Visualizing Kernels

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An ecosystem for this…

MROCAM1
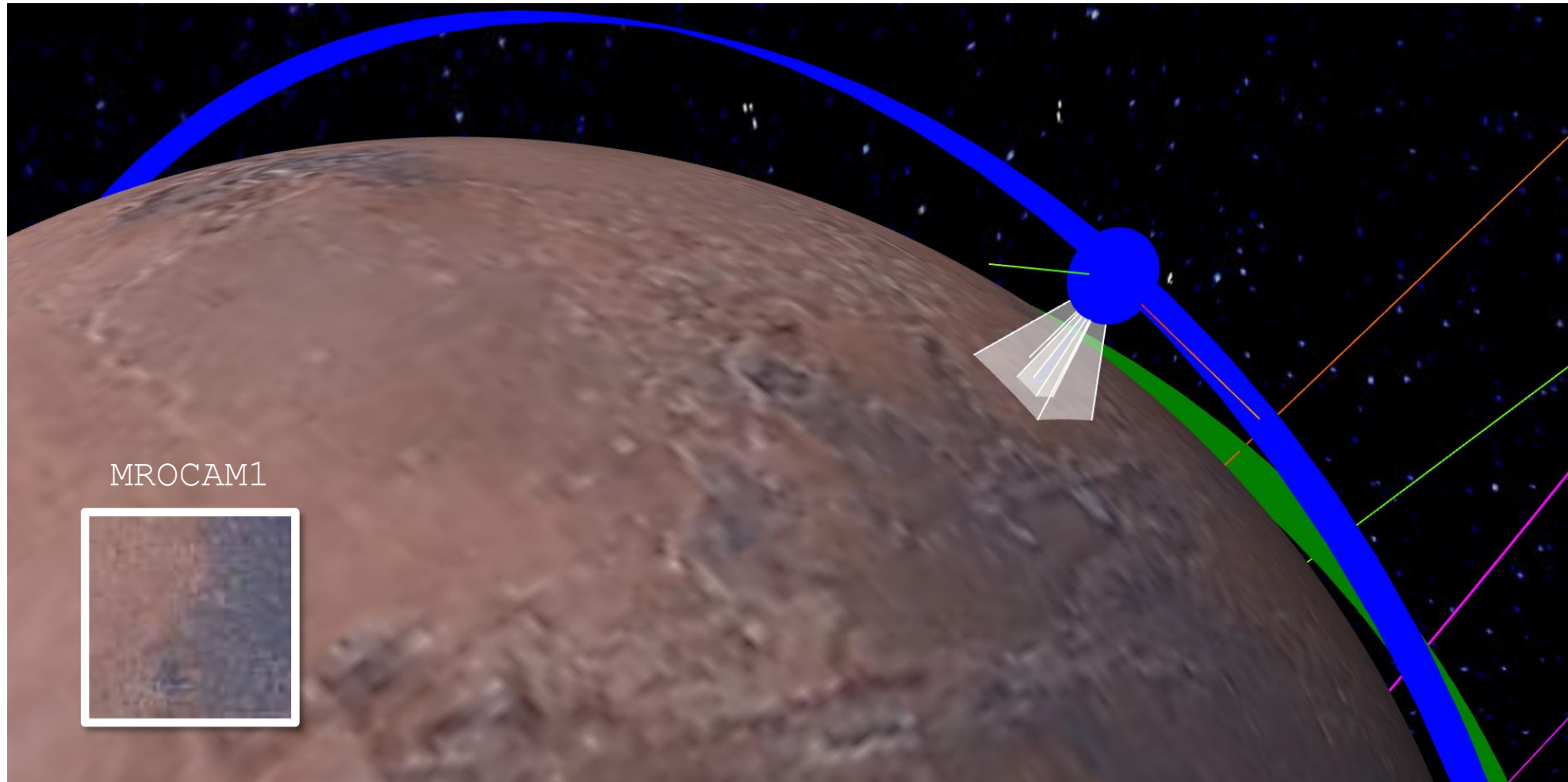
Yet another Spice overview: Kernels

