Looking Toward the Future: Testing New Concepts

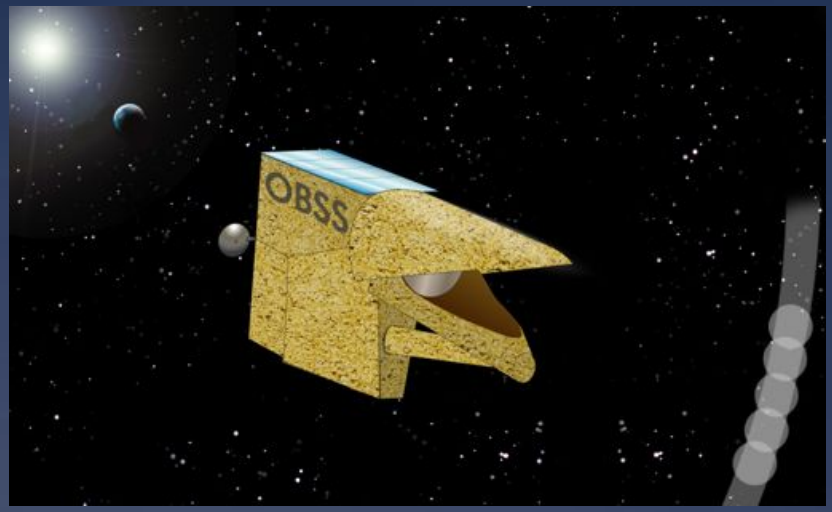
Ralph Gaume
U.S Naval Observatory

Introduction

- This story begins with the Origins Billions Star Survey (OBSS) program
- July 2004 USNO (K. Johnston, PI) funded (NASA) for 8 month mission concept development (One of 9 selected of 26 proposals)
- Several versions of OBSS were discussed:
  - Multi aperture, spinning/TDI
  - Single aperture, step/stare
  - Dedicated IR or radial velocity concept
- Single aperture, step stare implementation was chosen for concept development

OBSS Mission Concept

- OBSS:
  - Single Aperture 1.5m primary, TMA 50m Focal length
  - Two instruments:
    - Astrometric Instrument (AI) 1.2d FOV 1.2m Focal plane, 9 Gpixels
    - Low Resolution Spectroscopic Instrument (LRSI)
  - Operates at L2 5 yrs



USNO JPL SSC Spitzer Science Center UNIVERSITY of VIRGINIA e2v e2v technologies SSG Precision Optronics, Inc. tinsley

Evolution

- OBSS concept development did not proceed beyond NASA report of May 2005
- JMAPS program evolved out of OBSS concept
- Essentially, JMAPS is a micro-sat version of OBSS
- Desire to test:
  - New concepts and technologies
  - Update the bright star catalog
- Is JMAPS *real,* or is it just PowerPoint?

