Multimodal for All Traveler (MAT) Standards Support Project- Phase 2

White Paper on Comparison between Community Based Specification Development Organizations (CBDO) and Standard Development Organizations (SDO)

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Multimodal for all Traveler (MAT) Standards Support Phase 2

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CHANGE HISTORY

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DRAFT 0.1	8/5/2024	Initial Version	
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1 INTRODUCTION

1.1 Scope

The purpose of this white paper is to explore and analyze the roles, advantages, and challenges of Community-Based Specification Development Organizations (CBDOs) versus traditional Standards Development Organizations (SDOs) in the context of developing standards for Multimodal Accessible Travel (MAT) and Vulnerable Road Users (VRUs). This document aims to provide a comprehensive understanding of how these organizations contribute to the development, governance, and implementation of transportation standards. Specifically, it will explore the governance structures, maintenance, roles, timelines, and industry attitudes towards specifications and standards developed by CBDOs and SDOs.

Although there are many organizations that develop standards and specifications, the selected SDOs and CBDOs represent organizations that are representative of their "type" or promulgate standards/specifications that target the MAT/VRU domains.

1.2 Audience

The CBDO vs. SDO White Paper is intended to inform key stakeholders contributing to the development standards and specifications for MAT for VRUs. Key stakeholders include:

- **Government Agencies.** Transportation departments, safety regulators, and planning authorities who are responsible for policy making and infrastructure development.
- **Industry Partners.** Companies involved in transportation, technology, and mobility services such as public transport operators and automotive manufacturers.
- **Standards Development Organizations and Community-based Development Organizations.** Bodies (i.e. SDOs and CBDOs) that develop and maintain technical standards, ensuring interoperability and safety across different systems and services.
- **Community Groups.** Organizations representing underserved communities and vulnerable road users, such as disability, pedestrian and cyclist advocacy groups who can provide insights into the needs and challenges faced by these users.
- **Research Institutions.** Universities and other research entities that can contribute to research and data to support the development of effective and evidence-based solutions.
- **General Public.** End users and the public in general, who will be directly impacted by systems that implement the standards and specifications.

1.3 References

The development of this document has been informed by various sources, including the MAT Standards and VRU Cyber Security Coordination Plan[1], previous US Department of Transportation (USDOT) initiatives, and interviews with industry experts.

1.4 Document Organization

This white paper is organized into five sections:

[1] Institute of Transportation Engineers (ITE). (2023). *Multimodal and Accessible Travel (MAT) Coordination Plan* . U.S. DOT.

- Section 2 – Overview: This section defines the differences between CBDOs and SDOs. It also includes a description of the various comparison categories, including governance, membership, development cycles, publication, funding, deployment, and sustainability.

- Section 3 – CBDO Profiles: This section describes several CBDO profiles, detailing their governance structures and development processes.

- Section 4 – SDO Profiles: This section describes several SDO profiles, detailing their governance structures and development processes.

- Section 5 – Comparison Tables: This section details the differences between CBDOs and SDOs across various dimensions and their approaches to privacy and security. It highlights the strengths and weaknesses of each type of organization to inform future standards development and implementation strategies.

- Section 6 – Transition from Open Specifications to Standards: This section explains how open specifications can be formalized into standards.

2 OVERVIEW

2.1 Definition CBDO vs. SDO

CBDOs and SDOs play distinct roles in creating standards. CBDOs are typically grassroots organizations or stakeholder groups that develop specifications based on community needs and practical experiences. These specifications often emerge from collaborative efforts between stakeholders, including local communities, advocacy groups, and industry practitioners. CBDOs are characterized by their flexible approach to specification development, which can quickly adapt to emerging needs and technologies.

In contrast, SDOs are formal organizations that follow a strict, consensus-based process to create standards. These organizations, often accredited by groups such as the American National Standards Institute (ANSI), bring together a broad range of stakeholders, including industry experts and government agencies, to ensure that the standards they develop are comprehensive, reliable and widely accepted. The development process in SDOs can be slower and more structured compared to CBDOs.

Definition of Specification. *Specification* often refers to multiple types of products. This white paper refers to ***specification*** to represent the technical characteristics, requirements, interfaces (and more) that are produced and published by CBDOs. To differentiate other types of specifications, we will use *purchase specification* to refer to requirements in Request for Proposals and *profile specification* to refer to instances of specifications deployed in systems. The definition for purchase, profile and engineering specifications are described below.

> **Purchase Specification:** According to Williamson County, Texas, Purchasing Manual Policies (Revised 2001, 51),
>
> "A specification (part of an [invitation to bid] ITB / [invitation for bid] IFB or [request for proposal] RFP solicitation) is a concise description of a good or service that an entity seeks to buy, and the requirements the vendor must meet in order to be considered for the award. A specification may include requirements for testing, inspection or preparing an item for delivery, or preparing or installing it for use, requirements for samples, descriptive literature, warranty, and packaging. The specification is the total description of the purchase."
>
> **Profile Specification:** A profile is the structure or configuration used to deploy the technology. For example, when deploying General Transit Feed Specification (GTFS), several of the tables (files) are optional and there are several best practices. The profile represents the files and variables that are used to describe the transit services.
>
> **Engineering Specification:** A file that is encoded using an open file format and interface standard such as JSON (JavaScript Object Notation), XML (eXtensible Markup Language), or CSV (comma separated values).

The content of this document refers to only a profile or engineering specification (not a purchase specification).

2.2 Definition of Comparison Categories

As noted above, standards typically are vetted and approved through a formal review and voting process by a group of subject matter experts (SMEs) approved by their country, business, or peers. Specifications may be subject to the same rigorous governance or processes, but they might also be purchase specifications in which standards are referenced and optional items within a standard are specifically called out for purchase.

In this paper, CBDO and grassroots specification developers are described using several different categories so that the organizations and processes can be compared with formal standard development

organizations (i.e., certified by state or national government). SDOs are described using these same categories.

This paper describes the categories used to compare CBDOs and SDOs:

Governance. Governance defines the roles and rules for developing standards and other technical reports. The category includes who participates in standards development activities (membership), how participants contribute (roles), the processes for developing technical reports and standards including the review process, access to drafts, voting rights, comment resolution, and leadership.

Roles and Membership. Membership is a part of governance; it includes elements such as:

- Committee structure – are there formal structures, or is it self-evolving;
- Leadership – are leaders selected by the general membership, selected by supporting organizations, or other mechanism. Do the leaders need to represent a specific stakeholder group, e.g., country, public / private sector?
- Member roles – are there different types of members, e.g., members, observers, liaisons; what type of responsibilities are associated with each; how does a participant increase their responsibility (e.g., be able to vote)
- Recruitment – how are people recruited to participate in the organization, is it through nomination, request to join, showing up?