- 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
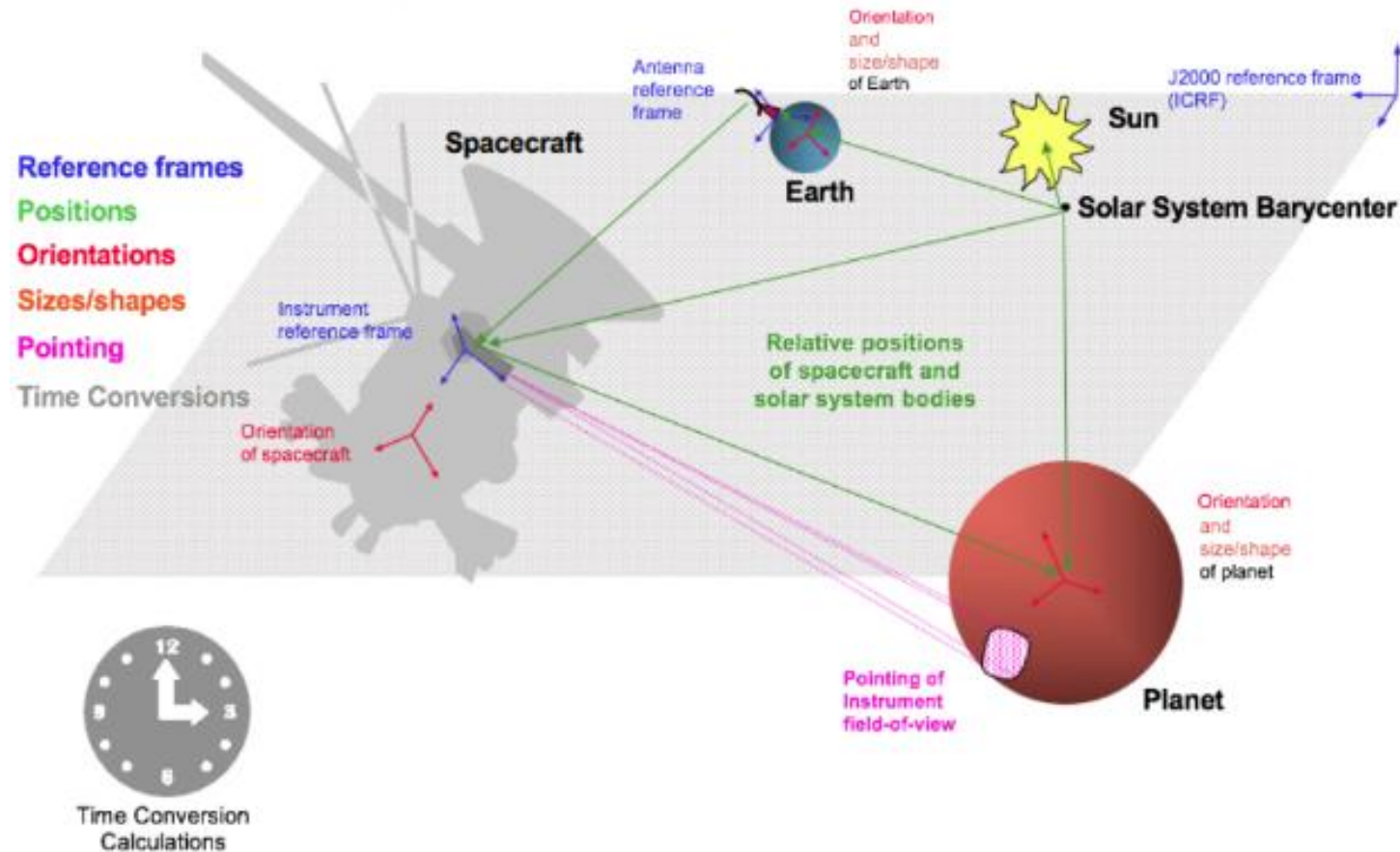
Ancillary data services of NASA's Navigation and Ancillary Information Facility", Acton, Charles H., Planetary and Space Science, Volume 44, Issue 1, p.65-70. Jan 1996.