JMAPS Mission Objectives

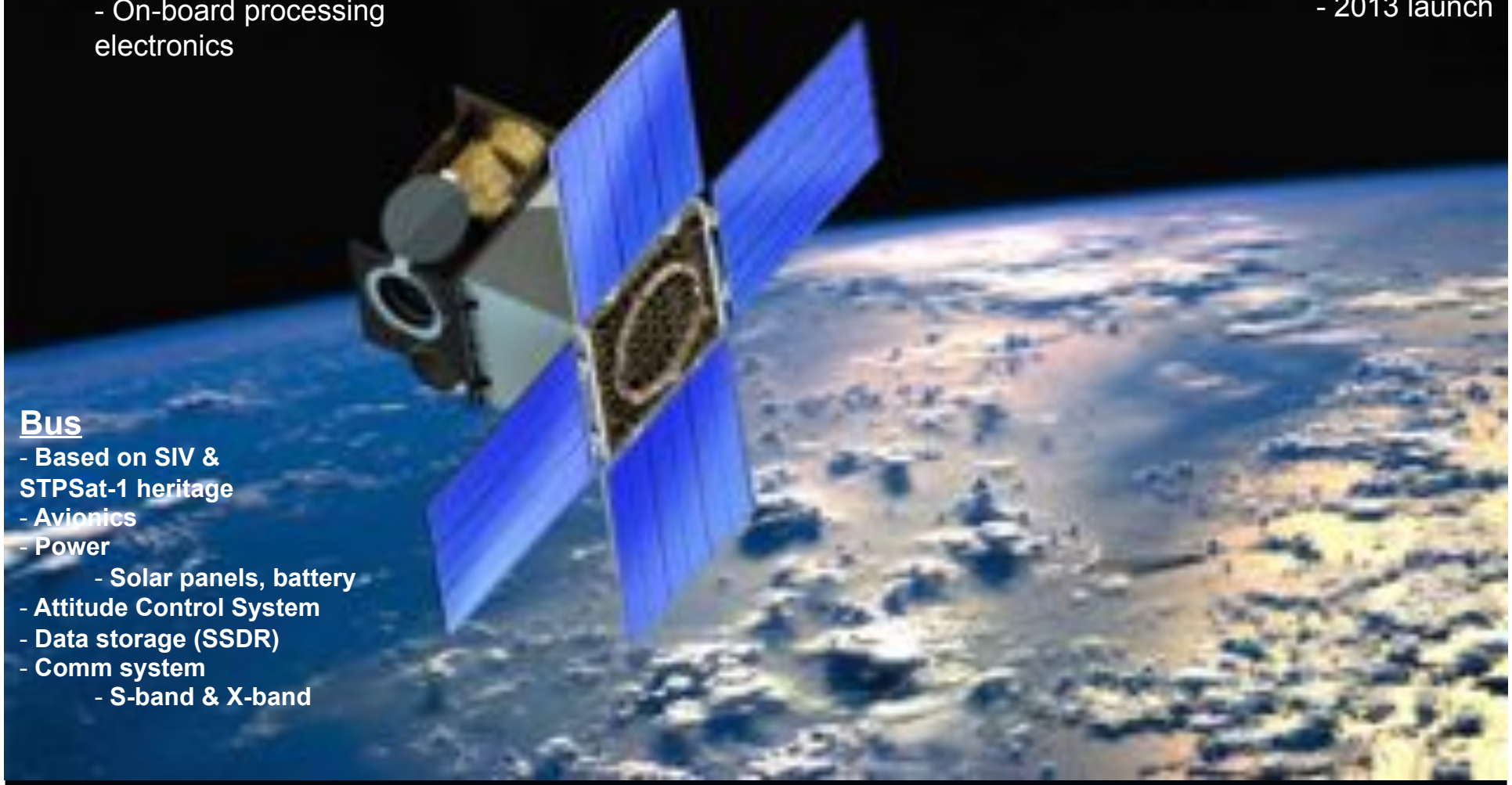
- Update bright star catalog for 2015+ epoch
  - 1 mas-accuracy
    - 0.5 to 12th (I-band)
    - Reduced accuracy 12th to 14th
  - Astrometry referenced to ICRS
- High accuracy photometry
  - 1% goal
- Technology development and concept demonstration
  - Focal plane arrays
  - High accuracy SiC optics
  - Use of low res gratings for color sensing
  - 10 mas attitude sensing
  - 50 mas microsat pointing stability

Payload

- Primary VIS/NIR instrument
  - 19 cm, f/20 SiC telescope
  - 2x2 array of 4k x 4k CMOS-Hybrid FPA
  - On-board processing electronics

Mission Parameters

- 3 year mission life
- 900 km sun synchronous terminator orbit
- Step-stare
- 60 obs per star over mission life
- 2013 launch



Bus

- **Based on SIV & STPSat-1 heritage**
- **Avionics**
- **Power**
  - **Solar panels, battery**
- **Attitude Control System**
- **Data storage (SSDR)**
- **Comm system**
  - **S-band & X-band**

What is JMAPS ?

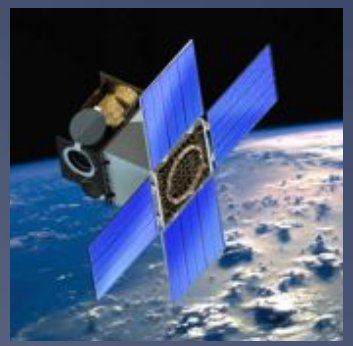
Comparison to Hipparcos

Hipparcos

- Two apertures
- Scanning
- "Complete" through 7th magnitude
- 3 years for proper motions
- HEO

