"Camera-matrix" Kernel CK

(Orientation or Attitude Kernel)

Emphasis on reading CK files

January 2017
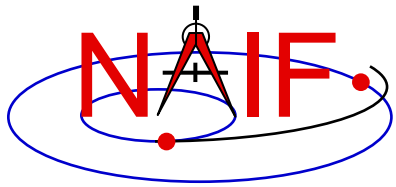
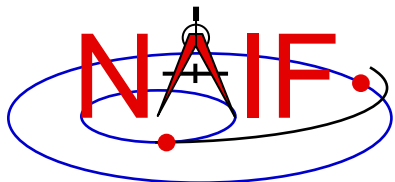**Navigation and Ancillary Information Facility**

- **A CK file holds orientation data for a spacecraft or a moving structure on the spacecraft**
  - "Orientation data" $\Rightarrow$ quaternions, from which orientation matrices are formed by SPICE software. These matrices are used to rotate position vectors from a base reference frame (the "from" frame) into a second reference frame (the "to" frame)
    - » In SPICE this is often called the "C-matrix or "Camera matrix"
  - Optionally may include angular velocity of the "to" frame with respect to the "from" frame
    - » Angular velocity vectors are expressed relative to the "from" frame.

- **A CK file should also contain comments–sometimes called metadata–that provide some details about the CK such as:**
  - the purpose for this particular CK
  - when and how it was made
  - what time span(s) the data cover
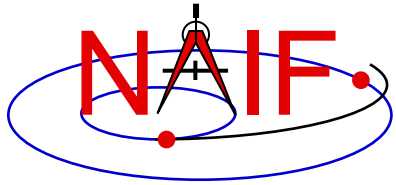
Navigation and Ancillary Information Facility

- **A single CK file can hold orientation data for one, or for any combination of spacecraft or their structures**
  - Some examples
    1. **Huygens Probe**
    2. **Cassini Orbiter and its CDA instrument mirror**
    3. **Mars Express Orbiter, PFS scanner, Beagle Lander**
    4. **MRO orbiter, MRO high gain antenna, MRO solar arrays**

- **But in most cases CKs contain data for just one structure**

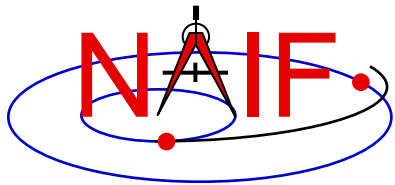**Navigation and Ancillary Information Facility**

- **"Reconstruction" CK (also called "definitive" CK)**
  - A CK file can be made from downlinked orientation telemetry returned from a spacecraft or other structure
  - A CK might also be made from some process that improves upon the pointing determined from downlinked telemetry ("C-smithing")
  - These kinds of files are generally used for science data analysis or spacecraft performance analysis

- **"Predict" CK**
  - A CK file can be made using information that predicts what the orientation will be some time in the future
    - » Input data usually come from a modeling program, or a set of orientation rules
  - This kind of file is generally used for engineering assessment, science observation planning, software testing and quick-look science data analysis
    - » If it has good fidelity, such a file might be used to "fill in the data gaps" of a reconstruction CK file
    - » In some cases (ESA in particular) the predict meets the reconstruction accuracy requirements; thus a true reconstruction CK is not generally produced
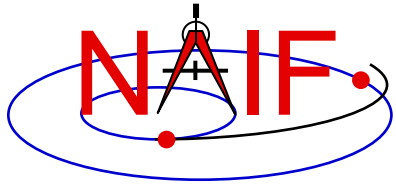
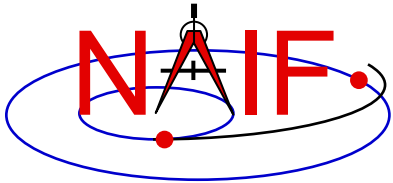**Navigation and Ancillary Information Facility**

- **Knowledge of CK variety–"reconstruction" or "predict"–might be implicit in the file naming schema, and/or might be provided in the comment section, but is not available using a SPICE API**

- **It is <u>in</u>advisable that both "reconstruction" and "predict" data be combined in a single file**

