SIM

Space Interferometry Mission

SIMTAC #27

SIM Science and the SOS

Ann Wehrle

Science Planning Team Lead

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Outline

SIM Space Interferometry Mission

- A Scientist's View of How SIM Works
- How to Analyze SIM Data in a Tile
- SIM Standard Product Definition

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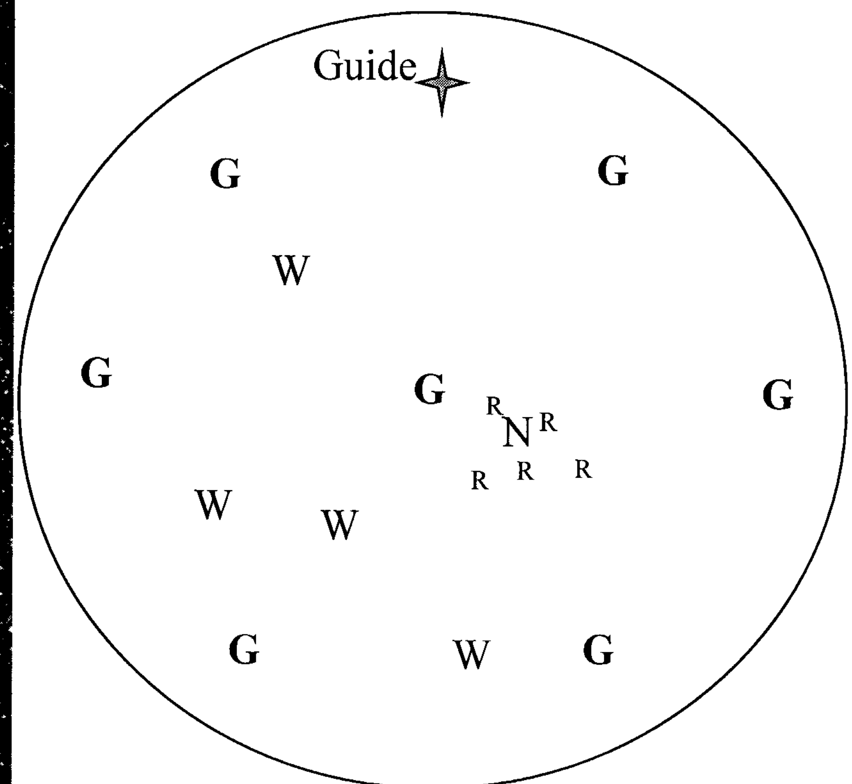

The FOR covers Orion. 1302 red giants form the grid of reference stars.

What SIM Sees

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- SIM's science siderostats can "see" 15 degrees at a time.
- Any 2 arcseconds may be selected to observe.
- Target positions must be known to 0.1 arcseconds before observing, or the interferometer will have trouble acquiring fringes. The USNO will provide these positions a year before launch.
- A " tile" will have about 7 grid stars, dozens of wide angle targets, and one or more groups of narrow angle targets.
- A "narrow angle" target is a science target like a nearby star suspected to have planets. Each narrow angle target requires at least 5 suitably stable "reference stars" within 1 degree.
- A "wide angle" target can be any science target for which accuracy needs to be only as good as (or worse than) the grid's accuracy of 4 microarcseconds.

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Launch Through In Orbit Checkout

- Launch on Shuttle to Low Earth Orbit
- Orbit the earth a few times, eventually leave earth orbit to Earth Trailing Solar Orbit (ETSO)
- Deploy instruments AFTER leaving earth orbit, implies astronauts cannot adjust anything
- Release covers, go into internal checkout of instrument
- Acquire starlight fringes, perform various checks and calibrations
- Observe standard stars for calibration
- Rehearse each observing scenario in full with test cases
- Conduct first two-week grid campaign - covers most celestial sphere excluding region around the sun
- Begin first "science" observations 6 months after launch.

