SMART CITY REFERENCE ARCHITECTURE WHITE PAPER—
SUPPLEMENT

GEOSPATIAL DATA INTEROPERABILITY PLATFORM

2nd Edition

May 23, 2025

Secretariat of the Science, Technology and Innovation Policy,
Cabinet Office, Japan

Table of Contents

1. Introduction

The effective utilization of geospatial information is indispensable for advancing smart city initiatives. However, traditional approaches have often been hampered by data fragmentation across various sectors, leading to significant challenges in creating viable use cases, managing costs effectively, and identifying successful implementation models.

To address these shortcomings, the 3rd Edition of the Smart City Reference Architecture (SCRA) establishes the "Geospatial Data Interoperability Platform" (hereinafter referred to as "this platform") as a core and essential component of the City Operating System (City OS). This strategic shift emphasizes a data-driven approach to resolving "interstitial" issues—those often overlooked by conventional, siloed administrative structures—and to providing better support for underserved populations and challenges.

This platform provides a mechanism to integrate, visualize, and reuse diverse geospatial data from public, private, academic, and citizen sources within a common digital mapping environment. This capability enables a more objective understanding of complex issues, particularly those that span traditional administrative boundaries, thereby fostering common understanding among various stakeholders, including citizens, and promoting consensus-building grounded in Evidence-Based Policy Making (EBPM). Furthermore, standardized APIs and spatial ID compatibility streamline data exchange between systems. The provision of maps and data in a readily reusable format allows for the automation of Key Performance Indicator (KPI) management and supports the rapid, low-cost development of applications by a wide range of entities. Ultimately, this facilitates concrete, consensus-driven problem-solving and establishes a crucial foundation for realizing smart cities.

This annex, building upon the SCRA 3rd Edition, elucidates the specific structure and role of this platform. Recognizing that successful data collaboration hinges on a clearly defined and shared architecture—encompassing structure, terminology, and data formats—among data providers and users, this document aims to deepen that understanding and support the widespread adoption and effective utilization of this platform.

2. Architecture

2.1 Significance

The main advantages of adopting a Geospatial Data Interoperability Platform are as follows:

- Cross-sectoral data collaboration: Integrates and collaborates previously siloed geospatial information across diverse sectors such as urban planning, disaster management, transportation, and infrastructure.

- Enhanced issue identification capabilities: Promotes issue discovery, sharing, and consensus building among diverse public and private stakeholders through comprehensive data visualization.

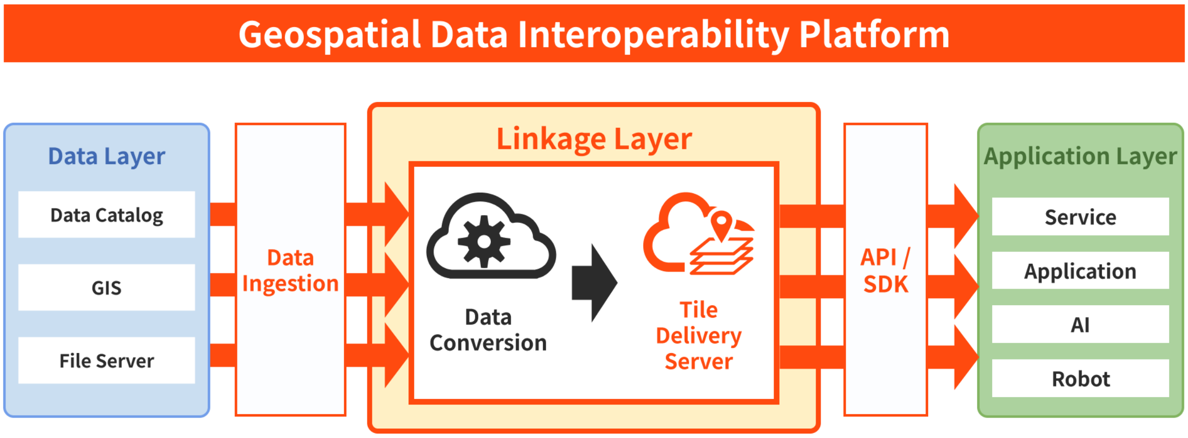
- Reduced application development costs: Reduces development costs and facilitates horizontal deployment through standardized data formats (map tiles and APIs).

