International Committee on Global Navigation Satellite Systems

Eighteenth meeting of the International Committee on Global Navigation Satellite Systems, Wellington, New Zealand

7 – 11 October 2024

JOINT STATEMENT

1. The eighteenth meeting of the International Committee on Global Navigation Satellite Systems (ICG) was held in Wellington from 7 to 11 October 2024 to continue reviewing and discussing developments in the field of global navigation satellite systems (GNSS) and to allow ICG members, associate members and observers to address recent developments in their countries, organizations and associations regarding GNSS services and applications.

2. Chris Penk, Minister for Land Information of New Zealand, and Amy Guihot, Deputy High Commissioner of Australia, delivered opening statements. Sharafat Gadimova, on behalf of the executive secretariat of ICG and the Office for Outer Space Affairs, also addressed the meeting.

3. The meeting was held with in-person and online attendance by representatives of Algeria, Australia, China, India, Italy, Japan, Malaysia, New Zealand, the Republic of Korea, the Russian Federation, the United Arab Emirates, the United States of America and the European Union. The following intergovernmental and non-governmental organizations were also represented: Civil Global Positioning System Service Interface Committee, European Space Agency (ESA), International Association of Geodesy, International Association of Institutes of Navigation, International Bureau of Weights and Measures, International Earth Rotation and Reference Systems Service, International Federation of Surveyors, International Global Navigation Satellite System Service, International Union of Radio Science, International Telecommunication Union and Radio Technical Commission for Maritime Services. A representative of the Office for Outer Space Affairs also participated.

4. Representatives of Norway, Pakistan, the United Kingdom of Great Britain and Northern Ireland, the Centre for Space Science and Technology Education in Asia and the Pacific, the Regional Centre for Space Science and Technology Education in Asia and the Pacific (China) and the United Nations Global Geodetic Centre of Excellence were invited to attend as observers.

5. Regarding the membership application of Pakistan, which had been submitted at the fifteenth meeting of ICG, ICG failed to attain consensus. ICG agreed to continue to work towards a swift conclusion on the matter. A member of ICG appealed to accelerate this process.

6. ICG noted that the working groups had focused on the following issues: systems, signals and services; enhancement of GNSS performance, new services and capabilities; information dissemination and capacity-building; and reference frames, timing and applications.

7. The Working Group on Systems, Signals and Services (Working Group S), through its subgroups and task forces, had continued the work outlined in its workplan during the intersessional period between the seventeenth and eighteenth meetings of ICG. Under the leadership of the subgroup on compatibility and spectrum protection, the Working Group had continued its campaign to promote adequate protection of the GNSS spectrum by reviewing relevant GNSS and radionavigation satellite service-related activities of the International Telecommunication Union. In April 2024, the subgroup had conducted a workshop on interference detection and mitigation focused on the aviation and maritime sectors, with discussion of existing processes as a possible baseline/reference for other industry sectors using GNSS services that could be used and implemented in their sector interference detection and mitigation strategies. The subgroup had also agreed to conduct a twelfth workshop on interference detection and mitigation in order to exchange processes to better communicate and disseminate information about GNSS interference incidents throughout the GNSS user community.

8. The subgroup on interoperability and service standards had continued to make progress on the work in its workplan, including overseeing the work of its task forces. The precise point positioning interoperability task force had held a workshop in January 2024 and completed the fourth edition of the "PPP/PPP-RTK service providers report", providing information about planned service. The international GNSS monitoring and assessment task force had conducted a workshop focused on discussing plans for the second run of the joint trial project with the IGS data exchange formats. The task force planned to hold another workshop in 2025 to evaluate the results of the second run of the joint trial project. The performance standards group had also continued its work on a "hints and tips" document. The international GNSS monitoring and assessment task force and the performance standards group planned to continue with combined virtual meetings on a monthly basis. Timing experts from the subgroup on interoperability and service standards had held a meeting to discuss the next steps and agreed on questions and criteria for reaching out to industry for views on timing interoperability. The expert group planned to conduct a workshop to review and share the results of the industry outreach.

