GEOSA
الهيئة العامة للمساحة والمعلومات الجيومكانية
General Authority for Survey and Geospatial Information

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GEOSandbox Standards

General Authority for Survey and Geospatial Information

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1 Introduction

1.1 Purpose of the GEOSandbox Standards

The GEOSandbox Standards serve as a benchmark framework for evaluating and verifying the technological readiness of applicants seeking to conduct proof-of-concept (PoC) testing within the sandbox environment. The standards define the minimum technical and regulatory requirements that applicants must meet to ensure their solutions align with industry best practices, safety protocols, and national data governance policies.

The purpose of these standards is to:

1. **Establish Accuracy Benchmarks:**

   Define measurable accuracy thresholds for different geospatial applications such as HD maps, navigation systems, and panoramic imagery to ensure reliable performance.

2. **Define Sensor Requirements:**

   Outline the minimum specifications for hardware, including LiDAR, GNSS, INS, panoramic cameras, and total stations, ensuring that all data collection processes maintain high precision.

3. **Ensure Security & Compliance:**

   Enforce adherence to data privacy, cybersecurity, and localization regulations, aligning with the Saudi Personal Data Protection Law (PDPL) and National Data Management Office (NDMO) policies.

4. **Facilitate Innovation & Market Readiness:**

   Support developers in refining and optimizing their solutions through a structured validation process that prepares them for commercial deployment.

Using the “self-assessment form” GEOSA provides, applicants can demonstrate the reliability, security, and effectiveness of their geospatial solutions during the proof of concept in the sandbox, ensuring seamless integration into real-world applications once they graduate the sandbox while meeting regulatory expectations.

1.2 Definitions

- **High-Definition Maps (HD Maps):** Static, high-precision maps that provide detailed geospatial information essential for autonomous navigation, ADAS (Advanced Driver Assistance Systems), and precision geospatial applications. These maps contain elements such as lane markings, traffic signs, 3D road structures, and road topology.
- **Global Navigation Satellite System (GNSS):** A satellite-based navigation system (GPS, GLONASS, Galileo, BeiDou) used to determine precise geographic location.
- **Real-Time Kinematic (RTK) Positioning:** A technique that improves GNSS accuracy to centimeter-level precision, useful for applications requiring high positional accuracy.
- **Inertial Measurement Unit (IMU):** A sensor system combining gyroscopes and accelerometers to track an object's movement and orientation.
- **Light Detection and Ranging (LiDAR):** A laser-based remote sensing method for capturing high-density 3D point clouds of the environment.
- **Vector Layer Accuracy:** The geometric accuracy of mapped road features such as lane lines, signs, and road structures, with strict 2D and 3D position constraints.
- **Point Cloud Density:** The resolution of LiDAR data, measured in points per square meter (pt/m^2), which determines how detailed the mapping of objects and terrain features is.
- **Navigation Applications:** Software systems that provide real-time routing, turn-by-turn guidance, traffic updates, and location-based services (LBS) for users. These applications integrate GNSS, HD maps, and real-time data to deliver accurate and efficient navigation solutions.
- **Lane-Level Guidance:** A navigation feature that provides precise lane-level positioning and turn instructions, critical for highway driving and urban navigation.
- **Dynamic Map Updates:** The process of updating road conditions, traffic incidents, construction zones, and closures in real time to enhance navigation reliability.

- **Data Storage**: The process of preserving geospatial and navigation-related datasets, ensuring availability, integrity, and security.
- **Data Residency**: Regulations requiring certain categories of data, especially Highly Confidential and national security-related data, to remain stored within Saudi Arabia as per SDAIA and CST mandates.
- **Data Retention Policy**: The timeframe and conditions under which geospatial data must be stored and securely deleted based on compliance regulations.
- **Encryption Standards**: The implementation of AES-256 encryption for data at rest and TLS 1.3 encryption for data in transit to safeguard geospatial information.
- **Cybersecurity Controls**: Measures implemented to protect geospatial data from unauthorized access, modification, or cyber threats
- **Data Localization**: Regulations requiring Highly Confidential geospatial data to be stored and processed within Saudi Arabia, in compliance with SDAIA and CST mandates.
- **Incident Response Plan**: A structured approach to detecting, responding to, and mitigating cybersecurity incidents, as mandated under SDAIA's PDPL.
- **Network Infrastructure**: The physical and virtual network components enabling secure, high-speed, and reliable data transmission within the GEOSandbox environment.
- **Edge Computing**: Processing data closer to the source (e.g., on vehicles or sensor nodes) to reduce latency and improve real-time decision-making.
- **5G & V2X Communication**: Vehicle-to-Everything (V2X) communication protocols that enable high-speed, low-latency connectivity between vehicles, infrastructure, and cloud systems.
- **Data Transmission Security**: Implementing end-to-end encryption, secure tunneling (VPNs), and authentication protocols to safeguard data integrity during transmission.
- **Machine Learning (ML) Models**: Algorithms that learn from geospatial data to improve mapping accuracy, navigation predictions, and autonomous decision-making.