- Avoidance of vendor lock-in: Ensures operational flexibility and sustainability through open and vendor-independent specifications.

- Advanced data utilization: Ensures interoperability with diverse systems, including AI, through machine-readable APIs.

2.2. Structure

The Geospatial Data Interoperability Platform adopts a three-layer architecture:



- Data Layer provides the original data for collaboration, such as data catalogs like CKAN, GitHub, and file systems. Multiple systems can be used in combination.

- Linkage Layer collects data from the data layer, converts it into standardized formats (map tiles, APIs), and distributes it.

- Application Layer consists of applications developed using data from the Linkage Layer (e.g., disaster prevention apps, event guides, facility management, etc.). Specific smart city services are realized in this layer. A "public GIS" for residents is a typical example of an application in this layer.

This structure allows data layer updates to be automatically reflected in the application layer, via the Linkage Layer, freeing data providers and users to focus on their tasks.

2.3. Data Layer

A group of systems that serve as the source of original data used by the platform.

2.3.1. Required Functions

The Data Layer must provide functions to store and serve geospatial information to the Linkage Layer, alongside capabilities for managing data freshness and accuracy.

2.3.2. Available Systems

Includes open data catalogs (e.g., CKAN), file storage, GitHub, etc. The Linkage Layer acquires the necessary data from these sources.

2.4. Linkage Layer

The Linkage Layer is the core component responsible for processing data from the Data Layer into formats suitable for the Application Layer and for distributing this processed data.

2.4.1. Collection

This function automatically acquires necessary geospatial data from various systems within the Data Layer, employing methods such as downloads or API calls tailored to each specific data source.

2.4.2. Conversion

Converts the collected data into standardized map tile formats compatible with map APIs and spatial IDs.

2.4.2.1. Format

Recommended output formats:

- Vector Tiles: Distributes geographic features such as points, lines, and polygons as object data. Highly machine-readable and efficient, suitable for extensive reuse (Mapbox Vector Tile specification recommended).
- Data PNG: Suitable for distributing data with gradations, such as elevation and weather information (AIST specification recommended).
- GeoJSON: While not a map tile format, it is a widely adopted format suitable for open data with a small number of records (e.g., facility location information). Vector tiles are recommended for large datasets.

Mapbox Vector Tile Specification https://github.com/mapbox/vector-tile-spec

Data PNG (AIST) https://gsj-seamless.jp/labs/datapng/

GeoJSON https://geojson.org/

2.4.3. Distribution

Distributes the converted map tiles and data to the application layer.

2.4.3.1. Map API

A server function (map API) is provided for distributing map tiles. Due to the static nature of map tiles, a simple web server (static file hosting) is recommended for implementation, enabling low-cost, straightforward, and highly scalable distribution.

2.4.3.2. SDK（Software Development Kit）

A set of componentized programs (SDK) is provided to simplify application development tasks such as using the map API, displaying maps, and acquiring information using spatial IDs, allowing developers to focus on core application logic rather than managing complex rendering or data communication processes.

Examples of available open-source libraries:

Name	URL	License	Usage
MapLibre GL JS	https://maplibre.org/maplibre-gl-js/docs/	MIT	JavaScript library for rendering vector tiles as visual maps

deck.gl	https://deck.gl/	MIT	JavaScript library for 3D data visualization
Ouranos Ecosystem	https://github.com/ouranos-gex/ouranos-gex-lib-for-JavaScript	MIT	A library for spatial IDs (promoted by Ministry of Economy, Trade and Industry)

2.4.3.3. Documentation

Comprehensive documentation, including sample code and usage guidelines for the API/SDK, must be provided to facilitate application development.