Development Cycles. Development cycles include the processes for developing products that the organization works on whether documents/publications or artifacts (i.e., testing tools, training materials). Underlying this definition is the assumption that only certain types of publications and/or artifacts are within the scope of the organization. For example, training materials or conformance tools may not be within the scope of an SDO's charter whereas example implementations and compliance specifications may be. The types of products may include:

- New standards and technical reports (e.g., concept of operations, reference architecture, use cases, best practices)
- New tools or training materials
- Existing standards and/or artifacts periodic reviews
- Amendments, Corrigenda and Errata to published standards

Important in the development process is how a document is proposed and approved to be a work item which may be conditional on the product type, the maximum duration for the work period, and the different levels of review to which the artifact is subject.

The tools used for product development are also critical. Is the work in progress posted on an interactive website for dynamic editing? Can anyone edit or propose suggestions for incorporation? Even within an organization that supports multiple development domains, the process for contributing to development may vary. Yet, there is a difference between an organization that uses a GitHub site to propose issues and pull solutions, versus an organization that uses a closed repository (e.g., Teams, GitHub) to post draft documents to solicit inputs and reviews from members.

Finally, the transition gateway to publication may be seamless or require verification and validation. For example, does the organization require a period in which the standard is tested and deployed prior to promulgation? Or does it just require consensus of the voting delegations?

Publication. Are the products published open or licensed? Are the products free or purchased by the public? This impacts the distribution and perhaps the use of the artifacts by the public. Some organizations follow a hybrid model, where certain publications are funded by government and freely accessible, while others are available for purchase.

Funding. No organization can operate without funding even if the participants are volunteers. Is there a membership fee? Who funds the travel and time of the volunteers? How are the organization's administrative and technical staff funded? Sustainability depends on funding the organization's infrastructure, tools, and meeting venues as well as resourcing participant's time and travel.

Deployment. Though not typically associated with SDO charters, the resources necessary to implement and use the standard/specification in technology deployments is a measure of the return on investment for any standard/specification organization. Taking into consideration the market scope of end-users and commercial products, the widespread use of the standard (or specification) whether used by utility or mandated by public sector may be driven by its access, testing or certification tools, training/best practices guide, reference implementations, or other factors. Some organizations produce these types of services prior to elevating a standard/specification to publication while other organizations rely on trade associations or government resources to publish the products and services for deployment.

Sustainability. Many of the categories described above contribute to sustaining both the organization and the standards/specifications including foremost funding and deployment penetration. Industry acceptance drives investment in standard/specification deployment; the standard/specification becomes a critical element of industry growth. Industry interest may grow based on access to standards/specifications, best practice documents, tools and other artifacts that may be used to develop and test technology. In addition, deployments may also drive participant interest to continue developing and improving the standard/specification. Funding participants to continue to invest in the product ensures that there are resources available to sustain the product. If sponsored by a CBDOs or SDOs, they need to continue maintaining the organizational structure that is used to manage the standard/specification development cycles including creating new standards or revising existing standards to meet new technology changes.

Profile descriptions in Sections 3 CBDO Profiles and Section 4 SDO Profiles do not cover all the elements of each category, however distinguishing elements of each category are included to highlight the purpose, history, governance, scope, development processes, and sustainability (publication, funding, deployment) of these organizations.

3 CBDO Profiles

As mentioned in the definition of CBDO (**Section 2.1**), CBDOs are typically grassroots organizations or stakeholder groups that develop specifications based on community needs and practical experiences. The products they develop and publish often emerge from collaborative efforts between stakeholders, including local communities, advocacy groups, and industry practitioners.

This section profiles six CBDOs that produce standards or specifications that support MAT deployments (activities). These six CBDOs are: (1) OASIS, (2) Open Mobility Foundation, (3) MobilityData, (4) Work Zone Data Working Group, (5) OpenSidewalks, and (6) Open Geodata Consortium. There are other CBDOs not profiled herein but who also develop products beneficial to the MAT community, including the American Public Transportation Association (APTA), the Shared-Use Mobility Center, and the National Association of City Transportation Officials (NACTO).

3.1 OASIS

OASIS is a non-profit standards body offering projects, including open-source projects, a path to standardization and de jure approval for reference in international policy and procurement. The main Uniform Resource Locator (URL) for OASIS can be found at www.oasis-open.org.

3.1.1 Organization Overview and Background

OASIS was founded in 1993 to develop guidelines for interoperability among products that support the Standard Generalized Markup Language (SGML). The consortium changed its name to "OASIS" in 1998 to reflect an expanded scope of technical work. It calls itself 'open' because it supports open-source developments of standards and specifications with the goal of turning those into open standards.

OASIS developed and maintains a large number of standards and specifications from various fields and industries, of which only very few are relevant for MAT/VRU purposes. Industry fields covered by OASIS currently include:

- e-business / manufacturing
- Cloud
- Content technologies
- Cybersecurity
- Data Center Management
- e-Government
- Emergency management
- Energy
- Internet of Things (IoT)
- IT infrastructure
- Lifecycle management
- Messaging
- Privacy / Identity / Security
- Software development
- Web services

The technical work on standards and specification development undertaken by OASIS relevant to MAT/VRU would be limited to underlying communications and data exchange protocols. OASIS manages some standards defining data models and schemata, however these are legal-related, emergency management-related, energy market-related, or similar.

The work undertaken by the Open Mobility Foundation (OMF), one of the OASIS-managed Foundation-as-a-Service (FaaS) created foundations, is of much higher interest to MAT/VRU. OMF is described further in

Section 3.2.

3.1.2 Governance

OASIS structures itself similarly to many SDOs, with a Board of Directors (BoD) and a process to develop and maintain standards (and specifications) which largely uses volunteers from their membership companies. Funding from other sources such as the USDOT are also utilized when possible. For example, OASIS also serves as administrators for US Technical Advisory Groups (TAGs) in partnership with ANSI.

3.1.2.1 Leadership

The OASIS BoD is comprised of executive-level officers dedicated to advancing open standards and experienced in managing organizational growth and defining policies. Directors exercise a major impact on the strategic direction of the consortium and guide OASIS in achieving its mission. Currently, there are 11 directors, including Board Chair and President, Vice Chair, Secretary, and Treasurer.

Members of the OASIS BoD are nominated in an open election process by the Sponsors and Contributors of the Consortium. Each director serves a two-year term.

Candidates for the BoD are nominated by OASIS members only. Only OASIS member organization employees are eligible to become BoD directors. Nominations are not made public.

Voting for candidates is completed during the annual election through e-mail and is exclusive to OASIS member organizations (one ballot per organization). Candidate profiles are published on the OASIS website when the nomination period ends. Profiles cannot be edited after the ballot opens. The election results, including number of votes for each candidate and any tie resolution, will be announced to the OASIS members via email.