- **Deep Learning (DL)**: A subset of ML utilizing neural networks for high-precision pattern recognition in panoramic imagery and HD maps.
- **Federated Learning (FL)**: A decentralized approach where AI models train on local edge devices before aggregation in a central server, preserving privacy.
- **Explainable AI (XAI)**: Methods ensuring transparency and interpretability of AI decisions in geospatial analytics.

- **Business Continuity Plan (BCP)**: A structured strategy to maintain critical operations during network failures, cyber incidents, or other disruptions.
- **Disaster Recovery (DR)**: A plan ensuring rapid restoration of geospatial infrastructure and datasets in the event of system failures.
- **Operational Resilience**: The ability of geospatial systems to sustain operations under stress, ensuring reliability in navigation and mapping applications.

2 Objectives of the GEOSandbox Standards

The key objectives of the GEOSandbox Standards include:

1. **Ensuring High-Accuracy Geospatial Data**
   - Define and enforce accuracy thresholds for HD maps, navigation applications, and panoramic imagery to ensure reliable and high-quality geospatial data.
   - Require compliance with precision benchmarks, such as 2D and 3D accuracy for HD maps.
   - Implement strict data validation and verification procedures to enhance the reliability of geospatial datasets.

2. **Standardizing Sensor and Hardware Requirements**
   - Establish the minimum technical specifications for LiDAR, GNSS, INS, panoramic cameras, and other mapping sensors to ensure consistency in data collection.
   - Require the use of multi-frequency GNSS receivers, high-resolution LiDAR systems, and inertial navigation units (INS) for enhanced precision.
   - Ensure proper calibration and verification of all sensing hardware before deployment in the sandbox.

3. **Regulating Data Collection and Processing Workflows**
   - Define best practices for data acquisition, processing, and post-processing in mapping and navigation applications.
   - Enforce data quality control measures such as point cloud density requirements, vector map validation, and internal accuracy checks.
   - Establish guidelines for metadata tagging, data standardization, and interoperability to enhance cross-platform compatibility.

4. **Strengthening Security, Privacy, and Data Localization**
   - Ensure compliance with Saudi Personal Data Protection Law (PDPL) and National Data Management Office (NDMO) regulations.
   - Enforce data encryption, access control, and secure storage policies to protect geospatial information from unauthorized access.
   - Require local data storage within Saudi Arabia and regulate cross-border data transfers to align with national cybersecurity policies.

5. Ensuring Business Continuity

The GEOSandbox plays a crucial role in ensuring business continuity by providing a secure and flexible simulation environment for testing geospatial solutions and assessing their readiness before real-world deployment. This environment enables organizations to test contingency plans, simulate failure scenarios, and validate the effectiveness of incident response strategies, thereby minimizing the risks of disruptions to critical operations. Additionally, the Sandbox supports the integration of cloud replication mechanisms and encrypted backup solutions, ensuring rapid data recovery and strengthening operational resilience during crises. To maintain the highest levels of security and reliability, solutions tested within the Sandbox are recommended to comply with the standards set by the National Cybersecurity Authority (NCA) and the Communications, Space & Technology Commission (CST). Adhering to NCA and CST guidelines ensures robust cybersecurity measures, secure data handling, and compliance with national regulations governing digital infrastructure, geospatial technologies, and data residency.