2.4.3.4. Logs

Access logs are managed for monitoring usage, security, server load, and analyzing promotion effectiveness. To support future audits and analysis, necessary information, including timestamps, IP addresses, request details, and response codes, is recorded in a standard web server format.

2.5. Application Layer

This layer actualizes the platform's value by delivering smart city services to citizens, staff, and businesses. Examples include public GIS sites, citizen collaboration tools using map forms, MaaS systems, tourism sites, disaster prevention systems, and private services that leverage the platform's API.

By utilizing the map API and SDK, developers can efficiently create applications without needing in-depth knowledge of map data preparation, server infrastructure, or the complexities of map display. This fosters a robust application ecosystem, encouraging contributions from diverse stakeholders such as local governments, private companies, academic institutions, and citizen developers.

3. Collaboration Technologies: Spatial IDs and FIWARE

3.1 Spatial IDs and the Geospatial Data Interoperability Platform

A spatial ID is an identifier (ID) system for uniquely indicating a specific location, position, or range in the real world. Spatial IDs are expressed in the ZFXY format, which combines the zoom level (Z) used for map tile numbers, horizontal tile coordinates (X, Y), and floor (F) representing hierarchy or height. Different organizations and systems can promote data collaboration by indicating specific locations or ranges using common rules.

Details can be found in the "Spatial ID Guidelines for Utilizing 4D Spatiotemporal Information" Social and Industrial Digital Transformation | IPA, Information-technology Promotion Agency, Japan.

The Geospatial Data Interoperability Platform and Spatial IDs have a mutually complementary relationship. Map tiles distributed from the Geospatial Data Interoperability Platform can be called by specifying a spatial ID and used directly as a response. For systems using spatial IDs, the Geospatial Data Interoperability Platform serves as a crucial mechanism for accessing existing geospatial data.

3.2 FIWARE and the Geospatial Data Interoperability Platform

FIWARE is an open-source platform that excels at managing dynamic context information (e.g., sensor data, events, etc.), particularly through its Orion/Orion-LD Context Brokers.

FIWARE details: FIWARE Foundation website (https://www.fiware.org/), NGSI-LD (https://fiware-datamodels.readthedocs.io/en/stable/ngsi-ld_howto/)

It is complementary to this platform, mainly handling static and semi-static geospatial information.

3.2.1. Enhancing Applications and Addressing FIWARE Challenges with the Geospatial Data Interoperability Platform

The platform's API/SDK facilitates the rapid and cost-effective development of map-based applications (e.g., tourism guides, hazard maps). Integrating real-time data (e.g., parking availability, evacuation shelter status) from the FIWARE API into these applications enables the provision of more context-aware services. This approach reduces both the cost and time involved compared to development using FIWARE alone.

3.2.2. Linking Dynamic and Static Data with Spatial IDs

FIWARE-managed dynamic data (e.g., from sensors) often includes latitude and longitude information indicating its placement. This platform can link this dynamic data with static geospatial data via spatial IDs. Applications can then use a shared spatial ID to retrieve both static information (from this platform) and real-time data (from FIWARE), answering questions like "What's the temperature of this building?" or "What's the traffic at this intersection?".

There are also potential cost savings. Local governments deploying FIWARE sometimes struggle with the expense of adding and managing data models. However, since the Geospatial Data Interoperability Platform handles static and semi-static geospatial information cost-effectively, FIWARE can concentrate its resources on its core strength—real-time data—leading to overall cost reduction.

4. Data for Linkage

The platform integrates data from a wide range of sources, including local government systems, government agencies (for instance, the Geospatial Information Authority of Japan and the Ministry of Land, Infrastructure, Transport and Tourism), and various private companies (supplying internal data, open data, map tile services, and more). Therefore, a flexible integration strategy that considers the specific method of data acquisition is essential.

