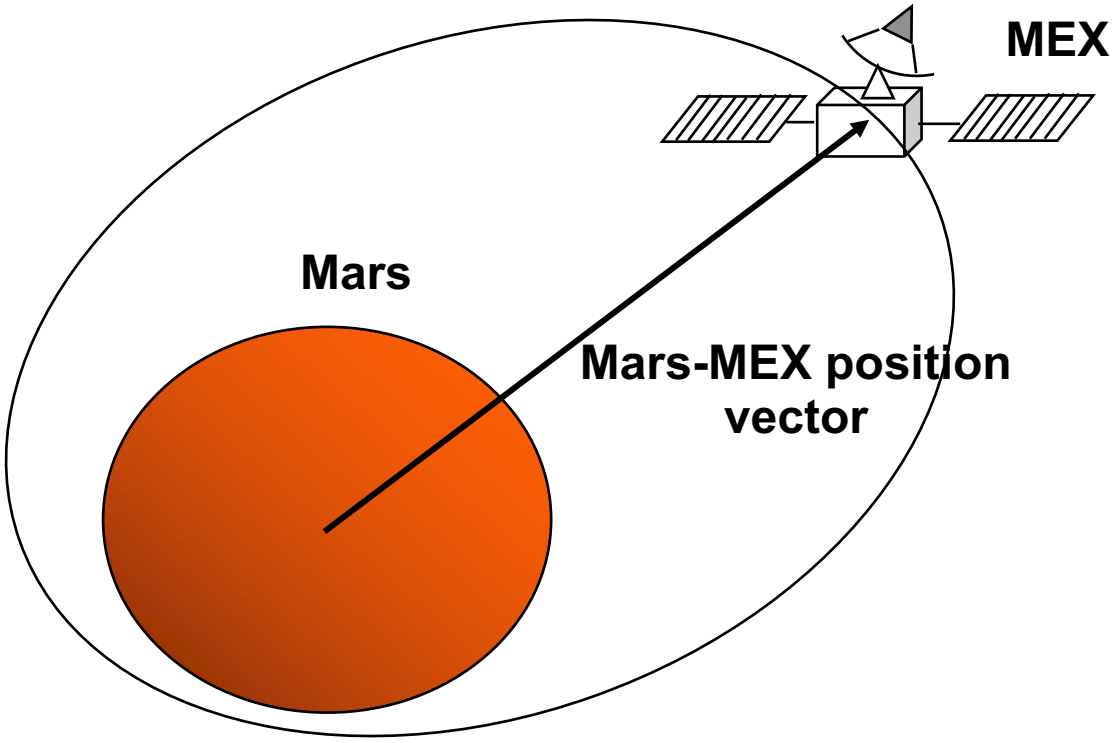
Result of angular separation search: second confinement window (“B”)

Window “C”: result of occultation search performed on window “B”

GF Search Examples

Distance is Local Maximum (or Minimum)

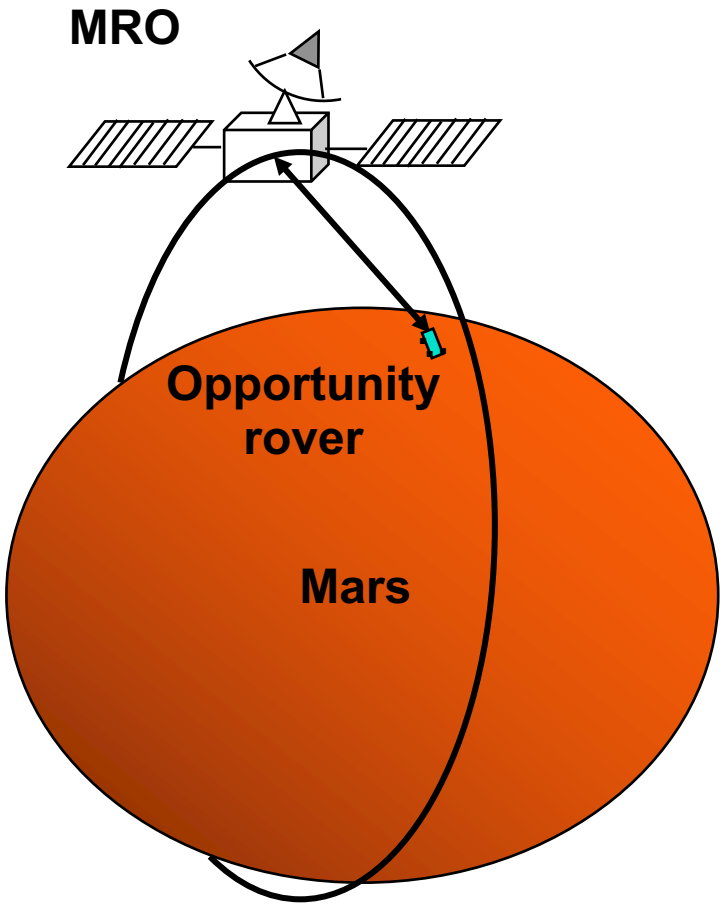
Find the times of apoapse of the Mars Express Orbiter (MEX)



