



POST MEETING REPORT FORM

1. **Meeting Identification Number:** Symposium 401
2. **Meeting Title:** ADVANCING REFERENCE SYSTEMS, EPHEMERIS, AND STANDARDS. From the Earth and the Moon to solar system bodies
3. **Coordinating Division:** Division A Fundamental Astronomy
4. **Dedication of meeting (if any):** N/A
5. **Location (city, country):** La Plata, Buenos Aires, Argentina
6. **Dates of meeting:** 4-9 August, 2025
7. **Number of participants:** 122 (65 in-person and 57 online)
8. **Total Amount of IAU Grant funds received (in euros):** 20 000€
9. **Number of IAU Grant recipients:** 18 recipients
10. **List of represented countries:** 22 countries and 1 international organization
11. **Anticipated number of separate papers in the proceedings:** TBD
12. **Report submitted by:** Alberto Escapa (co-chair SOC; coordinator), Laura Fernández (chair LOC), E. Felicitas Arias (co-chair SOC), Flora Paganelli (co-chair SOC), Ryan S. Park (co-chair SOC), and Susan G. Stewart (co-chair SOC)
13. **Date and place:** León (Spain), 16 October 2025
14. **Signature of SOC Chairperson:** Alberto Escapa, on behalf of the SOC and LOC co-chairs

Summary of the IAU Symposium 401 ADVANCING REFERENCE SYSTEMS, EPHEMERIS, AND STANDARDS. From the Earth and the Moon to solar system bodies

Date: 2025 August 04 - 094

Venue: Planetarium, National University of La Plata (UNLP), La Plata, Buenos Aires, Argentina

Coordinating IAU Division: Division A “Fundamental Astronomy”

Supporting IAU Divisions: Division B “Facilities, Technologies and Data Science”
Division F “Planetary Systems and Astrobiology”

Scientific Organizing Committee (Female 8/Male 7):

Alberto Escapa	University of León, Spain (co-chair; coordinator)
Elisa Felicitas Arias	Observatoire de Paris, France (co-chair)
Flora Paganelli	Centre de Recherche Astrophysique de Lyon, France (co-chair)
Ryan S. Park	Jet Propulsion Laboratory (JPL, NASA), USA (co-chair)
Susan G. Stewart	United States Naval Observatory (USNO), USA (co-chair)
Cheng-Li Huang	Shanghai Astronomical Observatory (SAO), China
Jolanta Nastula	Polish Academy of Sciences, Poland
Oleg Titov	Geoscience Australia, Australia
Manuela Seitz	Technische Universität München (TUM), Germany
Laura I. Fernández	MAGGIA Center, FCAG-UNLP, Argentina
Agnès Fienga	Observatoire de la Côte d'Azur, France
Mizuhiko Hosokawa	NICT, Japan
Dmitry Pavlov	St. Petersburg State University, Russia
Giovanni B. Valsecchi	Italian National Institute for Astrophysics (INAF), Italy
Catherine Y. Hohenkerk	HM Nautical Almanac Office (retired), UK

Local Organizing Committee (Female 6/Male 0):

Laura I. Fernández	MAGGIA Center, FCAG-UNLP, Argentina (chair)
Carla de la Pina	FCAG, UNLP, Argentina
Maria Eugenia Gomez	MAGGIA Center, FCAG-UNLP, Argentina
María Silvina De Biasi	IALP, UNLP, Argentina
María Paula Natali	MAGGIA Center, FCAG-UNLP, Argentina
Amalia M. Meza	MAGGIA Center, FCAG-UNLP, Argentina

Support staff (Female 4/Male 4):

Guillermo Bosch	Planetario, UNLP, Argentina
Wenceslao Salvo	Planetario, UNLP, Argentina
Romina La Malfa	Planetario, UNLP, Argentina
Valentina Cabral	Planetario, UNLP, Argentina
Juan Francisco Gómez	FCAG-UNLP, Argentina
Sara Delvechio	FCAG-UNLP, Argentina
Briana Rojas	FCAG-UNLP, Argentina
Lautaro Mosquera Vecchio	FCAG-UNLP, Argentina

(i) Final scientific programme

Sun 03, August 2025	
09:00-13:00	Registration, Planetarium UNLP
14:00-16:00	Registration, Library, FCAG, UNLP

Mon 04, August 2025 [Science session, day 1, Planetarium UNLP]				
08:00-09:30	Registration			
	Opening, Chair: Alberto Escapa			
09:30-09:35	Other	Welcome greeting from SOC	Alberto Escapa	University of León
09:35-09:40	Other (online)	Welcome greeting from the dean of Faculty of Astronomical and Geophysical Sciences (FCAG), UNLP	Amalia Meza	National University of La Plata
09:40-09:45	Other	Welcome greeting from the president of Argentina Astronomical Association	Maria Orellana	National University of Rio Negro
09:45-09:50	Other	Welcome greeting from LOC	Laura Fernández	National University of La Plata
09:50-09:55	Other	IAU info & Kavli Foundation prize video	Alberto Escapa	University of León
09:55-10:00	Other	Opening of symposium	Alberto Escapa	University of León
	[Session 1] Earth rotation models and Earth Orientation Parameters (EOP). Chairs: Alberto Escapa & Jolanta Nastula			
10:00-11:00	Plenary	Earth rotation and reference frames	Harald Schuh	TU Berlin and GFZ Potsdam
11:00-11:30	Coffee Break (and poster viewing)			
11:30-12:00	Invited	Achievements, needs and prospects of updating the standards, theories and models of the Earth's rotation	José Manuel Ferrándiz	Universidad de Alicante
12:00-12:15	Contributed (online)	Re-understanding of the Earth polar motion with complete solution of Liouville equation	Cheng-Li Huang	Shanghai Astronomical Observatory, CAS
12:15-12:30	Contributed	Non-rigid contributions to the value of the dynamical ellipticity of the Earth	Alberto Escapa	University of León
12:30-14:00	Lunch (and poster viewing)			
	[Session 1] Earth rotation models and Earth Orientation Parameters (EOP). Chairs: Alberto Escapa & Jolanta Nastula			
14:00-14:30	Invited (online)	Lights and shadows on the resonant modes of the Earth rotation axis	Christian Bizouard	Observatoire de Paris
14:30-14:45	Contributed	New determination of the Earth's dynamical flattening and improvements of the IAU 2006 precession	JiaCheng Liu	Nanjing University
14:45-15:00	Contributed	Analysis of polar motion excitation using C21 and S21 coefficients from GRACE, SLR and hybrid solutions	Jolanta Nastula	Centrum Badań Kosmicznych PAN
15:00-15:30	Invited	Interannual changes in length-of-day driven by a hydromagnetic core waves inside the fluid outer core	Pengshuo Duan	Shanghai Astronomical Observatory, CAS
15:30-15:45	Contributed	A novel approach for direct estimation of the instantaneous Earth rotation velocity	Oleg Titov	Geoscience Australia
15:45-16:00	Contributed	NTSC's activities on UT1 measurements and Earth Rotation Studies	YuanWei Wu	National Time Service Center, CAS