Examples of sources providing original data include:

- The National Land Numerical Information offered by the Ministry of Land, Infrastructure, Transport and Tourism
- Local government systems (such as CKAN, internal GIS, and ledger data)
- Data from the private sector (e.g., human flow patterns, weather data, traffic data, base maps)

Examples of data sources directly readable by the application layer (through map tile distribution) are:

- Map tiles from the Geospatial Information Authority of Japan (GSI): https://maps.gsi.go.jp/development/ichiran.html
- Tiles available from the Hazard Map Portal Site: https://disaportal.gsi.go.jp/hazardmapportal/hazardmap/copyright/opendata.html#kasaneru
- The Real Estate Information Library API provided by the Ministry of Land, Infrastructure, Transport and Tourism: https://www.reinfolib.mlit.go.jp/help/apiManual/

5. Open Source

Utilizing Open Source Software (OSS) is a crucial strategic choice for developing and operating digital infrastructures of significant public and social importance, such as this platform.

5.1. Avoiding Vendor Lock-in and Freedom of Technology Choice

Adopting open-source technologies, independent of specific vendors or proprietary software, mitigates the risk of 'vendor lock-in.' This also provides greater flexibility in future technology decisions, leading to adaptable and sustainable operations. Moreover, the transparency of OSS and its community support enhance reliability.

5.2. Open-Source Technologies Constituting the Geospatial Data Interoperability Platform

Many of the platform's elements can be built using a combination of open-source software, such as:

- Data catalog: CKAN, etc.
- Tile conversion/generation: Tippecanoe
- Distribution server: Common web servers like Nginx and Apache
- Map libraries (SDK): MapLibre GL JS, deck.gl, Ouranos Ecosystem's spatial ID library, etc.

5.3. Horizontal Deployment and Sustainability Through Open Sourcing of Development Assets

Making developed assets (tools, apps, etc.) open source allows for easier horizontal deployment of software to other regions and enables affordable, sustainable maintenance. Reusing and improving successful solutions across regions speeds up the promotion of smart cities throughout Japan. Furthermore, community-driven improvements in quality and features, along with cost sharing, are expected to significantly contribute to the system's sustainability.

6. Case Studies

6.1. Takamatsu My Safety Map

Takamatsu City utilizes the Geospatial Data Interoperability Platform to provide this disaster prevention information service for its residents. The service enables users to visualize risk information, such as that pertaining to floods and landslides (based on hazard map data), elevation data (provided by the Geospatial Information Authority of Japan), and disaster response facility information (e.g., the location of nearby evacuation shelters, obtained from open data), by interacting with a map interface.

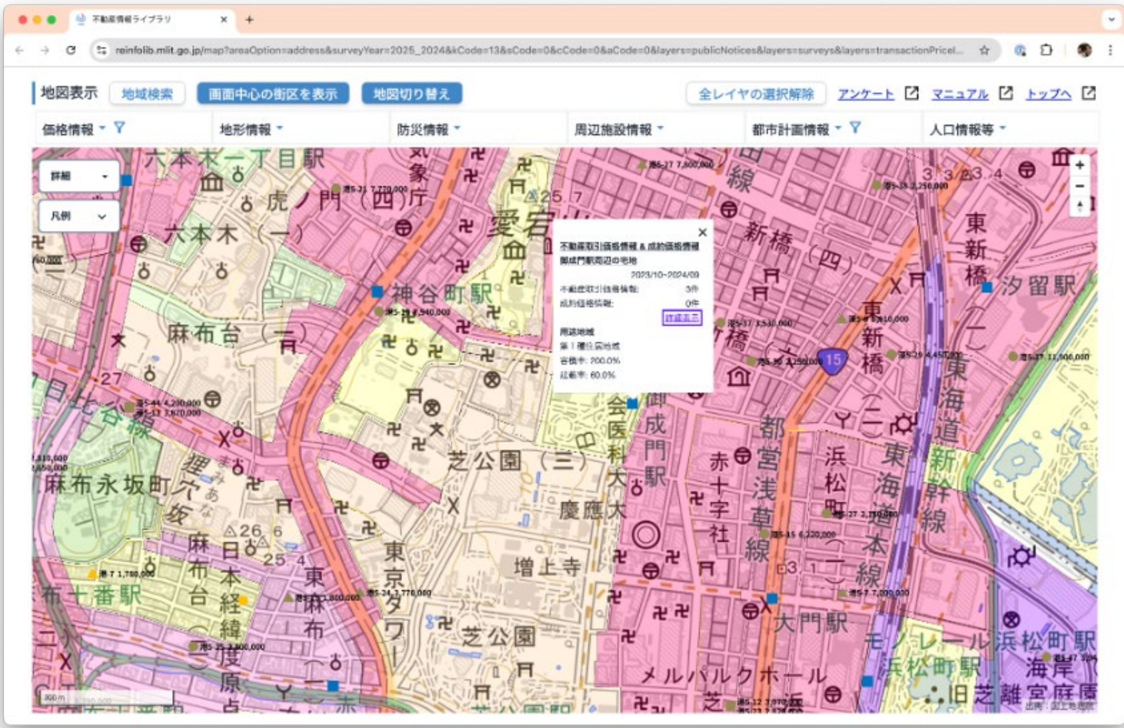
Takamatsu My Safety Map: https://safetymap.takamatsu-fact.com/

