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CONSOLIDATED DISCUSSION DOCUMENT (CDD) ON POSITIONING, NAVIGATION AND TIMING (PNT) SERVICES

Council 29/2024: The Open Consultation team will draft the consolidated discussion document which is revised by the initial discussion document according to the comments received from all experts registered. This document will be largely reflective of the Council-approved proposal, complemented by inputs from the full Open Consultation team.

Introduction

The positioning, navigation and timing (PNT) services provided by Global Navigation Satellite System (GNSS) which refers to any satellite constellation are a largely invisible system used for the benefits of humanity and nature, technology and infrastructure, arts and industries, including people with nomadic and mobile devices, all modes of transportation, communications infrastructure, the electrical power grid, precision agriculture, weather forecasting, or emergency response.

In order for all moving objects globally (approx. 10 billion units including people, transportation means, etc.) have become essential to modern life, enabling a wide array of applications that improve safety, efficiency, and economic performance, the expectations for the PNT services are growing. Recently, PNT services for all moving objects worldwide have shown potential to deliver benefits in their entire process of navigation between origin (birth) and destination (death) during not only life times of the living things, i.e. human beings but also life cycles of the non-living things, i.e. any kind of industrial products. However, it is an area that has not yet been thoroughly addressed in standardization efforts, prompting the KATS (Korea Agency for Technology and Standards) to address the topic of PNT services.

To address these challenges, KATS is launching an ISO Open Consultation, a new mechanism designed to explore an emerging topic with a broad range of stakeholders, and to document and consolidate global stakeholder expectations into an analytical report with recommendations for ISO action. While the aim is not to reach consensus and develop a standard, it is intended to achieve its goal to develop a roadmap for the standardization of emerging topics. Through this ISO open consultation on PNT services, KATS aims to engage a broad spectrum of stakeholders, including PNT service experts in leadership roles, as well as practitioners such as product owners, requirements engineers, and developers. Additionally, it is intended for a broader group of stakeholders, including representatives from academia, government bodies (digital departments), communities, private sectors, administration, and procurement. Through international workshop(s), we will identify key challenges and opportunities and develop an overview of the current standardization landscape. Additionally, we will explore stakeholder expectations, define user stories, and draft strategic and technical recommendations to ISO on how to approach the topic most effectively.

Landscape and drivers of change

TOPIC: Positioning, Navigation and Timing (PNT) Services

A Global Navigation Satellite System (GNSS) refers to any satellite constellation that provides global positioning, navigation, and timing (PNT) services. There are currently four GNSS constellations in operation or in deployment phase: GPS (USA), GLONASS (Russia), BeiDou (China), and Galileo (Europe). These are

complemented by several regional GNSS ,called Regional Navigation Satellite Systems (RNSS), including QZSS (Japan), NavIC (India) in operation, and KPS (Republic of Korea) in the development phase. PNT and GNSS are acronyms that often seem to be used interchangeably when talking about satellite positioning and navigation.

Figure 1. Positioning, Navigation and Timing (PNT)

Positioning, Navigation, and Timing (PNT) services encompass three key capabilities: (*Ref: What is Positioning, Navigation and Timing (PNT)? - US Department of Transportation*)

- Positioning: This capability enables the precise determination of location and orientation, typically referenced to a standard geodetic system such as the World Geodetic System 1984 (WGS84). This precision is crucial for applications ranging from mapping and surveying to navigation for all types of mobility systems.
- Navigation: This involves determining both current and target positions, whether relative or absolute. It requires adjusting direction, orientation, and speed to reach a specified destination, covering environments from underwater to the surface and extending from the surface to outer space.
- Timing: This involves acquiring and maintaining accurate and precise time from a standard, such as Coordinated Universal Time (UTC), anywhere in the world. It is essential for synchronization in communications, financial transactions, and power grid operations, where timing discrepancies can lead to significant issues.

According to *EUSPA EO and GNSS Market Report* , global revenues from GNSS and Earth Observation (EO) stood at approximately €260 billion and €3.4 billion, respectively, as of 2023. By 2033, GNSS global revenues are expected to reach €580 billion, with services enabled by GNSS (or PNT) devices generating more than 80% of total GNSS revenues. Furthermore, global GNSS shipments will hit 2 billion units per year by 2027, GNSS (or PNT) devices forecasted to reach nearly 9 billion by 2033. The market for the devices, expected to grow from around €70 billion in 2023 to almost €120 billion in 2033, will progressively become more mature in the long term, while the added-value service market will experience rapid growth thanks to continuous innovation: revenues are foreseen to soar from around €190 billion in 2023 to more than €460 billion in 2033.

