

Navigation and Ancillary Information Facility

Digital Shape Kernel Subsystem (DSK)

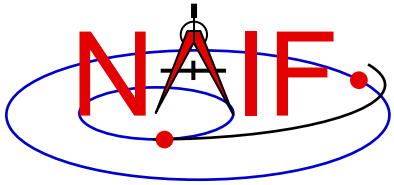
April 2023



Topics

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- **DSK subsystem overview**
- **DSK shape representations**
- **N67 version of DSK subsystem**
- **DSK APIs and graphical depictions**
- **DSK API example**
- **DSK utility programs**
- **DSK concepts**
- **Writing and using DSK files**



DSK Subsystem Overview

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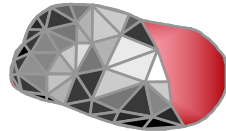
- **The DSK subsystem**
 - enables SPICE-based applications to conveniently make use of high fidelity surface shape (topographic) data in geometry computations
 - serves as a format for transmission and archival of surface shape data
 - consists of SPICE software, DSK file format specifications, and documentation



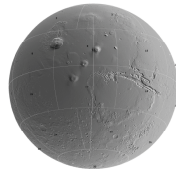
DSK Shape Representations

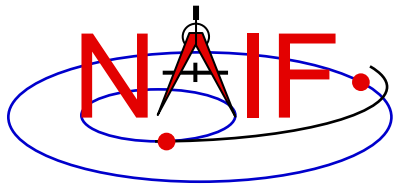
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- The DSK subsystem handles two representations of shape data
 - Tessellated plate model (Type 2)



- Digital elevation model (development not yet finished) (Type 4)

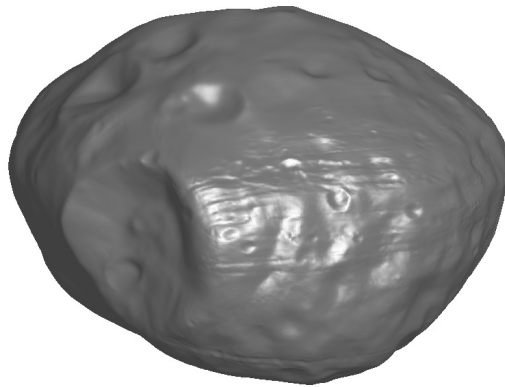




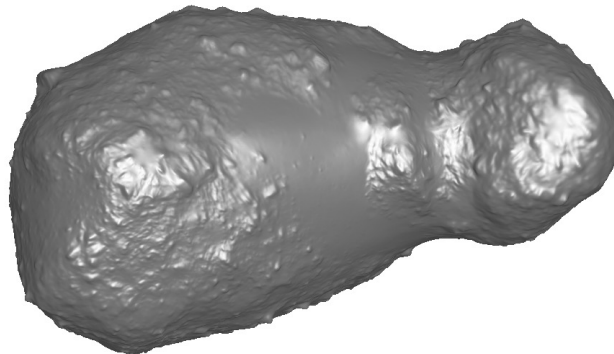
Tessellated Plate Model – Type 2

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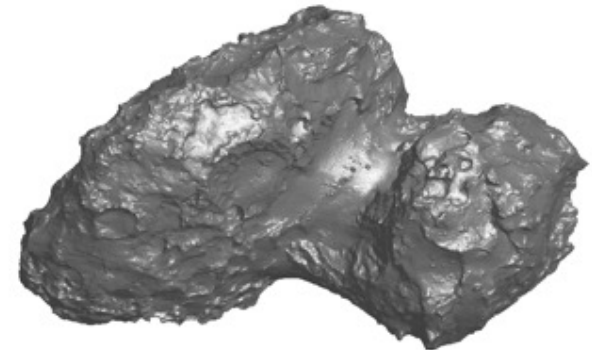
- The surface of the object is represented as a collection of triangular plates
- More flexible than digital elevation model: any arbitrary 3-D surface can be modeled
 - Surface could be a complicated shape with multiple surface points having the same latitude and longitude
 - » Examples: “dumbbell”-shaped asteroid, caves, arches
- Less efficient than digital elevation model (DSK Type 4) of similar resolution in terms of storage and computational speed



Phobos



Itokawa



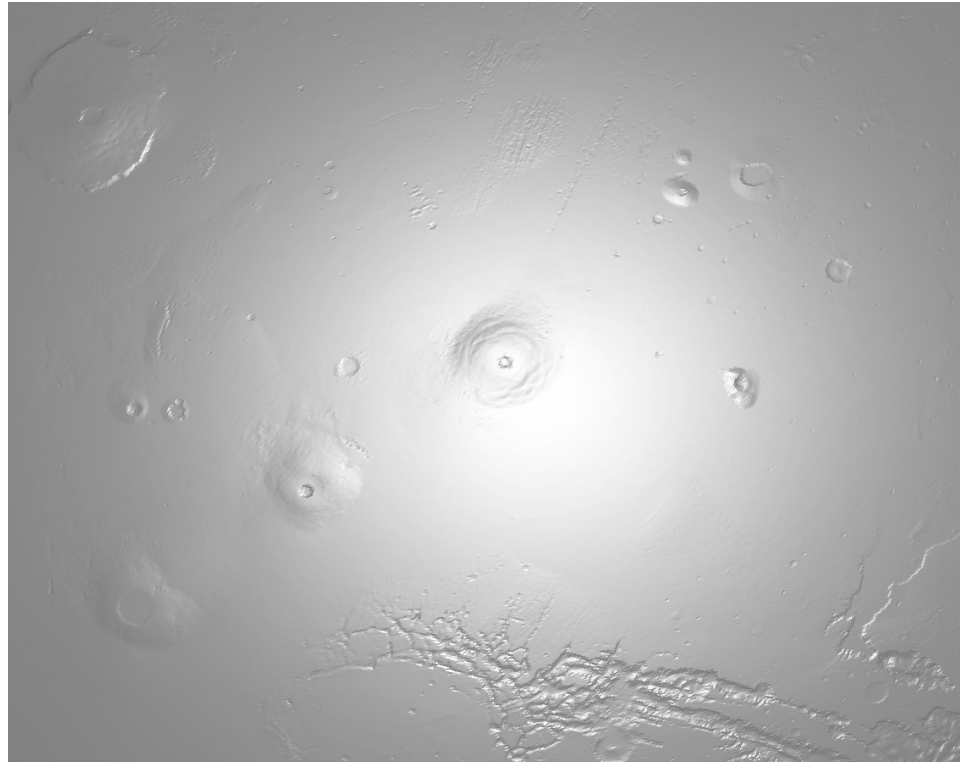
Churyumov-Gerasimenko

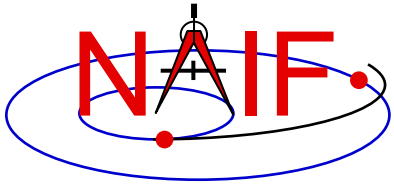


Digital Elevation Model – Type 4

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- **Maps longitude/latitude to “elevation”**
 - Elevation of a surface point can be defined as distance from the origin of a body-fixed reference frame or height above a reference ellipsoid
- **Example: rendering of a piece of DSK data created from MGS laser altimeter (MOLA) Mars DEM**