6.2. Public GIS "Smart Map Yaizu"

Yaizu City's public GIS, "Smart Map Yaizu" complies with Digital Agency model specifications. Beyond local government data, it displays FIWARE-provided disaster prevention information (evacuation shelter status, road conditions, rainfall/water level, weather etc.). The UI/UX prioritizes visual clarity, with icons dynamically changing based on disaster conditions. This exemplifies an application within the Geospatial Data Interoperability Platform's application layer.

Smart Map Yaizu: https://maps.yaizu-smartcity.jp/

6.3. Real Estate Information Library API

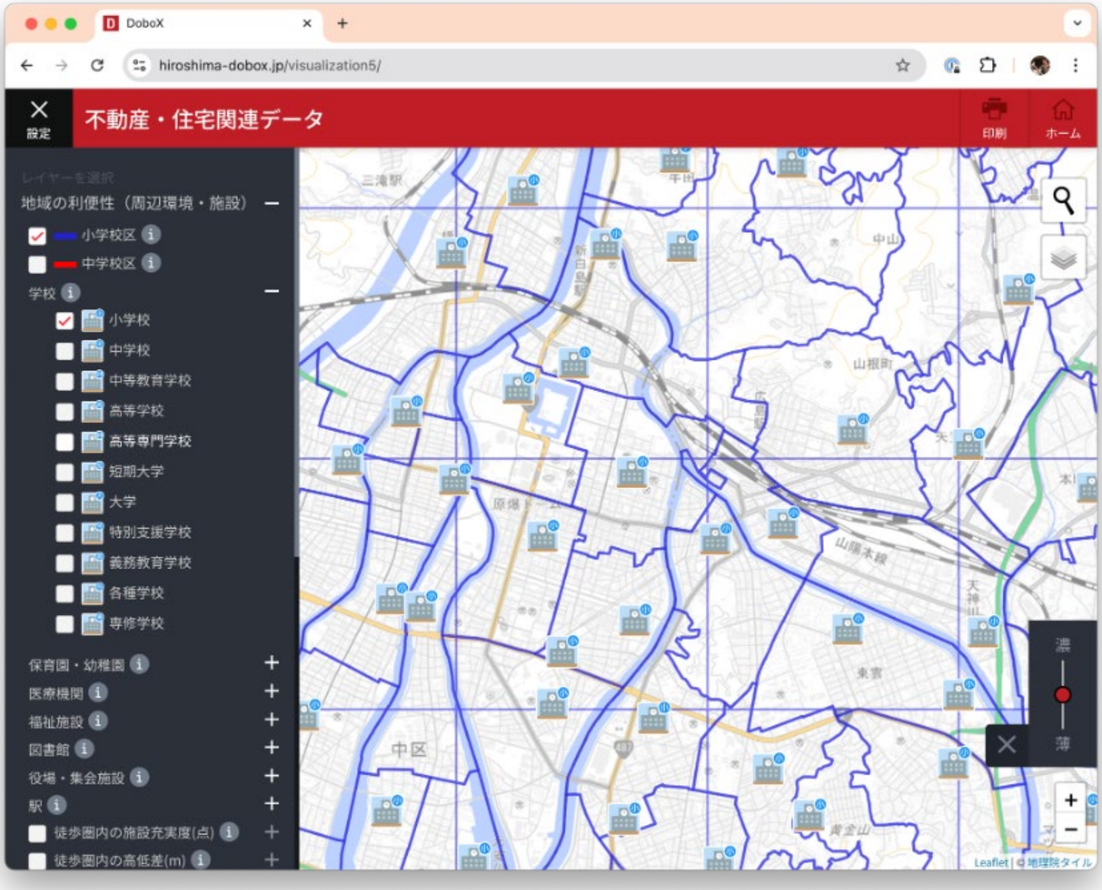


Operated by the Ministry of Land, Infrastructure, Transport and Tourism, the Real Estate Information Library is a WebGIS service displaying open data on real estate transactions (price, disaster prevention, city planning, nearby facility, etc.) on a map. An API provides access to some of this data, used by sectors like local governments and real estate agents. Launched in 2024, the API has received over 47 million requests in its first year, returning tiled GeoJSON and PBF based on zoom level and X/Y coordinates—an approach very similar to the Spatial ID API method envisioned for the Geospatial Data Interoperability Platform.

Real Estate Information Library: https://www.reinfolib.mlit.go.jp/

Real Estate Information Library API Operation Manual:
https://www.reinfolib.mlit.go.jp/help/apiManual/

Hiroshima Prefecture's Dobox is a system platform centralizing and opening up information (including geospatial data) on public civil engineering facilities, enabling external data collaboration. Its visualization feature reads and overlays data from the Real Estate Information Library, such as facility, real estate, and urban planning information. By using the Real Estate Information Library API, Dobox avoids independent data development and maintenance, providing valuable information to real estate agents and residents.



Hiroshima Prefecture Dobox: https://hiroshima-dobox.jp/visualization5/

7. Appendix