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

- <u>In</u>: Kernels
- <u>Out</u>: 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*
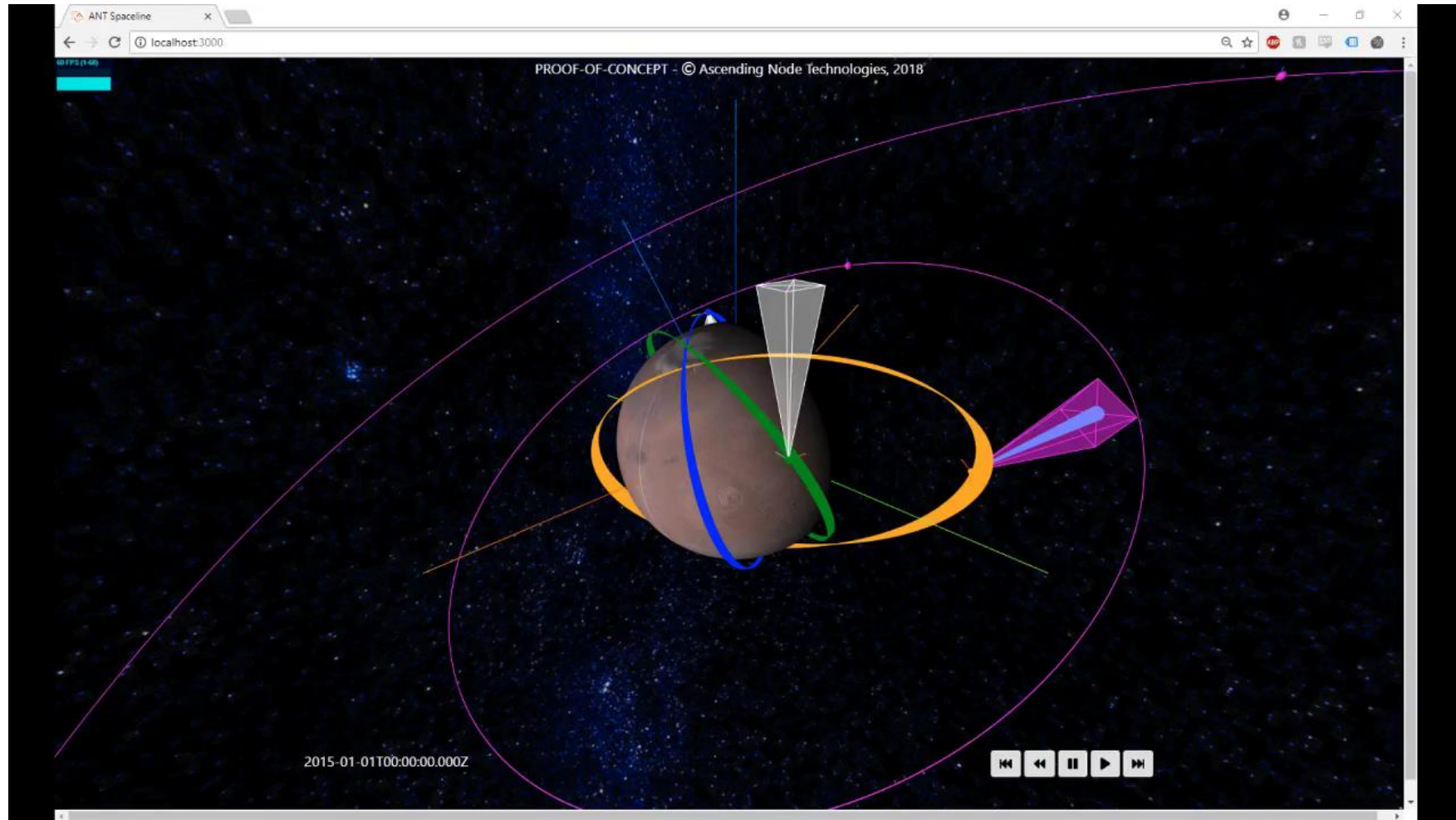 - <u>*In its infancy*</u>