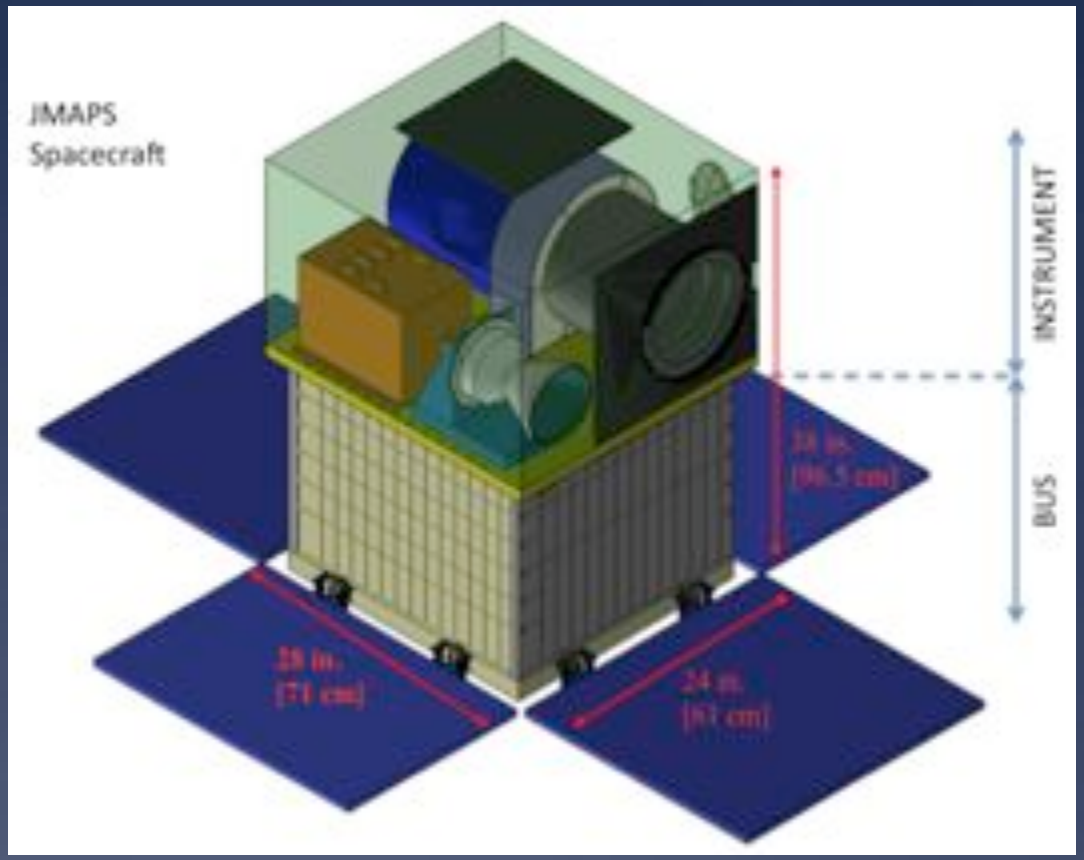
JMAPS

- Single aperture
- Step-stare
- "Complete" through 14th magnitude
- 20 years for proper motions (using Hipparcos data)
- LEO/circular