API: GFDIST

Distance Within a Range

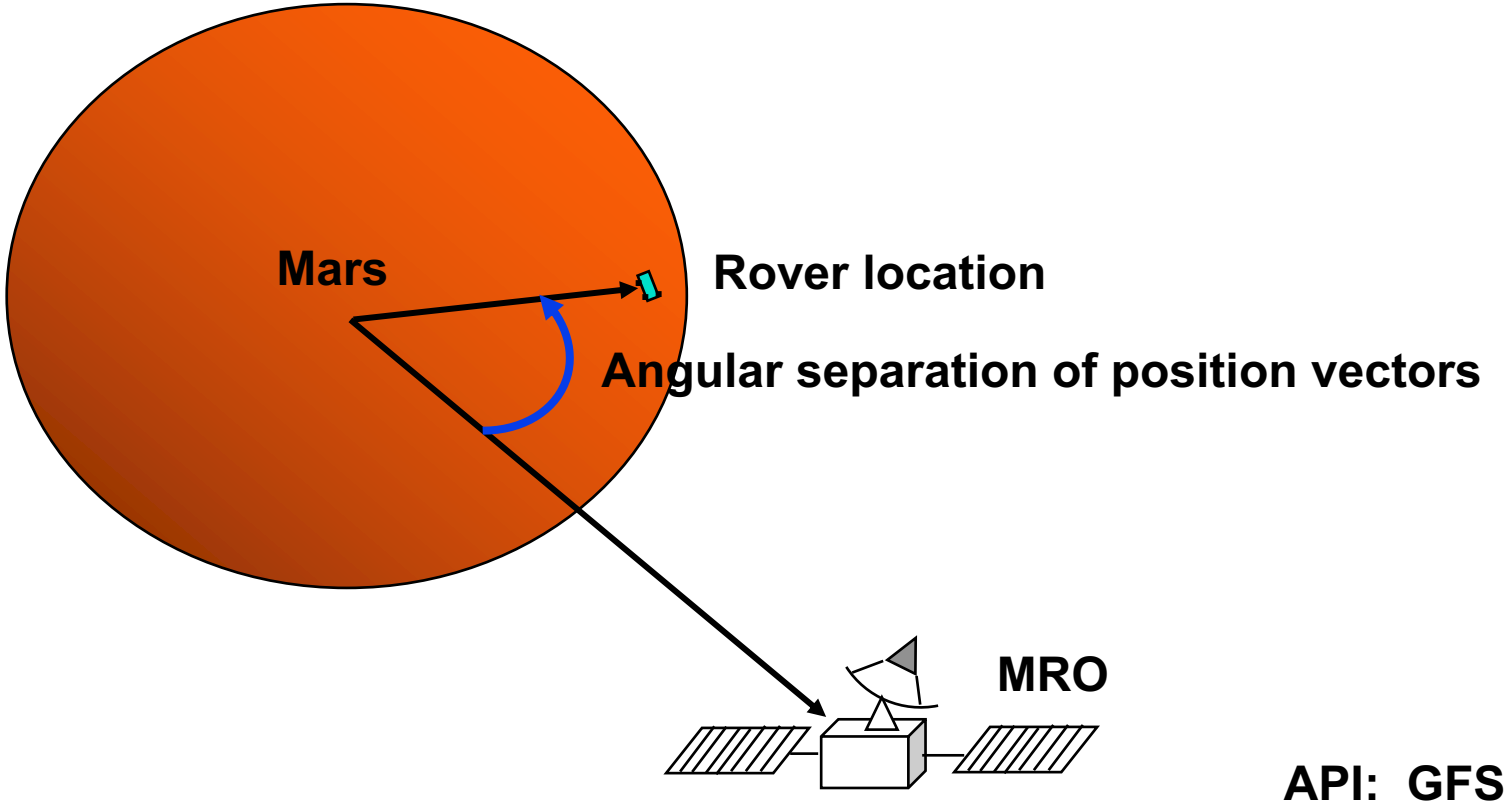
Find the time periods when the Mars Reconnaissance Orbiter (MRO) is within 500km of the Opportunity rover.