Kernel Data needed
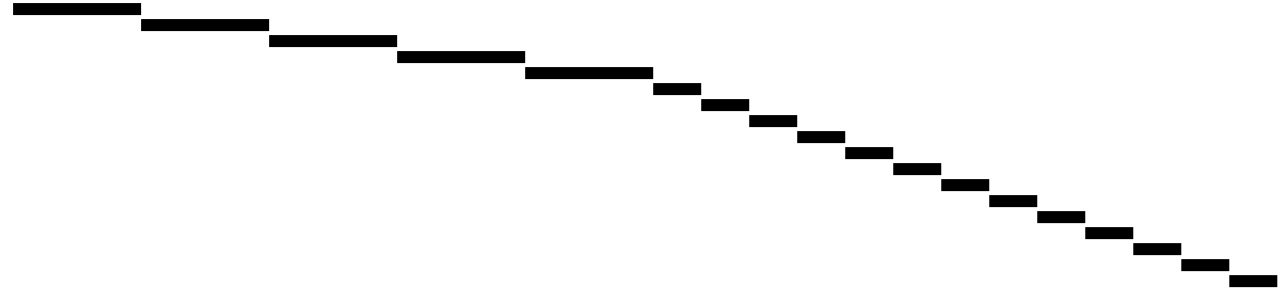
- **To obtain orientation one needs at least three SPICE kernel types: CK, SCLK, and LSK.**

  – **CK contains spacecraft or other structure orientation**

  – **SCLK and LSK contain time correlation coefficients used to convert between ephemeris time (ET) and spacecraft clock time (SCLK)**
    » **Sometimes an LSK is not needed in this conversion, but it's best to have it available as it is usually needed for other purposes**

- **One may also need an FK if planning to access CK data via high level SPICE interfaces.**

  – **FK associates reference frames with CK data via CK IDs**
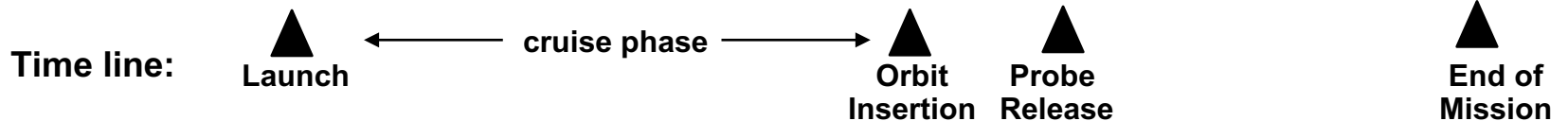
Navigation and Ancillary Information Facility

**Cassini
Orbiter:**

**Huygens
Probe:**

**Cassini
CDA Mirror:**

Time line:
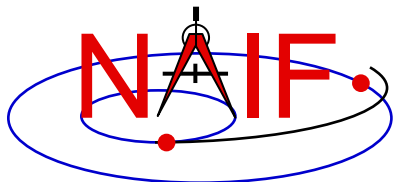
▲
Launch

◄———— cruise phase ————►

▲
Orbit
Insertion

▲
Probe
Release

▲
End of
Mission

*** Note: This is not an actual Cassini/Huygens scenario; it is a highly simplified illustration
of some of the possibilities for orientation delivery on a planetary mission.**
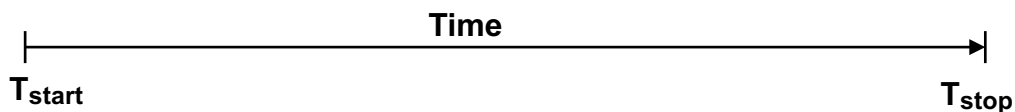
Even though a project's CK production process may suggest that CK files provide continuous coverage for the interval of time for which they were generated, in reality this is rarely the case. **CK files almost always contain gaps in coverage!** Below is an example of this.

Time

Coverage of …

T_{start} T_{stop}

a CK file:
as appears in file name/comments

CK file segments:
as appears in ckbrief/spacit summary

CK segments showing data gaps:
(CK Types 2 - 6)

The **blue line segments** represent interpolation intervals–times when pointing will be returned and the FOUND flag set to "TRUE."