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SIM's First Year after IOC

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- Perform grid campaign four or five times to nab all the grid stars, make first reference frame available for use
- Do early release observations, public relations observations early in mission.
- All algorithms to be exercised early.
- Use "all science, all the time" philosophy for most of year:
  - Intersperse grid stars, wide angle targets, narrow angle targets in each tile
  - Cover the sky in a systematic fashion
    - Options: "orange peel" spiral coverage or "ball of string" great circle coverage or random pointings
    - **Baseline must be flipped 90 degrees to get both coordinates within a short period of time (usually few weeks?)**
    - Narrow-angle targets like planets may require immediate baseline flipping
- Anticipate first scientific papers may be published

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What's An Orange Peel?

"Orange peel" coverage means that the celestial sphere is covered in a spiral pattern that moves from one side of the sphere to the opposite side.

Escher

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Years 2-5

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- Spacecraft may continue to drift away from earth
- Continue observing targets systematically around the celestial sphere.
- Modify observing plans, tune up efficiency, reduce time spent on calibration, streamline operations
- Insert new target series
- Start releasing some data to general science community (policy under negotiation)
- Publish scientific papers
- Call for additional proposals
- Make case to extend mission from 5 to 10 years

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What is an observation?

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- **SIM will observe ~ 10,000 different targets, total over 2 million observations.**
- An observing "plan" is delivered by a scientist.
- An observing "schedule" is delivered by the ISC.
- An observing "sequence" is delivered by Mission Systems.

- An "observation" is a single integration on a target, generally 30 seconds to 30 minutes long.
- An "observation group" is a collection of identical observations of the same target, spaced a few minutes to several months apart. All the data is used together to form a scientific investigation of that target.
- There will be millions of individual observations made by SIM. That means each individual observation has to be checked automatically, not by a person. Unlike other astronomy missions, the individual observations are too many and too short to be checked by the Principal Investigators.

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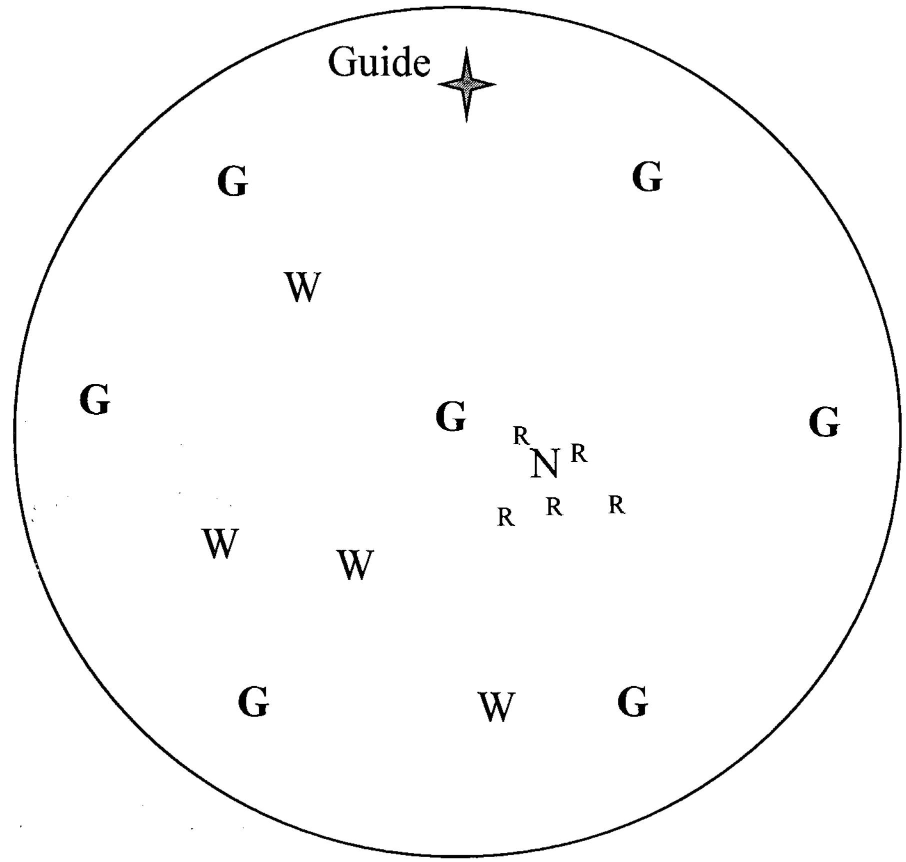
How are observations done within a tile?