There are also several OASIS BoD Committee Charters including Executive, Governance, Finance / Audit, IP Rights, Process, and Staffing. For more information, see https://www.oasis-open.org/board/committee-charters/.

3.1.2.2 Membership

Members join OASIS to advance projects for cybersecurity, blockchain, IoT, emergency management, cloud computing, legal data exchange, and more. The technologies vary, however their mission remains the same: to advance fair, transparent development of open-source software and standards through the power of global collaboration and community.

As of June 26, 2024, OASIS has members from 113 organizations (www.oasis-open.org/tc-members/) from around the world including:

- **Governmental entities:** US Federal Bureau of Investigation (FBI), US Department of Homeland Security (DHS) Cybersecurity and Infrastructure Security Agency (CISA), Australian Signals Directorate, Arizona Supreme Court;

- **Academic organizations**: Carnegie Mellon University, University of North Carolina -Chapel Hill, University of Oslo, University of Westminster, University of Luxembourg;

- **Private entities**: International Business Machines (IBM) as founding member, Adobe Systems, Aetna, Alibaba Cloud Computing Ltd, Apple, Inc., AT&T, Broadcom, Cisco Systems, Google LLC, Hewlett Packard Enterprise (HPE);

- **Other standards bodies**: Open Geospatial Consortium, Inc. (OGC), National Association of Professional Process Servers, National Institute of Standards and Technology (NIST), National Oceanic and Atmospheric Administration (NOAA) / National Weather Service (NWS), Real Estate Standards Organization (RESO), Disaster Relief Communications Foundation.

Individuals can participate in any Technical Committee (TC) given their employer is on the member list and can even establish new TCs with no additional dues required. An individual whose employer is not a member is not able to join any TCs.

To become a member as an organization, contact the OASIS Organization directly via email at join@oasis-open.org.

All OASIS members are provided with benefits. Non-members are able to download all standards free of charge, however, are not able to participate in projects or other technical work. OASIS offers the benefits of an SDO in terms of governance, infrastructure and programs. Volunteer Members are offered four key programs including:

- **TCs.** Develop specifications in an open, lightweight process with a path to recognition in international policy and procurement—with both integrity and rapid progress.
- **Open Projects.** Work in an environment of cross-organizational sharing and collaboration, where members can develop open-source code and standards.
- **Foundation-as-a-Service (FaaS).** Get the infrastructure and fiscal agency services to quickly form and run an independent foundation.
- **Technical Advisory Groups to International Organization for Standardization (ISO).** Represent U.S. interests in global standards produced by ISO.

OASIS offers a service called FaaS in which it developed a process to form and run a foundation for a collaborative development community. It is a smart solution for groups that want to advance open-source code, standards, or related activities. Foundations operate independently while enjoying the benefits of the OASIS nonprofit corporate structure. There are core services covered by an annual fee and supplemental services with a-la-carte fees (see https://www.oasis-open.org/foundation-as-a-service/). For the transportation industry, the most important foundation under OASIS is likely the OMF, which OASIS supports with expenses of around $1 Mil/year (in 2023).

OASIS also has a separate foundation called “OASIS Open Europe Foundation”, which focuses on European issues, setting standards for open collaboration and allows OASIS to provide long-term sustainability for European Union research projects.

3.1.3 Development Cycles

In OASIS TCs, members come together to develop specifications using open process and Intellectual Property (IP) policy. Standards produced by TCs can be approved and published by other SDOs such as ISO, International Electrotechnical Commission (IEC), or the International Telecommunication Union (ITU). They are recognized in international policy and procurement and are widely adopted.

Features include:

- Lightweight process that ensures integrity of work while allowing rapid progress
- Publicly accessible standards that anyone can use without fee
- Membership that is open to all organizations and individuals
- Operating rules that ensure transparent governance and democratic participation, ensuring all TC members have the same rights
- Public reviews, comment facilities, and other channels to allow non-members to provide input

Each TC operates independently in which members determine the scope and set the technical direction. Members also elect their own chairs, make decisions by consensus, and approve their work by open ballot. They choose a licensing mode from a set of options curated by OASIS. Most TCs operate under a Non-Assertion IP mode, although three other options are available.

A TC or its output must avoid appearing to endorse any particular products, services or companies. Therefore, it generally is not acceptable for a TC to include manufacturer lists, service provider lists, or similar material in the text of a Standards Track Work Product (or the equivalent). Committees may elect to supply or point to provider-neutral lists of known implementation claims in informative statements or on their web pages.

The primary deliverables of an OASIS TC are its Work Products. These are descriptive, narrative documents and associated materials such as schemas, data dictionaries, UML models, or other associated content that address the scope of work described in the TC's charter.

Work Products may be either Standards Track Work Products intended to specify how to implement some data interchange format, protocol, process definition, service protocol, etc., or Non-Standards Track Work Products intended to provide ancillary information to assist in understanding and implementing the Standards Track work. Non-Standards Track Work Products may not contain Normative content except as excerpts from a Standards Track Work Product.

3.1.3.1 Products

In general, the content of a Work Product is the domain of the participants in the TC who are presumed to be the SMEs in their field and best positioned to know both the solutions that must be developed and the optimum way to organize and present those solutions to their community.

For Standards Track Work Products:

- All normative computer language definitions must also be provided in separate plain text files;
- Each text file must be referenced from the Work Product; and
- Where any definition in these separate files disagrees with the definition found in the specification documentation, the definition in the separate file prevails.

A Standards Track Work Product that is approved by the TC at the Committee Specification Public Review Draft, Committee Specification or OASIS Standard level must include a separate section, listing a set of numbered conformance clauses, to which any implementation of the specification must adhere in order to claim conformance to the specification (or any optional portion thereof).

OASIS follows a common Standards Track Work Products scheme with:

1. Committee Specification Draft – drafts can be developed, revised and re-approved any number of times as the TC decides. A majority of TC voting members are required to approve a draft.

2. Committee Specification – a public review must be conducted for a draft to become a Specification. This public review includes the OASIS Membership, any external stakeholders identified by the TC, and optionally any other public mail lists or venues. The OASIS' Intellectual Property Rights (IPR) disclosure will have to be issued for anyone challenging any draft-associated OASIS IRP claims. The TC must acknowledge the receipt of each comment, track the comments received, and post to its primary and comment e-mail lists its disposition of each comment after the end of the review period.

   The TC may conduct any number of public reviews. The initial public review of a draft must take

place for at least 30 days, and any subsequent reviews must be held for 15 days. Changes made to a committee draft after a review must be clearly identified in any subsequent review, and the subsequent review shall be limited in scope to changes made in the previous review.
Any material changes to the draft – based on comment resolutions or other inputs – require another public review. Non-material changes and edits do not require another public review.

