Looking Toward the Future: Testing New Concepts

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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
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 12\textsuperscript{th} (I-band)
  • Reduced accuracy 12\textsuperscript{th} to 14\textsuperscript{th}
  • 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 8.9 kg (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 ~ \lambda/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

CCD Row shifts

CMOS Device

Front side circuitry

CMOS hybrid Device

Combines CCD with CMOS

Detector array

Illumination

Indium interconnects

Silicon read-out array

Multiplexed output
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

Detector array
Indium interconnects
Silicon read-out array
Multiplexed output
Illumination
JMAPS in 900 km Sun synchronous-terminator orbit
- 1.2° x 1.2° FOV
- > 100 stars per FOV (avg)
- ~10 guide stars per FOV (~10 m)
- t_{int} = 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

Bright star fields: 10 x 0.01 or 0.2 sec observations
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