- Observe all grid stars
- Observe wide angle targets
- Observe cluster of narrow angle target and its reference stars
- Reobserve some (all?) grid stars

- Go to Next Tile



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How do you cover the celestial sphere?

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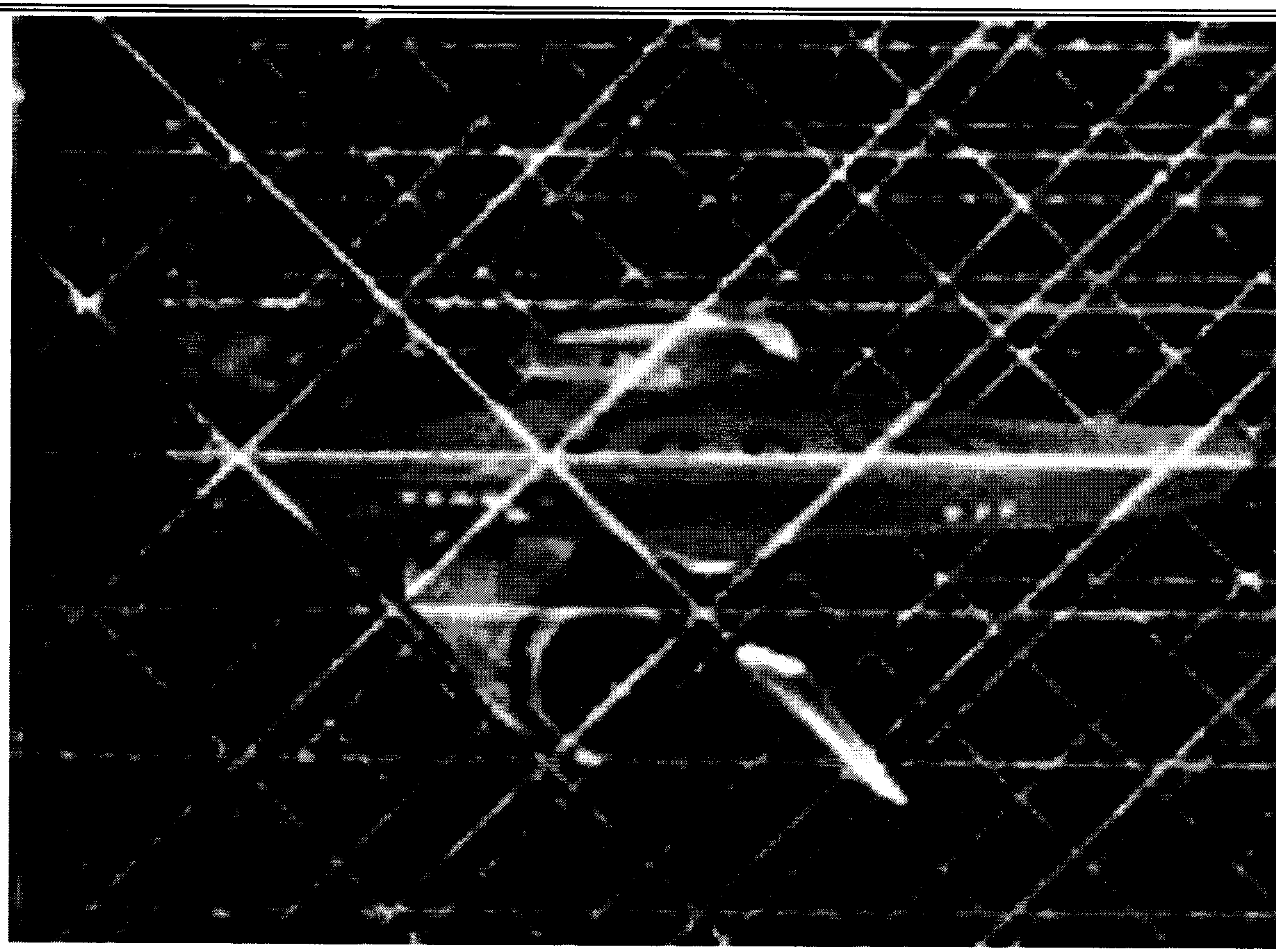

We want: a fast, simple method with no unnecessary duplication of coverage; this problem has been solved in several contexts.