The markets to be strongly influenced by PNT applications may include the following;

- Agriculture, Fisheries and Aquaculture, Forestry
- Climate, Environment, and Biodiversity
- Emergency Management and Humanitarian Aid
- Energy and Raw Materials, Infrastructure
- Urban Development and Cultural Heritage
- Maritime and Inland Waterways
- Aviation and Drones
- Rail
- Road and Automotive
- Insurance and Finance
- Consumer Solutions, Tourism and Health

- Internet of Things
- Geofencing and surveillance
- Surveying (i.e. land surveying, aerial surveying, earth observation, hydrographic surveying and geodetic survey)
- Tracking and monitoring of assets (i.e. goods, trucks, vessels, vehicles…)

PNT services are critical across numerous sectors, providing essential support for:

- Transportation and Logistics: Enabling efficient route planning and real-time tracking of vehicles and goods.
- Aviation, Maritime, Rail, Road, and UAVs Navigation: Ensuring safe and precise navigation for aircraft and maritime vessels.
- Space: Facilitating precise navigation, tracking, and timing for spacecraft and satellite operations
- Emergency Services: Offering crucial location information for search and rescue operations, such as earthquake and tsunami early warning systems.
- Telecommunications: Synchronizing networks to ensure uninterrupted communication.
- Finance: Providing accurate time-stamping of transactions for security and regulatory compliance.
- Energy: Optimizing the distribution of power through smart grids, and ensuring the precise timing for grid management.
- Forestry: Improving the management and monitoring of forest resources through accurate positioning data, aiding in sustainable practices and conservation efforts.
- Urban Development: Enhancing urban planning and development through accurate geographic data, supporting the creation of smart cities with efficient infrastructure and services
- Surveying and Mapping: Supporting the carrying out of e.g. cadastral, cartographic, topographic and geodetic services, seas and oceans for navigation, and the protection of critical underwater infrastructure, earth and tectonic plate movement, maintaining the global geodetic reference frame
- Construction: Providing reliable geospatial information for building construction, heavy and civil engineering construction projects

The range of PNT applications is expanding, demanding higher levels of accuracy, robustness, and safety in PNT information. As an example, with the rise of automation in mobility systems, there is a substantial need for high-integrity positioning information alongside accuracy. Consequently, a significant challenge for PNT services is maintaining reliability and accuracy in various environments. Furthermore, the vulnerability of PNT systems to cyber-attacks and signal jamming is a growing concern, particularly for safety-critical applications. PNT system authentication services are to verify the authenticity of received GNSS signals and to ensure that the signals have not been spoofed though authenticity of signals and open service navigation message authentication; which is crucial for applications reply on precise location and timing information such as aviation, autonomous driving and financial systems.

Addressing these challenges requires advancements in technology and robust security measures to ensure the continuous and reliable operation of PNT services. Moreover, PNT technologies play a crucial role in combating climate change by optimizing transportation routes, reducing fuel consumption, and supporting renewable energy management. Enhancing PNT services can lead to significant public benefits, such as improved emergency response times, better resource management in forestry and agriculture, and more efficient urban development, ultimately contributing to a more sustainable and resilient society.

Enhancing PNT services for all moving objects worldwide can provide significant benefits throughout their entire birth and death process during life times of the living things including human beings and life cycles of the products:

- Improved Safety and Efficiency: More reliable navigation systems reduce accident risks and enhance operational efficiency in various industries.
- Innovation: Advancements in PNT technology can drive progress in fields like autonomous vehicles, drones, and other emerging technologies.
- Economic Growth: Optimizing logistics and supply chains leads to cost savings and increased productivity for businesses.

- Resilience: Developing robust and secure PNT systems strengthens national security and ensures the continuity of critical infrastructure under challenging conditions.

In conclusion, PNT services are essential to modern life, enabling a wide array of applications that improve safety, efficiency, and economic performance. Addressing the challenges and leveraging the opportunities within PNT can lead to substantial benefits across multiple sectors.