9. Under the Working Group's workplan focused on system of system operations, the Working Group had organized a workshop on future low Earth orbit positioning, navigation and timing systems focused on examining compatibility and interoperability issues and the role of future low Earth orbit positioning, navigation and timing system providers in ICG. The Working Group agreed to a recommendation supporting annual workshops focused on such compatibility and interoperability issues. Providers also continued to review feedback on the 2020 report from the Inter-Agency Space Debris Coordination Committee that followed a recommendation from the thirteenth meeting of ICG to study the issue of debris mitigation practices relevant to the medium Earth orbit and inclined geosynchronous orbit orbital regimes used by GNSS. The Working Group planned to hold a small group discussion, led by China and the European Union, to finalize feedback to the Inter-Agency Space Debris Coordination Committee on the report. Under the topic of system of system operations, the Working Group received presentations from system providers, who were looking into methods for the authentication of open civil signals. Finally, the Working Group agreed to a recommendation supporting the update of its workplan to incorporate the following four topics: precise point positioning interoperability, civil signal authentication, compatibility and interoperability of low Earth orbit positioning, navigation and timing systems and lunar positioning, navigation and timing system compatibility issues with GNSS and radionavigation satellite services.

10. The Working Group on Enhancement of GNSS Performance, New Services and Capabilities (Working Group B) had progressed in its activities. The Working Group B space use subgroup presented its accomplishments since the seventeenth meeting of ICG. Monthly virtual meetings had been held to make progress on its workplan. The subgroup

had organized a dedicated space service volume session at the Munich Satellite Navigation Summit in March 2024, including on lunar activities, which reflected increasing interest in this topic. The subgroup had held a hybrid meeting in Vienna in June 2024, in which it had adopted status definitions for its workplan activities and began discussions towards a third edition of the space service volume booklet. The progress made by the subgroup work package two on space user profiles and needs was presented, including analysis of available mission databases, and a space use term list was drafted. Members of the subgroup work packages one, three and five, currently in dormant status, indicated their intentions to return the packages to active status in the next year.

11. The space use subgroup work package four on GNSS space service volume and lunar positioning, navigation and timing reviewed progress on planning for the joint ICG-Interagency Operations Advisory Group multilateral workshop on cis-lunar positioning, navigation and timing, which had been initiated as a recommendation at the seventeenth meeting of ICG. Active planning was under way by the organizing committee. The workshop was planned to be held in Vienna from 11 to 13 February 2025, with both in-person and online attendance options. Registration was now open on the ICG information portal[1] and would close on 22 November 2024. The subgroup encouraged all members of ICG to participate in this workshop.

12. The space use subgroup provided an update on the successful joint working group session on lunar positioning, navigation and timing held in Vienna in June 2024. The session had received 14 presentations from lunar positioning, navigation and timing provider agencies and international organizations on the topics of systems, spectrum, reference frames, timing, lessons learned in relation to GNSS, and lunar positioning, navigation and timing within ICG. During the session, the need had been identified to establish a centralized, dedicated working group within ICG at the earliest opportunity in order to continue the active and necessary coordination among the lunar positioning, navigation and timing community without affecting the scope and work of the existing Earth-focused working groups. The subgroup presented the proposed recommendation and initial workplan as a reference for the ICG Working Group on Lunar Positioning, Navigation and Timing (Working Group L), which had received the support of Working Group B for endorsement by ICG.

13. Since the seventeenth meeting of ICG, the Working Group B application subgroup had made significant progress on its initiative entitled “GNSS applications: for present and future”. The subgroup’s current activities focused on studying cases of operational GNSS applications that were on the market or were under final development before market release. The subgroup was finalizing the research report entitled “GNSS applications for sustainable development: case studies”, which was intended to provide assistance and guidance to GNSS users based on lessons learned. The co-chairs expressed their gratitude for the contributions received from China, India, Japan, the United States and the European Union and encouraged continued proactive support from all providers to ensure the release of the first issue by early 2025.