The approval of a Committee Specification shall require a Special Majority Vote. The TC Chair shall notify the TC Administrator that the TC requests a Special Majority Vote for the advancement of the draft as a Committee Specification and provide the TC Administrator with any other required information. The TC Administrator shall set up and conduct the ballot to approve the Committee Specification.

Approval of an OASIS standard is then a multi-step process:

1) Submission of a Committee Specification to the TC Administrator as a candidate for OASIS standard,
2) Completion of a public review lasting a minimum of 60 days, and
3) A call for consent to approve the Committee Specification as OASIS standard.
4) A potential single, second call for consent after addressing negative comments.

3. Approved Errata - A TC may approve a set of Errata to an OASIS standard that it developed by:

a. Adopting the set of proposed corrections as a Committee Specification Draft, in the form of a list of changes, and optionally accompanied by a copy of the original OASIS standard text marked to incorporate the proposed changes,
b. Confirming by Full Majority Vote that the proposed corrections do not constitute a Material Change,
c. Submitting the proposed corrections for a 15-day public review, and completing that review, pursuant to Section 2.6, and
d. After the public review, confirming the proposed corrections as Approved Errata by a Full Majority Vote.

Once approved, the Approved Errata shall be made available with the OASIS standard it corrects, in any publication of that OASIS standard. A TC may not adopt Approved Errata to an OASIS standard more than once in any six-month period.

3.1.3.2 Technical reports, specifications, standards

OASIS standards are approved within an OASIS Committee, submitted for public review, implemented by at least three organizations, and finally ratified by the Consortium's membership at-large.

OASIS has developed several policies and guidelines describing how certain standards, rules and conducts are performed by members (see https://www.oasis-open.org/policies-guidelines/).

3.1.3.3 Cycle / Process

As shown on the OASIS website (https://www.oasis-open.org/standards/), most standards and specifications managed by OASIS are able to be downloaded free of charge.

3.1.3.4 Development Support

OASIS TCs that wish to develop TC chartered deliverables using dedicated version control system support may request the creation of GitHub public repositories and/or a Subversion (SVN) repository. Whereas SVN

repositories are allocated on a one-per-TC basis, multiple GitHub repositories may be requested by any TC for distinct development projects. Each GitHub repository will be configured using the default setup to support issues tracking, project boards, and a Wiki instance. For more information, see https://www.oasis-open.org/policies-guidelines/github-repositories-for-oasis-tc-members-chartered-work/.

3.1.4 Sustainability

Once an OASIS standard is developed and approved, it falls under Standards "Maintenance Activity". Maintenance Activity on an OASIS standards Final Deliverable is always within the scope of the TC that created the deliverable, whether or not the TC's Charter explicitly references it.

3.1.4.1 Funding / Resources

OASIS funds itself via different means, including:

1. Organization / member organizations pay a yearly fee.
2. FaaS pay a yearly fee for Core Services and an *a-la-carte* Fee for optional services.
3. Membership donations (voluntary and limited).
4. Sponsorship via privately and/or publicly funded projects or contributions.

Volunteers are largely assumed to pay their own way for both labor and travel costs but can be sponsored by private companies or via partnerships with public agencies especially for ANSI-related international standards work.

3.1.4.2 Deployment

OASIS supports national and international implementation and deployment workshops to promote the deployment of developed standards and specifications.

Source Information: The contents about OASIS were largely obtained in July 2024 from OASIS' webpage and documents contained there.

3.2 Open Mobility Foundation (OMF)

3.2.1 Organization Overview and Background

Established in 2019, the OMF is an open-source organization focusing on mobility-centric data standards. OMF developed the Mobility Data Specification (MDS), which encompasses a set of Application Programming Interfaces (APIs) and code projects that support standard communications between cities and vulnerable roadway users to enhance safety. MDS was initially created in 2018 by the Los Angeles Department of Transportation to help local planners effectively administer micro-mobility programs, including shared dockless e-scooters. Founding municipal members of OMF include Austin, Bogota (Colombia), Chicago, Los Angeles, Louisville, Miami, Miami Dade, Minneapolis, New York City DOT, New York City Taxi and Limo Commission, Philadelphia, Portland, San Francisco, San Jose, Santa Monica, Seattle, and Washington DC. Currently, OMF specifications cover MDS and Curb Data Specification (CDS), with plans to cover specific passenger transportation services.

OMF is legally a subsidiary of OASIS Open yet operates, is funded, and is governed independently. The OMF is a non-profit membership organization under 501c6, financed by membership fees and philanthropic contributions.

3.2.2 Governance

OMF structure contains a BoD that consists of public entities responsible for managing the public right-of-way. The BoD oversees three committee groups: 1) Strategy Committee, 2) Technology Council, and 3) Privacy, Security, & Transparency Committee. Under the purview of these three committees are two working groups, one focused on MDS while the other is focused on CDS. Both working groups include OMF members from both the public and private sectors. The Working Group Steering Committees collaborate and oversee their respective working groups. The OMF networks also coordinate with the three committees to plan and implement public-facing events, roundtables, and discussions.

3.2.2.1 Leadership

OMF's leadership consists of a BoD and an Executive Director. To secure a BoD role, an individual must be a public or governmental agency employee and be appointed to a two-year term, with the exception of founding members who serve to ensure institutional knowledge. The Municipal Member employer must nominate one of their employees as a candidate to be considered as a Board member. If the board member discontinues employment with the sponsoring Municipal Member that nominated them to be on the board, then their tenure as a Board member will cease. To fill a vacancy on the board, an election is directed by the Executive Director and each Public Member votes among the nominees. The Board has the option to adopt a resolution to establish member classes that reflect participation or geographic diversity. The Board is responsible for the hiring and termination of the Executive Director.

3.2.2.2 Membership

An application must be submitted to become an OMF member. While OMF membership is free for cities and government agencies, private sector members pay annual dues that vary by company size. In addition, the OMF solicits voluntary financial contributions from city members. Members may obtain a leadership role, participate in one of the three committees, or engage in member networks. A member may be appointed as a liaison to a committee. There are two membership levels offered by OMF, Premier and Associate. Premier members are eligible to be elected to the Technology Council, serve as voting members in committees, or chair a working group steering committee. To maintain eligibility as a Technology Council member, the candidate must be and remain during their term an employee or Appointed Representative of a Member of the Foundation, with at least two-thirds of the members representing Non-Public Members of the Foundation. Technology Council members are subject to one-year terms for which then they are up for re-election.

Individual contributors are encouraged to participate in software development activities or collaborate in

committees. Contributors must review and sign Contributor Guidelines that cover OMF's bylaws, code of conduct, and redistribution policies. While OMF engages in an open recruitment process to attract members and interested contributors, the foundation may actively work to fill vacancies by advertising positions via its networks publicly (e.g., LinkedIn) and privately.

