PREFACE

On October 5 and October 6, 2011, a colloquium on *Decoupling Civil Timekeeping from Earth Rotation* was hosted in Exton, Pennsylvania by Analytical Graphics, Inc. (AGI), a leading software solutions company for the aerospace, defense, and intelligence industries. AGI's involvement with the topic of UTC redefinition began in 2003, when the company was asked to provide a position statement in preparation for the ITU-R *Special Colloquium on the Future of the UTC Timescale* at IEN in Torino, Italy. At the time, AGI's Chief Orbital Scientist did not expect UTC redefinition to impact its own internally developed software, yet AGI recognized that its own software products might experience indirect impacts from the adoption of third-party software models. AGI also realized that UTC redefinition "could adversely affect software applications or database definitions" as well as the "accuracy of certain low precision applications" throughout the astrodynamics community. AGI's position was that the company would necessarily adapt to changing standards to meet customer needs, but it was the company's "sincerest hope that the voice of the astrodynamics community is heard." Therefore, it seemed fitting that AGI should open its facilities to host a colloquium, co-sponsored by the American Astronautical Society (AAS) and the American Institute of Aeronautics and Astronautics (AIAA), to afford an opportunity for the astrodynamics community to be heard before a concluding vote to decouple civil timekeeping from Earth rotation by the Radiocommunications Assembly of the ITU-R in January 2012.

The colloquium was co-hosted by the National Optical Astronomy Observatory (NOAO) and the Virtual Astronomical Observatory (VAO). The opportunity for participation was not limited to astronomical and astronautical interests, however. Understanding that the implications of decoupling extend from technical infrastructure to legal, historical, logistical, sociological, and economic domains, technical and non-technical contributions were solicited from widely disparate fields. These fields included, but were not limited to: astronomy, astrodynamics and celestial mechanics, geophysical Earth-orientation, navigation (GNSS and celestial), remote sensing and space surveillance, spacecraft applications, sundialing, *etc*.

International interest in the colloquium was remarkable given that the meeting was announced with about four months' notice, with presenters having to provide original papers for the colloquium's archival proceedings. The meeting chairmen received many regrets from interested parties who were unable to contribute due to the constraints of personal schedule or economy. The number of contributed manuscripts was very strong relative to the efforts of similar meetings:[*] twenty-two (22) papers were eventually contributed on diverse topics related to a variety of timekeeping aspects. These were presented over two days to an audience of seventeen discussants representing opinions both favoring and opposing the decoupling of civil timekeeping from Earth

[*] Fourteen presentations were given at the 2003 ITU-R *Special Colloquium on the Future of the UTC Timescale* in Torino, and twelve presentations were given at the 2011 meeting *UTC for the 21st Century* sponsored by the Royal Society.

rotation (Figure 1). Six contributing co-authors could not attend in person: Danny Hillis of Applied Minds, Inc., Denis Savoie of the Palais de la découverte and Observatoire de Paris, Florent Deleflie, Jérome Berthier, and Christophe Barache of the Observatoire de Paris, and Jon Giorgini of the Jet Propulsion Laboratory (JPL). Neil deGrasse Tyson of the Hayden Planetarium and the American Museum of Natural History, and Steven Slojkowski of NASA Goddard Space Flight Center, also participated as interested discussants.

In addition to the scheduled technical presentations and discussions, Frank Reed, a navigation instructor with Reed Navigation and Mystic Seaport Museum, provided a suppertime presentation entitled *GMT by Observation: The Historical Method of Lunars* on Wednesday, October 5. The "method of lunars" involves a determination of time using a hand-held sextant, as based on the angle of the Moon from other bright celestial objects. Mr. Reed's presentation featured excerpts from historic ship logbooks and plots of ocean voyages during the 18th and 19th centuries as determined from navigation fixes recorded in these logbooks. Blank pages from the backs of old logbooks often contained completely worked examples of the method of lunars, each requiring roughly 20 minutes of arithmetic to reduce sextant observations of the Moon to obtain the time. *The American Ephemeris and Nautical Almanac* continued to carry "lunar distance" ephemerides, used by practitioners of the method, through the 1911 edition. However, by the mid- to late-19th century, the method of lunars had become mostly obsolete, as it became more accurate and convenient to carry multiple ship-borne chronometers to determine and maintain time (and therefore position) at sea.

Mr. Reed offered attendees the opportunity to try their hand at determining time using the historical method of lunar-distance observation using a sextant. After supper, a handful of colloquium attendees gathered under darkness at a nearby hotel parking lot. Participants exercised their traditional navigation skills by measuring the arc between Jupiter and the lunar limb using sextants supplied by Mr. Reed. Using software, Mr. Reed reduced the limb measurements into a determination of time almost instantly. The best measurements obtained would have been good enough to fix a position to better than a nautical mile.

On Friday, October 7, nine colloquium attendees and their guests participated in a morning tour of the grand Analemmatic Sundial at Longwood Gardens in nearby Kennett Square, Pennsylvania. This event included a special orientation and behind-the-scenes technology tour of the Longwood Gardens facilities by staff historian Colvin Randall, and featured a short talk by P. Kenneth Seidelmann who redesigned the sundial in the early 1970s to keep accurate standard time. Dr. Seidelmann's manuscript on the analemmatic sundial adds to these proceedings a significant example of a timeless public apparatus that presumes civil timekeeping will remain accurately coupled to Earth rotation.

At the request of some colloquium attendees and other interested professionals, the co-chairs have included an extended introduction and summary of meeting's topic and technical points as a separate paper. This summary, which is an expression of the co-chairs, is no substitute for exploring the actual manuscripts and discussions, therefore readers are encouraged to consider the proceedings volume in its entirety.

John H. Seago

Robert L. Seaman

Steven L. Allen

Figure 1. Colloquium Attendees.

Figure 2. The Analemmatic Sundial at Longwood Gardens.

Table 1. Colloquium Attendees (as ordered from left to right in Figure 1)

Name	Organization	Nationality
George H. Kaplan	IAU Commission 4	USA
Robert L. (Rob) Seaman	National Optical Astronomy Observatory (NOAO)	USA
Wolfgang R. Dick	IERS Central Bureau, Bundesamt für Kartographie und Geodäsie (BKG)	Germany
John H. Seago	Analytical Graphics, Inc. (AGI)	USA
Daniel Gambis	IERS Earth Orientation Center, Observatoire de Paris	France
Steven (Steve) Malys	National Geospatial-Intelligence Agency (NGA)	USA
Steven L. (Steve) Allen	UCO/Lick Observatory	USA
Neil deGrasse Tyson	Hayden Planetarium American Museum of Natural History	USA
Paul Gabor	Vatican Observatory	Czech Republic
Mark F. Storz	United States Air Force Space Command (AFSPC)	USA
Dennis D. McCarthy	United States Naval Observatory (USNO, retired)	USA
Arnold H. Rots	Smithsonian Astrophysical Observatory (SAO)	The Netherlands
P. Kenneth (Ken) Seidelmann	University of Virginia (UVa)	USA
David G. Simpson	NASA Goddard Space Flight Center (GSFC)	USA
Steven Slojkowski	NASA Goddard Space Flight Center (GSFC)	USA
Frank E. Reed	Reed Navigation, Mystic Seaport Museum	USA
David L. Terrett	Rutherford Appleton Laboratory (RAL) Space	UK