14. The Working Group recognized the significant impact of the increasing solar activity in the current twenty-fifth solar cycle on GNSS services and satellites. To better understand the potential effects of space weather events and the necessity of international data-sharing in support of monitoring and notification activities, further expert discussions were needed. The formation of a task force under Working Group B would be considered in a dedicated workshop focused on the impact of solar activities on GNSS and their usage. In line with the new recommendation, the Working Group would organize the workshop during the intersessional meeting in 2025. Providers and members of ICG were encouraged to actively support the planned workshop with expert contributions.

[1] www.unoosa.org/oosa/en/ourwork/icg/working-groups/b/CislunarPNT2025.html.

15. During the Working Group B meeting, presentations were made on varied topics such as GNSS applications, space weather, GNSS reflectometry, low Earth orbit positioning, navigation and timing and lunar positioning, navigation and timing systems.

16. In preparation for the nineteenth meeting of ICG, Working Group B planned to revise its workplan endorsed at the tenth meeting of ICG to reflect the evolved scope of the Working Group's activities and to identify new work topics of relevance to ICG members and providers. The workplan revision would be the main subject of the intersessional meeting in 2025. All members of the Working Group were invited to revise the current workplan and identify potential work areas in preparation for the intersessional meeting. Relevant technical contributions to support discussion of the Working Group workplan were welcomed.

17. The Working Group on Information Dissemination and Capacity-building (Working Group C) addressed all areas of its workplan. Representatives of Australia, China, India, Italy, Japan, New Zealand, Norway, the Republic of Korea, the United States, ESA and the European Union participated in the work of the Working Group. Presentations were made on GNSS education programmes, resources and activities carried out by the respective organizations. The Working Group also received an update on the activities undertaken or supported by the Office for Outer Space Affairs during 2024 and to be carried forward into 2025, with a continued focus on training for capacity-building; promoting the use of GNSS technologies for scientific applications; regional workshops on applications; and information dissemination.

18. The Working Group noted the provision of continued training for capacity development through the international delivery of various GNSS training programmes, including the support of developing countries through scholarships. It was recognized that scholarships for these GNSS training courses might be enhanced by individual countries and companies sponsoring individuals. The Working Group further discussed the balance between in-person, online and hybrid modes of training delivery, with a preference for in-person training because of the benefits of networking and informal mentoring and/or the hands-on requirements of the coursework, such as fieldwork at GNSS sites or work to understand receivers and devices. Recognizing the benefits of in-person attendance and in order to further increase capacity development within regions, the Working Group encouraged the United Nations-affiliated regional centres for space science and technology education to connect with the ICG experts to deliver training courses at the centres. The Working Group further encouraged exploration of a train-the-trainers programme by regional centres whereby they could identify and support the development of in-region qualified trainers. Recognizing the importance of information-sharing and dissemination, the Working Group supported engagement between the regional centres to share training materials and the exchange of lecturers.

19. The Working Group noted an update by the Working Group's project team on space weather monitoring using low-cost GNSS receiver systems, led by the Office for Outer Space Affairs and consisting of experts representing the Abdus Salam International Centre for Theoretical Physics (Italy), Boston College (United States), the University of Tokyo (Japan) and the Laboratory of Plasma Physics (France). It was noted that the project had continued to conduct a comparison between low-cost receivers and scientific-grade instruments, which demonstrated that the low-cost receivers tested could be used for monitoring ionospheric total electron content and related studies. The project team would further explore whether ionospheric modelling and the analysis of space weather effects such as the ionosphere scintillation index, also called the S4 index, could also be computed. It was noted that the project team was invited to form the working group under Commission 4 (Positioning and Applications) of the International Association of Geodesy.

20. The Working Group noted that various activities supporting GNSS science applications had been carried out, including through other working groups and multilateral forums. In particular, the Working Group had been invited to collaborate with international initiatives that offered capacity-building programmes and applications, such as the newly established Antarctic Geospace and Atmosphere Research Scientific Research Programme under the Scientific Committee on Antarctic Research.