3.2.3 Development Cycles

3.2.3.1 Products

OMF embraces a hierarchical structure for its development process of data standards, software tools, and documentation. The BoD provides guidance and priorities, which then is translated by the Technical Council to establish objectives for the architecture and design of each specification they manage including MDS and CDS. The working groups coordinate and strategize under these established guidelines to design and modify the specification accordingly. In realizing that ideas and suggestions may arise from working groups, the Strategy Committee provides direction, while the Privacy, Security, and Transparency Committee reviews the work and provides guidance. Work products created by OMF include:

- Periodic reviews and updates of MDS (e.g., API specifications)
- Technical reports
- Implementation tools
- Use cases
- Reference implementation
- Best practices
- Testing tools
- Privacy checklists
- Implementation of the State of Practice
- Privacy and Security Guide
- General Data Protection Regulation (GDPR) Guidance (European adoption of MDS)

It is not uncommon for reference implementation documents to lag the release of a MDS or CDS update due to limited time and resources.

On the topic of data privacy and security, OMF serves as a clearinghouse for proposed methods that are not limited to data minimization, anonymization, and aggregation.

3.2.3.2 Cycle / Process

OMF undergoes a three-step approval process to develop standards and other technical reports. Any interested individual can contribute to OMF. OMF uses a GitHub site (github.com/openmobilityfoundation) to address issues raised by its members. Members may propose code changes to a specification, which is then elevated to the appropriate OMF working group. The working group then allows for public participation in the meetings to maximize transparency and thorough vetting to address the need for a change to the specification. Once a working group reaches a consensus with changes to the specification, the Working Group Steering Committee reviews and approves a release candidate (RC). Next, the Technology Council determines whether the release aligns with the OMF's technology framework and addresses business needs. The last step in the approval process is a review by the BoD, which ensures that the specification modification is aligned with city needs and policy prerogatives.

To make updates to a specification, OMF describe guidelines for implementation as listed in **Table 1**. This implementation framework is described in the OMF Architectural Landscape document (https://github.com/openmobilityfoundation/governance/raw/main/documents/OMF-MDS-Architectural-Landscape.pdf, 2021).

Table 1. OMF Specification Update Guidelines

Guidelines	Description
Design must be need-driven	All new features must respond to a distinct business need of MDS that is not adequately met by existing features.
Ensure each feature/endpoint has a clear purpose	To the extent possible, each feature should serve a specific purpose or business need, exchanging the minimum amount of data possible to meet that need.
Design for consistency and interoperability across features	Build modular components that share consistent formats and identifiers to serve as a "kit of parts", allowing for flexibility in how sets of features can be implemented to meet the needs of a specific context.
APIs must be usable for both producers and consumers of MDS data alike	Features must meet the needs and technical capabilities/resources of both producers and consumers, or they will likely go unused and become "orphan" features within the specification.
New features should be discussed by community before formal inclusion in specification	To ensure that new features are meeting the needs of the broad MDS stakeholder community and aligned with our principles, it is important for new ideas to be discussed and refined before being added to the specification.
Allow for experimentation and incremental design	Encourage experimental features and informal extensions outside of formal releases or with a 'beta' designation. All extensions and experimental features should be published and discoverable, allowing them to be auditable by the MDS community. The Technology Council shall develop criteria for vetting potential speculative features. At a minimum, the addition of a new feature or the modification or deletion of an existing feature must be co-sponsored by both a producer and consumer of data via that API.
Design for future expansion and flexible application	We aim to build features that meet the needs of today while supporting the larger vision for MDS. We prefer design patterns that work for multiple modes of transportation and support a variety of policy implementations that cities may want to pursue.
Allow for flexibility in technology stack	MDS will be implemented in a variety of contexts and technology environments. Any code managed by OMF should be implementable in a variety of software ecosystems and be minimally prescriptive about the technology stacks that end users choose to implement MDS code. MDS specification should be machine-readable in a way that can be interoperable in a variety of programming languages and tools.
Support low/no-cost deployment environments	The design of new MDS functionality should not require paid or private services or platforms to function. For example, OMF should not pick a cloud-provider and build software features that can only be implemented on that provider.
Design for individual privacy	MDS should be designed to protect individual privacy while enabling digital right of way management. Where appropriate, the specification should incorporate features that support data minimization, aggregation, anonymization, and other approaches to privacy protection. The Privacy, Security, and Transparency Committee should be consulted when new privacy features are introduced.
Plan for privacy and security at every stage of development	Because mobility data is often sensitive, privacy and security considerations should be reviewed throughout the development lifecycle. Privacy and security considerations should be incorporated in both technical implementations and any accompanying documentation and guidance. The Privacy, Security, and Transparency Committee should be informed of proposed privacy changes within the release development timeline.

When a new version of the specification is released, OMF recommends phasing out the outdated version. However, to ensure that users have time to adapt, support is provided for six months after an updated release is made publicly available. Additionally, OMF recognizes the need for versioning and backward compatibility as some cities may need to continue to require non-recommended versions of MS due to operating permit conditions.

Reference implementations are developed by OMF to assist developers and users with implementing or integrating MDS in addition to serving as a tool for testing software, verifying data needs, and refining API implementations. The landscape architecture document also discusses the need for full-scale reference implementations for the development of plug-ins, which can add new capabilities that may be either official stand-alone applications or be integrated into future references.

Understanding that MDS has a broad range of users, which thereby leads to inconsistencies in different implementations of MDS, MDS can offer certification and conformance testing to verify that data is consistent, interoperable, and reliable. This also helps inform OMF's development of tools and best practices for implementation. OMF also provides guidance and supports the notion of users and cities enforcing compliance and conformance through Service Level Agreements.

Data privacy and security considerations are a focal point for OMF, and opportunities within MDS should be explored to mitigate the need to store privacy-sensitive data without compromising the overall validity of raw data. The Privacy, Security, and Transparency Committee leads the efforts to establish policy, guidance, and best practices in this area.

3.2.3.3 Development Support

As previously indicated, OMF uses GitHub to propose issues and solutions related to its specifications. Prior to gaining consensus via voting on a modification to MDS or the CDS, OMF undergoes a series of verification and validation activities to ensure that the change is seamless and upwardly compatible before being published. Tested components include interoperability with APIs, data security and privacy, penetration testing, and auditing.

OMF has identified user personas so that interested parties can better leverage the specifications to meet their organizational goals and objectives.

OMF ensures adequate transparency and public engagement before deploying a standard. Consensus among the public entity members is critical in ensuring that modifications to managed specifications are approved since they are deployed by cities and other local public entities. OMF recognizes two categories of deployment efforts, “sanctioned” and “unsanctioned,” by their working groups, committees, and broader membership. The former reflects policy goals and priorities set by the organization’s BoD which are vetted by the Technology Council to working groups and committees. Examples of sanctioned work include ongoing maintenance or updates to existing MDS features or the development of new features approved by the organization’s leadership. Unsanctioned work is also referred to as “community projects,” which encompasses any efforts conducted outside of the scope of OMFs bylaws, such as experimental or speculative development of new MDS features. OMF is working to develop a process for transitioning successful unsanctioned work to sanctioned features of the MDS or CDS as well as establishing “exploratory committees” to formalize the efforts of unsanctioned work.