16:00-16:45	Poster flash talks 1 (approx. 5 min recorded flash talks for each poster contribution in sessions 1 & 4)			
16:45-17:15	Coffee Break (and poster viewing)			
	[Session 1] Earth rotation models and Earth Orientation Parameters (EOP). Chairs: Alberto Escapa & Jolanta Nastula			
17:15-17:45	Invited	Prediction of Earth Orientation Parameters – achievements, challenges, and future perspectives	Justyna Śliwińska-Bronowicz	Centrum Badań Kosmicznych PAN
17:45-18:00	Contributed (online)	A data – driven multichannel prediction of celestial pole offsets	Marcin Ligas	AGH University of Krakow
18:00-18:15	Contributed	EOP determination using VLBI at IGN Argentina	Natalia L. Cañas	Instituto Geográfico Nacional
	[Social event] Welcome reception			
18:45-20:45	Ice-breaker welcoming cocktail with tango dancing (exhibition and classes)			

Tue 04, August 2025 [Science session, day 2, Planetarium UNLP]				
08:30-09:00	Registration			
	[Session 2] Celestial and terrestrial reference systems/frames. Chairs: Oleg Titov & Laura Fernández			
09:00-09:30	Invited (online)	The International VLBI Service in its transition to VGOS	Lucia McCallum	University of Tasmania
09:30-10:00	Invited (online)	The International Terrestrial Reference System (ITRS) realization ITRF2020 and its update	Xavier Collilieux	IPGP/IGN/ENSG
10:00-10:15	Contributed	A global worldwide VLBI network to strengthen the celestial reference frame at K band for ICRF4	Patrick Charlot	Laboratoire d'astrophysique de Bordeaux
10:15-10:30	Contributed	Global VLBI solutions: advancing the realization of reference frames IAA202	Renata Urunova	Institute of Applied Astronomy RAS
10:30-11:00	Coffee Break (and poster viewing)			
	[Session 2] Celestial and terrestrial reference systems/frames. Chairs: Oleg Titov & Laura Fernández			
11:00-11:30	Invited (online)	Building the Celestial Grid: The ICRF and Global VLBI Collaboration	Aletha de Witt	Department of Science, Technology and Innovation
11:30-11:45	Contributed (online)	Characterizing the astrometric quality of AGNs in Gaia-	Shilong Liao	Shanghai Astronomical Observatory, CAS
11:45-12:00	Contributed	Effect of negative parallax in VLBI	Angelina Osetrova	Institute of Applied Astronomy of the Russian Academy of Sciences
12:00-12:15	Contributed	The contribution of South American VGOS sites to EOP and reference frames determination	M. Eugenia Gómez	MAGGIA Center-UNLP
12:15-12:30	Contributed	CART: history, current status, development and future collaborations	Marcelo Segura	Universidad Nacional de San Juan
12:30-14:00	Lunch (and poster viewing)			
	[Session 2] Celestial and terrestrial reference systems/frames. Chairs: Oleg Titov & Laura Fernández			
14:00-14:30	Invited	Consistency Between Celestial and Terrestrial Reference Frames and Earth Orientation Parameters: A Geodetic Perspective	Maria Karbon	Universidad de Alicante
14:30-14:45	Contributed	Secular aberration drift in stellar proper motions and their implication on the stellar reference frame	Niu Liu	Nanjing University
14:45-15:00	Contributed	VLBI-detected Blazars for Construction of the ICRF	Kyle Corcoran	US Naval Observatory
15:00-15:15	Contributed	Blazars as Ideal Reference Frame Objects	Andrew Sargent	US Naval Observatory
15:15-16:00	Poster flash talks 1 (approx. 5 min recorded flash talks for each poster contribution in sessions 2 & 3)			
16:00-16:30	Coffee Break (and poster viewing)			

	[Educational Activity No. 1, part a] Talks for UNLP astronomy and aerospace engineering students, FCAG, UNLP			
17:00-18:00	Other	Techniques of Celestial Navigation	Susan G. Stewart	US Naval Observatory
18:15-19:15	Other	La rotación de la Tierra: un problema de Mecánica Analítica (y más) —in Spanish	Alberto Escapa	University of León

Wed 06, August 2025 [Science session, day 3, Planetarium UNLP]				
08:30-09:00	Registration			
	[Session 3]: Reference systems/frames for the Moon and other solar system bodies. Chairs: Flora Paganelli & Agnès Fienga			
09:00-09:30	Invited (online)	Reference Systems and the Rotation of Celestial Bodies: Insights from the Moon and beyond	Nicolas Rambaux	Sorbonne University – LTE – Observatory of Paris
09:30-10:00	Invited	Lunar and Planetary Coordinates and the IAU Working Group on Cartographic Coordinates and Rotational Elements	Brent A. Archinal	US Geological Survey (Emeritus)
10:00-10:30	Invited (online)	MoonLIGHT+MPac on the Moon for Precision Tests of General Relativity	Luca Porcelli	INFN-LNF
10:30-11:00	Coffee Break (and poster viewing)			
	[Session 3]: Reference systems/frames for the Moon and other solar system bodies. Chairs: Flora Paganelli & Agnès Fienga			
11:00-11:30	Invited	Variety of relativistic time scales in the Solar system	Sergei Klioner	Lohrmann Observatory, TU Dresden
11:30-11:45	Contributed (online)	Implementation of Lunar Celestial Reference System (LCRS) for Practical Use and Interoperability	Meredith Elrod	US Naval Observatory
11:45-12:00	Contributed	Lunar Laser Ranging calibrated analytical representation of lunar physical librations	Yixing Li	Shanghai Astronomical Observatory, CAS
12:00-12:15	Contributed	Mars orientation and rotation angles	Marie Yseboodt	Royal Observatory of Belgium
12:15-12:30	Contributed (online)	Report from the IAG JWG 1.1.3 about Lunar reference	Agnès Fienga	Observatoire de la Côte d'Azur
12:30-12:45	Group photo			
12:45-14:00	Lunch (and poster viewing)			
	[Educational Activity No. 2] Workshop for Argentine high school physics, geography, natural sciences, and technology teachers, FCAG, UNLP			
10:00-14:00	Other	La materialización de los sistemas de referencia astronómicos en los niveles primario y secundario de la educación argentina —in Spanish	María Silvina De Biasi	IALP, UNLP
			Mariela Alejandra Corti	IALP, UNLP
	[Session 4] Time scales and time metrology. Chairs: E. Felicitas Arias & Mizuhiko Hosokawa			
14:00-15:00	Plenary	Challenges of time metrology	Noël Dimarq	ARTEMIS (UniCA, OCA, CNRS)
15:00-15:15	Contributed	UTC updates	Frédéric Meynadier	BIPM
15:15-15:45	Invited	Continuous Coordinated Universal Time adopted by the ITU	Joseph Achkar	LNE-OP, LTE/Observatoire de Paris
15:45-16:00	Contributed	Simplified Evaluation of CCGTTS Generation Without Navigation RINEX Corrections: Impact on UTC(INXE)	Marcelo De Cicco	INMETRO
16:00-16:30	Coffee Break (and poster viewing)			
	[Session 4] Time scales and time metrology. Chairs: E. Felicitas Arias & Mizuhiko Hosokawa			