API: GFDIST

Angular Separation Inequality

Find the time periods when the angular separation of the Mars-to Mars Reconnaissance Orbiter (MRO) and Mars-to-Opportunity Rover position vectors is less than 3 degrees. Both targets are modeled as points.



API: GFSEP

Occultation/Transit Search

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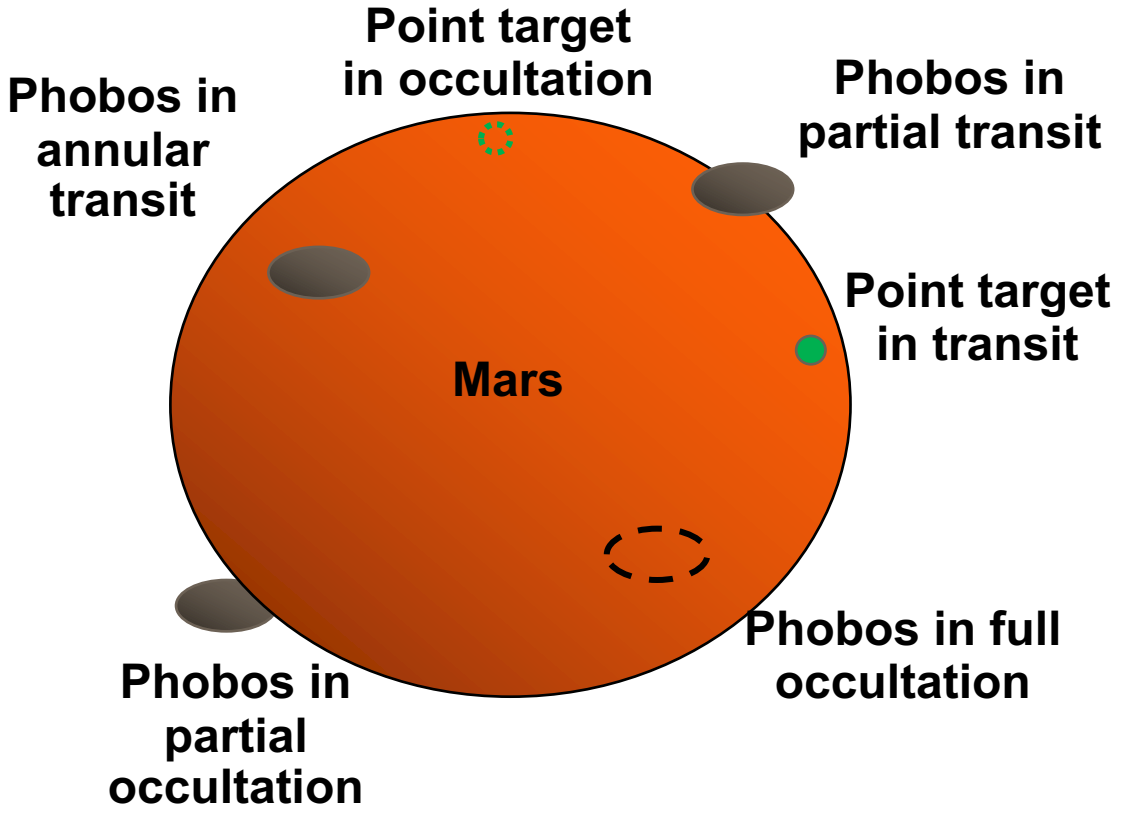
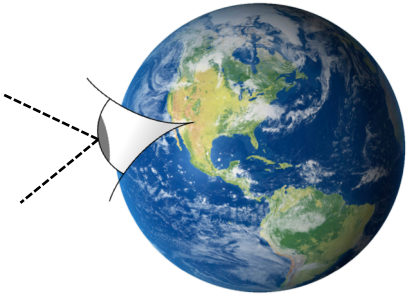
Find the ingress and egress times of an occultation of Phobos or a spacecraft by Mars, as seen from Earth. Phobos and Mars are modeled as triaxial ellipsoids; a spacecraft is modeled as a point target.