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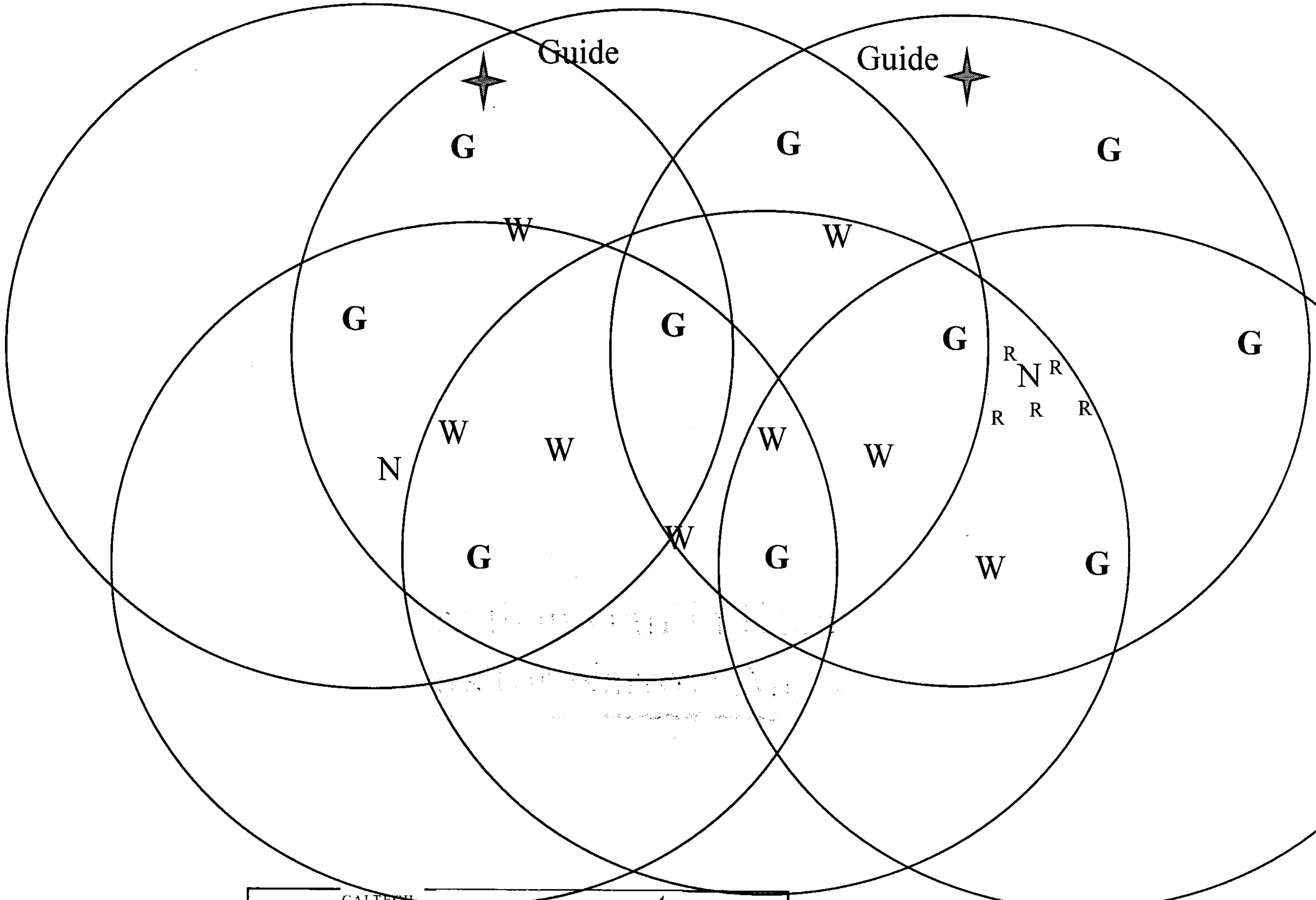
Tiles Overlap by More than Half in Each Direction, centered on Grid Stars (or Narrow Angle Targets)