16:30-17:00	Invited (online)	Current status of frequency standards toward the redefinition of the SI second	Tetsuya Ido	NICT
17:00-17:30	Invited	Lunar Time	Pascale Defraigne	Royal Observatory of Belgium
17:30-17:45	Contributed	A numerical realization of Lunar time ephemeris and its harmonic decomposition	Wei Tian	Shanghai Astronomical Observatory, CAS
17:45:18:00	Contributed	Ground-space VLBI Near-field Delay Model for LOVEX Project	Yidan Huang	Shanghai Astronomical Observatory, CAS
	[Social event] Gala dinner			
20:00-23:00	Dinner at Restaurante Cortez, La Plata, Buenos Aires, Argentina			

Thu 07, August 2025 [Science session, day 4, Planetarium UNLP]				
08:30-09:00	Registration			
	[Session 5] Ephemerides of solar system objects. Chair: Dmitry Pavlov			
09:00-10:00	Plenary	The importance of high-precision astrometry in the orbit determination and ephemeris computation for small bodies	Marco Micheli	ESA NEO Coordination Centre, Planetary Defense Office
10:00-10:30	Invited	A statistically sound model for astrometric uncertainties to improve minor planet orbit accuracies	Federica Spoto	Center for Astrophysics, Harvard and Smithsonian
10:30-11:00	Coffee Break (and poster viewing)			
	[Session 5] Ephemerides of solar system objects. Chair: Dmitry Pavlov			
11:00-11:30	Invited	New views of the Oort Cloud	Luke Dones	Southwest Research Institute
11:30-12:00	Invited (online)	The Astrometric Observing Campaign for the First Interstellar Object, 'Oumuamua	Karen Meech	Institute for Astronomy, University of Hawaii
12:00-12:15	Contributed	Refining the Ephemeris of Solar System Objects through Observational Data using Kottamia Telescopes, Egypt	Ahmed Moursi	National Research Institute of Astronomy and Geophysics
12:15-12:30	Contributed	A PCA based effective model for asteroid accelerations	R. Zachary Murray	University Cote d'Azur
12:30-14:00	Lunch (and poster viewing)			
	[Session 5] Ephemerides of solar system objects. Chair: Dmitry Pavlov			
14:00-14:15	Contributed	Analytical Representation of Saturnian Satellite Numerical Ephemerides over Limited Time Spans	XiaoJin Xi	National Time Service Center, CAS
14:15-14:30	Contributed	Boosting decision trees for Main Belt Asteroid selection in planetary ephemerides	R. Zachary Murray	University Cote d'Azur
14:30-14:45	Contributed	The SORA package for Stellar Occultations: sub-mas precision technique	Altair Ramos Gomes-Jr.	Federal University of Uberlândia
14:45-15:00	Contributed (online)	Evolution of INPOP planetary ephemerides	Agnès Fienga	Observatoire de la Côte d'Azur
15:00-15:15	Contributed	The invariable plane of the solar system based on modern long-term ephemerides of the major, dwarf and minor planets	Sergey Kudryavtsev	Sternberg Astronomical Institute, Lomonosov Moscow State University
15:15-15:30	Contributed	Determination of the MESSENGER spacecraft orbit and calculation of Earth-Mercury range points by processing raw range and doppler data	Maksim Subbotin	Saint Petersburg Electrotechnical University

15:30-16:00	Poster flash talks 1 (approx. 5 min recorded flash talks for each poster contribution in sessions 5 & 6)			
16:00-16:30	Coffee Break (and poster viewing)			
	[Educational Activity No. 1, part b] Talks for UNLP astronomy and aerospace engineering students, FCAG, UNLP			
17:00-18:00	Other	Futuros cambios en el Tiempo Universal Coordinado – Impacto en astronomía y geodesia—in Spanish	E. Felicitas Arias	Observatoire de Paris

Fri 08, August 2025 [Science session, day 5, Planetarium UNLP]				
08:30-09:00	Registration			
	[Session 6] Ephemerides of solar system objects. Chair: Susan G. Stewart			
09:00-10:00	Plenary (online)	Building on the Legacy of Astronomical Standards	George Kaplan	US Naval Observatory
10:00-10:30	Invited (online)	Status of the IERS Conventions	Sharyl Byram	US Naval Observatory
10:30-11:00	Coffee Break (and poster viewing)			
	[Session 6] Ephemerides of solar system objects. Chair: Susan G. Stewart			
11:00-11:30	Invited (online)	Role and Activities of the GGOS Bureau of Products and Standards	Detlef Angermann	Technical University of Munich
11:30-12:00	Invited	Standard of Fundamental Astronomy	Antonia J. Wilmot	HM Nautical Almanac Office
12:00-12:45	Round table	How International Standards services and organizations for space and surface navigation can develop and collaborate to meet changing needs	Brent A. Archinal	US Geological Survey (Emeritus)
			Christin Bizouard (online)	Observatoire de Paris
			Catherine Y. Hohenkerk (online)	HM Nautical Almanac Office (retired)
			Sergei Klioner	Lohrmann Observatory, TU Dresden
			Frédéric Meynadier	BIPM
	Closing. Chair: Alberto Escapa			
12:45-12:50	Other	Closing remarks from SOC	Alberto Escapa	University of León
12:50-13:05	Other	Closing words from the president of IAU Div. A Fundamental Astronomy	Bonnie Steves	University of Glasgow
13:05-13:10	Other	Closing remarks from LOC	Laura Fernández	National University of La Plata
13:10-13:15	Other	Closing of symposium	Alberto Escapa	University of León
13:15-14:30	Lunch (and poster viewing)			
14:30-16:00	Splinter meetings, FCAG, UNLP			
16:00-16:30	Coffee Break (and poster viewing)			
	[Outreach] General audience talk at Planetarium UNLP—simultaneous English-Spanish translation			
19:00-20:15	Other	The danger from asteroids: what can we do?	Marco Micheli	ESA NEO Coordination Centre, Planetary Defense Office

Sat 09, August 2025				
	[Social event] Excursion			
08:00-20:00	Visit to Estancia La Candelaria, Lobos, Buenos Aires, Argentina			

40 min talk +10 min discussion for plenary; 20 min talk +5 min discussion for invited; and 12 min talk +3 min discussion for contributed.