Moreover, testing and applying new technologies within the GEOSandbox in Saudi Arabia is essential for sustaining business continuity in an era of rapid technological advancements. With the Kingdom's strong support for startup initiatives and digital transformation under GEOSA strategy and the national geospatial ecosystem, the Sandbox provides a controlled and adaptive environment where cutting-edge innovations—such as AI-driven geospatial analytics, autonomous navigation systems, high-definition (HD) mapping, panoramic imagery, and advanced navigation applications—can be validated before large-scale implementation. The NCA and CST play a critical role in this process by ensuring that these technologies are securely deployed, mitigating cybersecurity risks, and aligning with national data protection and digital governance policies. By fostering a thriving startup ecosystem and enabling enterprises to refine their strategies, the GEOSandbox, in alignment with NCA and CST regulations, enhances resilience, agility, and competitiveness in an ever-evolving digital landscape. This strategic approach supports the seamless integration of advanced geospatial solutions, reinforcing Saudi Arabia's position as a leader in innovative and secure digital infrastructure.

3 GEOSandbox Standards

3.1 Panoramic Imagery Standards

Panoramic imagery involves capturing wide-angle views, often encompassing a full 360-degree perspective, to provide immersive visual representations of environments. This technique is essential in various applications, including urban planning, virtual tourism, and autonomous navigation.

3.1.1 Activity Definition

The primary activity in panoramic imagery is the systematic acquisition of high-resolution, wide-field images that seamlessly cover the desired environment. This process requires precise planning to ensure comprehensive coverage and minimal visual distortions.

3.1.2 Deliverables

The outputs from panoramic imagery activities include:

- **Stitched Panoramic Images**: High-resolution, seamless 360-degree images of the captured environment.
- **Georeferenced Imagery**: Panoramic images accurately linked to geographic coordinates, enabling spatial analysis and integration with other geospatial data.
- **Metadata**: Comprehensive information detailing capture time, sensor specifications, calibration data, and processing methodologies.

3.1.3 Target Resolution/Precision/Accuracy Specifications

Ensuring the precision of panoramic imagery is crucial for its effective application. The target accuracy encompasses both spatial resolution and georeferencing precision:

- **Spatial Resolution**: High spatial resolution is vital to maintain uniform detail across the entire panoramic image, preventing information loss in critical areas.
    - Target: minimum of 16000x8000
- **Georeferencing Accuracy**: The positional accuracy of georeferenced panoramic images should align with established geospatial data standards, ensuring consistency and reliability when integrated with other datasets.
    - Target: lane-level accuracy (<0.5 m in std dev.)

3.1.4 Sensor Requirements and Specifications

Sensor	Feature	Specification requirements
Camera	Resolution (all cameras combined)	Minimum: 60 MP Recommended: 200 MP
	Resolution (each camera)	Minimum: 12MP Recommended: 50 MP
	HFOV (all cameras combined)	360 degrees
	HFOV (each camera)	Minimum: 60 degrees Recommended: 120 degrees
	VFOV	180 degrees
	Frame rate	Minimum: 30 FPS Recommended: 60 FPS
	Dynamic range	Minimum: 70 dB
	Shutter type	Over rolling shutters
GNSS	Horizonal 2D Accuracy	<2cm
	Vertical Accuracy	<3cm
	Constellations support	GPS, GLONASS, Galileo, BeiDou
	RTK	Supported
	Dual Frequency	Supported
IMU	Gyro Bias	<0.01 degrees/hour
	Accelerometer Bias	<50 micro.g
	rate	Minimum: 200 Hz
Calibration	Reprojection error (camera)	±0.2 pixels
Time Synchronization		±1 ms

3.1.5 Calibration Guidelines and Specifications

To achieve the desired accuracy, rigorous calibration of panoramic imaging systems is essential:

- **Geometric Calibration**: Ensures that all cameras within the system are accurately aligned, correcting for lens distortions and ensuring seamless image stitching. This involves calibrating the relative positions and orientations of each camera to maintain consistent spatial relationships.

- **Regular Calibration Intervals**: Implementing a schedule for periodic calibration is crucial to maintain system accuracy over time, accounting for potential shifts in sensor alignment or performance.

