Visualizing Kernels

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An ecosystem for this...
Yet another Spice overview: Kernels

• Files that contain information about a spacecraft:
  • Where the spacecraft is in time and space (spk)
  • Where the spacecraft is pointing in time and space, attitude (ck)
  • Where the instruments are in relation to the spacecraft (ik)
  • Frames, or points of reference (fk)
  • Clock calibrations (sclk)
  • Leap seconds (lsk)

• Or similar information, but about bodies:
  • Digital Shape Kernels (dsk)
  • Planetary Constants (pck)

• For convenience an ordered list of kernel references can be added to a single called a metakernel
Relationships from SPICE kernels

What does the math tell us?

• Kernels and/or metakernels are then fed to SPICE to do math

• Ultimately
  • A picture of what every instrument is looking at any point in time.

• Where do Kernels come from?
  • Curation by the Navigation and Ancillary Information Facility (NAIF)
  • Dreamers (Private)
    • Planning with “What if” scenarios
    • Scenario comparison
    • The more the better
Our future goals for Visualizing Kernels

• Make kernel handling easy
  • “Go shopping” for kernels from NAIF
  • Build a metakernel
  • Manage and back up configuration
  • Add your own meta-kernels

• No special software
• Works on any device: phone to laptop
• Easy sharing of any scenario, with permissions and security
• Encourage experimentation
• Easy to use
• Fast
Introducing Spaceline

• A new product from our small business Ascending Node Technologies

• **In:** Kernels
• **Out:** Interactive 3D Animations through spacetime

• What you’re about to see
  • Renderings of 3 independent metakernels for three active Mars missions
  • Maven, Odyssey, MRO, Mars with moons Phobos, Deimos
  • Instrument points of view
  • Rendered at 60 frames per second
  • In an off-the-shelf *browser*
  • *In its infancy*
Traditional Animation
We’ve all seen this before...

- STK / Cesium
- Cosmographia
- Eyes on the Solar System
- Solar Walk
- Small Body Mapping Tool
- ISIS (Mapping, from USGS, *integration with Spaceline*)
- JMars/JAsteroid

- How Spaceline is different:
  ✓ Just a browser
  ✓ Built in kernel management
  ✓ Kernel based
  ✓ Accepts live updates
  ✓ API
... with animation
Error Handling

Spaceline not only handles the visualization of a scenario and the rendering of proposed test data, but also provides a simple interface to identify and debug any existing issues with the SPICE metakernel

• Identify coverage gaps
• Identify broken links in meta-kernel reference paths
• Issues are identified and presented to the user via visual graphs (the Informatics part of Spaceline)
Handling Coverage Gaps

• Getting kernels right is hard
• Over a time range, they don’t always have data or coverage
• Graphical view of attitude kernels inside a meta-kernel:

 Error! No Data, No Coverage, No Math.
Handling Broken Links

- Kernels define telemetry with respect to some prior defined coordinate system
- Sometimes, a kernel containing a required coordinate system isn’t present

* Non-standard frame
Flight Ready: The three pillars of engineering

- Systems Engineering: Keepers of the truth and mouthpiece of the truth
- Development: Execute the truth
- Testing: Test against the truth
## Potential Uses

All Phases of a typical deep space mission (A-F)
- Experimentation, Proposal development, Trade analysis, Quick turnaround
- Low overhead
- Easy sharing

Science data simulation – Live insets to show what an instrument is looking at.

Public outreach

Education

Museums

Customization, private installs
http://ascendingnode.tech