List of posters

Session 1 (online)	Contributions to the Earth's rotation due to tidal mass redistribution	Tomás Baenas	University Centre of Defence at the Spanish Air Force Academy
Session 1 (online)	Next-Generation Celestial Pole Offset Prediction	Santiago Belda	University of Alicante

Session 1	Effect of a Non-Hydrostatic Core-Mantle Boundary on Earth's and Mars' Rotational Dynamics	Marta Folgueira-López	Complutense University of Madrid
Session 1	Length of Day and geomagnetic field asymmetry: an observed correlation for the last three millennia	Marta Folgueira-López	Complutense University of Madrid
Session 1 (online)	Assessment of Earth orientation parameters from K-band VLBA sessions until 2025	Hanna Krásná	TU Wien
Session 2	The Fundamental Reference Image Data Archive (FRIDA)	Christopher DiLullo	US Naval Observatory
Session 2 (online)	Topological-geometrical incursion into the internal structure of the Pleiades open cluster and its relationship with some astrophysical parameters	Francisco J. Marco	Universidad Jaume I
Session 2	70 Years of Astrometry at the Félix Aguilar Astronomical Observatory in San Juan	Ana M. Pacheco	Observatorio Astronómico Félix Aguilar – UNSJ
Session 2	Polarimetric Reference Frames for Exoplanetary Atmosphere Characterization	Abdul Qadir	University of Turku
Session 2	Spatial Geodesy from Colombia: Starting Contributions from Academia	Edilberto Suárez Torres	Universidad Distrital – Bogotá
Session 2 (online)	Investigation of the Effect of Different Crustal Density Models on the Gravimetric Geoid Models on the Gravimetric Geoid	Nazan Yilmaz	Karadeniz Technical University
Session 3	Spin Orientation of the Galilean Satellites	Marie Yseboodt	Royal Observatory of Belgium
Session 4	Revitalizing the Observatorio Naval de Buenos Aires (ONBA): Modernization, Outreach, and New Challenge	Romina Miculán	Observatorio Naval Buenos Aires
Session 4	Modernizing the Time and Frequency Laboratory of the Observatorio Naval de Buenos Aires (ONBA): Advancing Precision and Global Integration	Romina Miculán	Observatorio Naval Buenos Aires
Session 4 (online)	Earth Rotation: Measurement of TT-UT, -720 to +1950	Catherine Y. Hohenkerk	HM Nautical Almanac Office (retired)
Session 5	Dynamical evolution of Inner-Earth objects (IEO)	Romina Di Sisto	Instituto de Astrofísica de La Plata (CONICET-UNLP)
Session 5	Three-Dimensional Shape of (50000) Quaoar and Orbit Refinement Using Data from 29 Stellar Occultations	Giuliano Margoti	National Observatory
Session 5	Astrometric Precision of Light Deflection in Stellar Occultations: Gravitational Effects of Multiple Solar System Bodies	Maisa Poiani	Federal University of Uberlândia
Session 5	Rotating-drift-scan observation and orbit determination of near-Earth asteroid	Kai Tang	Shanghai Astronomical Observatory, CAS
Session 5	Near-Earth Asteroid Orbit Determination with Physics-Informed Extreme Learning Machine	Kai Tang	Shanghai Astronomical Observatory, CAS
Session 5	Radar astrometry of near-Earth asteroids from the Arecibo Observatory	Flaviane Venditti	University of Central Florida
Session 6 (online)	Constellation Boundaries Update - 21st Century Complete	Steve Durst	ILOA – Hawai'i
Session 6	Possible upgrade of the Galactic coordinate system	JiaCheng Liu	Nanjing University

Flash talk videos of poster contributions will be introduced by the chairs of the sessions and projected in the corresponding time slots on Monday 4, Tuesday 5, and Thursday 7.

Number of speakers plenary talks: Female 0/Male 4

Number of speakers invited talks: Female 9/Male 12

Number of speakers contributed talks: Female 12/Male 20/Prefer not to say 1

Number of presenters poster contributions: Female 12/Male 11

Number of session chairs: Female 6/Male 4

(ii) Summary of the scientific highlights of the meeting

During the IAUS 401, we discussed 6 key topics on reference systems, ephemeris, and standards. They were developed in the respective session of the meeting. Specifically:

- (1) Earth rotation models and Earth Orientation Parameters (EOP)
- (2) Celestial and terrestrial reference systems/frames
- (3) Reference systems/frames for the Moon and other solar system bodies
- (4) Time scales and time metrology
- (5) Ephemerides of solar system objects
- (6) Astronomical standards

In the following, we summarize the scientific highlights discussed at the IAU Symposium 401.

Session 1 included a plenary talk reviewing Earth rotation and reference frames with an emphasis on observation techniques and four invited presentations. They addressed issues concerning the update of the standards, theories and models of the Earth's rotation; the observation and modeling of the resonant free modes of the non-rigid Earth; the interannual changes in length-of-day (LOD) driven by a hydromagnetic core waves inside the fluid outer core; and the achievements, challenges, and future perspectives on EOP prediction. There were also eight contributed talks and five posters discussing different topics related to the revision of IAU2000/2006 precession-nutation models, the analysis and observation of polar motion, UT1, and LOD; the geophysical excitation of Earth rotation; novel techniques to measure the Earth angular velocity; and the operative determination of EOP combining different observational and prediction methods.

Session 2 was devoted to celestial and terrestrial reference frames, focusing on VLBI and its improvements as the fundamental technique determining the ICRF, providing the whole set of EOP, and contributing to the TRF. This session also discussed the comparison and interplay between Gaia-CRF and ICRF3 to get a consistent, integrated multi-waveband Celestial Reference Frame focusing on the next ICRF realization (ICRF4) to be released in 2027. The selection of the astrometrically stable radio sources using their optical characteristic based on the catalogue of the blazars detected across a broad frequency range was suggested. Finally, this session also addressed the consistency between celestial and terrestrial reference frames and the EOP linking them.

Session 3 had very insightful contributions that outlined key standards for the proposed frame attached to the lunar surface identified as the lunar body-fixed reference system (LRS - not officially named yet by IAU resolution), the established Lunar Celestial Reference System (LCRS), the use of the Moon's reference Principal Axis (PA) system and the Mean Earth direction and rotation system (ME). The new generation of lunar Corner-Cube Retroreflectors (CCR) plan was introduced for precision tests of gravitational physics, and improvement of the Lunar Laser Ranging Retroreflector (LLRR) determinations. In view of the future exploration of the Moon, thus the need for interoperability across agencies and organizations, a new Moon ephemerides model derived as weighted combination of currently accepted DE (JPL), INPOP (OCA), and EPM (IAA RAS) ephemerides models, was proposed.

Session 4 addressed the most relevant aspects of time scales and time keeping today, as signaled by the Consultative Committee for Time and Frequency (CCTF). The presentations included the future evolution of UTC, on one hand concerning the redefinition of the SI second, on the other hand concerning its long-term continuity by modifying its link to Earth's rotational time UT1. The latest achievements on frequency standards, reaching fractional frequency uncertainties of order 10⁻¹⁸ were presented, opening the way to the redefinition of the SI second, probably around 2030. Lunar references require of an accurate time scale linked to the international reference UTC; the issue was presented and discussed. Some presentations and posters covered the activities at Latin-American and Argentinian institutes maintaining local representations of UTC.

Session 5 featured insightful presentations covering a broad range of solar system bodies, including planets, planetary satellites, small bodies, and the Oort Cloud. The session included a plenary talk on the importance of high-precision astrometry for orbit determination, four invited presentations addressing new perspectives on distant solar system populations, interstellar object observation campaigns, and uncertainties of astrometry for small bodies, as well as eight in-person talks and two posters reflecting diverse research contributions. Topics explored recent advances in orbit prediction and reconstruction, with special emphasis on Near-Earth Objects, statistical models to improve orbital accuracy, and the evolution of planetary ephemerides. Observational techniques such as stellar occultations, radar ranging, and multi-site telescope campaigns were highlighted for their role in refining ephemerides.