3.1.6 Integration of Value-added Applications

Accurate panoramic imagery is foundational for several advanced applications:

- **Autonomous Navigation**: Provides vehicles with comprehensive environmental context, enhancing path planning and obstacle avoidance capabilities.
- **Urban Planning and Smart City Development**: Offers city planners detailed visual data to inform infrastructure development and environmental assessments.
- **Virtual Reality and Tourism**: Enables the creation of immersive experiences by providing users with realistic representations of real-world locations.

3.2 HD Mapping Standards

3.2.1 Activity Definition

The primary activities in **HD Mapping** are the acquisition, processing, and validation of high-precision geospatial data to construct digital road models. This includes:

1. **Mobile Mapping System (MMS) Data Collection** – Capturing **LiDAR, GNSS, camera, and IMU data** while moving along road networks.
2. **Feature Extraction & Annotation** – Identifying **road geometry, lane information, curbs, traffic signs, and obstacles**.
3. **Data Verification & Quality Control** – Ensuring that mapping data meets **accuracy and consistency thresholds**.
4. **Georeferencing & Fusion** – Integrating data from **GNSS, IMU, and LiDAR** to achieve precise positional alignment.

3.2.2 Deliverables

HD Mapping activities result in several key outputs:

- **HD Vector Maps (SHP Format or NDS)**: Georeferenced vector files containing detailed lane markings, road edges, traffic sign locations, and other road features of interest.
- **LiDAR Point Cloud Data (LAS Format)**: 3D data capturing road features and surrounding infrastructure.
- **Geospatial Metadata**: Including sensor specifications, calibration logs, coordinate systems, and projection details.
- **Validation Reports**: Accuracy assessment documents ensuring compliance with mapping guidelines.

3.2.3 Target Resolution/Precision/Accuracy Specifications

Map Parameter	Grade 1	Grade 2	Grade 3
Absolute 2D Accuracy	≤ 20 cm	≤ 30 cm	≤ 50 cm
Absolute 3D Accuracy	≤ 30 cm	≤ 50 cm	≤ 1 m
Relative 2D Accuracy	≤ 10 cm	≤ 15 cm	≤ 30 cm

Relative 3D Accuracy	≤ 15 cm	≤ 20 cm	≤ 50 cm
Point Cloud Density	2500 - 10000 pts/m^2 (High Precision)	400 - 2500 pts/m^2 (Lane-Level Accuracy)	100 - 400 pts/m^2 (General Navigation)
Vector Map Accuracy	Lane position error ≤ 10 cm	Lane position error ≤ 20 cm	Lane position error ≤ 50 cm
Feature extraction, labeling, and annotation quality	95%	95%	95%

3.2.4 Sensor Requirements and Specifications

Sensor	Feature	Specification requirements
LiDAR	Point Density	Min: 400 pts/m^2 (Lane-Level) Recommended: 10,000 pts/m^2
	Range Accuracy	≤ 2 cm
	Wavelength	905 nm - 1550 nm
	Scan Rate	≥ 600,000 points/sec
LiDAR (Solid state)	Point Density	Min: 400 pts/m^2
	Range Accuracy	≤ 2 cm
	FOV	120 degrees
Camera	Resolution (all cameras combined)	Minimum: 60 MP Recommended: 200 MP
	Resolution (each camera)	Minimum: 12 MP Recommended: 50 MP
	HFOV (all cameras combined)	360 degrees
	HFOV (each camera)	Minimum: 60 degrees Recommended: 120 degrees
	VFOV	180 degrees
	Frame rate	Minimum: 30 FPS Recommended: 60 FPS
	Dynamic range	Minimum: 70 dB
	Shutter type	Over rolling shutters
GNSS	Horizonal 2D Accuracy	<2cm

	Vertical Accuracy	<3cm
	Constellations support	GPS, GLONASS, Galileo, BeiDou
	RTK	Supported
	Dual Frequency	Supported
IMU	Gyro Bias	<0.01 degrees/hour
	Accelerometer Bias	<50 micro.g
	rate	Minimum: 200 Hz
Calibration	Reprojection error (camera)	±0.2 pixels
Time Synchronization		±1 ms

For HD Map updates, sensor specifications for crowd-sourcing vehicle sensors are listed below:

Sensor	**Feature**	**Specification requirements**
Camera	Resolution	Minimum: 32 MP Recommended: 50 MP
	HPOV	Minimum: 80 degrees Recommended: 120 degrees
	Frame rate	Minimum: 10 FPS Recommended: 30 FPS