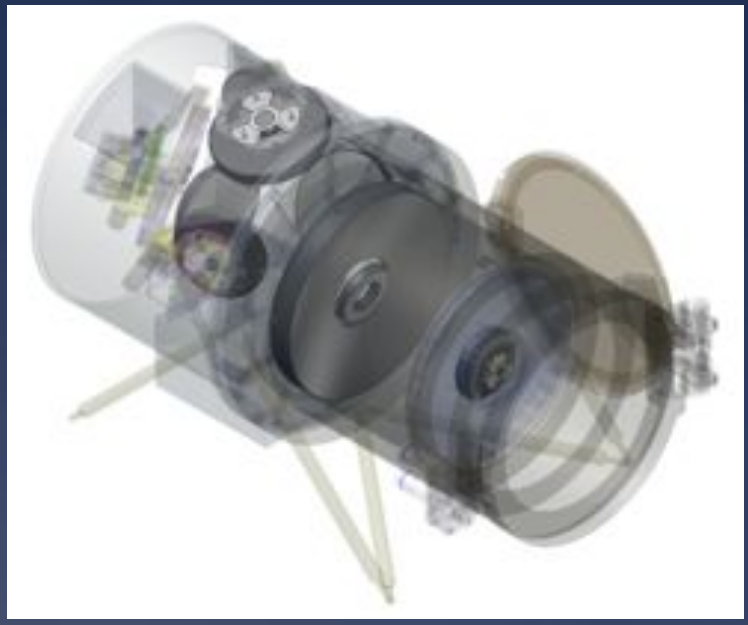
Spacecraft Overview

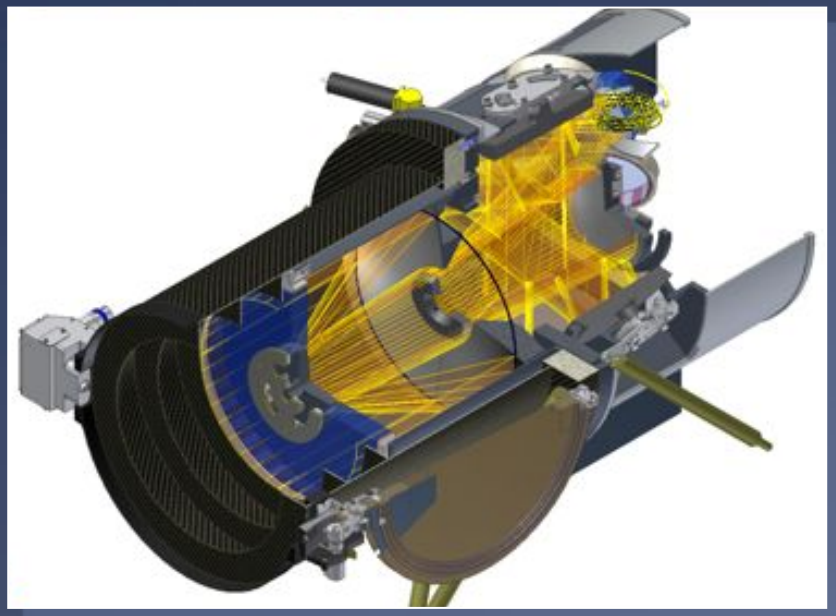
- Small high-performance spacecraft bus
  - Versatile design supports wide range of low earth orbit missions
  - Bus mass: 101.5 kg plus 17.8 kg (17.5%) allocated growth margin
- Payload Accommodation
  - Payload volume: 17.7-in. x 22-in. x 26-in.
  - Payload mass: 32 kg with 8.9kg (28%) allocated growth margin



JMAPS Optics

- Silicon Carbide (SiC) Design
  - Optical elements, metering structure, FPA housing, FPA packaging
  - Increased stiffness
  - Minimized CTE mismatches
  - Minimized thermal gradients

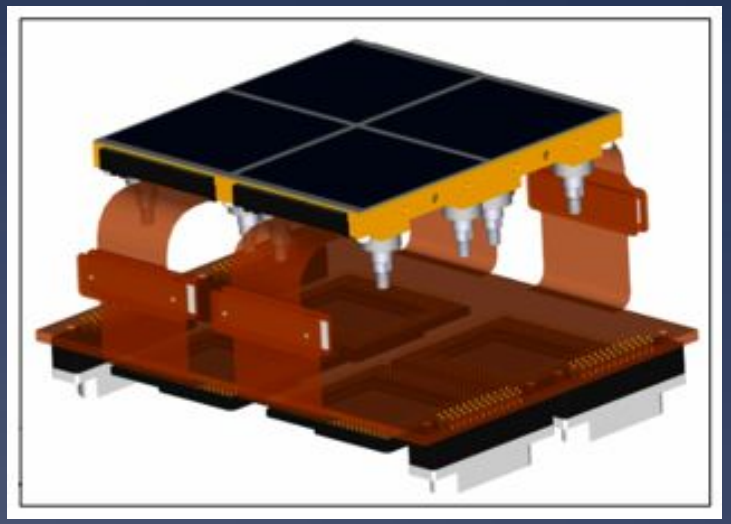




- 7.5" Primary (M1)
- f/20 focal ratio (3.8m FL)
- Length ~ 25"
- Baffled for stray light
- On-axis (9cm obstruction)
- Ultra-low distortion, WFE ~ λ/20 (@ HeNe)
- No spider
- Four rotating flats filter system
- Color sensing over range 450—900 nm

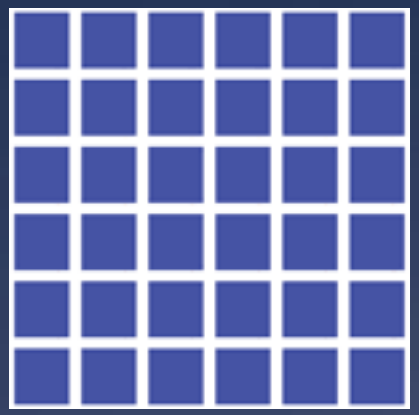
JMAPS Focal Plane

- 8k by 8K Focal Plane
  - 2 x 2 array of TIS H4RG-10 CMOS-Hybrid detectors
- Development Status
  - First generation:
    - Testing Complete 2007
  - Second generation:
    - Testing Complete 2010
  - Third generation:
    - Delivery first parts in 2010
  - Third generation will produce flight units