Traditional Animation
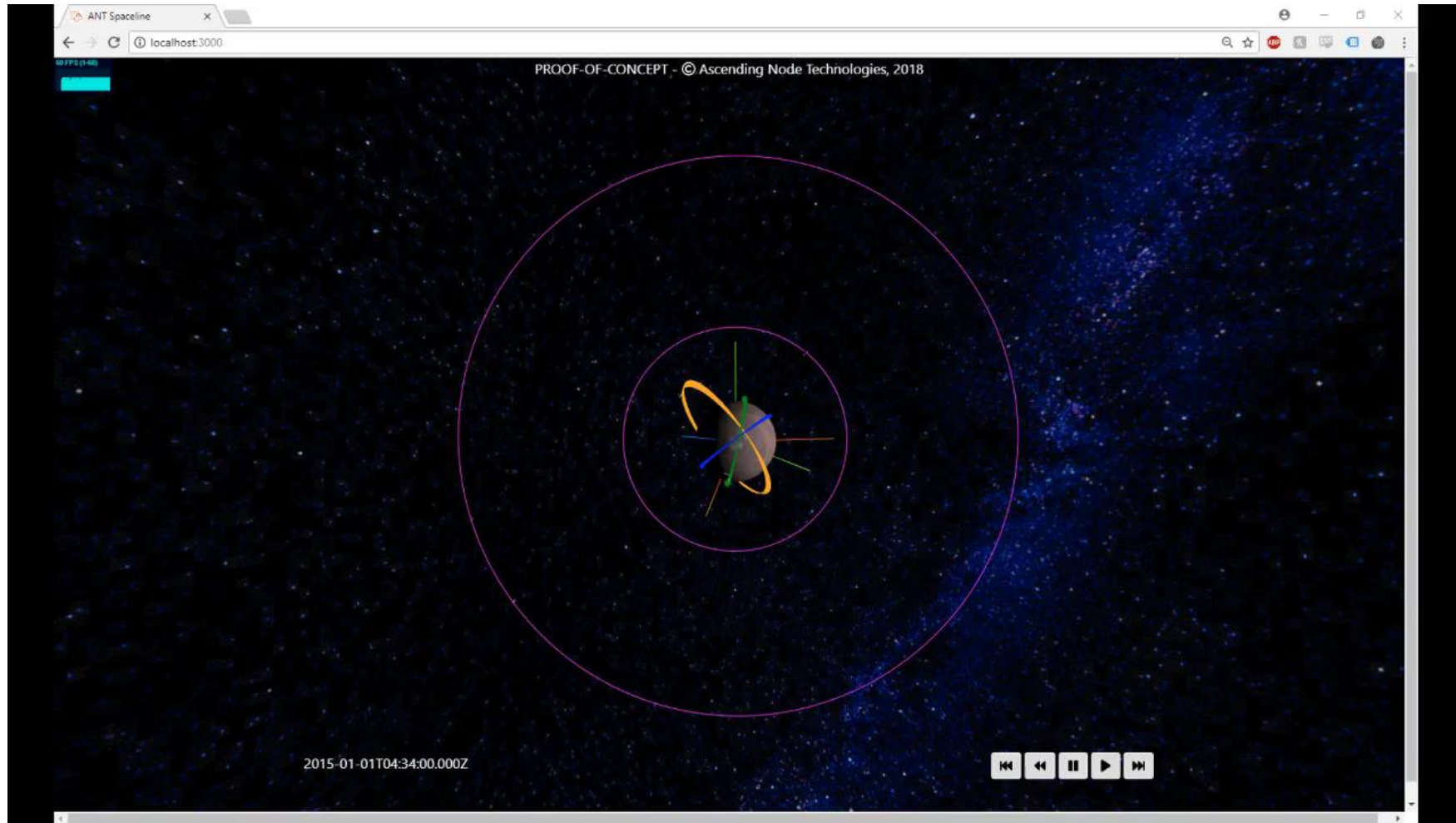
We've all seen this before…