3.2.4 Sustainability

3.2.4.1 Funding

The foundation is funded through a number of sources. Commercial members contribute annual dues to the OMF, which fluctuate based on the size of the company (determined by the number of full-time employees) and the chosen membership tier. To understand more about membership levels, refer to the current dues schedule found at https://www.openmobilityfoundation.org/wp-content/uploads/2022/08/2022-OMF-Overview-Commercial-Membership-Dues.pdf. The OMF has also been a recipient of funds from the

Rockefeller and Knight Foundations, as part of their continuous efforts to aid communities and promote safety. Moreover, funds may be derived from an approved activity that generates revenue, as well as cash or in-kind services from members or non-members that are approved by the Board. These funds are restricted to fund administration costs and cannot be used to pay for "core expenses," which are defined as a direct cost of staff salaries and compensation.

3.2.4.2 Deployment

The OMF GitHub site includes a robust open-source software (OSS) repository that includes engineering specifications, APIs and software to implement, test and consume its sanctioned specifications. OMF does not directly implement or host software and does not manage data from MDS/CDS implementation efforts. However, OMF recognizes that planners, policymakers, and other personnel within transportation departments may not have the technical capacity to understand its specifications and engineering specifications and APIs. Thus, OMF is committed to adapting, producing, and providing resources to help such stakeholders develop the necessary skills to leverage the specification and other tools published on its GitHub site. Such resources may include webinars, conference content, blog posts, case studies, and other content. To further support the deployment of its specifications, OMF is actively adding documentation, purchase specifications, implementation examples, and guidance. OMF is also coordinating with Mobility Service Providers (MSPs) to streamline data and metrics from raw data shared by cities. Moreover, OMF leverages the experiences and knowledge of its members and stakeholders to develop use cases and best practices to ultimately advance policy and service implementation.

OMF catalogs users who are relying on MDS to highlight examples of real-life applications (OMF Architectural Landscape, 2021). This also enables OMF to share "minimum viable products" to exemplify less advanced approaches to implementing MDS or CDS, which may be useful for new or smaller cities seeking to use the specifications. While OMF identifies and produces its own resources, it also leverages resources created by its members or community contributors and publicizes such content following a vetting process. Examples of a minimum viable product (MVP) according to OMF include:

- **Mobility Data Sharing Platform**: An MVP could include a simple dashboard that allows users to view mobility data (like traffic patterns) but lacks advanced analytics features. This could help generate interest in data sharing among stakeholders.
- **Mobility as a Service (MaaS) Integration**: An MVP could allow users to plan multi-modal trips (e.g. bus and bike) with minimal route options, testing the core functionality before adding payment integration or personalized recommendations.
- **Data Analytics Dashboard for Cities**: A simple visualization tool that displays a limited set of mobility metrics (e.g., traffic volume, peak hours) to assess user engagement and gather feedback on data needs.

Source Information: The contents about OMF were largely obtained in July 2024 from OMF's webpage and documents contained there including the FAQ and Bylaws.

3.3 MobilityData

MobilityData is a global, nonprofit, membership-driven organization dedicated to developing the open-source data formats that provide traveler information.

3.3.1 Organization Overview and Background

3.3.1.1 History

MobilityData's origin traces to the development of the Google Transit Feed Specification initiated by Google and TriMet (Portland, Oregon), based on TriMet transit schedule data. In 2006, Google Transit Feed Specification began to be successful worldwide, and its name was changed to General Transit Feed Specification (GTFS) and opened to an informal grassroots community. In 2011, the specification was extended to provide realtime updates using GTFS-realtime. In the 2010s, the data format started to splinter due to a lack of synchronization in the community, with different organizations developing different versions. In 2015, the GTFS community started a project hosted by the Rocky Mountain Institute, aiming to realign the GTFS community and practice by consolidating the diverging practices. This effort led to the creation of MobilityData as an independent organization in 2019, headquartered in Montreal, Canada. Today, there are over 20 staff, with an international BoD, and over 120 member organizations from all over the world.

The GTFS family of standards has grown to include additional transit service specifications, including flexible transit, fares, pathways, vehicles, and ridership. In 2023, the Federal Transit Administration (FTA) began requiring recipients of federal transit funding to use the GTFS format in their regular reporting to the National Transit Database (NTD).

Additionally, in June 2019, MobilityData was selected to manage the General Bikeshare Feed Specification (GBFS) by the North American Bikeshare and Scooter-share Association, replicating the approach refined in the public transit sector into the shared mobility sector.

MobilityData has also since been asked to manage and maintain related efforts, including the Mobility Data Interoperability Principles (MDIP), the Transit ITS Data Exchange Specification (TIDES), and the Transit Operational Data Standard (TODS).

MobilityData publishes a growing Mobility Database (https://mobilitydatabase.org/) that contains a list of over 2,000 mobility feeds from across the world. The Mobility Database provides data quality reports from the Canonical GTFS Schedule Validator to enhance data transparency and quality, aiming to become a "sustainable, central hub for global mobility data."

In addition, MobilityData supports the GTFS GitHub repository (https://github.com/google/transit#readme), GTFS best practices site (https://gtfs.org/), and GTFS Data Quality Tools (including the canonical validator used to validate FTA NTD submissions) - https://gtfs.org/schedule/validate/.

They also support the GBFS GitHub site (https://github.com/NABSA/gbfs#general-bikeshare-feed-specification), best practices site (https://gbfs.org/), validator site (https://gbfs-validator.mobilitydata.org/?_gl=1*7u63jq*_ga*MjAxMDE3NjUwOC4xNzE4NzIxNTE4*_ga_55GPMF0W9Z*MTcyMTEzNTA3Mi41LjEuMTcyMTEzNTQzNS4wLjAuMA..) and discovery tools (https://github.com/MobilityData/gbfs/blob/master/systems.csv)

3.3.2 Governance

MobilityData governance includes a set of principles, leadership and membership rights, and voting rules.

The key principles described on MobilityData.org include:

- **Focus on the traveler experience.** By developing and supporting work on mobility specifications.

- **Exemplify openness of data formats, software, and governance.** By making the core of our work the development of systemic solutions with open data formats, open tools and an open governance process.
- **Develop specifications that support interoperability.** By focusing on projects that enable information exchange between different data sources.
- **Bring stakeholders together from across the industry to build a shared vision.** By intentionally seeking out a broad variety of viewpoints to achieve a common vision and to develop solutions.
- **Prioritize individual privacy.** By taking a principled approach to evaluating and managing potential privacy risks.