The scope of international standardization for PNT services to be proposed potentially includes the followings;

- Ensuring the compatibility of PNT services so they can be used independently or in combination without interfering with each other or their signals
- Encouraging interoperability between different GNSS (including RNSS) based PNT services to be used together to provide the user better capabilities that would be achieved by relying on one service
- Promoting transparency in civil service provision and enable market access for entire global industry
- Supporting responsibility to be promoted for utilization of GNSS (including RNSS) as the pre-eminent PNT service
- Improving security, integrity, and resilience in the face of growing privacy and cyber threats
- Supporting international activities to detect, mitigate, and increase resilience to harmful disruption or manipulation of GNSS (including RNSS)
- Supporting international receiver's output format to ease the development of different type of applications based on the same input data
- Supporting secure and reliable PNT based services that are able to alert users when an issue is identified in the role of mapping and monitoring the land and sea
- Indicating the attributes of accuracy, reliability, integrity, continuity, availability and safety are essential, and that they can be obtained at different levels, making it possible to use them in numerous applications and services, such as safety of life

By applying PNT services to all moving objects globally, we can significantly improve efficiency, safety, and environmental impact, thereby mitigating the climate crisis.

Performance-Based Navigation (PBN) in aviation exemplifies this by enabling aircraft to follow precise, optimized flight routes, rather than following the restricted pre-defined paths guided by ground-based navigation aids, reducing travel distance, fuel consumption, and emissions, and decreasing air traffic congestion.

In smart city planning, PNT data optimizes transportation systems and infrastructure. Smart traffic management uses PNT data to reduce congestion and improve public transportation efficiency, leading to lower emissions and increased ridership.

Applying PNT services to all moving objects worldwide throughout their entire process between birth and death during life time and/or life cycles offers powerful tools for improving efficiency, safety, and environmental sustainability across various sectors, as shown in Figure 2.

- Monitoring the moving objects: for ensuring they are safe, efficient and environmentally sustainable during the process of staying and moving from the origin (birth) to destination (death).
- Certification of moving records: including life records (living things), aging records (non-living things), mobile (moving) records (by walking, driving, flying, delivering, etc.), biography, traces/vestiges, evidences, alibi, eco-records (mileage, CO2 footprint), etc.
- Early and/or real-time warning to moving objects: signal interference detections (i.e jamming and spoofing), solar activities and space weather warnings, geographical event detections, disaster detections at different levels such as national, regional as well as global.

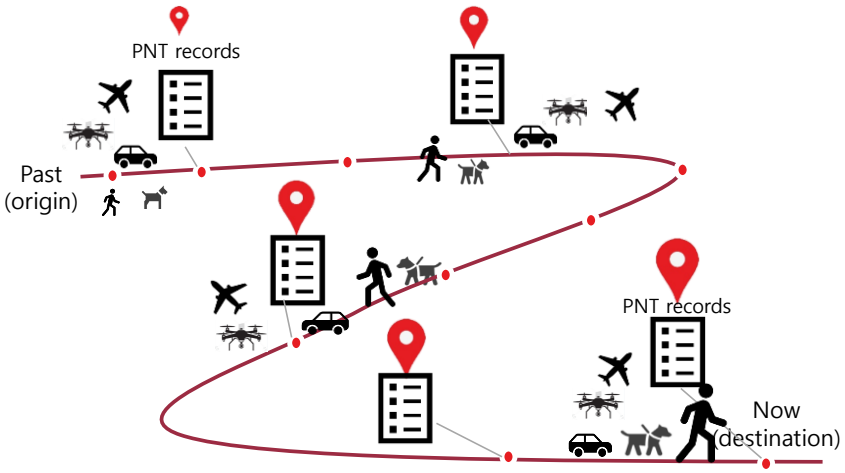

Figure 2. Conceptual Explanation of PNT Services

By leveraging these technologies, we can reduce fuel consumption, lower emissions, and enhance operational efficiency, contributing to the global effort to combat the climate crisis.

Standardization for PNT services is crucial to ensure interoperability between different GNSS systems, enhancing global navigation accuracy, reliability, and safety. It also promotes consistent performance across various applications and industries, fostering international collaboration and widespread adoption of PNT technologies by supporting responsibility to be promoted for utilization of GNSS (including RNSS) as the pre-eminent PNT services. Here is the summary for GNSS programs and activities of countries around the world.

- The United States operates GPS, continuously upgrading it for improved accuracy and reliability with the latest GPS III satellites.
- Russia's GLONASS is undergoing modernization with GLONASS satellites to enhance performance.
- The European Union's Galileo system, managed by the European Union Agency for the Space Program, aims to provide highly accurate positioning and timing information, with a focus on interoperability with other systems.
- China's BeiDou system has expanded globally, enhancing its precision and reliability.
- Japan's QZSS and India's NavIC focus on regional services with plans for broader applications.
- Republic of Korea's KPS (Korean Positioning System) is being developed to provide high-precision positioning services over the Korean Peninsula.