3.2.5 Calibration and Validation Requirements

The following requirements must be ensured during data collection:

- **Control Survey Verification** – GNSS and total station-based control points must achieve **≤ 10 cm plane accuracy** and **≤ 15 cm 3D accuracy.**
- **INS/GNSS Function Tests** – Positioning accuracy verified using **baseline field tests** before mapping.
- **Point Cloud Internal Accuracy Check** – Relative scanning errors should be **≤ 10 cm** within the same mapped route.
- **Vector Layer Shape Validation** – Road feature geometry should maintain **≤ 20 cm** deviation in 2D and **≤ 30 cm** in 3D.

3.2.6 Integration of Value-added Applications

HD maps are categorized into different **grades** based on their resolution, accuracy, and level of detail. The choice of HD map grade depends on the specific application requirements, balancing precision with computational efficiency.

1. Grade 1 (High-Precision HD Maps (2500 – 10,000 pts/m²)):
    a. Autonomous Driving (Level 3+ AVs):

       Provides ultra-high accuracy for lane-level vehicle localization, required for self-driving cars operating in complex urban environments.

    b. ADAS (Advanced Driver Assistance Systems):

       Used in adaptive cruise control, lane-keeping assistance, and predictive navigation.

    c. Robotics & Industrial Automation:

       Supports precision-guided robots and drones for warehouse automation and last-mile delivery.

    d. Geospatial Research & Infrastructure Planning:

       Utilized in civil engineering and city planning for road alignment analysis and traffic optimization.

2. Grade 2 (Lane-Level HD Maps (400 – 2500 pts/m²)):
    a. Navigation & Smart Mobility:

       Used in commercial navigation apps, enabling accurate lane guidance and enhanced turn-by-turn directions.

    b. Fleet Management & Logistics:

       Supports route optimization for delivery and transport fleets, ensuring precise positioning on highways and urban roads.

    c. Public Transportation & Mobility-as-a-Service (MaaS):

       Provides optimized transit planning and predictive travel time analytics.

d. Autonomous Shuttle & Last-Mile Delivery Vehicles:

Enables localized AV deployment in geofenced areas such as campuses and business districts.

3. Grade 3 (General Navigation & Mapping (100 – 400 pts/m²)):

a. Standard GPS-Based Navigation:

Supports map-based vehicle navigation and pedestrian routing.

b. Emergency & Disaster Management:

Provides base-level geospatial data for crisis response planning.

c. Surveying & General GIS Applications:

Used for land-use planning, environmental monitoring, and urban development.

3.3 Navigation Apps Standards

3.3.1 Activity Definition

Navigation applications utilize **GNSS, HD maps, and real-time traffic data** to provide users with optimal routes based on **current road conditions, traffic congestion, and road geometry**. The primary activities include:

1. **Route Calculation & Optimization** – Algorithms compute the shortest, fastest, or most fuel-efficient routes based on **real-time data**.
2. **Lane-Level Positioning** – Uses HD maps and sensor fusion to **position vehicles within specific lanes**, improving safety and navigation accuracy.
3. **Turn-by-Turn Guidance** – Provides **real-time voice and visual instructions** for drivers, cyclists, and pedestrians.
4. **Dynamic Traffic Updates** – Integrates **real-time traffic feeds, incident reports, and predictive analytics** to adjust routes dynamically.

3.3.2 Deliverables

Navigation applications generate multiple outputs to ensure efficient and accurate routing:

- **Routing Data (API or Map Service Format)** – Includes road geometries, lane configurations, and speed limits.
- **Live Traffic Data Feeds** – Real-time updates on congestion, road closures, and accidents from users and real-time traffic cameras.
- **Geospatial Metadata** – Sensor logs, GNSS accuracy data, and timestamped location records.
- **User Feedback Data** – Crowdsourced reports on road conditions, traffic incidents, and infrastructure changes.

3.3.3 Target Resolution/Precision/Accuracy Specifications

The following targets are required for the maps delivered for the navigation App development activity.