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How to Process SIM Data in a Tile (1 of 2)

Prelude: Scientist -> Grid AOR + Science Target AOR ->Tile Plan->Tile Schedule ->S/C->DSN->ISC

Also on S/C

1. **Write Level n Measurement files {sci data, met data, ancillary data, cal files}**
2. **For both guide and science interferometers, compute fringe phasors from CCD data; average fringe phasors for timescales of 100-500 msec**
3. **Combine group delay with internal metrology**
4. **Solve for S/C structure and orientation**
5. **Correct delays for S/C motion (produce regularized baseline, inst. regularized delays)**

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How to Process SIM Data in a Tile (2 of 2)

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6. Average over 30 sec; produce mean regularized delays and associated regularized baseline
7. Split processed delay measurements into grid and non-grid (science) targets
8. Perform global LSQ fit (grid code) on grid targets in this tile and previous tiles
9. Write catalog of grid star positions, parallax, proper motion (Grid-of-the-Week)
10. Apply grid star information to science targets to solve for astrometric parameters
11. Write catalog of science target positions, parallax and proper motion
12. Do final quality checks, notify scientist of successful data acquisition, update plan, etc.

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SIM Standard Product Definition

- Three Data Product Levels
- Significant contributions from Science Team in science software algorithm definition and review
- Data processed, archived, distributed from, and analysis supported by ISC

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End to End Information System Components

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- Spacecraft
  - Generates science and engineering packets
- DSN & Ground Communication Facility (GCF)
  - Provides standard transport packetization
  - Ensures data integrity, but adds about 30% overhead
- Advanced Multi-Mission Operations System (AMMOS)
  - Performs Level 0 processing:
    - Strips out transport packets
    - Time orders the data
    - Removes Redundancy – Data besting
      - Same data *could be* received by more than one antenna.
    - Outputs science and engineering packets
- ISC
  - Generates, archives and makes available standard SIM science products to users.

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End to End Information System