N67 Toolkit with DSK

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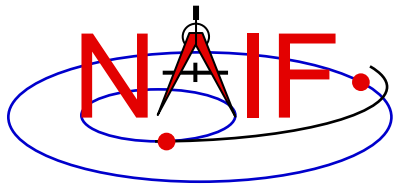
- **Supports only the tessellated plate model data type (Type 2 DSK)**
- **Support for Digital Elevation Model (DEM) (Type 4 DSK) will be added in a future Toolkit version**



Some DSK Features

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- **Supports multi-segment, multi-file DSK data sets**
 - Up to 5000 DSK files can be loaded simultaneously
 - Up to 10,000 DSK segments can be loaded simultaneously
- **Supports run-time data translation: big-endian DSK files can be read on little-endian platforms, and vice versa**
- **Pre-DSK era SPICE Toolkit geometry APIs will support DSK shape data, where applicable**



APIs Available in N66 Toolkits -1

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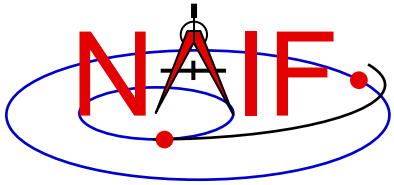
- **Kernel load/unload/info:**
 - FURNISH, UNLOAD, KCLEAR, KTOTAL, KINFO, KDATA
- **Geometry:**
 - Ray-surface intercept: SINCPT, DSKXV, DSKXSI
 - Sub-observer point: SUBPNT
 - Sub-solar point: SUBSLR
 - Illumination angles at surface point: ILLUMF, ILLUMG, ILUMIN
 - Longitude-latitude pairs to surface points: LATSRF
 - Find occultation state at a given time: OCCULT
 - Find occultation or transit of point target behind/across DSK shape: GFOCLT
 - Generate limb points: LIMBPT
 - Generate terminator points: TERMPT
 - Compute outward normal vector at surface point: SRFNRM



APIs Available in N66 Toolkits -2

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- **Low-level access:**
 - DLA segment traversal: DLABFS, DLABBS, DLAFNA, DLAFPA
 - Fetch type 2 counts/plates/vertices/normals: DSKZ02, DSKP02, DSKV02, DSKN02
 - Fetch all type 2 data structure contents: DSKI02, DSKD02
 - Fetch DSK segment descriptor: DSKGD
- **Plate utilities:**
 - PLTVOL, PLTAR, PLTEXP, PLTNP, PLTNRM
- **Create DSK files:**
 - DSKOPN, DSKW02, DSKCLS, DSKMI2, DSKRB2
- **Summary routines:**
 - DSKOBJ, DSKSRF
- **Surface name-code translation:**
 - SRFS2C, SRFSCC, SRFC2S, SRFCSS



Graphic Depictions

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- **In the next several charts we provide graphic depictions of the high-level APIs that should be of interest to many users**

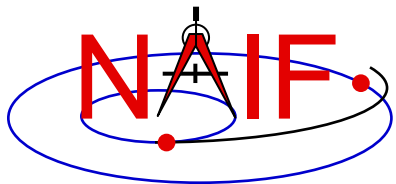
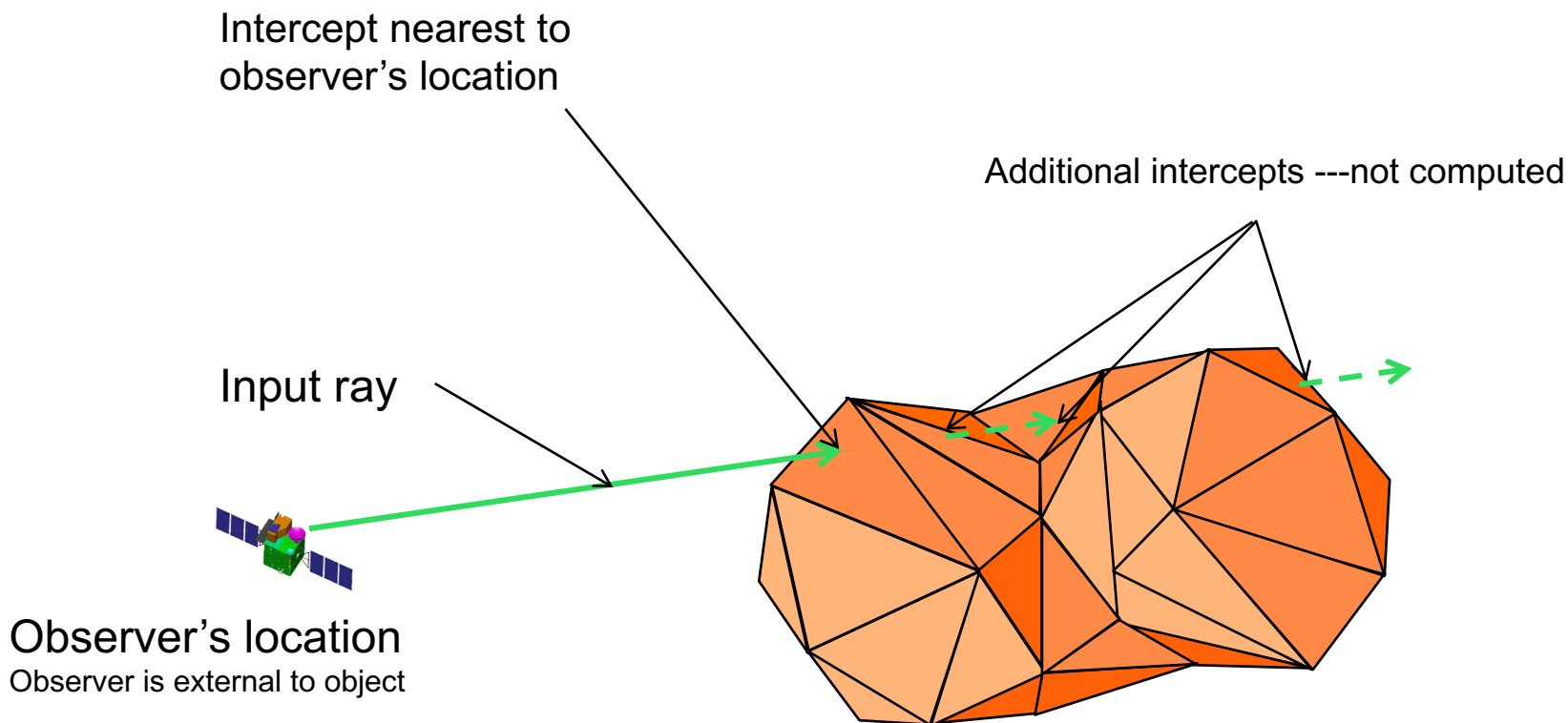