Session 6 included one plenary talk, three invited talks, and a round table discussion. The plenary talk focused on the enduring importance of established astronomical standards by giving a well-received history of standardized reference frames in the IAU. The invited talks expanded gave status reports from standards organizations, specifically covering the IERS Conventions for Earth rotation and reference frames, the GGOS Bureau of Products and Standards for global geodetic observing, and the Standard of Fundamental Astronomy (SOFA) software. The round table then explored international collaborations, with emphasis on the need for integrated standards related to celestial, lunar, and terrestrial frames, time systems, and ephemerides. The discussion also raised the need of forming a unified Lunar standard working group to foster interoperability.

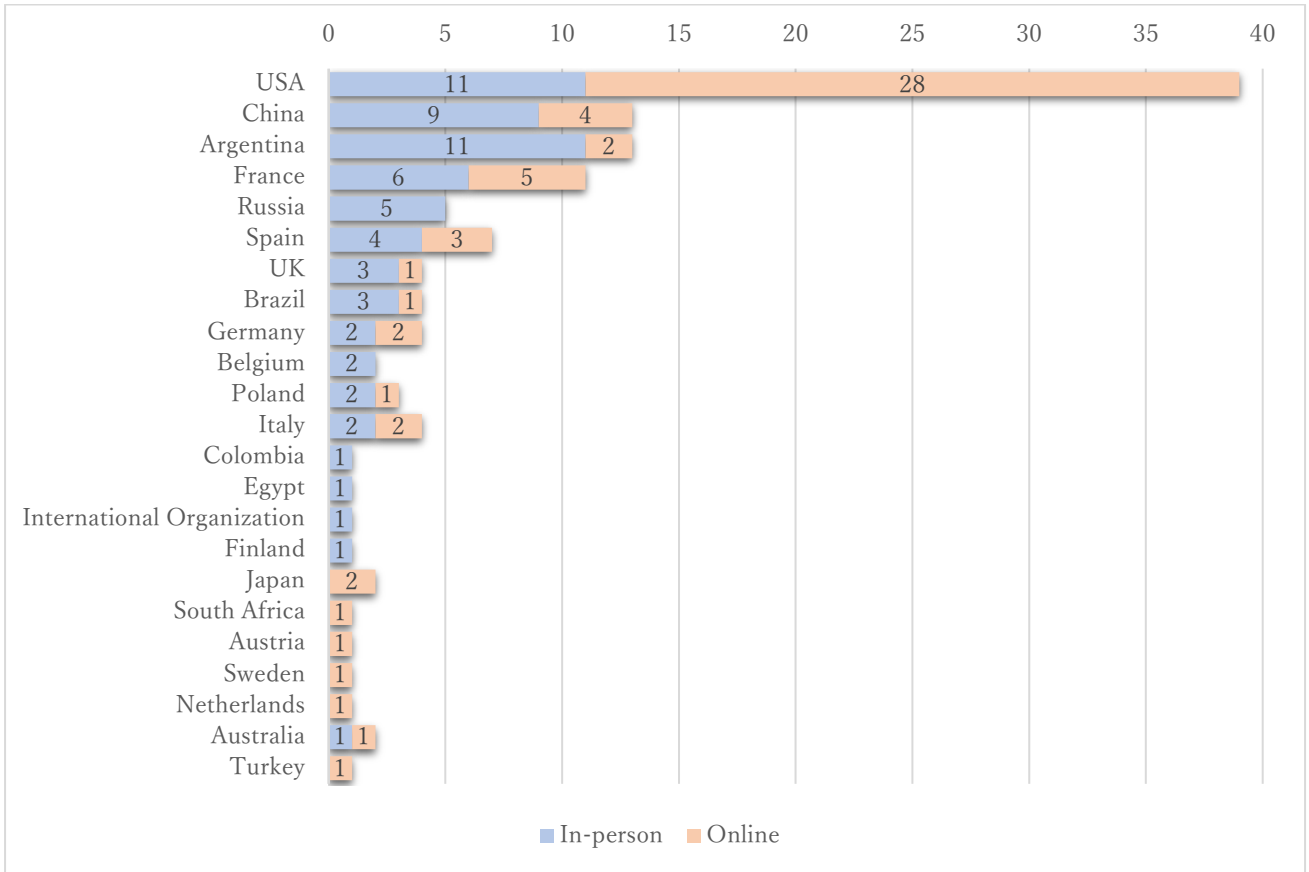
(iii) List of participants

Family name	Given name	Country	Institution	Participation
Achkar	Joseph	France	LNE-OP, LTE/Observatoire de Paris	In-person
Angermann	Detlef	Germany	Technical University of Munich	Online
Anzalone	Evan	USA	NASA	Online
Archinal	Brent A.	USA	US Geological Survey (Emeritus)	In-person
Arias	Elisa Felicitas	France	Observatoire de Paris	In-person
Baenas	Tomás	Spain	University Centre of Defence at the Spanish Air Force Academy	Online
Belda	Santiago	Spain	University of Alicante	Online
Bell	Steven	UK	HMNAO	In-person
Bizouard	Christian	France	Observatoire de Paris	Online
Bruzewski	Seth	USA	United States Naval Observatory	In-person
Byram	Sharyl	USA	US Naval Observatory	Online
Cañas	Natalia L.	Argentina	Instituto Geográfico Nacional	In-person
Capitaine	Nicole	France	Observatoire de Paris	Online
Charlot	Patrick	France	Laboratoire d'astrophysique de Bordeaux	In-person
Cigan	Philip	USA	US Naval Observatory	Online
Collilieux	Xavier	France	IPGP / IGN / ENSG	Online
Corcoran	Kyle	USA	US Naval Observatory	In-person
Cramer	Claire	USA	US Naval Observatory	Online
Davis	Maria	USA	US Naval Observatory	In-person
De Biasi	M. Silvina	Argentina	IALP, UNLP	In-person
De Cicco	Marcelo	Brazil	INMETRO	Online
De La Pina	Carla	Argentina	FCAG, UNLP	In-person
De Witt	Aletha	South Africa	Department of Science, Technology and Innovation	Online
Defraigne	Pascale	Belgium	Royal Observatory of Belgium	In-person
DiLullo	Christopher	USA	US Naval Observatory	In-person
Di Sisto	Romina	Argentina	Instituto de Astrofísica de La Plata (CONICET-UNLP)	In-person
Dimarcq	Noël	France	ARTEMIS (UniCA, OCA, CNRS)	In-person
Dones	Luke	USA	Southwest Research Institute	In-person
Duan	Pengshuo	China	Shanghai Astronomical Observatory, CAS	In-person
Durst	Steve	USA	ILOA – Hawai'i	Online
Efroimsky	Michael	USA	US Naval Observatory	Online
Elrod	Meredith	USA	US Naval Observatory	Online
Escapa	Alberto	Spain	University of León	In-person
Fernández	Laura I.	Argentina	MAGGIA Center-UNLP	In-person
Ferrándiz	José M.	Spain	Universidad de Alicante	In-person
Fienga	Agnès	France	Observatoire de la Côte d'Azur	Online
Folgueira-López	Marta	Spain	Complutense University of Madrid	In-person
Foster	Deatrick	USA	US Naval Observatory	Online
Geiger	Nicole	USA	US Naval Observatory	Online
Gomez	M. Eugenia	Argentina	MAGGIA Center-UNLP	In-person
Gonzalez Marquez	Christian D.	Argentina	Observatorio Naval Buenos Aires	Online
Gordon	David	USA	US Naval Observatory	Online
Gramling	Sheryl	USA	NASA	Online
Hennessy	Gregory	USA	US Naval Observatory	Online
Hilton	James	USA	Retired	In-person
Hohenkerk	Catherine Y.	UK	Retired	Online
Hosokawa	Mizuhiko	Japan	NICT	Online
Huang	Cheng-Li	China	Shanghai Astronomical Observatory, CAS	Online
Huang	Yidan	China	Shanghai Astronomical Observatory, CAS	In-person
Ido	Tetsuya	Japan	NICT	Online
Kaplan	George	USA	US Naval Observatory	Online
Karbon	Maria	Spain	Universidad de Alicante	In-person
Klioner	Sergei	Germany	Lohrmann Observatory, TU Dresden	In-person
Kopf	Andrew	USA	US Naval Observatory	Online
Krásná	Hanna	Austria	TU Wien	Online
Kudryavtsev	Sergey	Russia	Sternberg Astronomical Institute, Lomonosov Moscow State University	In-person
Laos	Emily	USA	US Naval Observatory	Online
Le Bail	Karine	Sweden	Chalmers University of Technology / Onsala Space Observatory	Online
Li	Yixing	China	Shanghai Astronomical Observatory, CAS	In-person