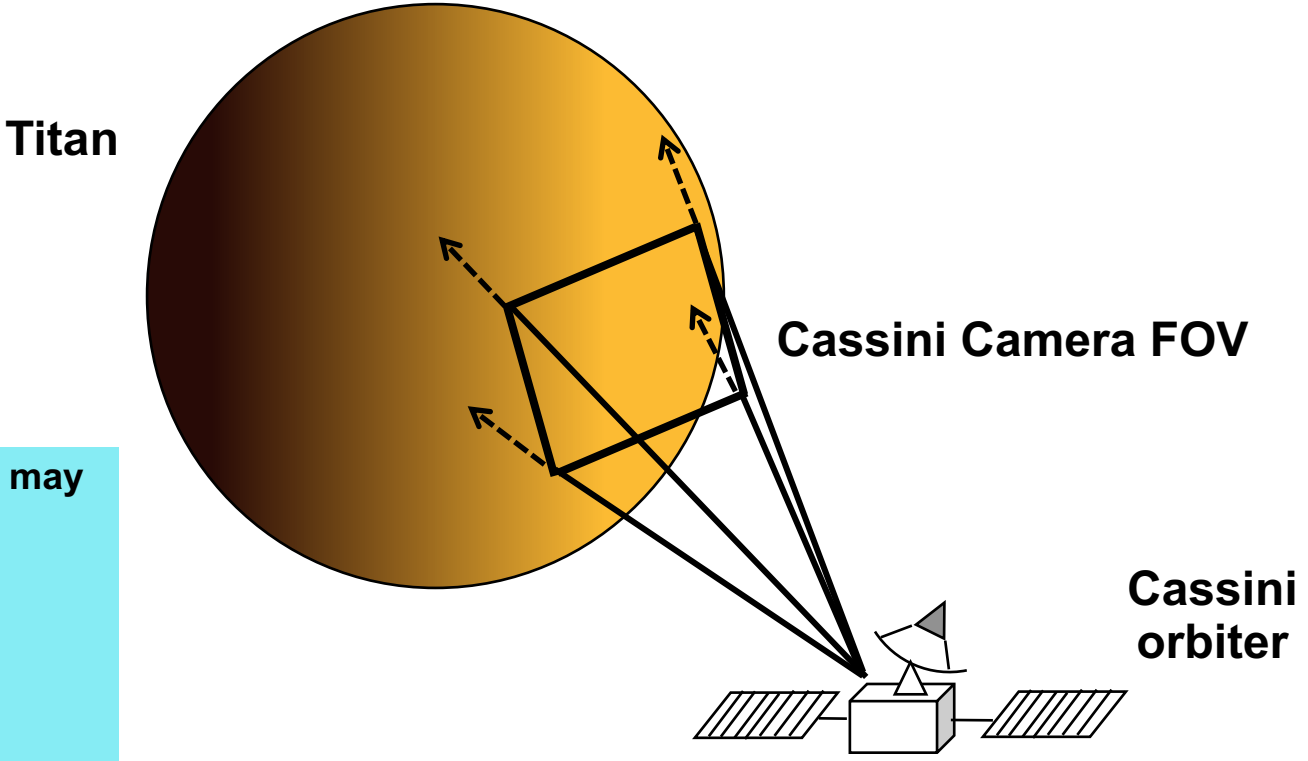


Earth

API: GFOCLT

Target in Field of View

Find the time periods when Titan appears in the FOV of the Cassini ISS Narrow Angle Camera (NAC). The target is an ephemeris object; the target shape is modeled as an ellipsoid. (Point targets are also supported.)