Satellite Based Augmentation System (SBAS) are designed to augment GNSS providing corrections and integrity by broadcasting additional signals from SBAS satellites. They are deployed worldwide: Wide Area Augmemtation System (WAAS) in North America, European Geostationary Navigation Overlay Service (EGNOS) in Europe, MSAS in Japan, GAGAN in India, SDCM in Russia, KASS in South Korea, BDSBAS in China, ASECNA/AFI SBAS in Africa, and Southern Positioning Augmentation System (SouthPan) in Australia and New Zealand.

Standardization landscape

There are several standards related to positioning, navigation and timing (PNT), which are developed in various committees, such as:

- ISO/TC 8/SC 6: Navigation and ship operations
- ISO/TC 20/SC 14: Space systems and operations
- ISO/TC 23/SC 19: Agricultural electronics
- ISO/TC 113/SC 5: Instruments, equipment and data management
- ISO/TC 172/SC 6: Geodetic and surveying instruments
- ISO/TC 204: Intelligent transport systems
- ISO/TC 211: Geographic information/Geomatics

A few sectors in the world have also addressed the topic with various standardization activities, e.g. International Electrotechnical Commission (IEC), International Telecommunication Union (ITU), United Nations International Committee on GNSS (UN ICG), European Union Agency for the Space Programme (EUSPA), Civil GPS Service Interface Committee (CGSIC), European Position Determination System (EUPOS), European Organization for Civil Aviation Equipment (EUROCAE), International Association of Geodesy (IAG), International Cartographic Association (ICA), International GNSS Service (IGS), International Earth Rotation and Reference Systems Service (IERS), International Society for Photogrammetry and Remote Sensing (ISPRS), International Civil Aviation Organization (ICAO), Open Geospatial Consortium (OGC), International Maritime Organization (IMO), Society of Automotive Engineers (SAE International), Institute of Navigation (ION), Radio Technical Commission for Aeronautics (RTCA), Early Warning System (EWS) in World Meteorological Organization (WMO), National Marine Electronics Association (NMEA), Radio Technical Commission for Maritime Services (RTCM), American Society for Testing and Materials (ASTM), UN Global Geodetic Centre of Excellence (UN-GGCE), International Hydrographic Organization (IHO), UN Global Geospatial Information Management (UN-GGIM), Royal Institution of Chartered Surveyors (RICS), etc.

Although a limited number of general and technical standards, including PNT system requirements, aim to improve positioning and navigation solutions for transport and to ensure the safety and security of critical infrastructure, these standards are not specifically tailored to PNT services. To effectively enhance global navigation accuracy, reliability, and safety - while also fostering consistent performance across diverse applications and industries - additional standards and complements are needed. Promoting international collaboration and widespread adoption of PNT technologies is essential for achieving these goals.

The project relates to existing international standards by addressing similar foundational principles. However, this project is to encompass standardization for PNT services that can be applied to all moving objects globally. The outlined the key aspects that differentiate it from existing standards are as shown below:

Relevant standards	Relation and/or differentiation of our project
IEEE P1952, Standard for Resilient Positioning, Navigation and Timing (PNT) User Equipment	This standard defines different levels of resilience for PNT user equipment. This enables users to select PNT equipment with appropriate resilience based on their risk tolerance, budget, and application criticality. While there are overlapping aspects in terms of the standard's focus from the user's point of view, our project focuses more on PNT services rather than user equipment. This approach provides a more service-specific standard that can support a broader range of PNT services. Our project can be applied not only to user equipment but also to the wider range of stakeholders listed in the section above.
NIST IR 8323 Rev. 1, Foundational PNT Profile: Applying the Cybersecurity Framework for the Responsible Use of PNT Services	This standard focuses on integrating cybersecurity with PNT services, emphasizing the responsible use of PNT through the application of a cybersecurity framework. It is particularly strong in addressing the security aspects of PNT. Our project, which focuses on standards for PNT services for all moving objects, could expand on this by incorporating not only cybersecurity but also other crucial aspects for PNT services, such as accuracy, integrity, continuity, reliability, and resilience across various applications beyond cybersecurity.
ISO/AWI 22090-3, Ships and marine technology — Transmitting heading devices (THDs) — Part 3: GNSS principles	This standard is specific to GNSS principles in the context of transmitting heading devices for marine technology. The new standards could extend to cover a wider range of industries and applications, not just marine, ensuring a more comprehensive approach to PNT services that includes terrestrial and aerial navigation for moving objects.
ISO/AWI 25082-1, Space systems — Assessment of GNSS-based positioning systems — Part 1: Definitions and system engineering procedures for the	This standard covers the assessment of positioning system performances equipped with a given GNSS-based positioning terminal, with or without external augmentation data (SBAS, RTK, PPP, etc.). However, values of performance metrics for specific application certifications (such as autonomous guidance systems, road user charging applications, etc.) are not provided; only a

