

# **U.S. Naval Observatory roles and missions in the application of astrometric principles toward Space Situational Awareness**

**CAPT Jonathan W. White, USN, Superintendent**  
*U.S. Naval Observatory, Washington, DC*

## **Abstract**

The United States Naval Observatory (USNO), founded in 1830 as the progenitor of Positioning, Navigation, and Timing (PNT) operations, is the DOD agency mandated by the Joint Chiefs to establish, maintain, and coordinate precise time (such as for GPS), and the celestial reference frames used by all components for navigation, precise positioning and orientation, space operations, and command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR). Specifically, the USNO-charged astrometric programs address fundamental needs and gaps in several key aspects of Space Situational Awareness (SSA), Space Control (SC), and space-borne ISR systems.

## **1. Introduction**

The unique mission of the U.S. Naval Observatory (USNO) is to:

- Determine positions and motions of celestial bodies, Earth's motion/orientation and precise time
- Disseminate astrometry and timing data to Navy and DOD for navigation, targeting, weapons guidance, communications, etc., and to other agencies, and the public
- Conduct research to improve these services, ensuring the U.S. / DOD remain the world leader in each area and in the capabilities they yield

As such, USNO is the sole official source of precise time and celestial reference frame information for DOD, as specified by the Secretary of Defense [1] and the Chairman of the Joint Chiefs of Staff [2]. The proven capabilities of USNO to determine the positions and proper motions of celestial objects, and to create and maintain catalogs of these data, represent an opportunity to enhance similar functions associated with space situational awareness mission functions.

USNO is an operational command under the Chief of Naval Operations, assigned to the Commander of Naval Oceanography and Meteorology as part of U.S. Fleet Forces command. USNO is also directed to operate as a direct supporting command to other services, Joint components, and other DOD/national activities as required.

## **2. Astrometric Capabilities**

USNO maintains operational astrometric telescopes at the headquarters in Washington, DC, and at the dark sky detachment in Flagstaff, AZ as depicted in Figure 1.

In addition, USNO maintains several star catalogs for primary use by DOD activities that are also available to the public. These catalogs include:

- Naval Observatory Merged Astrometric Dataset (NOMAD). NOMAD is a simple merge of data from preexisting catalogs (Hipparcos, Tycho-2, UCAC-2 and USNO-B1), supplemented by photometric information. The primary aim of NOMAD is to help users retrieve the best currently available astrometric data for any star in the sky by providing these data in one place.
- USNO CCD Astrograph Catalog (UCAC). UCAC is an astrometric, observational program, which started in February 1998. All sky observations were completed in May 2004. The final catalog (UCAC3) is expected to be distributed in early 2008. The second data release (UCAC2) became public in 2003. Positions accurate to 20 mas for stars in the 10 to 14 magnitude range are obtained. At the limiting

magnitude of  $R=16$  the catalog positions have a standard error of 70 mas. Proper motions are provided using various earlier epoch data. Photometry is poor, with errors on the order 0.1 to 0.3 magnitudes in a single, non-standard color.

- Washington Double Star Catalog (WDS). The WDS is the world's principal database of astrometric double and multiple star information. The WDS Catalog contains positions (J2000), discoverer designations, epochs, position angles, separations, magnitudes, spectral types, proper motions, and, when available, Durchmusterung numbers and notes for the components of 102,492 systems based on 728,813 means.