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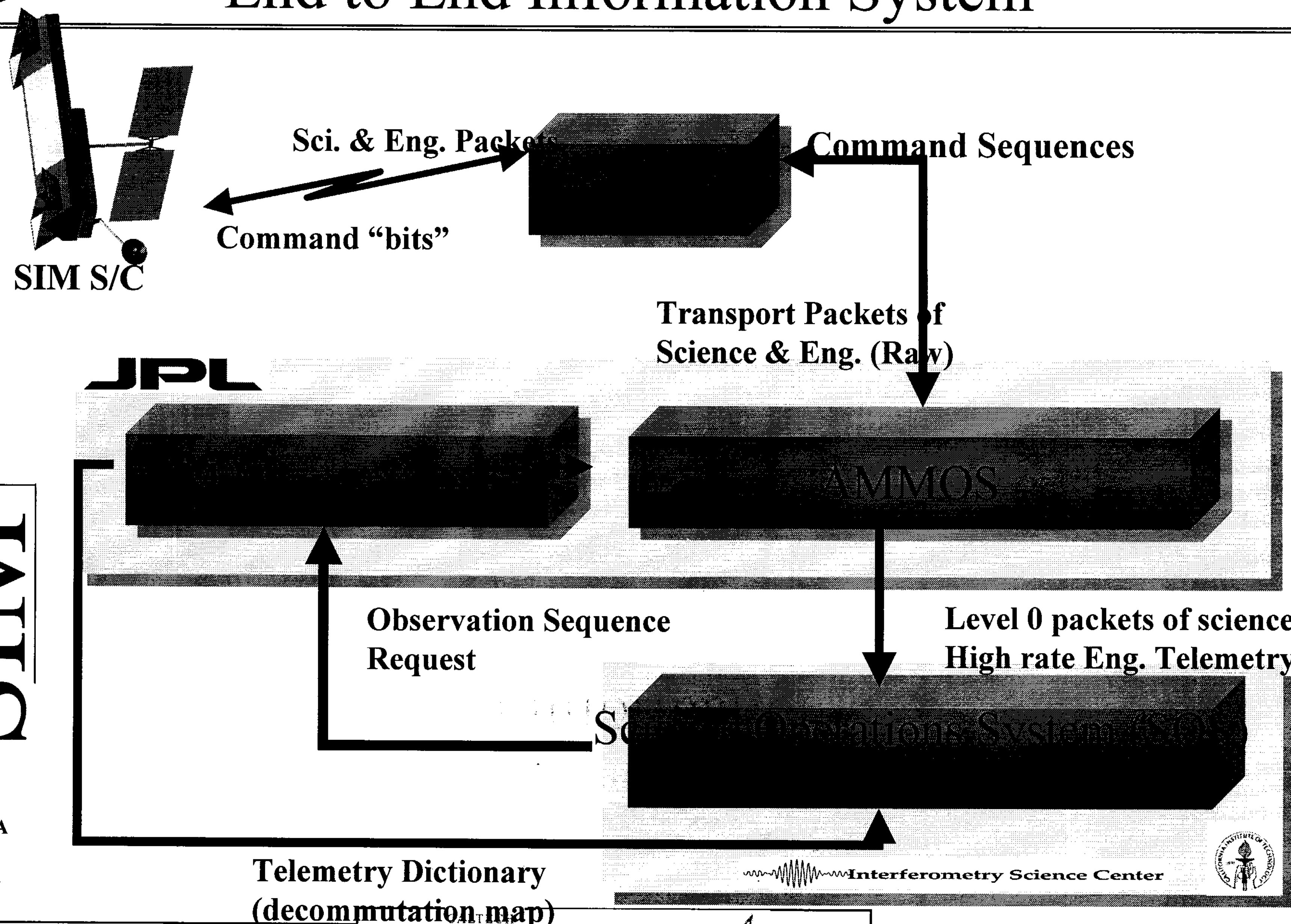