21. The Working Group on Reference Frames, Timing and Applications (Working Group D) noted progress on geodetic and timing references made by GNSS and radionavigation satellite service providers and thanked the providers for their continued efforts. The Working Group encouraged all providers to continue to review and update their templates on geodetic and timing references, and to make these available on the ICG information portal.

22. The IGS Real-Time Working Group presented an update on its real-time service and recent activities. The real-time service provides real-time corrections for all four main constellations, clock corrections being of particular interest to the IGS Working Group. IGS noted a desire to increase collaboration with system providers in order to improve the IGS real-time tracking network, in particular in Africa and large parts of Asia, and to strengthen the IGS real-time data infrastructure in view of the increase in the number of user requests.

23. In a joint working group discussion, a representative of the United Nations Global Geodetic Centre of Excellence highlighted weaknesses in the global geodesy supply chain,[2] in particular issues relating to the reliability of geodetic products such as Earth orientation parameters and future realizations of the International Terrestrial Reference Frame, which were essential to the operation of GNSS satellites. ICG members openly acknowledged the risks that had been highlighted by the Centre and recognized that strengthening the global geodesy supply chain should be prioritized in order to ensure that GNSS services were made more robust.

24. The Working Group task force on timing references reviewed the Working Group's previous recommendations (recommendations 11, 16-A, 19, 20, 21, and 27) for GNSS timing templates on the redefinition of Coordinated Universal Time (UTC), rapid UTC, the offset between GNSS times and naming conventions. Work on recommendations 11, 19, 20, 21-B was ongoing. Recommendation 16-A had been addressed by resolution 4 of the 2022 General Conference on Weights and Measures. Recommendation 27 did not have any specific item open for updates. The task force on timing references continued to encourage system providers to update their GNSS timing templates on the ICG information portal. The task force thanked India for updating the NavIC timing template in 2024.

25. The International Bureau of Weights and Measures (BIPM) provided updates on the new Section 4 of Circular T, which publishes the difference between UTC and the bUTC_GNSS. BIPM reported an improvement of the processing chain, which now featured a pool of UTC Group 1 laboratories, each of them providing calibrated multi-GNSS observations that were then combined by the Bureau. Details were published,[3] and results were available through an updated application programmatic interface [4] and online.[5]

[2] The global geodesy supply chain refers to ground observatories (very-long-baseline interferometry, satellite laser ranging, GNSS, Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) and gravitational wave); data centres; analysis, correlation and combination centres; and the development of geodetic products including terrestrial reference frames and Earth orientation parameters (see https://ggim.un.org/UNGGCE/).

[3] Further information is available at https://iopscience.iop.org/article/10.1088/1681-7575/ad0562.

[4] https://webtai.bipm.org/api/v1.0/.

[5] https://webtai.bipm.org/database/canvas_gnss.html.

26. BIPM reminded ICG about the work towards a continuous UTC being carried out in collaboration with the International Earth Rotation and Reference Systems Service. BIPM also reminded ICG that the International Telecommunication Union had endorsed a continuous UTC during the World Radiocommunication Conference held in 2023. BIPM had launched a survey among GNSS providers to assess the impact of the forthcoming Universal Time (UT1)-UTC tolerance increase and to gather potential preferred values for the maximum tolerance; responses had been received from the operators of the Global Positioning System (GPS) of the United States, the Global Navigation Satellite System (GLONASS) of the Russian Federation, the European Satellite Navigation System (Galileo), the BeiDou Navigation Satellite System (BDS) and NavIC.

27. BIPM noted that a negative UTC leap second might become necessary in the near future and acknowledged that this might create a risk of disruption. BIPM urged ICG members and GNSS providers to consider the unprecedented possibility of a negative leap second and its broader impact. Some States members of BIPM asked for the implementation of continuous UTC before 2035 to avoid the risk of a negative leap second. Unfortunately, limited knowledge and models of the Earth's rotation did not allow an accurate forecast to be made of UT1-UTC in the long term.