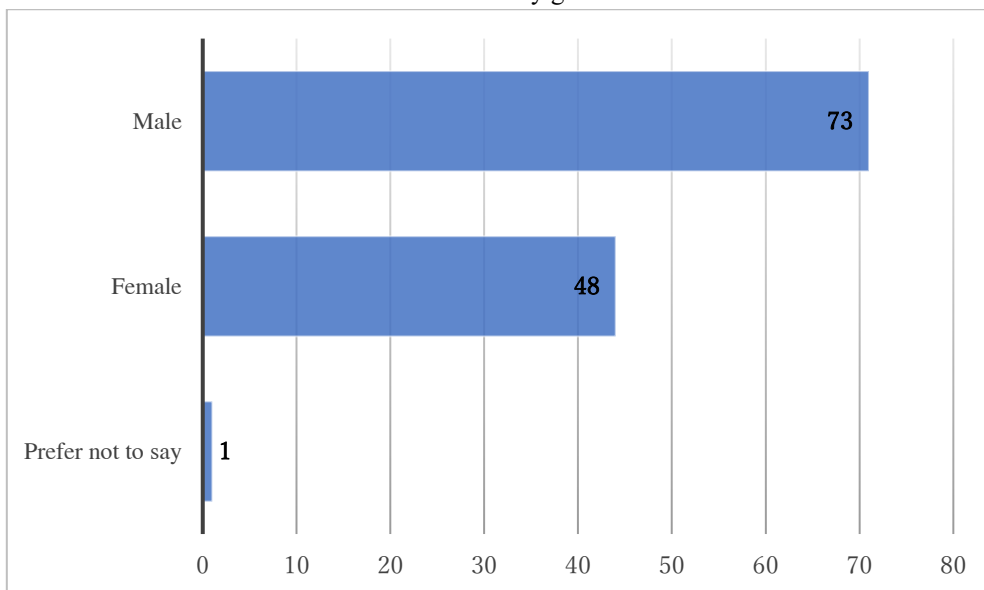
Family name	Given name	Country	Institution	Participation
Liao	Shilong	China	Shanghai Astronomical Observatory, CAS	Online
Ligas	Marcin	Poland	AGH University of Krakow	Online
Liu	JiaCheng	China	Nanjing University	In-person
Liu	Niu	China	Nanjing University	In-person
Lorek	Ryan	USA	US Naval Observatory	Online
Makley	Nicholas	USA	National Geospatial-Intelligence Agency	Online
Marco	Francisco J.	Spain	Universidad Jaume I	Online
Margoti	Giuliano	Brazil	National Observatory	In-person
Mariani	Vincenzo	Italy	Sapienza University of Rome	In-person
Markiel	JN M	USA	National Geospatial-Intelligence Agency	Online
Massarweh	Lofti	Netherlands	TU Delft	Online
Matlin	Daniel	USA	JHU Applied Physics Lab	Online
Matsakis	Demetrios	USA	Masterclock, Inc.	Online
McCallum	Lucia	Australia	University of Tasmania	Online
Meech	Karen	USA	Institute for Astronomy, University of Hawaii	Online
Meza	Amalia M.	Argentina	MAGGIA Center, FCAG-UNLP	In-person
Meynadier	Frédéric	International Organization	BIPM	In-person
Micheli	Marco	Italy	ESA NEO Coordination Centre, Planetary Defense Office	In-person
Miculán	Romina	Argentina	Observatorio Naval Buenos Aires	In-person
Mortensen	Danielle	USA	JHU/APL	Online
Moursi	Ahmed	Egypt	National Research Institute of Astronomy and Geophysics	In-person
Murison	Marc	USA	US Naval Observatory	Online
Murray	R. Zachary	France	University Cote d'Azur	In-person
Natali	M. Paula	Argentina	MAGGIA Center, FCAG-UNLP	IN-person
Nastula	Jolanta	Poland	Centrum Badań Kosmicznych PAN	In-person
Osetrova	Angelina	Russia	Institute of Applied Astronomy of the Russian Academy of Sciences	In-person
Pacheco	Ana M.	Argentina	Observatorio Astronómico Félix Aguilar – UNSJ	In-person
Paganelli	Flora	France	Centre de Recherche Astrophysique de Lyon (CRAL)/CNRS	In-person
Pavlov	Dmitry	Russia	St. Petersburg Electrotechnical University	In-person
Peil	Steven	USA	US Naval Observatory	Online
Poiani	Maisa	Brazil	Federal University of Uberlândia	In-person
Porcelli	Luca	Italy	INFN-LNF	Online
Puatua	Wendy	USA	US Naval Observatory	Online
Qadir	Abdul	Finland	University of Turku	In-person
Rambaux	Nicolas	France	Sorbonne University – LTE – Observatory of Paris	Online
Ramos Gomes-Jr.	Altair	Brazil	Federal University of Uberlândia	In-person
Sargent	Andrew	USA	US Naval Observatory	In-person
Schuh	Harald	Germany	TU Berlin and GFZ Potsdam	In-person
Segura	Marcelo	Argentina	Universidad Nacional de San Juan	In-person
Seitz	Manuela	Germany	DGFI-TUM	Online
Śliwińska-Bronowicz	Justyna	Poland	Centrum Badań Kosmicznych PAN	In-person
Spoto	Federica	USA	Center for Astrophysics, Harvard and Smithsonian	In-person
Steves	Bonnie	UK	University of Glasgow	In-person
Stewart	Susan G.	USA	US Naval Observatory	In-person
Suarez Torres	Edilberto	Colombia	Universidad Distrital – Bogotá	In-person
Subbotin	Maksim	Russia	Saint Petersburg Electrotechnical University	In-person
Tang	Kai	China	Shanghai Astronomical Observatory, CAS	In-person
Terry	Alexandria	USA	National Geospatial-Intelligence Agency	Online
Tian	Wei	China	Shanghai Astronomical Observatory, CAS	In-person
Titov	Oleg	Australia	Geoscience Australia	In-person
Urunova	Renata	Russia	Institute of Applied Astronomy RAS	In-person
Valenti	Ma. Cecilia	Argentina	ARSAT	Online
Valsecchi	Giovanni B.	Italy	IAPS-INAF	Online
Venditti	Flaviane	USA	University of Central Florida	In-person
Viswanathan	Vishnu	USA	NASA/GSFC/UMBC	Online
Wilmot	Antonia J.	UK	HM Nautical Almanac Office	In-person
Wu	YuanWei	China	National Time Service Center, CAS	In-person