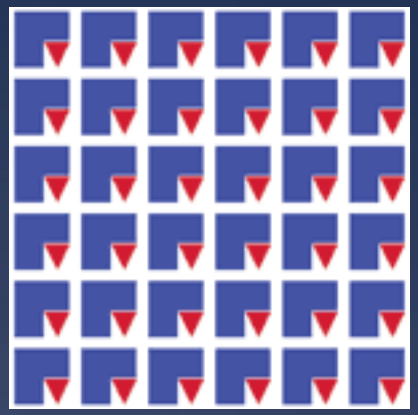
Detectors: CCDs, CMOS, CMOS-hybrid

CCD Device

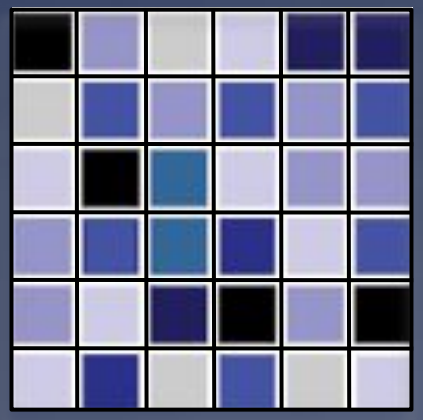


CMOS Device

Front side circuitry

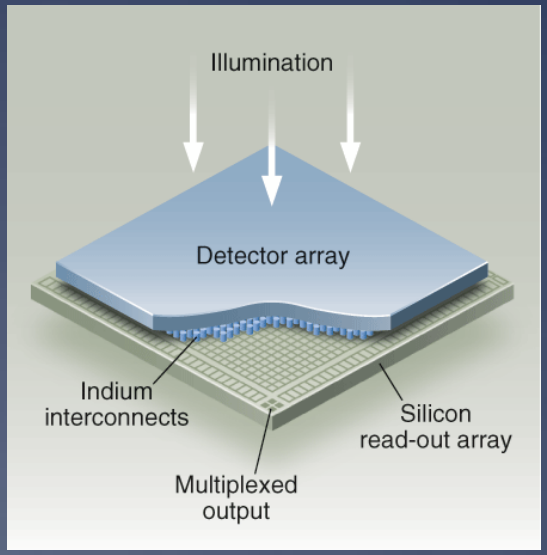


CCD Row shifts



CMOS hybrid Device

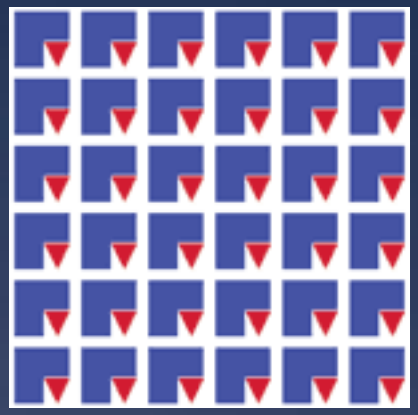
Combines CCD with CMOS



Detectors: CCDs, CMOS, CMOS-hybrid

- Strong reasons to use CMOS-Hybrids
  - ROIC flexibility: windowing, random access read, reset, non-destructive read, etc.
  - Radiation hardness