Parameter	Target
2D Positioning Accuracy	≤ 1 m
3D Positioning Accuracy	≤ 1.5 m

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Lane-Level Accuracy	≤ 50 cm deviation from actual lane center
Real-Time Position Update Rate	≥ 1 Hz
Traffic Data Update Latency	≤ 5 seconds for real-time updates

3.3.4 Sensor Requirements and Specifications

Sensor	Feature	Specification requirements
Camera	Resolution (each camera)	Minimum: 12MP Recommended: 50 MP
	HFOV (each camera)	Minimum: 60 degrees Recommended: 120 degrees
GNSS	Horizonal 2D Accuracy	<1 m
	Vertical Accuracy	<1.5 m
	Constellations support	GPS, GLONASS, Galileo, BeiDou
	RTK	Supported
	Dual Frequency	Supported
IMU	Gyro Bias	<0.01 degrees/hour
	Accelerometer Bias	<50 micro.g
	rate	Minimum: 200 Hz
Traffic sensors	Latency	≤ 5 seconds for real-time data feeds

3.3.5 Calibration and Validation Requirements

- **GNSS/INS Validation** – Navigation apps using sensor fusion must verify GNSS positioning with inertial navigation data to maintain accuracy in areas with weak satellite signals (e.g., tunnels, urban canyons)
- **Lane-Level Accuracy Tests** – Road tests with RTK-supported GNSS should confirm ≤ 50 cm lane deviation for high-precision navigation
- **Real-Time Data Synchronization** – Navigation apps must sync GNSS, traffic updates, and HD maps within ≤ 5 seconds to ensure accurate real-time guidance

3.3.6 Integration with Value-added Applications

Navigation applications support multiple industries requiring real-time geospatial data and routing intelligence:

- Autonomous Driving & ADAS:
  Uses precise lane guidance, predictive path planning, and high-accuracy maps.
- Fleet & Logistics Management:
  Optimizes delivery routes using real-time traffic and predictive analytics.
- Public Transportation & MaaS:
  Enhances transit route planning, multimodal transport coordination, and predictive arrival times.
- Emergency & Disaster Response:
  Enables first responders to navigate blocked or hazardous routes efficiently.

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3.4 Storage Standards

3.4.1 Storage Infrastructure Requirements

Control	Standard requirements
Data Residency	Geospatial data must be stored in a locally-resident facility in Saudi Arabia.
Cloud & Hybrid Storage	Cloud storage providers must comply with Saudi security protocols issued by Saudi government legislation bodies, e.g., SDAIA, NCA, and CST. Visit CST-approved cloud service providers
Data Retention	Organizations must retain data for a minimum of 5 years
Encryption Standards	- AES-256 encryption for stored geospatial data. - TLS 1.3 encryption for secure data transmission.
Anonymization & Pseudonymization	Data must be **de-identified** before public use or external processing.
Backup & Disaster Recovery	Encrypted **automated backups** must be conducted daily, with **geo-redundant storage** for business continuity.

3.4.2 Storage Access Control Requirements

- **Role-Based Access Control (RBAC):** Data access must be restricted based on user roles, ensuring least privilege access.
- **Data Classification:**
  Data classification is a fundamental component of geospatial data security, ensuring that datasets are categorized based on sensitivity, regulatory requirements, and access controls. According to the Data Classification Policy issued by SDAIA, data is classified into four categories:
  - **Public Data**: Open-access geospatial data.
  - **Restricted Data**: Internal-use datasets with controlled access.
  - **Confidential Data**: Sensitive geospatial information requiring encryption and multi-factor authentication.
  - **Highly Confidential Data**: National security-related geospatial data, which must not be transferred outside Saudi Arabia
- **Audit Logs & Monitoring:** Real-time system logging and access tracking must be maintained to detect unauthorized access or anomalies.

3.5 Security Standards

Sandbox applicants must comply with the security policies issued by the National Cybersecurity Authority (NCA) to ensure compliance with Saudi cybersecurity regulations. These policies cover various aspects of data protection, access control, risk management, and incident response. Adhering to these guidelines is essential for maintaining a secure and resilient digital environment while fostering innovation within the regulatory framework. Failure to comply may result in disqualification for the sandbox program.