7.1. Terms and Definitions

- API: Application Programming Interface. A mechanism for exchanging information between different systems/users. Map APIs provide map-related functions/data.
- Geographic Information System (GIS): A system for managing, processing, visualizing, and analyzing geospatial data.
- SDK: Software Development Kit. A set of development environments, tools, documents, etc.
- Machine Readability: The property of data that makes it easy for machines to automatically read and process.
- Interoperability: The property of different systems being able to exchange data securely and automatically.
- Attribute/Property: Information about a geographic feature (e.g., name, category). Consists of a name and a value.
- NGSI-LD: A data model specification for context information representation and exchange used in FIWARE, etc.

7.2. Geospatial Data Interoperability Platform Procurement Specification Example

Geospatial Data Interoperability Platform Construction Project Specification (Sample)

First Edition

Author Geolonia Inc.

Second Edition

Author Geolonia Inc. Writing assistance • Digital Infrastructure Development Office, Urban Planning Division, Takamatsu City Hall • DX Promotion Division, Department of Administrative Management, Yaizu City Hall • Geospatial Information Division, Office of the Director-General for Policy Planning, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) • Digital Infrastructure Center, Information-technology Promotion Agency, Japan (IPA) • Department of Civil Engineering and Architecture, Hiroshima Prefectural Government

Contact information

(For more information on geospatial information)

Geolonia Inc.

https://geolonia.com

(For general information on the smart city reference architecture white paper)

Secretariat of the Science, Technology and Innovation Policy, Cabinet Office, Japan

Please see the "Contact Us" section at the bottom of the page.
https://www8.cao.go.jp/cstp/society5_0/smartcity/index.html

May 23, 2025

Secretariat of the Science, Technology and Innovation Policy, Cabinet Office, Japan