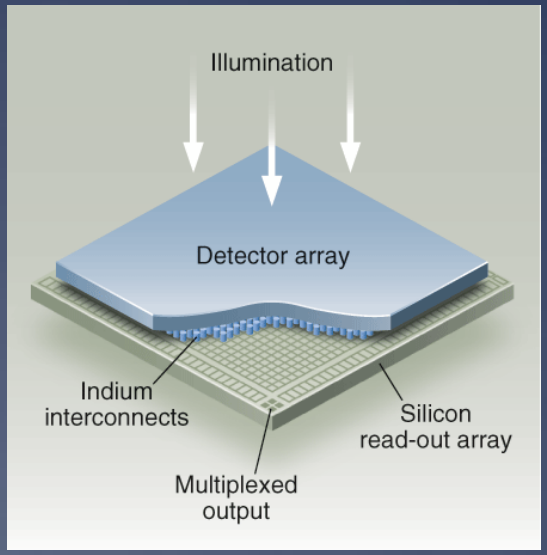
CMOS Device



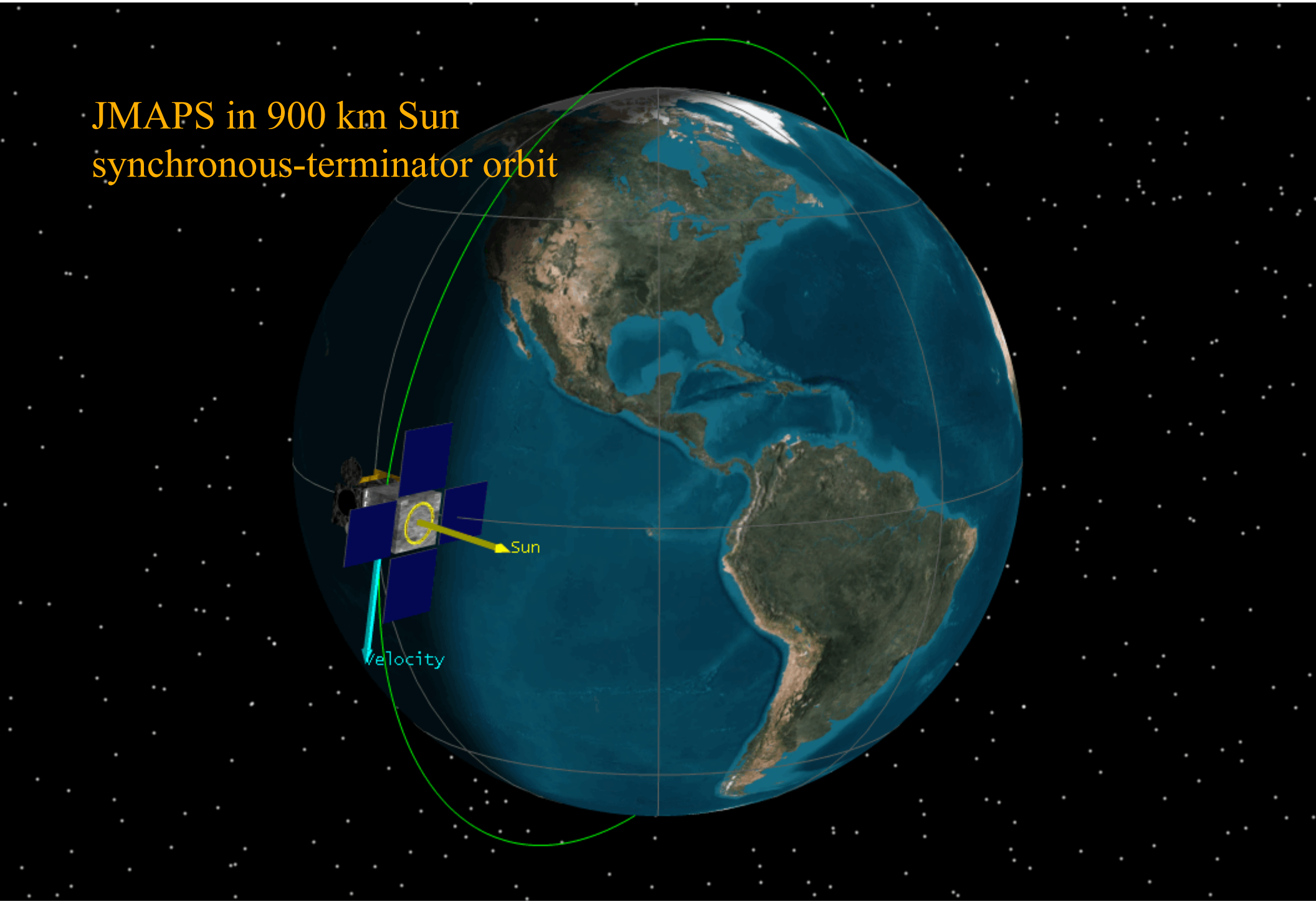
Front side circuitry

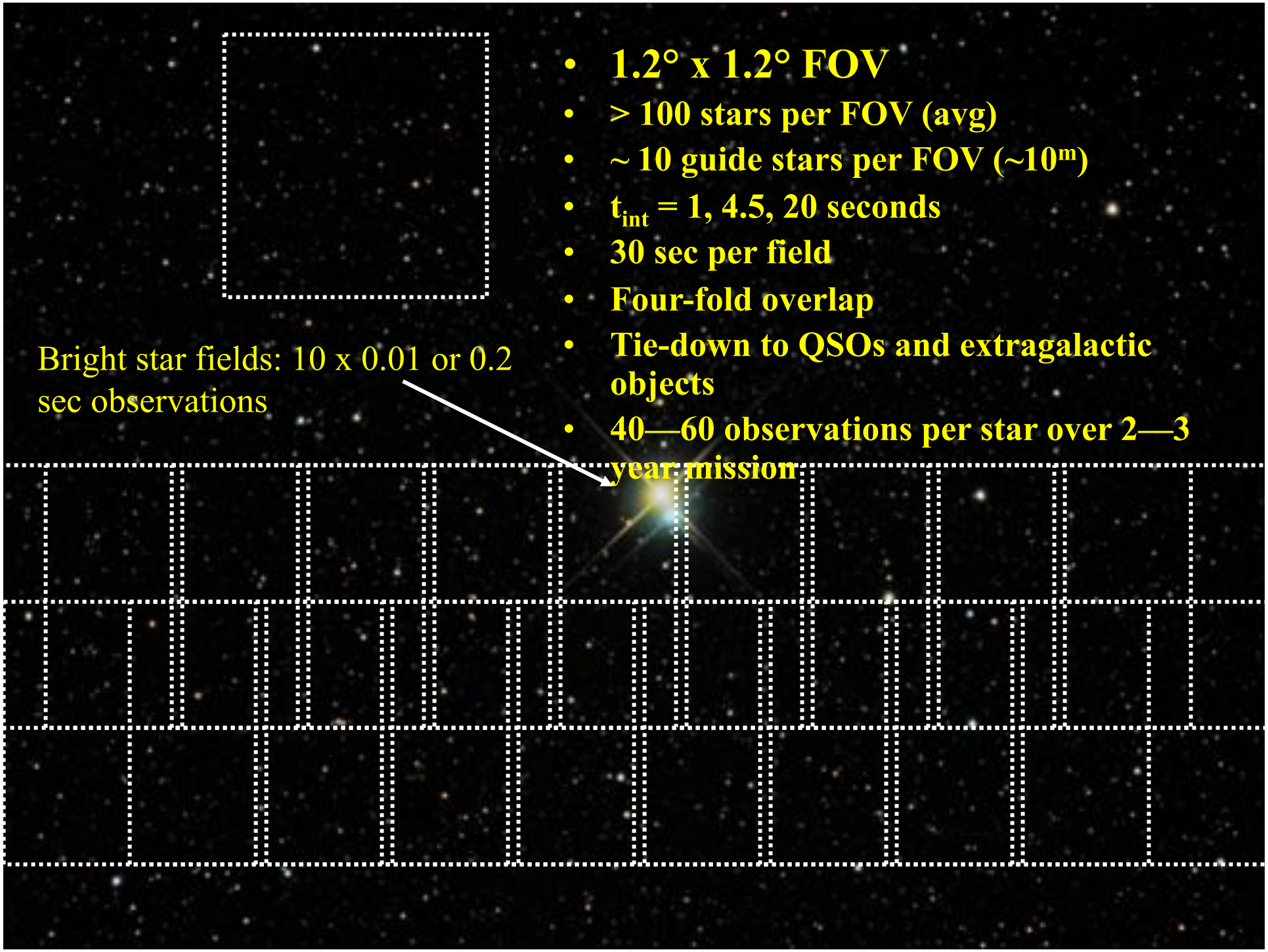
CMOS hybrid Device

Combines CCD with CMOS

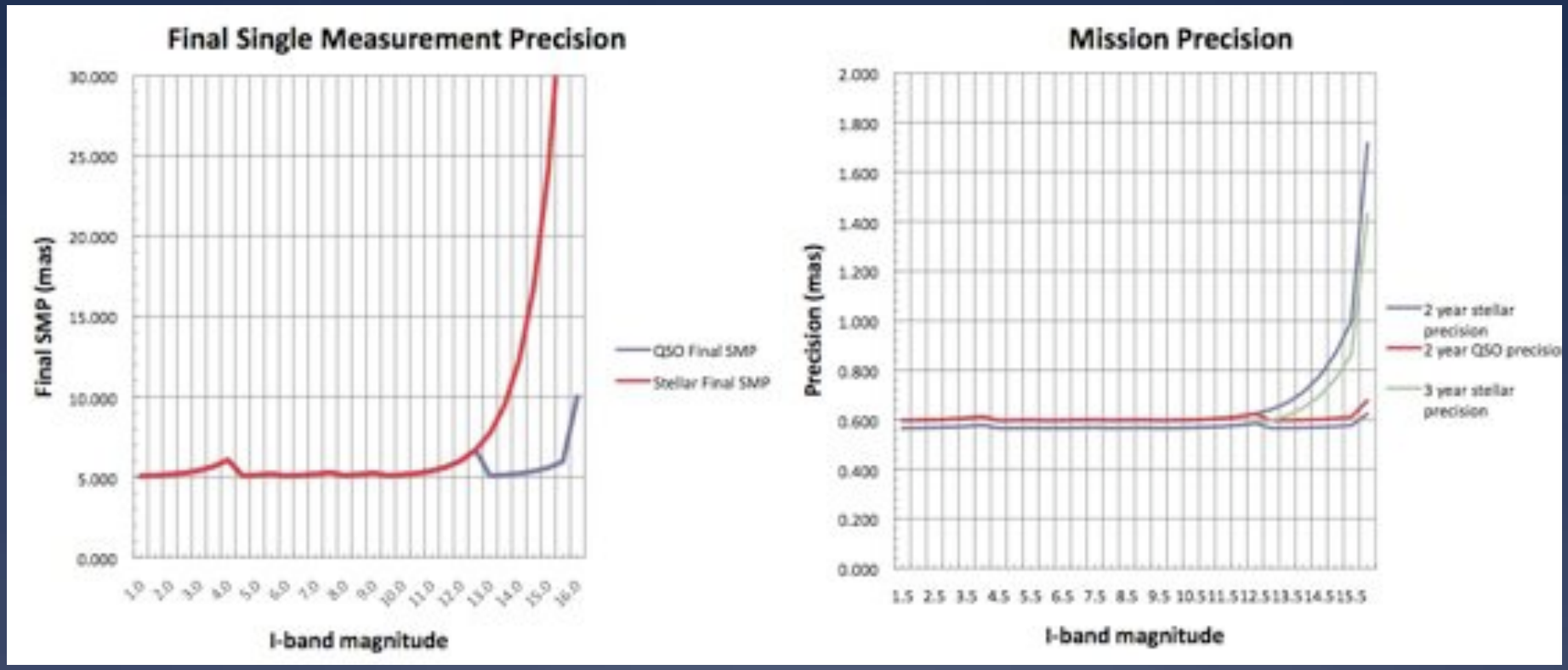


JMAPS in 900 km Sun synchronous-terminator orbit




Bright star fields: 10 x 0.01 or 0.2 sec observations
• 1.2° x 1.2° FOV
• > 100 stars per FOV (avg)
• ~ 10 guide stars per FOV (~10m)
• tint = 1, 4.5, 20 seconds
• 30 sec per field
• Four-fold overlap
• Tie-down to QSOs and extragalactic objects