3.5.1 Security Requirements

Control	Target requirements
Network Security	Firewalls, Intrusion Detection Systems (IDS), VPNs must be deployed to secure data transmissions.
Access Control	- Multi-Factor Authentication (MFA) is mandatory for accessing geospatial datasets. - Role-Based Access Control (RBAC) must restrict user permissions.
Data Encryption	- AES-256 encryption for data at rest. - TLS 1.3 encryption for data in transit.
Threat Monitoring	24/7 security monitoring and anomaly detection to identify cyber threats.
Incident Response	All data breaches must be reported to SDAIA within 72 hours, following the PDPL guidelines.
Penetration Testing	Applicants must conduct annual cybersecurity audits and penetration testing.
Data Integrity Protection	Digital signatures and cryptographic hash functions must be used to verify data authenticity.
Secure Data Transfers	Highly Confidential data must not be transferred outside KSA without explicit approval from SDAIA and CST.

3.6 Networks and Communication Standards

Category	Requirements
5G & V2X Connectivity	- Support 5G NR (New Radio), C-V2X (Cellular-V2X), and DSRC. - Minimum 1 ms latency for real-time applications.

Edge Computing	- AI-based data filtering and processing at sensor nodes. - Synchronization with cloud AI models for continuous learning.
Secure Communication	- AES-256 encryption for data in transit. - TLS 1.3 for API and cloud communication.
Bandwidth Requirements	- Min: 1 Gbps for HD mapping and real-time applications. - Recommended: 10 Gbps for data-intensive workloads.
Resilient Network Design	Redundant network paths and failover mechanisms for business continuity.

3.7 AI and Machine Learning Standards

Category	Requirements
Model Accuracy	- Navigation models must achieve ≥ 95% accuracy in path prediction. - HD Map segmentation models must have IoU ≥ 90%.
Real-Time Inference	ML models must process geospatial data within 100 ms latency.
Edge AI Processing	AI models must support on-device inference with embedded GPUs/TPUs.
Explainability	AI decisions must be traceable with confidence scores for regulatory compliance.
Data Augmentation	AI training datasets must use synthetic augmentation (GANs, data fusion) to improve accuracy.

3.8 Business Continuity Standards

A business Continuity Plan (BCP) is required for all business processes with focus on disaster recovery.

Category	Requirements
High Availability (HA)	99.9% uptime SLA for critical mapping services.
Backup & Redundancy	Daily encrypted backups stored in a geo-redundant cloud infrastructure.
Incident Response Time	Cyber incidents must be reported within 72 hours and mitigated within 24 hours.
Automated Failover	AI-driven failover mechanisms must be in place for real-time navigation apps.
Regulatory Compliance	BCP must align with Saudi NCA (National Cybersecurity Authority) regulations.

4 Appendix

4.1 Appendix A: Workstreams and Key Activities for AVs

1. Vehicles, Infrastructure, and Autonomy

- **Vehicle Importation Approvals:** Complete all import and regulatory steps (e.g., SASO approvals), ensuring compliance with local standards and customs requirements.
- **Customs Clearance Processes:** Manage logistics and documentation for vehicle entry, including duties, taxes, and inspections upon arrival.
- **Licensing and Registration:** Obtain necessary permits and license plates; maintain official records and documentation for each autonomous vehicle.
- **Regular Vehicle Inspections:** Conduct routine checks to ensure roadworthiness, compliance with local transport authorities, and ongoing readiness for autonomous operation.
- **Motor Vehicle Insurance:** Secure and maintain appropriate policies to cover liability, collision, and any specialized coverage needed for AV equipment.
- **AV Kit Installation and Calibration:** Equip vehicles with autonomous driving kits; calibrate sensors and systems to local driving environments.
- **Parking and Storage Facilities:** Identify and arrange adequate parking spaces or garages to house the AV fleet when off-duty.
- **EV Charging Infrastructure:** Develop plans for electric vehicle charging (where applicable), including site selection and electrical capacity assessments.
- **Connectivity and Data Transfer:** Establish reliable network solutions to download trip data, transmit real-time telemetry, and perform software updates.
- **Maintenance Facilities and Procedures:** Designate service locations and create protocols for regular maintenance, repairs, and parts management.
- **Onboarding onto Platform:** Integrate the vehicles into the ridesharing or fleet-management platform, ensuring smooth dispatch and user interface functionality.

- **Mapping and Performance Validation (AV Developer-Specific):** Define a detailed service area map; regularly test and refine autonomous features to verify accuracy and reliability.