Plate Model Surface Intercept

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API: SINCPT



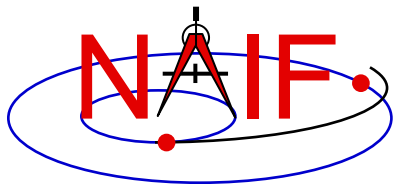
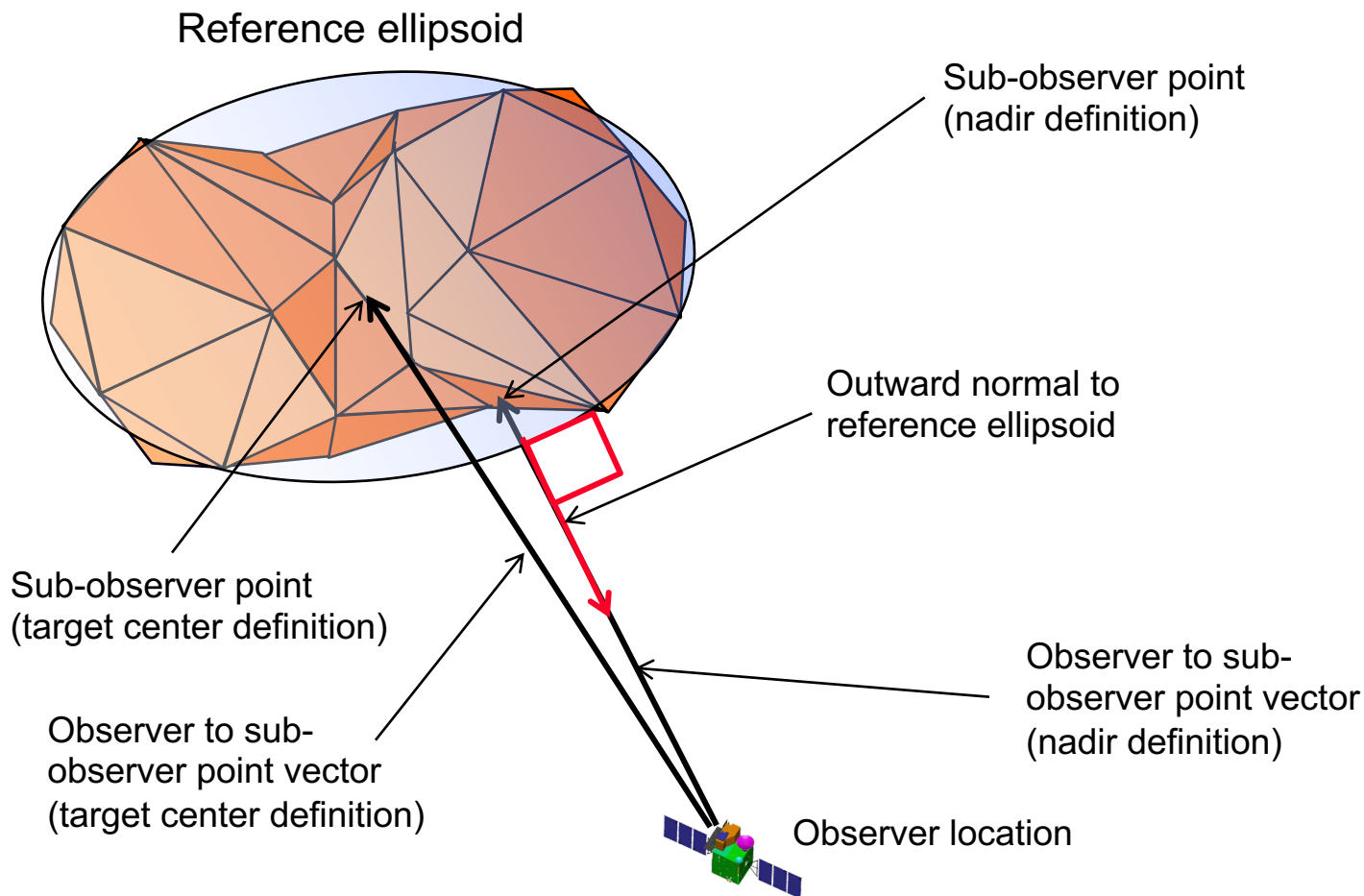


Plate Model Sub-observer Point

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API: SUBPNT



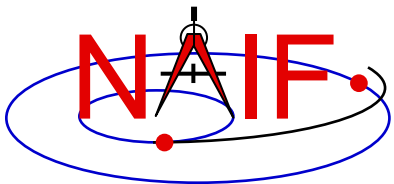
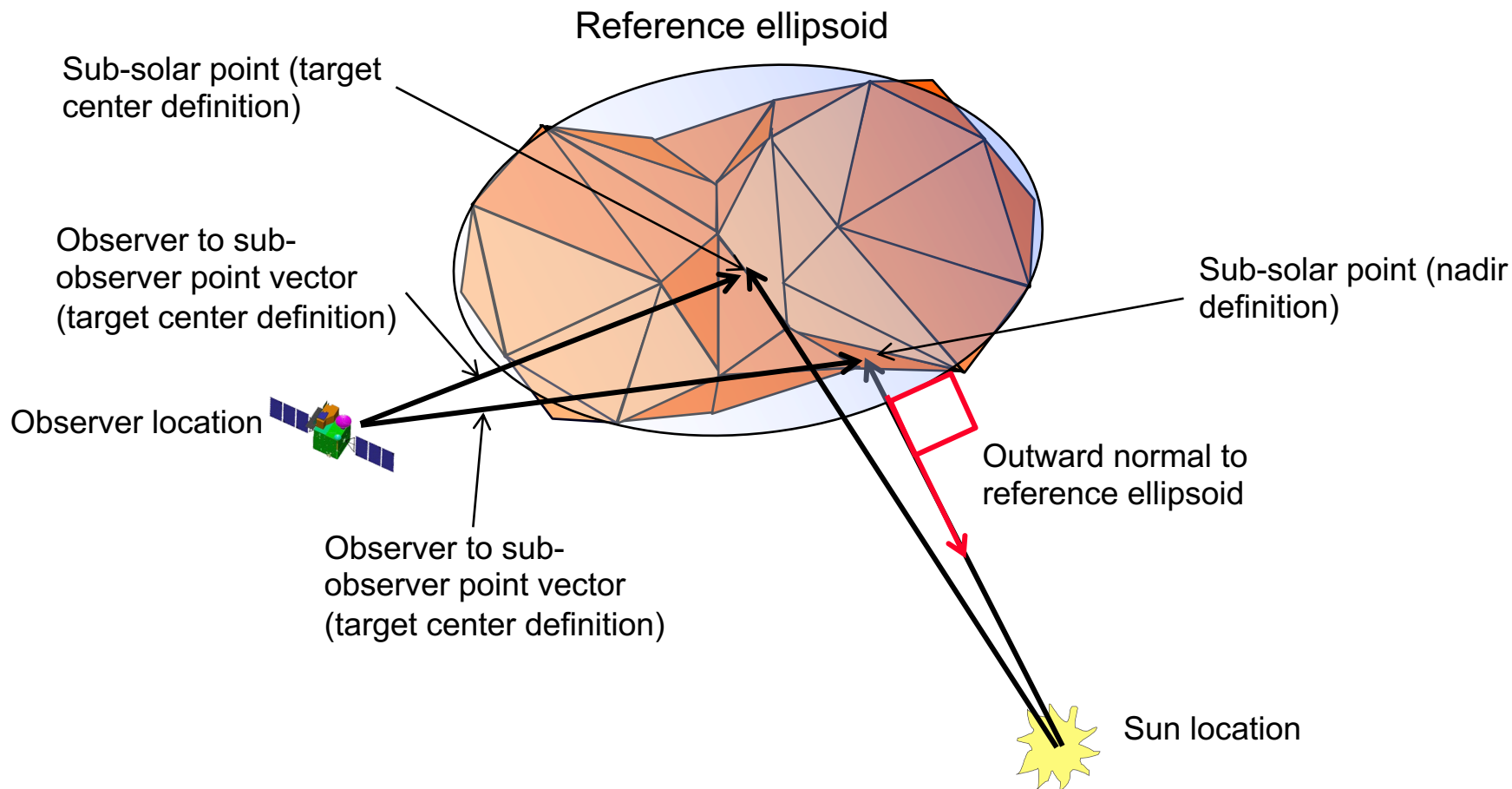