28. The French National Space Agency (CNES) made a presentation on the Galileo and the European Geostationary Navigation Overlay Service (EGNOS) Monitoring of Performances (GEMOP), which had the goal of monitoring the Galileo Open Service and EGNOS services (open service, safety-of-life, EGNOS data access service, time), in particular the Galileo System Time. GEMOP results show that the Galileo timing requirements were met with a large safety margin.

29. The Working Group noted the willingness of India to include NavIC time in the BIPM Circular T, Section 4. As ICG cannot take decisions on the work of BIPM, BIPM recommended that NavIC representatives establish contact with the Consultative Committee for Time and Frequency (CCTF) for that purpose. The Indian Space Research Organization (ISRO) reported that a NavIC-capable receiver had been sent to the National Metrology Institute (PTB) of Germany, for testing and calibration. Efforts were ongoing to establish NavIC-capable receivers at other UTC Group 1 labs, with agreements currently under discussion with Italy and France.

30. ESA reported on the development of operating tools to monitor GNSS timing systems and to perform receiver calibrations. Routine calibrations are performed yearly, with a set (non-changing) procedure; sequential calibrations show good stability as a function of time.

31. The European Space Research and Technology Centre offers state-of-the-art facilities and tools for the monitoring of multi-GNSS timing performances. These resources are available to ICG members interested in conducting calibration tests or participating in campaigns.

32. ESA reported on a new cross-support agreement between ESA and ISRO focused on network operations and calibration facilities. Two GNSS timing receivers supplied by ISRO were to be calibrated by ESA, and the calibration report would be shared with ISRO. These receivers would be used as references for NavIC timing, and ISRO would broadcast the calibrated time offset through the NavIC system.

33. China reminded the Working Group about the UTC pivot methodology and provided time offsets results for different constellations. The National Time Service Centre of China showed that the deviation from UTC of the reference time UTC(k) involved in GNSS timekeeping is getting smaller. This was beneficial for the application of the UTC pivot method.

34. The Working Group's geodetic references task force hosted seven presentations focusing mostly on updates regarding several global and regional reference frames. The task force

commended the efforts of ESA on the GENESIS project (the ESA navigation mission) and to highlight the value of that mission.

35. The International Federation of Surveyors (FIG) has released the 2024 edition of the *Reference Frames in Practice Manual*,[6] building on the 2014 edition with inputs from IGS and the United Nations Global Geodetic Centre of Excellence. Announced after the FIG Working Week 2024, it includes updates on global geodesy initiatives, GNSS constellations and processing methodologies. FIG welcomes feedback from providers and opportunities for future collaboration on the next edition of the Manual or the technical report on cost-effective GNSS.

36. The Shanghai Astronomical Observatory of China provided transformation parameters for the differences between the BeiDou Coordinate System and the international terrestrial reference frames ITRF14 and ITRF20, reporting millimetre-level agreement on the alignments. The Observatory also provided updates and recent results on the satellite laser ranging tracking of BDS satellites, highlighting the value of this effort for validating GNSS ephemerides and improving solar radiation pressure models and antenna phase centre offsets.

37. ESA reported that the Galileo terrestrial reference frame (GTRF), a high-accuracy realization of ITRF, continued to be developed. ESA was working towards a requirement that differences of position compared to the most recent ITRF should not exceed 3 cm and reported that the GTRF reference frame would be updated and published in the next few months.

38. ESA reported that the GENESIS mission would be launched in 2028, with an initial operation period of two years. GENESIS would be managed by the ESA navigation team and involve industry partners for satellite development, launch, operations and data acquisition. To ensure coordination, five working groups had been established, one working group dedicated to ITRF and combined solutions, and four dedicated to observation techniques (GNSS, very-long-baseline interferometry (VLBI), satellite laser ranging, and Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS)). ESA emphasized the importance of the VLBI working group due to the fact that VLBI stations around the globe would need to start tracking the GENESIS VLBI transmitter. ESA had also issued a call for international collaboration to help achieve the mission's objectives and highlighted the importance of collaborating with the science community through the five working groups.