establishment and assessment of performances	template for application fields is given. Building on these standards, the linking system performances to various PNT services for all moving objects are suggested to encourage the widespread use of PNT information.
ISO/PRF 17438-3, Intelligent transport systems — Indoor navigation for personal and vehicle ITS stations — Part 3: Requirements and specification for indoor positioning reference data	This standard addresses indoor navigation for intelligent transport systems. Our project could expand to ensure seamless integration between indoor and outdoor PNT services and extend its applications for moving objects across various sectors.
ISO 17123-8:2015, Optics and optical instruments — Field procedures for testing geodetic and surveying instruments - Part 8: GNSS field measurement systems in real-time kinematic (RTK)	This standard specifies field procedures to be adopted when determining and evaluating the precision (repeatability) of Global Navigation Satellite System (GNSS) field measurement systems in real-time kinematic (GNSS RTK) and their ancillary equipment when used in building, surveying, and industrial measurements. It is specialized in surveying-related fields, but we will explore ways to utilize GNSS in various fields, including surveying
ISO 19111: 2019, Geographic information – Referencing by coordinated	This standard defines the conceptual schema for the description of referencing by coordinates. It describes the minimum data required to define coordinate reference systems.
ISO/FDIS 17123-11: GNSS instruments	This standard specifies a field procedure for the verification that a given Global Navigation Satellite System (GNSS)-based system and measurement procedure meets a required measurement uncertainty at the location and time of interest. It is designed to be applicable to the technically versatile GNSS systems on the market and can be used for any kind of GNSS based coordinate determination application, not only geodetic.
ISO 22086-2:2024, Intelligent transport systems (ITS) — Network-based precise positioning infrastructure for land transportation — Part 2: Functional requirements and data sets for nomadic devices	This standard specifies the functional requirements of nomadic devices for lane-level positioning and integrity monitoring with the network-based precise positioning infrastructure for land transportation. However, techniques and methods which can be different for each provider or vendor are not addressed in this standard. This standard is defining the requirements for precise positioning to increase PNT service utilization but does not include a description of the technology that meets the requirements or how to utilize PNT services.
ISO/TS 22591:2021 Space systems — Space-based services for a high accuracy positioning system with safety requirements	This standard specifies requirements and recommendations for space-based systems (using satellite radionavigation) that provide high-accuracy positioning for ground vehicles, particularly for operations requiring enhanced safety in low-visibility conditions. Also includes methods to verify system compliance, along with annexes covering mobile mapping, augmented positioning, and application examples.
ISO 18197:2015 Space systems — Satellite-based services for centimetre-level positioning	This standard specifies requirements for wide-area, centimetre-level positioning using satellite-based augmentation services. It standardizes service goals and real-time capability.
ISO 19116:2019 Geographic Information — Positioning Services	This standard defines a standardized interface, including data structures and content, that enables communication between position-providing devices (e.g., GNSS receivers) and position-using devices (e.g., navigation systems). Its purpose is to ensure that position-using devices can unambiguously interpret position information, assess its reliability, and determine if it meets the needs of a specific application