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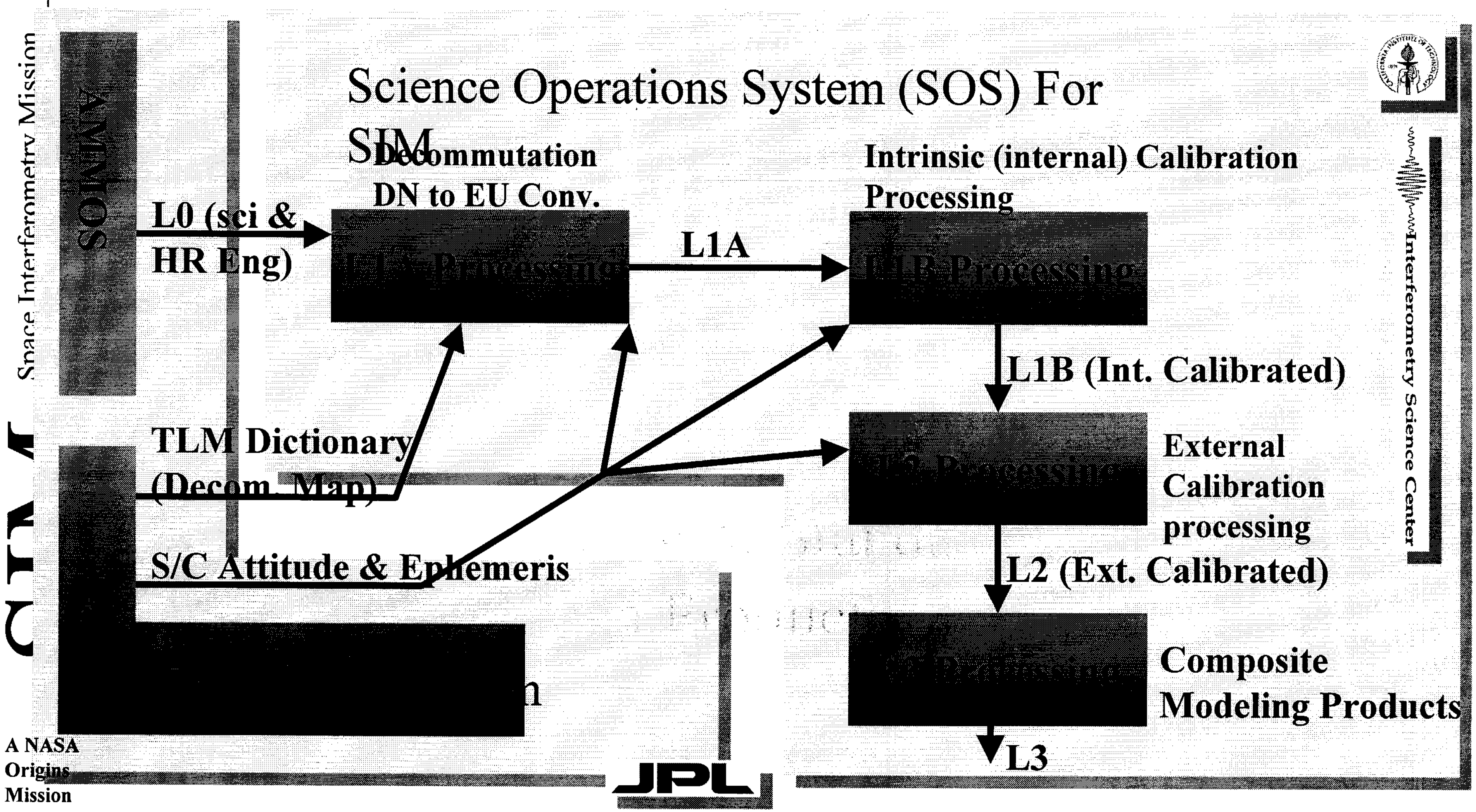
Processing of Standard Data Products



Level 1A Processing

- Decommutation – Telemetry map of science and engineering packets
- DN-to-EU (data numbers to engineering unit) conversion.

L1B Calibration Processing

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- In level L1B, the required calibration information comes from metrology and other measurements which are intrinsic to spacecraft and are used to derive calibration functions.
- These functions are implemented as calibration files which are applied to data files. The calibration files are initially populated pre-launch by testing the flight article.
- Post-launch, the internal calibration files are updated at TBD intervals which depend on thermal drift and other effects.

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L2 Calibration Processing

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- In Level 2, the required calibration information comes from external calibration sources. External calibration in this context means information derived from observing a star rather than something intrinsic to the spacecraft.
- It is TBD how often external calibration will need to be done, and whether the ISC should apply calibration derived from the nearest external calibration runs bracketing the observations or apply a model derived from months or years of infrequent external calibration runs.
- The externally-derived calibration functions will be incorporated into calibration files of the same type and format as in L1B calibration, with ancillary information files as needed.

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L1B/L2 Calibration File

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- External Calibration (L2)
  - External calibrator used (e.g. grid stars use for calibration)
  - Delays
    - Fringe delays
    - Metrology delays
      - Internal
      - External
    - Composite (astrometry quantity)
  - Visibility (squared) data
    - External visibility calibrators
    - U-v coordinates added
  - Photometry data
    - Calibrated photometric estimates (~1%)
  - Composite quantities (e.g. regularized baseline model)

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Level 3 Processing

- Products of Composite Modeling of all SIM Data
  - Global Grid Solution
    - Composite Astrometric Model For "Grid Stars"
      - Select Astrometric Grid Sample, or
      - All "Wide-Angle" Targets
    - "Best" Instrumental Parameter Solutions
      - Effective 3-Vector Baseline & Bias
      - Instrument-Internal Calibration Parameters
  - Flight System Kinematics Model
  - Solar System Model
  - Inferred Per-Visit Astrometric Positions (RA, Dec)
  - Target Cross-Reference Index

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