Plate Model Sub-solar Point

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API: SUBSLR



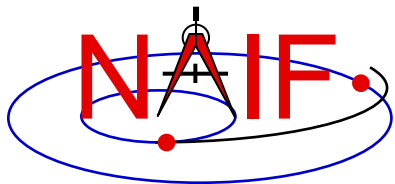
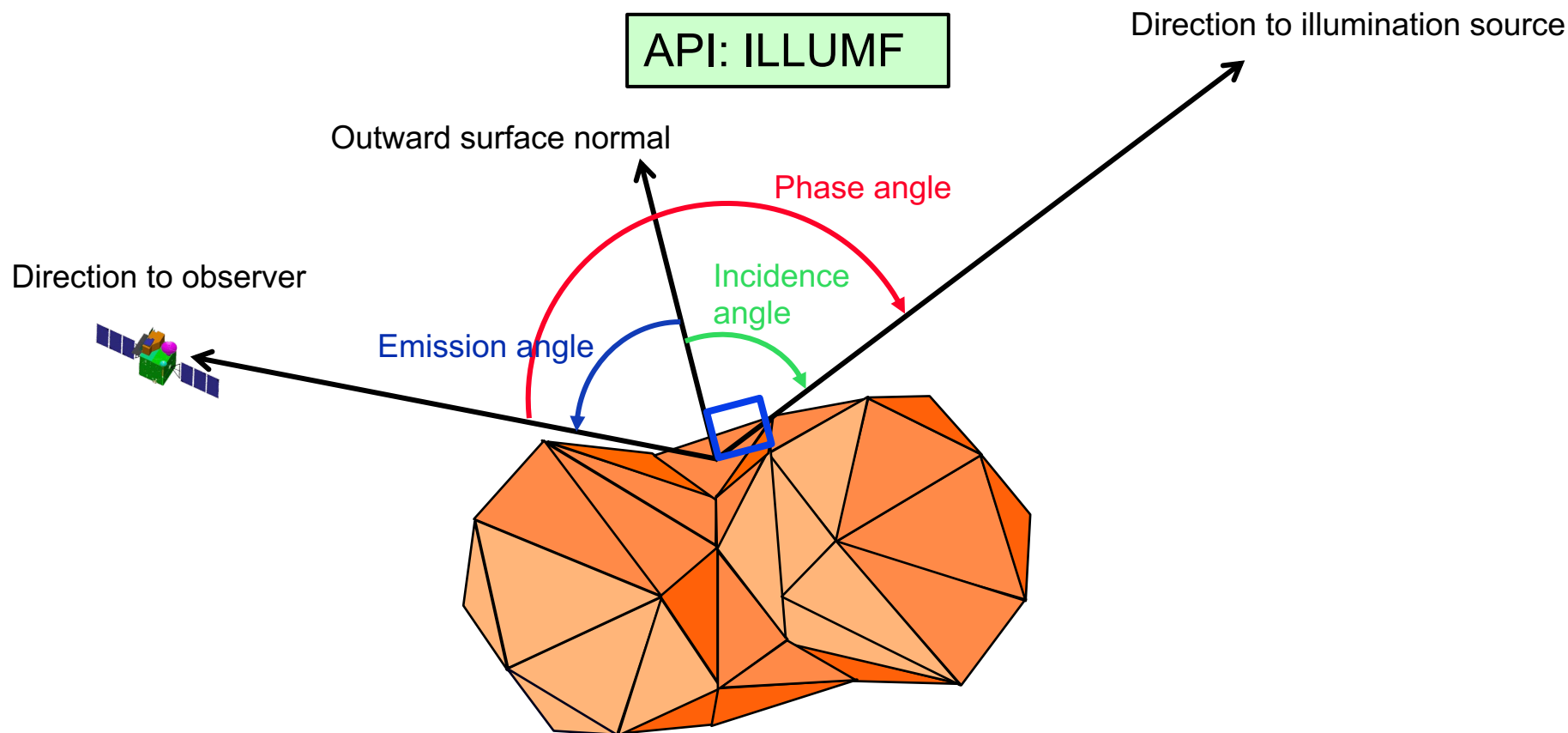


Plate model Illumination Angles

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Also returned:

- target epoch (corrected for light time),
- observer visibility flag,
- illumination source visibility flag