- 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.
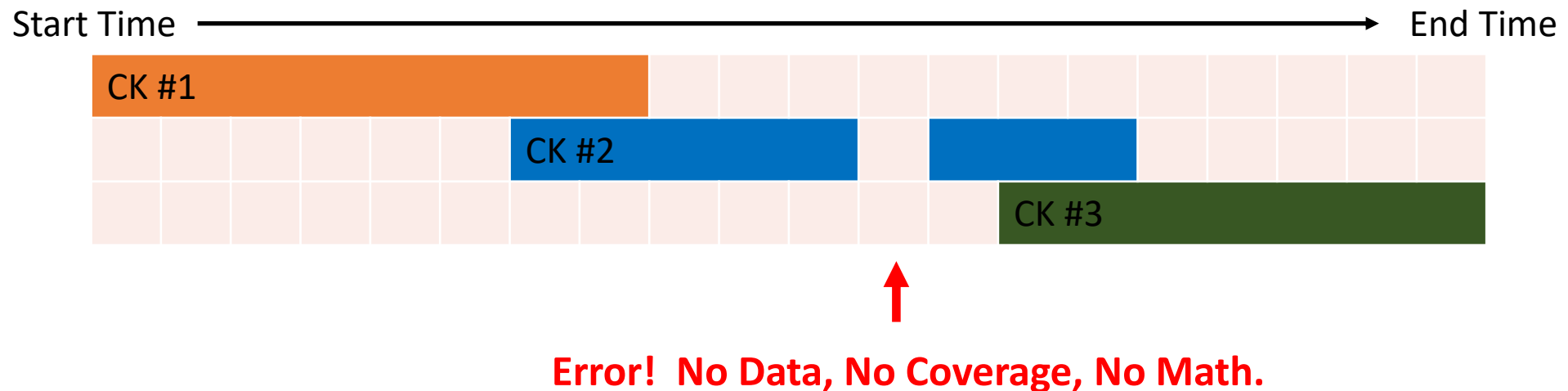
Handling Broken Links