<table>
<tr><td>IEC 61108 Series, Maritime navigation and radiocommunication equipment and systems — Global navigation satellite systems (GNSS) — Receiver equipment — Performance standards, methods of testing and required test results</td><td>These standards focus on performance standards and testing methods for various types of shipborne GNSS receiver equipment based on the relevant IMO resolution.<table><tr><td>Part 1. (2003)</td><td>GPS</td><td>Part 5. (2020)</td><td>BDS</td></tr><tr><td>Part 2. (1998)</td><td>GLONASS</td><td>Part 6. (2023)</td><td>IRNSS</td></tr><tr><td>Part 3. (2010)</td><td>Galileo</td><td>Part 7. (2024)</td><td>SBAS</td></tr><tr><td>Part 4. (2004)</td><td>DGNSS</td><td>Part 8. (2028)</td><td>QZSS</td></tr></table>While these are relevant to our project in terms of providing performance standards, our proposed standards offer a more comprehensive set of performance standards applicable to various PNT services beyond maritime navigation.</td></tr>
<tr><td>International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPs) Annex 10 – Aeronautical Telecommunications</td><td>ICAO establishes international standards and recommended practices (SARPs) to support PNT services in aviation. SARPs define Standards, which member states must comply with or formally notify ICAO if unable, and Recommended Practices, which are encouraged but not mandatory. Annex 10 – Aeronautical Telecommunications includes standards related to PNT services, covering GNSS performance requirements, integrity monitoring, and interoperability between aircraft and ground infrastructure. It also specifies standards for SBAS and Ground-based Augmentation System (GBAS), including operational procedures and performance requirements, ensuring reliable PNT services in aviation.
This is a practical example of standardizing PNT services in the aviation industry. Our project could further extend the standardization of PNT services to a wider range of applications.</td></tr>
<tr><td>SAE1014, Standard for Interfacing Resilient GNSS Receivers</td><td>This standard defines how a resilient GNSS receiver provides enough information for an alternative PNT source to be selected when the GNSS receiver does not meet the required levels of accuracy, availability, integrity, or continuity even when the GNSS signals are subject to interference.
We are not going to define when the environment of PNT services is not smooth. Therefore, it will be a good example for creating much smoother PNT utilization environment for standardizing PNT services.</td></tr>
<tr><td>SAE1027, Standard for Interfacing Resilient GNSS Receivers</td><td>This standard establishes the minimum navigation system performance requirements for UAS operation within a specific use case.
We will define the performance requirements according to the PNT service utilization plan in various fields of daily life including UAS. We may refer to the relevant standards in defining performance for UAS and its similar fields.</td></tr>
<tr><td>RTCA DO-229, Minimum Operational Performance Standards (MOPS) for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment</td><td>This standard contains Minimum Operational Performance Standards (MOPS) for airborne navigation equipment (2D and 3D) using the Global Positioning System (GPS) augmented by Satellite-Based Augmentation Systems (SBAS).
While this standard is relevant to our project in terms of providing performance standards, our proposed standards could expand other GNSS systems beyond GPS. Furthermore, our standards are not stuck to SBAS and PNT services of airborne navigation.</td></tr>
<tr><td>RTCA DO-253, Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment</td><td>This standard contains minimum operational performance standards (MOPS) for airborne navigation equipment using the Global Positioning System (GPS) augmented by the Local Area Augmentation System (LAAS).
While this standard is relevant to our project in terms of providing performance standards, our proposed standards could expand other GNSS systems beyond GPS. Furthermore, our standards are not</td></tr>
</table>

	stuck to LAAS and PNT services of airborne navigation.
IMO Resolution MSC.401(95) - Performance Standards For Multi-System Shipborne Radionavigation Receivers	This standard defines the performance criteria for navigation receivers that support multi-GNSS installed on ships. While this standard is relevant to our project in terms of providing performance standards, our proposed standard defines for PNT services in various fields that are not specific to ship-related fields.
IMO Resolution A.1046(27) – Worldwide Radionavigation System	The standards support safe navigation of ships by establishing standards (utilized equipment, accuracy, etc.) for wireless navigation systems that are used worldwide. On the other side, our standards define standards not only for the ship sector, but also for various areas of everyday life.
ITU-R recommendations related to GNSS; for example, ITU-R M.1318, M.1787, M.1901, M.1902, M.1904, M.1905, M.1906, M.2030, and M.2031	These standards specify a continuous interference model, system descriptions and parameters, high-level guidance/mapping, receiver protection in respective sub-bands, feeder-link space/earth station protection, pulsed interference model, and feeder-link protection in the adjacent band.
EUROCAE ED-282 E-identification for UA Drone Remote ID (Europe)	This standard specifies the minimum performance required for e-identification (Remote ID) systems in unmanned aircraft (UAS). It ensures UAS and their remote pilot stations can reliably broadcast surveillance data to other UAS and U-space/UTM services during routine operations
ASTM F3411 Remote ID for UAS, for UAS identification based on PNT based services	This standard defines performance requirements for Remote Identification (Remote ID) of unmanned aircraft systems (UAS), enabling government and public tracking for safety, security, and compliance while preserving pilot privacy.