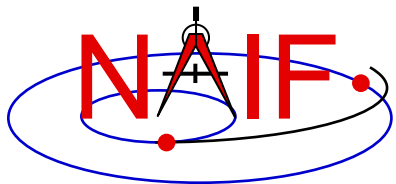


Plate Model Surface Point Grid

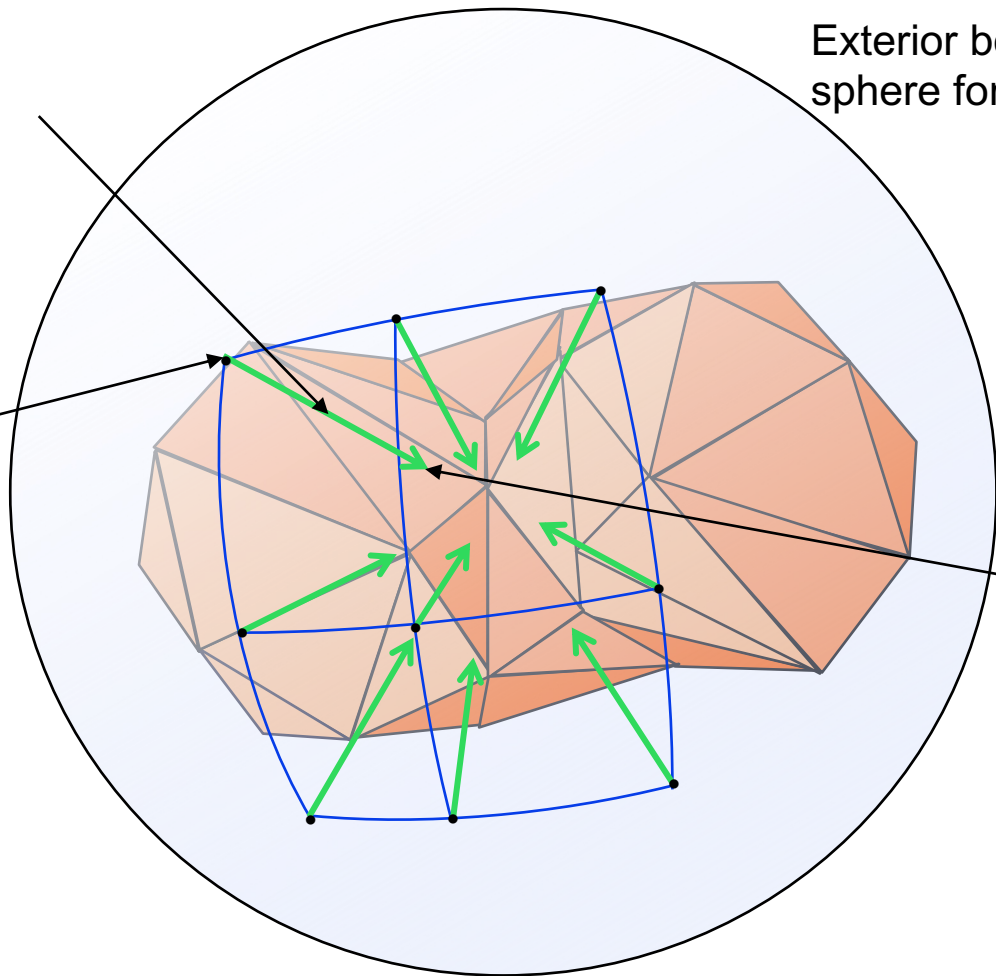
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API: LATSRF

Ray emanating from sphere point, pointing toward center of body-fixed, body-centered reference frame

Exterior bounding sphere for target object

Point on bounding sphere, specified by planetocentric longitude and latitude, and by radius of exterior bounding sphere. This grid contains 9 such points.



Surface intercept point corresponding to point on bounding sphere: planetocentric longitude and latitude of intercept match those of the sphere point. An intercept is computed for each input sphere point.

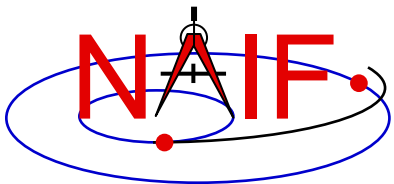


Plate Model Limb-1

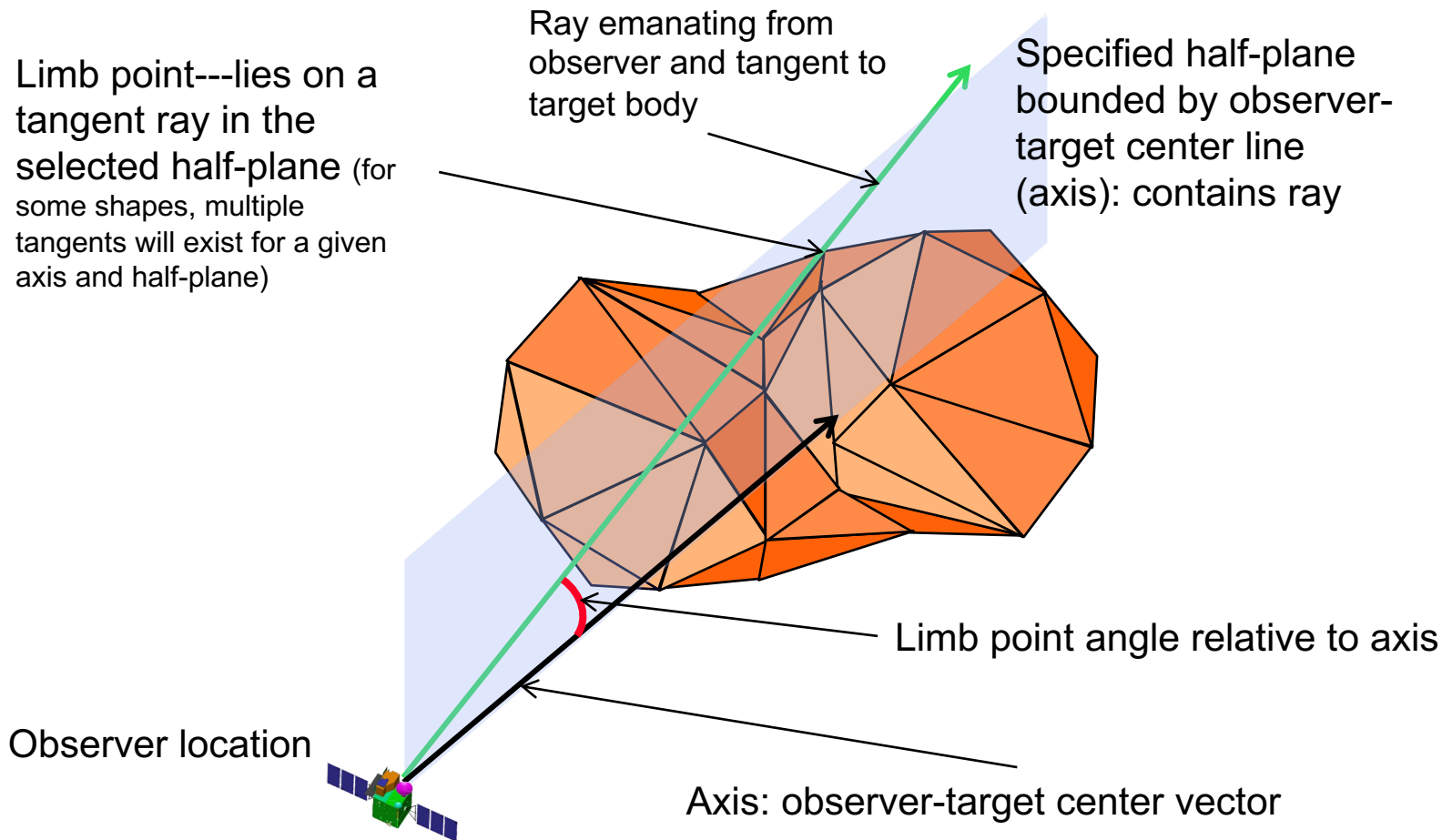
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API: LIMBPT

Limb point---lies on a tangent ray in the selected half-plane (for some shapes, multiple tangents will exist for a given axis and half-plane)