MobilityData is a membership organization composed of a BoD, organizational members and executive team that are responsible for managing the organization on a day-to-day basis, including a team with expertise in policy and technology, senior developers, and data specialists.

3.3.2.1 Leadership

MobilityData's BoD is composed of international representatives and provides MobilityData with guidance while making sure that the organization stays true to its vision.

3.3.2.2 Membership

MobilityData organizational member benefits include:

- Voting Rights:
  - elect BoD and vote for revisions in bylaws

- Open-Source Development
  - underwrite specification work
  - participate in working groups to accelerate standard development

- Networking
  - participate in Community of Practice and peer-learning
  - participate in events including workshops and annual meetings

- Resources / Training
  - have access to the resource library

The technical development cycles are open processes which include the broader community, described as "any stakeholder worldwide who is part of the ecosystem [from] the public and private sector." The technical voting governance allows anyone from the community—not limited to members—"to be part of, express their vote, use, consume or produce the data, etc." Additionally, anyone from the community can submit a proposal for consideration, review and adoption.

3.3.3 Development Cycles

MobilityData describes different types of development processes – specification process and change process.

3.3.3.1 Development Process

MobilityData-led specifications are open projects that aim to extend and improve official mobility data formats (such as GTFS and GBFS). Transit agencies, software developers, and other stakeholders in the community actively participate in specification improvements and extension development.

MobilityData oversees development projects by monitoring the relevant debates, offering expertise, and

directly managing extension proposals. They facilitate the creation, adoption, and extension of mobility data formats that provide traveler information. The process is as follows:

Spark Management. A need for a specification improvement or extension is expressed by the community or by the staff team. MobilityData records this need and gives it a priority level according to members' interests.

Needs Analysis and Scoping. When the spark becomes a priority, MobilityData conducts a needs analysis that documents real-world use cases and helps with scoping the project. Members and the community are consulted to consider related use cases.

Data Model Drafting. Once needs and scope are defined, MobilityData drafts one or several model options that will allow transcribing these real-world use cases into data. The model options are then submitted to the members and the community for feedback so they can select their preferred option.

Seeking Implementations. When consensus has been reached on a model option through analysis of the feedback provided by the members and the community, MobilityData gathers data producers and data consumers together to facilitate the first implementations, and to ensure that the project is reality-proof. A vote on the project is then held according to the specification amendment process.

Specification Support. Once the project is adopted, MobilityData continues to provide support by creating training content around the project and by incorporating any new specifications in open tools such as data validators, grading schemes, or dataset repositories.

3.3.3.2 Products

The types of products that are provided by MobilityData include:

- Standards and specifications, including the engineering specifications
- Testing or validation tools
- Training and best practices guides
- Reference Implementations and Engineering Specifications to validate and verify the specifications prior to final adoption

3.3.3.3 Change Process for GTFS and GBFS

MobilityData published two development and update processes, one for GTFS and another for GBFS.

Changes to GTFS consist of the following steps:

Step 1 – Idea: Someone shares an idea for a new feature as an issue on the GitHub repository. This can be anyone across the world.

Step 2 – Feature Proposal: A proposal is shared on how to implement this feature in the specification.

Step 3 – Feedback: Anyone can read the proposal and provide feedback. MobilityData facilitates workshops to resolve issues.

Step 4 – First adopters: One data producer and one data consumer commit to implementing the new feature as first adopters.

Step 5 – Dataset published: The first adopters share their dataset with the new feature to get feedback and insight from the public.

Step 6 – Public Vote: The proposed change goes to a vote. Anyone can vote and the vote is made

based on consensus.

Step 7 – Adoption: The new feature is added to the official specification. Transit operators and trip planning applications across the world can now use it.

Changes to GBFS consist of the following steps:

The GBFS is used in over 40 countries, allowing shared mobility operators to share their data with trip planning applications. Anyone in the world can propose changes to the specification and vote on adopting new features.

Step 1 – Idea: Someone shares an idea for a new feature as an issue on the GitHub repository. This can be anyone across the world.

Step 2 – Feature Proposal: A proposal is shared on how to implement this feature in the specification.

Step 3 – Feedback: Anyone can read the proposal and provide feedback. MobilityData facilitates workshops to resolve issues. Discussion on changes are open for at least 7 calendar days.

Step 4 – Vote: The proposed change goes to a vote. Anyone can vote and the vote is made based on consensus. Votes are open for a total of 10 calendar days. A successful vote must have at least 3 votes not including the proposer.

Step 5 – Release Candidate (RC) version status: The change is placed into RC status. The change remains in RC status pending implementation. During this time, the change is added to the GBFS validator.

Step 6 – Adoption: The change is adopted when it is implemented by at least one GBFS producer and one BFFS consumer.

Step 7 – Official version status: Once the feature is adopted it can be implemented by different data producers and consumers.

3.3.4 Sustainability

3.3.4.1 Funding

The organization and all product development activities are underwritten by membership fees, donations and volunteers.

3.3.4.2 Publication

Standards are posted on a GitHub site, free of charge. Also, all tools, best practices and supporting software are available from the organization's GitHub site. Additional discovery tools are available for free as well.

Parts of the resource library are reserved for memberships only. Other parts are published on the organization's website.

3.3.4.3 Deployment

Deployment of the specifications are voluntary, however, the more commercial applications that consume and rely on the open specifications help drive the continued management of the standard – this is true for both GTFS and GBFS, the two largest product families published by MobilityData.

There are many data management tools that support the creation, collaboration and maintenance of GTFS

and related family of GTFS data including Slack and GitHub. There are also enumerable applications that consume GTFS family of specifications. Europe endorses competing formats, however, the market share of GTFS worldwide is significant – used by large internet companies as well as domain providers. Additionally, USDOT/Federal Transit Administration recently identified GTFS as a reporting requirement for recipients.

Source Information: The contents about MobilityData were largely obtained in July 2024 from MobilityData's webpage and documents and discussions with staff.

3.4 Work Zone Data Working Group (WZDWG)

The Work Zone Data Working Group (WZDWG) is the organization responsible for developing the Work Zone Data Exchange (WZDx) Specification. The working group has since been subsumed by the Connected Work Zones Standard Implementation (CWZ standard) effort; CWZ may be considered the standardization of the specification.

3.4.1 Organization Overview and Background

According to the Federal Highway Administration (FHWA), initial work on the specification was carried out by data producers and data users, led by USDOT agencies, including the FHWA and the Intelligent Transportation Systems Joint Program Office (ITS JPO). The working group was established in 2019 to continue development of the specification to a version 2. Multiple updated versions have since been developed.

The effort was initiated by the USDOT as a user led organization. Although early recruitment and leadership was initiated by USDOT, primary participants were recruited from state, academic and vendor organizations (traveler information and smart work zone equipment manufacturers) who fully engaged in developing the specification.