Family name	Given name	Country	Institution	Participation
Xi	XiaoJin	China	National Time Service Center, CAS	In-person
Yang	Yongzhang	China	Yunnan Observatories, CAS	Online
Yilmaz	Nazan	Turkey	Karadeniz Technical University	Online
Yin	Dongshan	China	National Time Service Center, CAS	Online
York	Gregory	USA	National Geospatial-Intelligence Agency	Online
Yseboodt	Marie	Belgium	Royal Observatory of Belgium	In-person

Distribution by country



Distribution by gender



(iv) List of recipients of IAU grants, stating the amount received, country and gender

Name	Affiliation	Country	Gender	Amount (€)
Natalia CAÑAS	Instituto Geográfico Nacional (IGN)	Argentina	F	325
Marcelo DI CICCO	INMETRO	Brazil	M	55
Romina DI SISTO	IALP-UNLP	Argentina	F	325
Marta FOLGUEIRA-LÓPEZ	Universidad Complutense de Madrid (UCM)	Spain	F	850
Sergey KUDRYAVTSEV	Sternberg Astronomical Institute, Lomonosov Moscow State University	Russia	M	1 025
Yixing LI	Shanghai Astronomical Observatory	China	M	1 000
Giuliano MARGOTI	National Observatory	Brazil	M	700
Marco MICHELI	ESA NEO Coordination Centre, Planetary Defense Office	Italy	M	2 000
Romina MICULÁN	Observatorio Naval Buenos Aires	Argentina	F	325
Ahmed MOURSI	National Research Institute of Astronomy and Geophysics	Egypt	M	2 220
Angelina OSETROVA	Institute of Applied Astronomy of the Russian Academy of Sciences	Russia	F	2 575
Ana María PACHECO	Observatorio Astronómico Félix Aguilar – UNSJ	Argentina	F	550
Máisa POIANI	Federal University of Uberlândia	Brazil	F	600
Yasir Abdul QADIR	University of Turku	Finland	M	1 200
Marcelo SEGURA	Universidad Nacional de San Juan	Argentina	M	500
Edilberto SUAREZ TORRES	Universidad Distrital – Bogotá	Colombia	M	600
Maksim SUBBOTIN	Saint Petersburg Electrotechnical University	Russia	M	2 575
Renata URONOVA	Institute of Applied Astronomy of the Russian Academy of Sciences	Russia	F	2 575

Number of recipients: Female 8/Male 10

Total 20 000 EURO

(v) An Executive Summary of the Meeting

The IAUS 401 “Advancing Reference Systems, Ephemeris, and Standards” was held from August 4 (Monday) 2025 to August 9 (Saturday) 2025 at La Plata, Buenos Aires, Argentina. All the scientific sessions took place at the Planetarium of the National University of La Plata (UNLP) in La Plata’s “Paseo del Bosque” area, and some complementary activities in the close dependencies of the Faculty of Astronomical and Geophysical Sciences (FCAG).

To foster the participation of the research community and scientists from all over the world, the Symposium was planned and organized in a hybrid format. The online part was developed through videoconferencing application Zoom whose licenses were made available by IAU, and also with the help of a dedicated UNLP Moodle site to host the poster contributions. This hybrid mode run smoothly during the sessions of the meeting thanks to the support of the technicians of the Planetarium — fully equipped with audiovisual facilities and high-quality Internet connection— and the FCAG student volunteers.

The IAUS 401 focused on questions encompassing the elements required to describe both the position and motion of planetary bodies and also relative to them, i.e., reference systems. Thus, it is necessary to specify their ephemeris, reference frames, time scales, and orientation with respect to a celestial reference frame, also to be determined. Such processes must be done in a consistent way, in order to derive a set of parameters and procedures that conform the astronomical standards. The outlined subjects constitute well-defined and scientifically relevant components in the heart of Fundamental Astronomy and are also the basis for many other fields of astronomy and astrophysics as the reduction of observed raw data; the physical study of the Sun, planets, satellites, or asteroids; space missions of diverse nature, etc. Furthermore, they impact technological applications, and serve societal requests by supporting navigation around the Earth and in space; monitoring the global change; contributing to time transfer; etc.

The topics of the Symposium embrace up-to-date questions, worth to discuss at this time. E.g., the development of Res. B1 and B2 in 2019 and B2 and B3 2021 about reference frames and Earth rotation and the results of its related working groups (e.g., WG ITMER, WG MICRF optical+VLBI, etc.); the impact on astronomy of the changes in UTC announced at the 27th CGPM (2022); the development of lunar models/ standards given the impending plans for operations on our satellite; the construction of accurate ephemeris for increasing NEO population observations; the revision of Current Best Estimates (CBEs), adopted in 2009; etc.

The last official IAU meeting related to the core topics of the IAUS 401 was the IAU Colloquium 180 “Towards Models and Constants for Sub-Microarcsecond Astrometry”, in year 2000. It did not include topics related to solar system reference frames and ephemerides. Close questions related to ICRS/ICRF and VLBI or NEOs and small bodies have been considered separately in recent IAU Symposium or Focus Meetings, but with different goals. Our approach and proposed target are different as CRFs and VLBI are considered as elements monitoring EOP, contributing to ITRF, and also to frames and orientations of other bodies; NEOS and small bodies are interesting to develop accurate ephemerides.

Because of such reasons, in 2023 we decided to prepare a proposal for organizing an IAU symposium. It was a joint initiative of CA2 Rotation of the Earth, CA3 Fundamental Standards, CX2 Solar System Ephemerides, WG Time Metrology Standards, and WG Cartographic Coordinates & Rotational Elements last. We received the support of all the IAU bodies integrating Div. A Fundamental Astronomy, as well as the own Div. A and also Div. B Facilities, Technologies and Data Science, and Div. F Planetary Systems and Astrobiology.