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

Legend	
Blue	Planet
Green	Spacecraft
Yellow	SPK
Orange	Frame from FK
Cyan	Time Variant Attitude (CK)
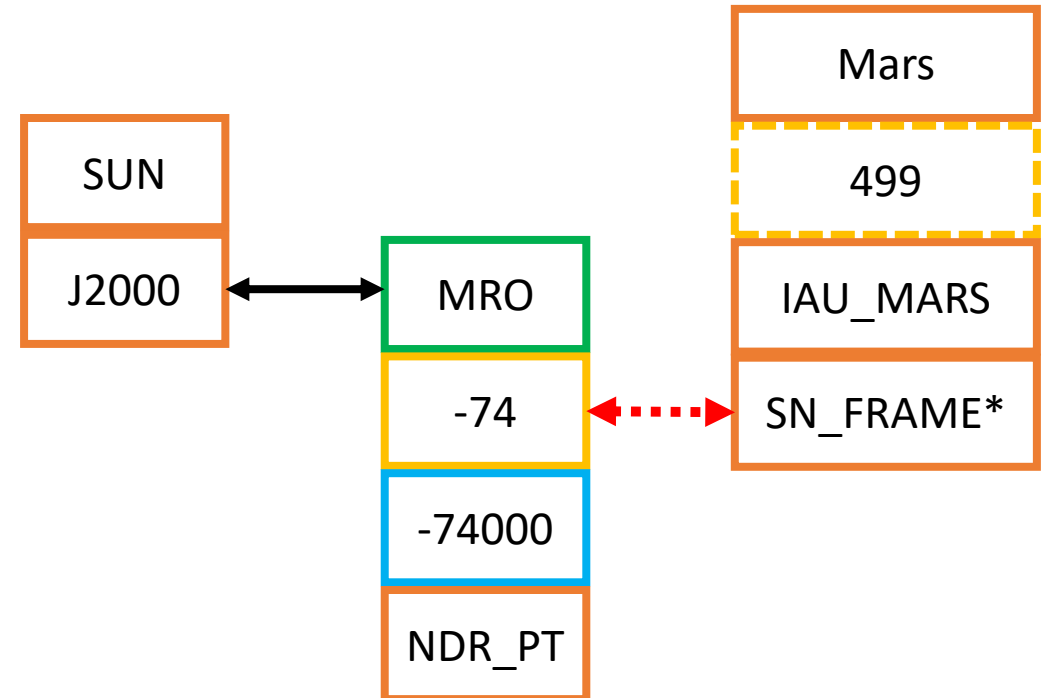
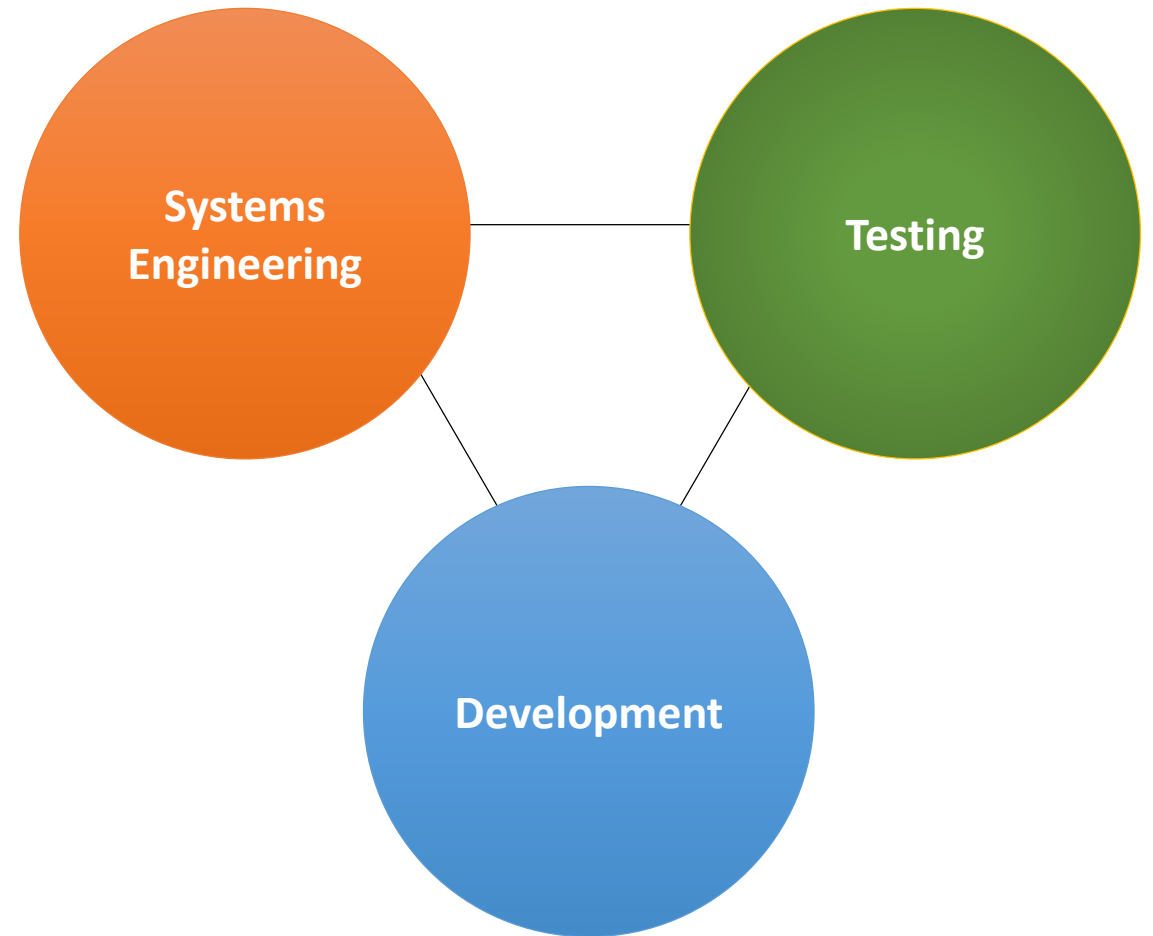* Non-standard frame

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

Systems Engineering

Testing

Development

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