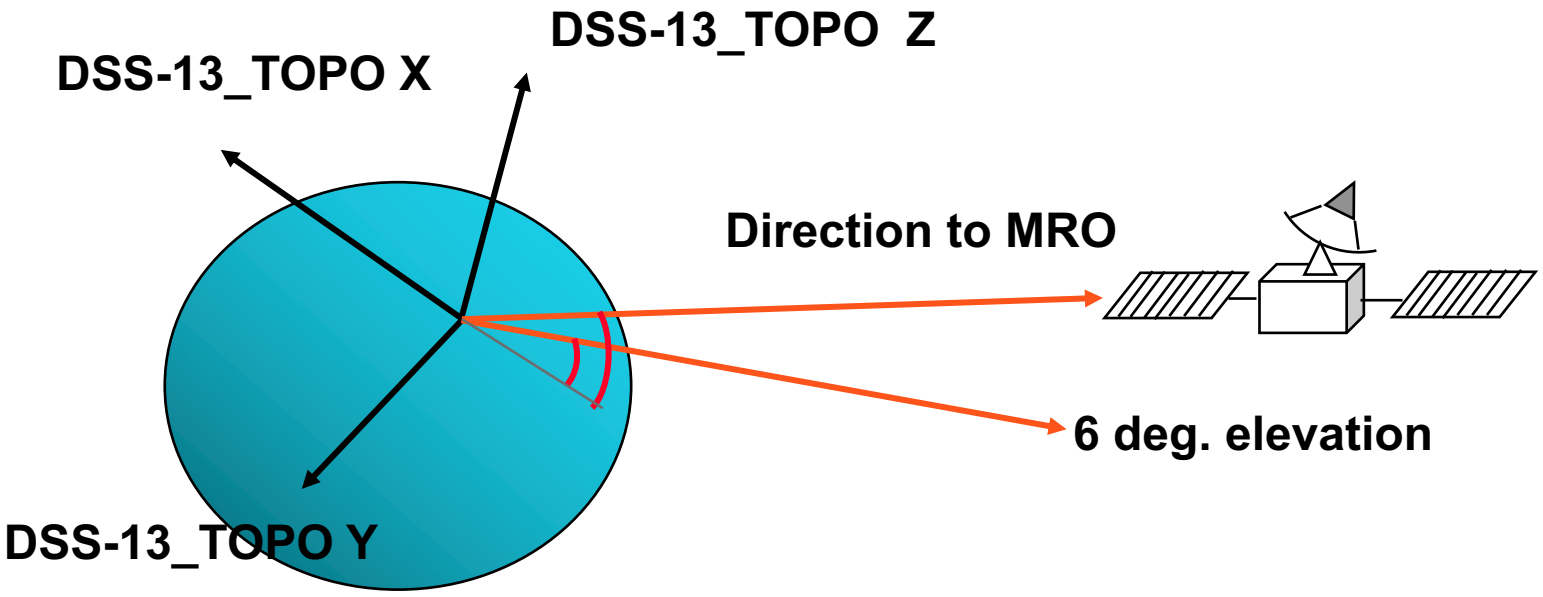
The FOV shape may be any of:

- Rectangle
- Circle
- Ellipse
- Polygon

API: GFTFOV

Position Coordinate Inequality Search -1

Find the time periods when the elevation of the DSS-13 to Mars Reconnaissance Orbiter (MRO) spacecraft vector, expressed in the DSS-13 topocentric frame, is greater than 6 degrees.



API: GFPOSC