2. Vehicle Operators (VOs)

- **"Train-the-Trainer" Program:** Develop a structured curriculum enabling experienced autonomous technology staff to train new vehicle operators.
- **Recruitment of Skilled Operators:** Set and communicate clear hiring requirements, including valid licenses, safety consciousness, and technical aptitude.
- **Policies and Training Materials:** Create comprehensive guidelines, covering AV operation, safety procedures, emergency protocols, and data handling.
- **Annotation of System Performance:** Introduce processes for operators to log and annotate real-world driving scenarios, feeding insights back to developers.
- **Driver Monitoring Implementation:** Install hardware and software solutions that track operator attentiveness; ensure these are in place before training begins.
- **Alert Verification and Response Program:** Monitor notifications from the driver monitoring system and act promptly on any safety or performance concerns.
- **Classroom Instruction:** Provide foundational lessons on AV theory, local regulations, and best practices before hands-on vehicle training.
- **On-Road Training:** Conduct supervised practice on public roads or closed-course environments, ensuring operators gain experience with live AV systems.

3. Safety

- **Comprehensive Safety Plan:** Combine input from the autonomous technology developer and fleet operations team, detailing operational design domain (ODD), incident response strategies, and cybersecurity measures.

- **Technical Safety Meetings and Demonstrations:** Organize on-site reviews of safety systems, showcasing vehicles' capabilities, redundancies, and fail-safes.
- **Autonomous Safety Assessments:** Perform in-depth evaluations of the AV's technology stack, operational protocols, and emergency procedures, culminating in official approval to operate.

4. Compliance

- **Operating and Location-Specific Approvals:** Secure any licenses or certifications needed by each participating entity; address special requirements for areas like airports or private campuses.
- **Insurance Coverage:** Maintain essential policies—such as Commercial General Liability, specialized commercial vehicle insurance, and garaging coverage—to protect all parties.
- **Vehicle and Technology Certifications:** Obtain relevant government endorsements for hardware, software, and mapping data (e.g., SDAIA approvals, GEOSA licenses).
- **Regulatory Coordination:** Ensure ongoing communication with local authorities, staying current on evolving autonomous vehicle policies and guidelines.

5. API Integration and Testing

- **Integration with Ridesharing Platform:** Establish secure connections and data flows between the AV developer's systems and the ridesharing API; address unique requirements for each partner.
- **Platform Configuration and User Experience:** Update the ridesharing app's interface and features to accommodate autonomous trip requests, ride status updates, and user feedback.
- **Alpha Testing (Dispatch Trials):** Run initial tests by dispatching live vehicles through the ridesharing API, monitoring trip creation, tracking, and performance metrics.
- **Beta Testing (End-to-End Trials):** Conduct production-level pilot tests with real passengers, ensuring the full experience—booking, pickup, ride, and support—meets quality and safety standards.

6. Support

- **Staffing and Training for Support Agents:** Recruit and prepare customer-facing teams to handle user inquiries related to autonomous rides, technical issues, or safety concerns.
- **Standard Operating Procedures (SOPs):** Develop clear guidelines for troubleshooting, incident escalation, and day-to-day AV support processes.
- **In-App Support Experience:** Integrate help resources, FAQs, and real-time agent assistance into the ridesharing app, tailored to AV use cases (if applicable).

7. Communications

- **Launch Communications Plan:** Outline key messaging, timelines, and promotional strategies for announcing and publicizing the autonomous service.
- **Stakeholder Engagement:** Develop proactive relationships with local communities, regulators, and influential voices to foster positive public sentiment and address concerns.

8. Project Management

- **Agreements and Contractual Arrangements:** Finalize terms with fleet operators, developers, and any third parties to define responsibilities and deliverables.
- **Launch Service Area Definition:** Identify and confirm the geographic boundaries and operational constraints for the initial autonomous deployment.
- **Ongoing Readiness Reviews:** Schedule regular check-ins to track progress, assess risks, and ensure all milestones and quality metrics are being met on time.

Attachments

Compliance List:

ComplianceSheet_GEOSandbox_Standards EN.xlsx

Versioning Table

Version	Date
1.0	Feb-2025
1.1	Feb-2025
1.2	Feb-2025
1.3	Mar-2025
1.4	Mar-2025
1.5	Mar-2025

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