39. The National Geospatial-Intelligence Agency of the United States reported the release of a new realization (G2296) of the World Geodetic System 1984 (WGS 84) terrestrial reference frame and provided a comprehensive report to the Working Group. The new release was aligned with both the ITRF2020 and IGS20 reference frames, and remained a linear frame defined by station positions and velocities. WGS 84 (G2296) improved the estimation technique by fitting both annual and semi-annual signals to the time series. These improvements introduced enhanced means of handling station discontinuities due to antenna movements, including post-seismic deformation terms after a significant earthquake. In addition, the new realization adopted the antenna phase centre offsets for the entire GPS constellation as provided by the IGS20 Antenna Exchange Format (ANTEX) file.

40. ISRO reported on its interest in establishing a widespread network with multi-frequency NavIC (L1, L5 and S bands) tracking capabilities. ISRO offered to support station operators in augmenting existing infrastructure or establishing new stations. ISRO is developing a GNSS data and analysis centre to generate and disseminate precise NavIC products.

[6] https://fig.net/resources/publications/figpub/pub64_2ed/Figpub64_2ed.pdf.

41. The Russian Federation continued to develop its geodetic infrastructure and noted that two additional GNSS stations had been installed in the last year following IGS station specifications guidelines. ICG Working Group D expressed its thanks to operators, who followed IGS guidelines in upgrading and installing new stations.

42. The Russian Federation reported on annual coincidence and monthly repeatability results for different terrestrial reference frames between 2021 and 2024. According to the analysis, the agreement between WGS84 and ITRF2020 was assessed at an accuracy of 1–4 cm, the BeiDou Coordinate System (BDCS) at 3–4 cm, and GTRF at 2–5 cm; Parametri Zemli (PZ-90.11) was at the level of 10 cm according to the GLONASS technical requirements. The best terrestrial reference frames repeatability performance was found for both GTRF and WGS84 (around 5 cm), while BDCS and PZ-90.11 showed discrepancies up to 7 cm and 12 cm, respectively.

43. The Working Group D task force on the applications of GNSS for disaster risk reduction noted a welcome increase in ICG activities related to the integration of GNSS data in disaster risk reduction strategies, especially during the Applications and Experts Seminar. The task force expressed thanks for the ongoing efforts of the workshop entitled "GNSS enhancement to Tsunami Early Warning Systems (GeTEWS) Oceania" in developing interactions and relationships in Oceania.

44. The task force, recognizing the need for more extensive outreach and advocacy with respect to the role of GNSS in natural hazard monitoring, had drafted a policy brief to clearly articulate the benefits of GNSS in disaster risk reduction and encourage the implementation of GNSS technology among stakeholders and policymakers. The Working Group approved the policy brief and recommended that it be published by ICG.

45. The Working Group held internal discussions on the topic of lunar positioning, navigation and timing and participated actively in the subsequent working groups joint session. The Working Group noted that those discussions could be extended to other celestial bodies.

46. The Working Group highlighted the importance of relating the existing (Earth) reference frames to lunar reference frames, and the careful consideration of the point of transition and transformation parameters to convert coordinates between reference frames.

47. The Working Group noted that there was a need for further research on the potential for joint services between Earth-based GNSS and Lunar positioning, navigation and timing, noting that the reference frames services provided at present by Earth-based GNSS did not fully meet the needs of a joint service covering both the Earth and the Moon. The Working Group welcomed collaboration on those activities.

48. BIPM recommended that any timescale on the Moon (and other celestial bodies) should have a clear and traceable connection to UTC, and that the work be carried out in close collaboration with the relevant international organizations. Relevant organizations should include, at a minimum, the International Astronomical Union, the International Association of Geodesy, ITU and the Consultative Committee for Time and Frequency of BIPM. BIPM provided a list of commissions, task forces, and working groups that were relevant to the upcoming efforts on Lunar positioning, navigation and timing.