Thus, in order to identify the need for new standards according to the ISO Open Consultation, an innovative and new approach in the PNT services offers the open process, enabling a well-founded, expectation-based assessment of standardization needs in the new cross-sectional areas globally, such as:

- Digital PNT records by location with respect to timing for;
  - Living things (human being, animal, livestock, pet, etc.): From birth to death in their lifetime (or from origins to destinations while moving in a certain amount of time);
  - Non-living things (transport means, goods, infrastructure and facilities, etc.): From birth (the time of being manufactured/constructed) to death (to be disused/junked/ demolished) in their lifecycle
- PNT Service Levels for;
  - Location accuracy: milli/centimetre (or feet), meter, deca/hectormeter, kilometre (or mile)
  - Timing accuracy: nano/micro/millisecond, second, minute, hour, day, week, month, year
  - Navigation interval: real-time or non-real-time
- PNT Service Requirements for;
  - Accuracy: Measure of PNT output deviation from truth
  - Integrity: Ability of a service to provide timely warnings when the system should not be used for service
  - Continuity: Likelihood that the PNT service supports accuracy and integrity requirements for duration of intended operation
  - Availability: Fraction of time PNT service is usable (as determined by compliance with accuracy, integrity, and continuity requirements)
  - Resistance to interface: privacy and cybersecurity
  - Independence: user equipment and ground infrastructure
  - Interoperability among PNT-capable systems: WiFi, Bluetooth, and UWB communications
  - Information on reliability and safety

Key players

IDENTIFICATION AND DESCRIPTION OF KEY PLAYERS

Stakeholder Group	Examples	Description
Industry and commerce – large industry	Automotive manufacturers	Use PNT data to optimize supply chain logistics, reducing costs and emissions. Implement PNT services to guarantee safe and secure automated vehicles.
Industry and commerce – SMEs	Small agricultural businesses	Employ PNT services for precision farming to increase yields and resource efficiency
Government (different levels)	National transportation agencies	Implement PNT-based traffic management to reduce congestion and improve public transport
Consumers	Individual drivers	Use PNT-enabled navigation apps to find efficient routes and reduce travel time
Labour	Delivery drivers	Benefit from optimized delivery routes through PNT data, enhancing job efficiency and safety
Academic and research bodies	Universities	Conduct research on PNT technologies to improve environmental sustainability
Standards application businesses	Standards development organizations	Develop and maintain standards for the reliable and safe use of PNT technologies
Non-governmental organizations	Environmental NGOs	Advocate for the adoption of PNT technologies in urban planning to lower emissions
Other (please specify)	Emergency services, such as search and rescue (SAR missions), health, security, etc.	Use PNT data to improve the efficiency and effectiveness of disaster response operations
Other (please specify)	GNSS equipment manufacturers GNSS service providers	

Policy priorities and drivers

PNT services can help improve peoples' lives in globe with a safer, greener and better quality related all the moving objects, infrastructure, and logistics which lead to gains and benefits across a number of UN SDGs.

- SDG 7. Affordable and Clean Energy: PNT technology ensures precise timing for smart grids, enhancing energy distribution efficiency, reducing losses, and improving reliability. It also optimizes transportation routes, cutting fuel consumption and emissions.
- SDG 9. Industry, Innovation, and Infrastructure: PNT technology improves construction precision, supports infrastructure management with reliable data, and facilitates smart cities and innovative technologies. It is also vital for autonomous vehicles, providing precise navigation, and timing.
- SDG 11. Sustainable Cities and Communities: PNT services enhance urban planning with accurate geographic data, support public transportation through real-time tracking and route optimization, and reduce traffic congestion and pollution with smart traffic management.

- SDG 13. Climate Action: PNT technology aids in environmental monitoring, improves disaster preparedness with accurate location data and real-time coordination, and lowers greenhouse gas emissions by optimizing transportation.
- SDG 15. Life on Land: PNT services improve monitoring of forests and wildlife, enhance land use planning, and support natural resource management with precise location-based data for conservation efforts.

Assessment of standardization expectations

	Benefits/Impacts/Examples
Quality	Standardization of PNT provides a safer, greener and better lives to all peoples in globe.
Safety	Safety of all moving objects including peoples could be much improved by the precise positioning.
Security	Standardization of real-time PNT for earthquake and tsunami hazard estimation.
Testing	Global application of PNT is to be adopted by the testing methodology of the standardization.
Terminology	Global terminology for PNT services is to be utilized by the standardization.
Accreditation / certification	The accuracy and reliability of PNT applications to all moving objects might be certified globally.
Interoperability	Interoperability between different GNSS (including RNSS) based PNT services is to be ensured.
Trade facilitation	Standardization of PNT will facilitate the global service markets in all the industries globally.
Sustainability	Standardization of PNT will not only save the peoples while moving but also save the globe facing climate changes.
Other (In general)	Standardization for PNT services ensures interoperability between different GNSS systems, enhancing global compatibility and efficiency for large industries and small and medium-sized enterprises (SMEs). It provides reliable and accurate positioning crucial for logistics, all types of mobility systems, construction, and energy systems, thereby improving operations and resource management. Standardization makes PNT technology more accessible and affordable, fostering innovation and competitiveness among SMEs. Governments benefit from improved public safety, security, and disaster response due to accurate and reliable PNT data. Additionally, standardized PNT services strengthen cybersecurity, protecting data integrity across various applications.