The IAUS 401 was hosted by the he National University of La Plata (UNLP), located at La Plata, 50 km away from the City of Buenos Aires, Argentina. The Faculty of Astronomical and Geophysical Sciences (FCAG) at UNLP has a long tradition is Astronomy, being the first faculty of Astronomy in Latin-America, founded in 1935, and with an astronomical observatory working since 1883. In addition, this venue is an excellent frame to spread the results of research in our fields and to strengthen the cooperation between scientists across Latin-American and other parts of the world. It was also an opportunity to foster the teaching and learning of astronomy among local communities through the planned educational activities and outreach (see program at section i of this report).

The number of participants of the IAUS 401 was 122, with 65 participants in-person and 57 online. The numbers of female and male participants were 48 and 73 (1 has no information). The procedence of the participants was quite diverse coming from 26 countries and 1 international organization: 45 from Europe (27 in-person and 18 online); 39 from North America (11 in-person and 28 online); 18 from South America (15 in-person and 3 online), with 13 participants from Argentina (11 in-person and 2 online); 15 from Asia (9 in-person and 6 online); 2 from Africa (1 in-person and 1 online); and 2 from Oceania (1 in-person and 1 online). Among them 18 received support from IAU Travel Grants, mainly colleagues from economically less privileged countries and young scientists, what allowed their in-person participation.

The science sessions started on August 4 (Monday) 2025 and ended on August 8 (Friday). We discussed 6 main topics as summarized in section ii of this report, each included in a session of the IAUS 401. Each session was developed in one day, but sessions 3 and 4 that took place on Wednesday 6. The IAUS 401 was structured through plenary, invited, and contributed talks and poster presentations. We had 4 plenary talks (3 in-person and 1 online); 21 invited talks (11 in-person and 10 online); 33 contributed talks (26 in-person and 7 online), and 23 poster presentations (17 in-person and 6 online).

The plenary talks reviewed and previewed issues about the topics, preceding a session or groups of sessions. Then, within each session several invited talks were delivered, developing topics of current interest in the respective fields. Although science was the main consideration when selecting plenary and invited speakers, we paid attention to achieving regional and gender balance. The sessions were completed with contributed talks and in session 6 we organized a round-table discussion about the development of international standards. All the talks were streamed via Zoom. Online participants had to record a video in advanced to be also streamed (to avoid problems with the connection), but be present via Zoom in the time for the questions.

With respect to the poster presentations, both in-person and online authors were asked for preparing a 5 min. video about their contributions —flash talk video. They were introduced by the chairs of the sessions and streamed in the corresponding time slots (see program at section i of this report). In-person participants posters were also displayed at the foyer of the Planetarium during the week. All poster contributions were available for the IAUS 401 participants at a dedicated UNLP Moodle site, where it was possible to interact with the authors asynchronously.

A splinter meeting coordinated by sessions 3 and 5 was held on August 8 (Friday) to discuss the potential inclusion of the PETREL (SAO CAS) ephemerides model into the newly proposed weighted combination Moon ephemerides model. As planned, the IAUS 401 offered ample time for discussion among in-person participants during coffee breaks —at the foyer of the Planetarium, after lunch periods, and in social events. It gave the opportunity of a more detailed analysis of some of the presented scientific contributions and also to explore the possibilities of future collaboration.

During the IAUS 401 two educational activities were organized. The first one was a set of talks addressed to the UNLP astronomy and aerospace engineering students. It was delivered in two days at the rooms of FCAG, UNLP. On Tuesday 5, a first talk was given by Susan G. Stewart (co-chair, SOC) with the title “Techniques of Celestial Navigation”. She explored the core techniques of celestial navigation, emphasizing the methods mariners use to determine their position using celestial bodies. Later, Alberto Escapa (co-chair, SOC) presented “The rotation of the Earth: An Analytical Mechanics problem (and more)” —in Spanish, showing how the rotation of the Earth can be well described in the framework of Analytical Mechanics, both for the rigid and non-rigid models. On Thursday 6, a last talk was delivered by E. Felicitas Arias (co-chair, SOC) about “Future changes in Coordinated Universal Time - Impact on astronomy and geodesy” —in Spanish. She introduced the rationale beyond a potential redefinition of the SI second, as well as the next change of the way of synchronizing UT1 and UTC.

The second educational activity was a workshop (in Spanish) entitled “The materialization of astronomical reference systems in primary and secondary Argentine education levels”. It was held on Wednesday 6 and given by Maria Silvina De Biasi (member, LOC) and Mariela Alejandra Corti, both National Astronomy Education Coordinators for Argentina —Office of Astronomy Education IAU <https://astro4edu.org/naec-network/AR>— at FCAG, UNLP. Teachers from Argentina, Spain, and Colombia participated in the activities in the form of naked-eye observations that can be used in everyday teacher practice. During four hours, the horizontal and equatorial reference coordinate systems were materialized with the aid of the Smooth Sphere, a sphere arranged in the open air and illuminated by the Sun, a Parallel Earth Globe, and a gnomon, which led to determining the North-South direction.

A general audience talk “The danger from asteroids: what can we do?” was also organized and hold in the UNLP, Planetarium on the afternoon of Friday 8. The speaker was Marco Micheli, also participating in a plenary contribution of the IAUS 401, from the ESA NEO Coordination Centre in Italy. He briefly introduced the importance of the asteroid impact threat and what the worldwide planetary defense community is doing to prevent it, starting from telescopic observations and continuing with the prediction of possible impacts and what humanity can do in case an asteroid is found to be on a collision course with our planet. This activity had simultaneous translation into Spanish and was very well received by the local audience, with a very active discussion.

The LOC also organized associated social events for the IAUS 401 participants. On Monday 4, a welcome ice-breaker reception was offered at the lobby of the Planetarium. The participants could taste different foods and Argentinian wines and enjoyed a tango performance, also including some tango practical classes. In the evening on Wednesday 6, the gala dinner was held at the Restaurant Cortez at La Plata downtown, in which traditional Argentinian products were served. During the dinner there was a tango dancers’ performance with live music. Finally, on Saturday 4, a visit to Estancia La Candelaria was held during all the day. It is located at Lobos, Buenos Aires, in the country side —pampa bonaerense. The participants could enjoy different Argentinian traditions that included foods (asado, empanada, etc.), drinks (wines, mate, etc.), and folklore in an atmosphere of nature and friendship.

We would like to thank the leading role of IAU in approving, promoting, and supporting the IAUS 401, as well as the additional logistical or financial aid of the following organizations FCAG, UNLP, CONICET, Asociación Argentina de Astronomía, Fundación Williams, and Kavli Foundation. We also acknowledge the support of Div. A, and also of Div. B and F, and of all of its bodies to hold this symposium. We thank the dedication and hospitality of the LOC in the organization of the IAUS 401, which made that the meeting run smoothly; and the SOC for preparing an interesting scientific program.

Finally, we would like to give special thanks to all the participants of the Symposium: plenary, invited, and contributed speakers, poster presenters, and in-person and online audience. You made the IAUS 401 possible.