Ray emanating from observer and tangent to target body

Specified half-plane bounded by observer-target center line (axis): contains ray



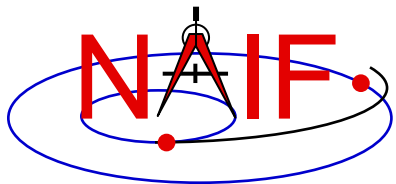
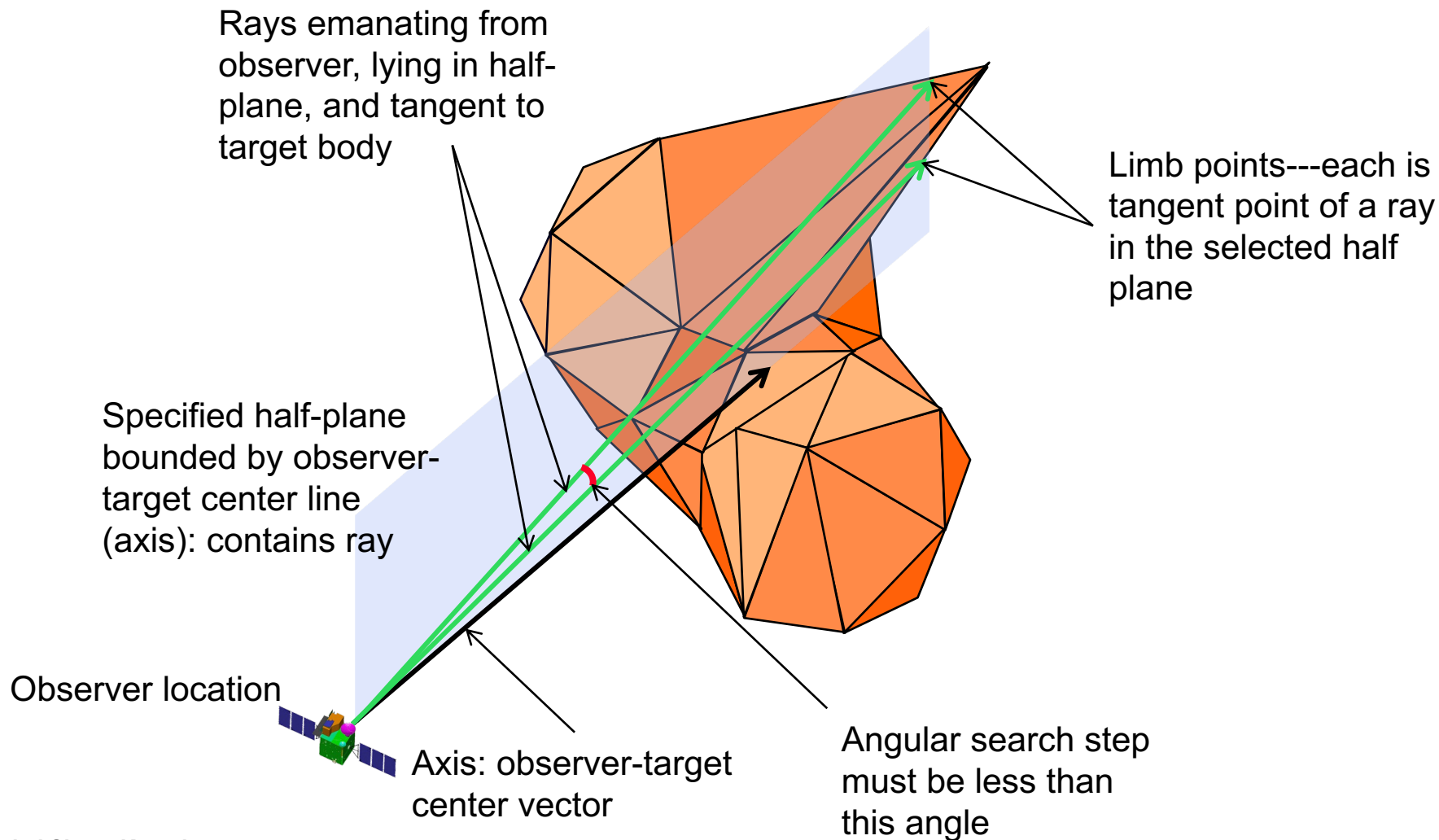


Plate Model Limb-2

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API: LIMBPT



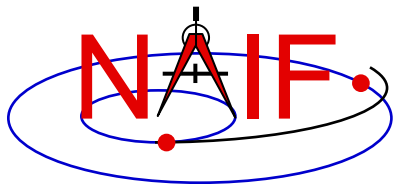


Plate Model Terminator-Umbral

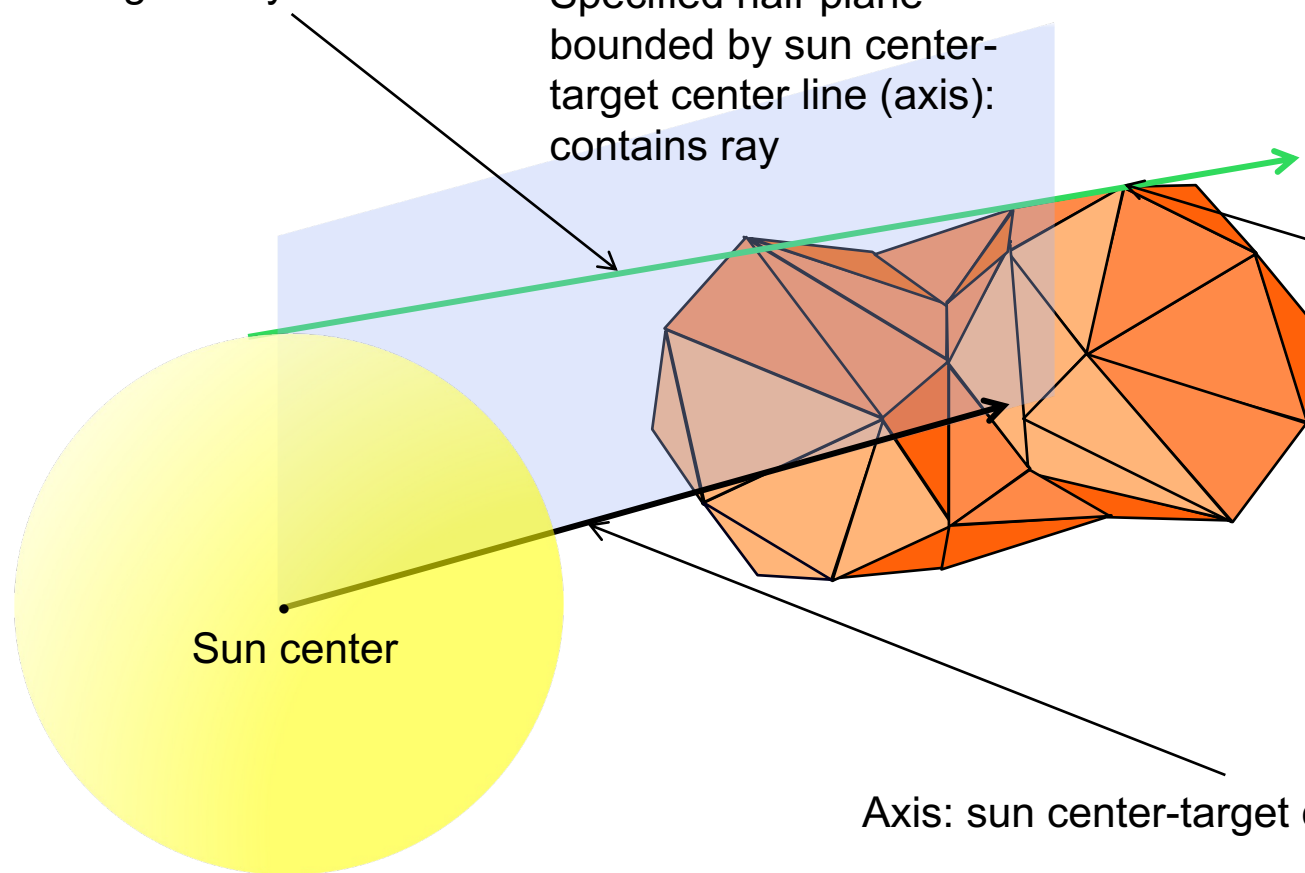
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API: TERMPT

Ray tangent to sun
and target body

Specified half-plane
bounded by sun center-
target center line (axis):
contains ray

Umbral terminator
point: lies on a tangent
ray in the specified
half-plane (for some
shapes, multiple tangents will
exist for a given axis and
half-plane). Terminator point
and ray vertex are on
same side of axis.