Repository of user stories [to be consolidated in use-cases]

Stakeholder / actor	Desired action	Value addition
Regulator	To keep PNT data reliable	Protect privacy and security
Peoples with nomadic devices	To use PNT data while moving	Optimize safety and mobility
All moving objects	To record the trajectory	Increase safety and

Stakeholder / actor	Desired action	Value addition
		sustainability
Corporate executive	To promote global PNT business	Expand business models to all moving objects in globe
Service provider	To provide on-demand PNT information	Create value added service models
Public administrator	To manage the optimized PNT	Promote the national or global policy for climate changes
Farmer	I would like to use precise PNT service so that I can optimize planting, irrigation, and harvesting for better crop yield and resource efficiency.	Promote fare trades and sustainable business
Agricultural equipment manufacturer	I would like to use PNT to support a range of automated and precision systems such as spreading and cropping.	Promote the smart and automated farming services
Drone operator/mapper	I would like to access accurate PNT service to ensure safe and efficient flight paths for surveying and delivery services.	Optimize safety and mobility
Environmental scientist	I would like to use precise PNT service to track wildlife movements and monitor environmental changes to support conservation efforts.	Create value added environmentally sustainable service models
Tourist	I would like to use precise PNT service to navigate unfamiliar cities and find points of interest easily.	Optimize safety and mobility
Emergency manager	I would like to use precise PNT service to locate disaster sites quickly and coordinate rescue operations effectively. (e.g. I would like to use PNT to rapidly assess earthquake location and issue tsunami warnings in under 5 minutes.)	Increase civil safety and security
Mining operator	I would like to use precise PNT service to manage the extraction of raw materials efficiently and safely.	Enhance business models
Forest manager	I would like to use precise PNT service to manage forest resources and monitor deforestation activities effectively.	Increase natural environment safety and sustainability
Civil engineer	I would like to use precise PNT service to plan and construct infrastructure projects with greater accuracy.	Optimize safety for workers and reduce construction times

Stakeholder / actor	Desired action	Value addition
Transport & logistics manager	I would like to use precise PNT service to optimize routes for freight delivery and reduce transportation costs.	Create value added mobility service models
Developer	I want to develop PNT services systems, that includes hardware, software, and infrastructure in order to not only provide PNT services to customers but to accumulate and analyse the PNT records for some specific purposes by customers on demand.	Offers comprehensive solutions that ensure accuracy, reliability across platforms
Company/enterprise	I want my products to meet PNT services targets (e.g. wearable/mobile or on-board PNT devices and landside units installed in infrastructure).	Boosts market competitiveness through standards, enabling interoperability and efficiency
Consumer	I want transparency (PNT services) including life records (living things), aging records (non-living things), mobile (moving) records, biography, traces/vestiges, evidences, alibi, eco-records (mileage, CO2 footprint), etc.	Enhances trust by enabling secure, verifiable digital footprints
Government/environmental ministry	I would like to create appropriate laws and regulations for PNT services to make lives easier, safer and better and to save the planet by energy consumption and CO2 emissions.	Establishes a sustainable regulatory framework
Environmental scientist	I would like to have reliable PNT data for recording and monitoring the moving objects' trajectory.	Facilitates real-time observation, supporting conservation, planning, and policy-making

Recommendations for ISO [to be finalized last]

ISO Open Consultation aims to align ISO's standardization efforts with stakeholder expectations and strengthen cross-sectional cohesion. The Content is developed during the workshops, and recommendations for ISO are formulated upon their completion. These elements will be included in a comprehensive report that covers:

- A summary of the landscape, key players, drivers, use cases, and a summary of standardization expectations.
- Recommendations, which will address national and international partnerships within ISO, standards development activities, conformity assessment policies, and capacity building.
- An implementation plan, detailing the prioritization and timing of the recommendations, along with proposed roles and responsibilities.

The report will be published and submitted to ISO Council for information and comment, and to ISO Council Standing Committee on Strategy and Policy for approval of strategic recommended actions and ISO Technical Management Board for approval of operational recommended actions.