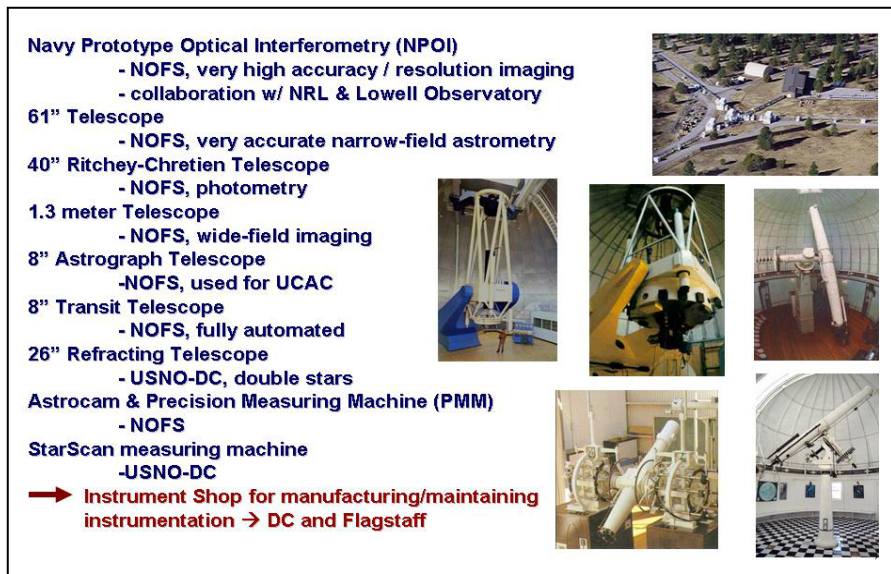


Figure 1. USNO Astrometric Observing Instruments

### 3. Ongoing Initiatives Related to SSA

USNO has several astrometric initiatives with the potential to enhance SSA capabilities. These include:

- Joint Milli-Arcsecond Pathfinder Survey (J-MAPS). J-MAPS is an initiative to launch one-time prototype satellite mission that would complete a full-sky survey of stars at 1 mas accuracy for 0 – 14 magnitude stars, while “path-finding” a new-technology star tracker for future ISR systems. The resulting catalogs from J-MAPS would enhance the performance of optical SSA sensors that use stars catalogs and star positions as a reference for Resident Space Object (RSO) detection and tracking. J-MAPS may also provide the capability to rapidly determine precise RSO orbital characteristics as a secondary mission function. J-MAPS is currently undergoing consideration for programmatic support as part of the DOD space program.
- Dynamic USNO Star Catalog (DUSC). A recent initiative to evolve USNO star catalogs from static datasets to a dynamic database that would provide a single best source for star position and proper motion data to support myriad DOD and national applications. DUSC would enable rapid update of star positions from ongoing astrometric measurements, and thus provide the most accurate and timely celestial astrometric data for DOD, to include numerous SSA applications.
- Expanded “ $A\Omega$ ” Survey Telescope Development. USNO is partnering with USAF, DARPA, and other national activities to refine and dramatically improve the capabilities for telescopic sky surveys through the use of large “ $A\Omega$ ”(or “*etendue*”) [3] instruments. The term “ $A\Omega$ ” is the product of the collecting area ( $A$ ) times the field of view  $\Omega$ , and determines the rate at which space objects can be detected and surveyed.

#### **4. Conclusion**

USNO is recognized as a world leader in astrometry, and with decades of experience and proven performance represents a unique skill set that is of growing importance to SSA operations. USNO astronomers possess considerable expertise and experience in the field of high metric accuracy astrometry and catalog development. As additional sensors and capabilities are developed to maintain space superiority, USNO should be considered as a supporting command to USAF, Joint, and national space-related activities and laboratories. USNO can provide expertise and support in the research, development and operation of SSA-related instruments and capabilities, to include CCD development and testing, optics design, and additional catalog development (e.g., infra red spectrum catalog). The recognized challenges associated with current and future SSA efforts dedicated to maintain space superiority demand closer partnerships between space-related DOD activities. The U.S. Naval Observatory stands ready to answer the call of the space and national communities to provide astrometric support.

#### **5. References**

1. DOD Directive 4659.5 *Positioning, Navigation, and Timing (PNT)*, 02 Jun 2003
2. CJCS Instruction 6130.01C *Master Positioning, Navigation and Timing (PNT) Plan*, 31 Mar 2003
3. Institute for Astronomy, University of Hawaii, *Wide Field Imaging*, <http://pan-starrs.ifa.hawaii.edu/public/design-features/wide-field.html>, 2005