• 40—60 observations per star over 2—3 year mission

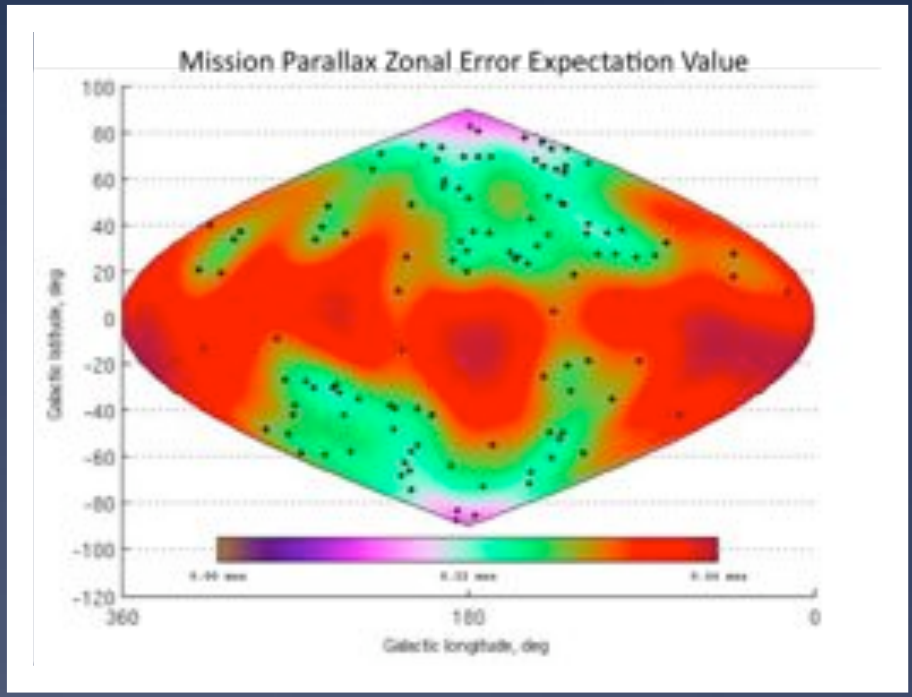
Predicted Performance



Astrometric Mission Requirement: (1 mas) is achieved through multiple observations of individual stars throughout the lifetime of the mission

JMAPS Zonal Parallax Errors

- Hennessy & Makarov
  - JMAPS single aperture astrometry more susceptible to zonal errors
  - Simulation utilize ~115 bright quasars to force parallax to zero
  - Results 0.2-0.3 mas parallax error
- Global block adjustment solution simulations underway
  - Utilize quasars as zero parallax, zero proper motion sources
  - Observe visible wavelength counterpart to ~20 ICRF sources to facilitate ICRF link.



JMAPS Rollup

- JMAPS is a bright star space astrometry mission to launch in 2013
- JMAPS develops and demonstrates new space technology
  - CMOS-Hybrid Focal plane, attitude sensing, microsat pointing stability
- JMAPS development on-going at USNO & NRL
  - USNO responsible for astrometric requirements, ground data-processing and catalog production
- JMAPS launch 2013, catalog delivery 2017


JMAPS