Axis: sun center-target center vector

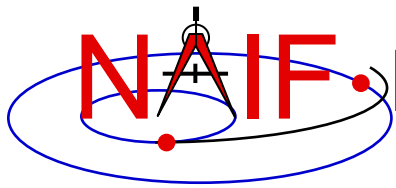
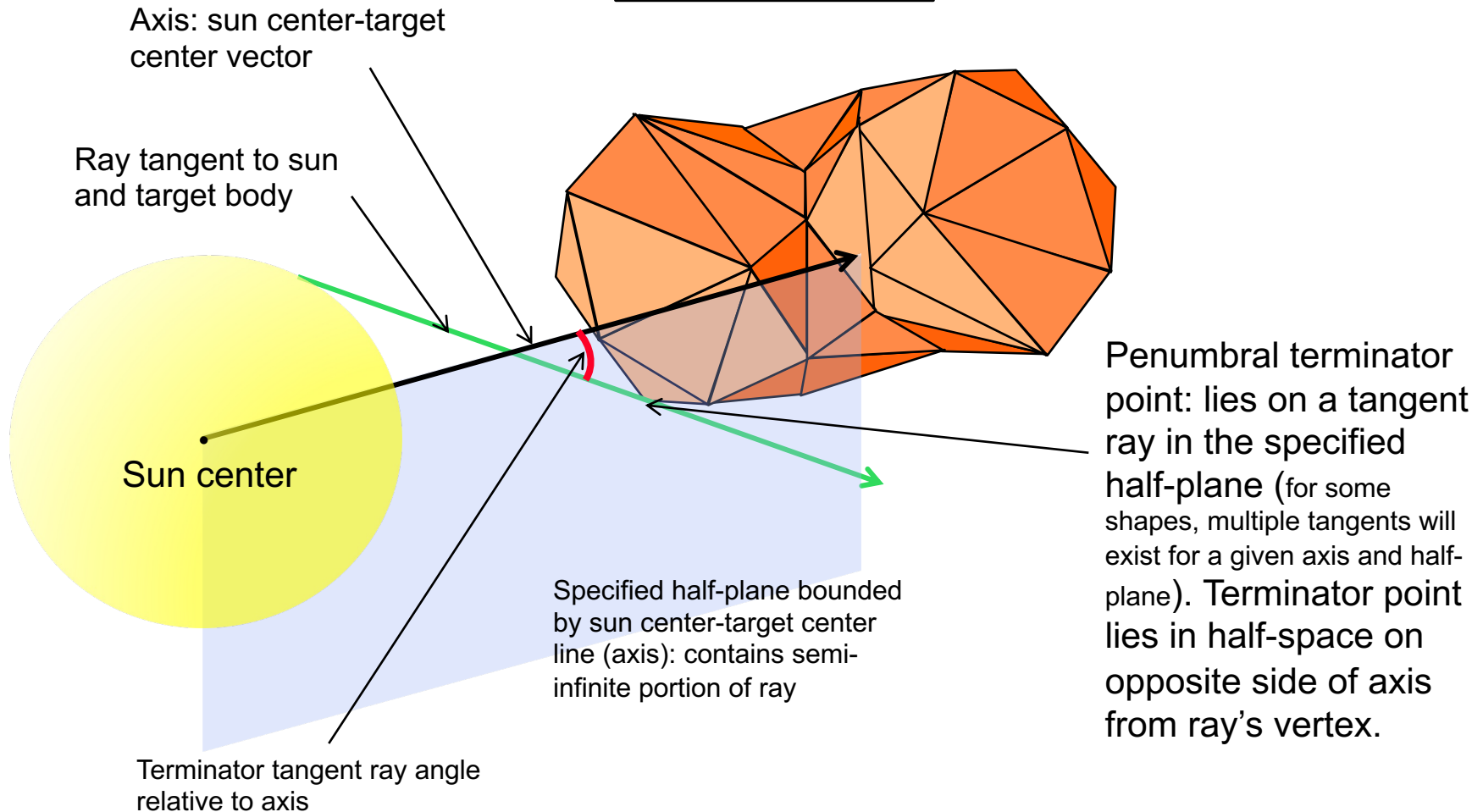
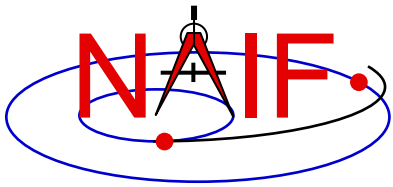


Plate Model Terminator-Penumbral

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API: TERMPT



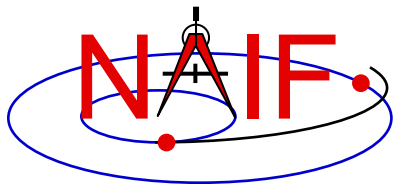


Example of API Using DSK - 1

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- Find ray intercept point on target surface:
 - CALL SINCPT (**METHOD**, TARGET, ET, FIXREF, ABCORR, OBSRV, DREF, DVEC, SPOINT, TRGEPC, SRFVEC, FOUND)
 - SINCPT is a high-level SPICE API.
 - The input string argument **METHOD** indicates the surface model to use.
 - » To model the target body shape using an ellipsoid, set METHOD to 'ellipsoid'
 - » To model the target body shape using DSK data, set METHOD to one of the forms
 - 'DSK/UNPRIORITIZED'
 - If all DSK segments for the body designated by TARGET are applicable
 - 'DSK/UNPRIORITIZED/SURFACES = <surface name or ID 1>, ...'
 - If only DSK segments for the specified surfaces associated with the body designated by TARGET are applicable
 - » For the DSK case, the keyword UNPRIORITIZED is currently required. This keyword indicates that no applicable segment can mask another.

Fortran code
example



Example of API Using DSK - 2

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- » **Other inputs:** target body name, epoch, body-fixed reference frame, aberration correction, observer name, reference frame for direction vector, direction vector.
- » **Outputs:** ray-surface intercept in Cartesian coordinates, expressed in the body-fixed frame associated with the target---evaluated at the optionally light-time corrected epoch TRGEPC, TRGEPC itself, observer-to-intercept vector expressed in body-fixed frame, and found flag indicating whether intercept exists.

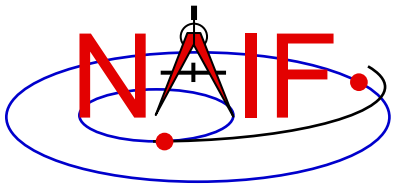


DSK Utility Programs

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- **Create DSK files: MKDSK**
 - Creates a DSK file containing a single type 2 segment
- **Export DSK data to text format files: DSKEXP**
 - Writes data from Type 2 DSK segments to one or more text files
 - Supports simple output formats such as “obj”
- **Summarize DSK files: DSKBRIEF**
- **Modify DSK segment attributes: DSKMOD**
- **Merge DSK files: DLACAT**
 - Concatenates segments from multiple DSK files into a single DSK file
- **Transform binary architecture of DSK file: TOXFR, TOBIN, BINGO (BINGO not part of standard SPICE Toolkit)**
- **Read/write comment area: COMMNT**

- **DSKMOD, DLACAT, and BINGO are provided on the NAIF Web site (<https://naif.jpl.nasa.gov/naif/utilities.html>)**



DSK Concepts-1

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- **Surface**
 - **"Surface"** is a second identifier, in addition to the central body
 - » A **"surface"** has a name and an integer ID code
 - Surfaces occupy a name space distinct from that of bodies
 - APIs are provided for surface name/ID conversion
 - **Used to distinguish different versions of data for a given body**
 - » **Allows use of different versions without loading and unloading kernels**
 - High-frequency kernel loading and unloading is too inefficient for DSK applications
- **Data class**
 - **Data class is a "hook" to differentiate kinds of data for different applications**
 - » **Distinct from concept of "data type"**
 - **Existing classes indicate geometric characteristics of surface data**
 - » **Class 1: shape is single-valued function of domain coordinates. Example, for latitudinal coordinates:**
 - Every ray emanating from the origin of the body-fixed reference frame associated with the body passes through the surface once
 - Such surfaces cannot have features such as cliffs or caves
 - DEMs can represent class 1 surfaces
 - » **Class 2: arbitrary shape**
 - Not required to be convex, closed, or connected
 - Plate models are the only DSK data type that can be used for class 2 surfaces



DSK Concepts-2

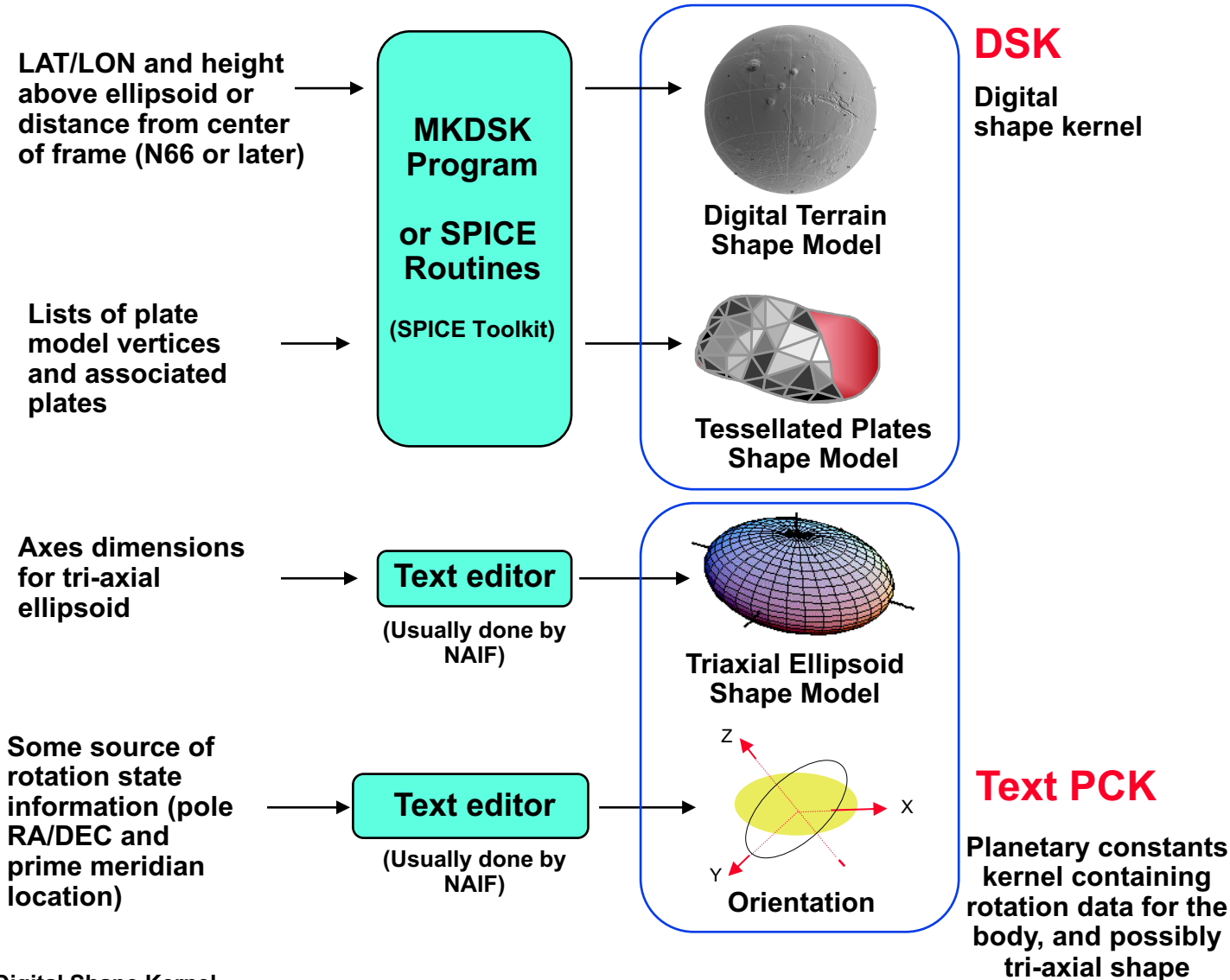
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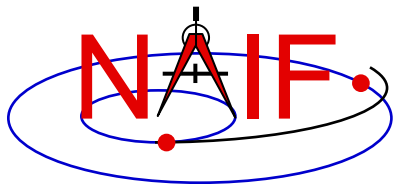
- **Kernel priority**
 - Unlike SPK, CK, and binary PCK files, the concept of segment “priority” does not apply to all DSK applications
 - » Not applicable to data sets including segments of class 2
 - Concept simply doesn’t make sense when multiple heights can correspond to a single longitude/latitude coordinate pair
 - » Can apply to data sets containing only class 1 segments
- **Coordinate systems**
 - Associated with segments
 - » Segment coverage is described in terms of a coordinate system associated with that segment
 - Can be any of
 - » Planetocentric (latitudinal)
 - » Planetodetic
 - » Cartesian
- **Segment coverage**
 - The spatial “coverage” of a segment is a region of space within which the segment provides valid surface data
 - » Characterized by three coordinate ranges
 - For example: min, max longitude; min, max latitude; min, max radius
 - » “Padding” data may be provided outside of a segment’s coverage region



Writing Shape and Orientation Kernels

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Using Shape and Orientation Kernels

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