USDOT continues this work by sponsoring the CWZ standard. The specification is currently being formalized into a standard lead by Institute of Transportation Engineers (ITE) (with the American Association of State Highway Transportation Officials (AASHTO) and National Electrical Manufacturers Associations (NEMA)) and SAE International (SAE).

The WZDx specification defines a common language that describes work zone information that infrastructure owners and operators (IOOs) may use to communicate road events. The goal is to allow this information to be more accessible, resulting in safer roads.

3.4.2 Governance

The WZDWG is chartered under the Transportation Subcommittee (TSC) of the Federal Geographic Data Committee (FGDC). Members include individuals and organizations in the public sector, private sector, and academia. According to the group's charter,

> "[the TSC] provides leadership and direction in the use and development of transportation geospatial data and information across federal geospatial programs. . . . The scope of the WZDWG is to incorporate information on work zone activity in planning, real-time, and historical operational contexts. . . . The WZDWG will establish an independent, sustainable Work Zone Data governance organization that will eventually lead the work of maintaining the work zone data standard, soliciting representative involvement from the broad spectrum of work zone data stakeholders" (WZDWG Charter).

There are multiple types of members: Chair, Co-chair, voting member, and non-voting member. All members of the working group, including non-voting members, could contribute feedback and input during the development of the specification. Voting members voted on changes and updates to the specification.

3.4.2.1 Leadership

Leadership was assigned from the federal agency, as well as public, private, or academic agencies, organizations, or institutions. The Working Group Chair was designated from a federal agency in which the USDOT nominates one person to assume that role. Co-chairs were voted in by the membership from the public, private, or academic agencies, organizations, or institutions. Additional information on membership is

available in the next section. The Chair and Co-chairs were elected annually.

3.4.2.2 Membership

Similar to how the working group is chartered under the TSC, the working group included subgroups chartered under WZDWG. These subgroups were created as needed to focus on specific areas of the specification, such as technical assistance and worker presence. These subgroups also contain elected Co-chairs.

In order to become a voting member, one must be the only voting representative from their organization, and this organization must be publishing or consuming work zone data. Ideally, one was a senior leader with decision making authority in a position to drive adoption in their organization. Voting members were able to be elected as Co-chairs. For a voting result to be accepted, agreement must exceed 75% of votes with at least four data producers and four data users participating.

More information about the four types of members and their roles are available in **Table 2**.

Table 2. WZDWG Membership Types and Roles

Member type	Chair	Co-chair	Voting member	Non-voting member
Provide feedback and input on GitHub	X	X	X	X
Vote on pull requests and elect co-chairs	X	X	X	
Required to attend at least two WZDWG meetings a year	X	X	X	
May volunteer for membership in subgroups and attend their monthly meetings	X	X	X	
Approve minor changes to the specification	X	X		
Responsible for overseeing subgroup activities	X	X		
Announce and conduct WZDWG meetings at least semi-annually	X			

The working group was open and anyone could participate in issue discussions or pulls on the GitHub repository, WZDWG meetings, and peer review activities.

3.4.3 Development Cycles

3.4.3.1 Products

The main product of the WZDWG is the WZDx Specification. The specification describes the format and content of GeoJSON data feeds. There were also subgroups that dealt with specific topics such as best practices, work zone personnel, work zone smart devices and more.

3.4.3.2 Cycle / Process

The development of the WZDx Specification was cyclical:

- At the beginning of the cycle, the working group solicited issues and suggestions for improvement to the specification from members and subgroups and proposed a schedule.
- Over a period of several months, a new version took shape as meetings were held to discuss the issues and suggestions.
- Near the end of the cycle, voting members reviewed the proposed changes and voted “yes,” “no,” or “neutral” on each item. The voting period is a minimum of 10 days, and votes were cast via

SurveyMonkey.

- A new version was published on GitHub. Usually, the new version has an incremented major number if updates made the version non backwards compatible with previous versions. Otherwise, the minor number is incremented.
- A few months passed before the next meeting initiated the next development cycle; meanwhile, new issues, discussions and suggestions were accumulated on the GitHub repository.

3.4.3.3 Development Support

The WZDx Specification is completely free and available to the public online on GitHub. Additional information such as project background, meeting minutes and recordings, issues and discussions, guidance documents, previous versions, and version histories are also publicly available. GitHub is the primary collaboration place for the specification.

3.4.4 Sustainability

3.4.4.1 Funding

A majority of the WZDWG members were volunteers, and because a majority of the work in developing the specification occurred remotely, online (web conferences, collaborations on the GitHub repository), the cost to sustain the working group was minimized.

Overall, the annual cost to run the WZDWG was estimated to be in the range of $250,000 to $500,000 according to the meeting minutes from the August 4, 2021 WZDWG Open Governance Conversation. The cost includes support for convening and facilitating the working group and its subgroups, as well as communication and outreach. The estimate includes the cost for USDOT staff who were also involved in leading meetings and hosting and maintaining the GitHub repository (source: https://github.com/usdot-jpo-ode/wzdx/wiki/WZDWG-Open-Governance-Conversation).

To accelerate the adoption of WZDx, the USDOT funded the WZDx Demonstration research program in January 2021. The demonstration grants awarded almost $2.4 million to transportation agencies in 13 states to fund projects related to WZDx deployment. The goal was for these project deployers to share technical expertise learned from their deployment with the working group.

3.4.4.2 Deployment

Multiple agencies have deployed WZDx feeds, including state and municipal transportation departments. USDOT collects and validates these feeds before providing them in the Work Zone Data Exchange Feed Registry, a webpage available to the public. As of July 2024, there are 25 entries in the registry. Almost all of the WZDx Demonstration grant awardees have feeds on the registry.

Examination of the feed URLs reveal the private sector companies that play an integral part in making this data available. While public agencies may be responsible for the project of deploying a feed, it is the private sector that provides the equipment, data handling, and storage necessary to bring it to fruition. Therefore, it was important that these companies were present during the development process of the specification.

The GitHub site includes implementation guidance and best practices for creating a WZDx feed.

3.4.4.3 Moving the Specification to a Standard

The WZDx Specification underwent multiple revisions over the years, ultimately stopping at version 4.2 (published February 2023). Work on the specification evolved into the development of the USDOT-sponsored CWZ standard, starting in 2022, with the goals of addressing gaps and ambiguities identified by

early deployers of WZDx and consolidating other standards efforts such as in connected vehicle technology in order to achieve interoperability of future CWZ deployments. The current standard follows a systems engineering process, comprised of a concept of operations, user needs, and requirements.

Because development of the CWZ standard started from the WZDx Specification, the working group for the CWZ standard includes individuals and organizations that also contributed to the WZDx Specification.

Source Information: The contents about WZDWG were largely obtained in July 2024 from their GitHub site and minutes from WG meetings.

3.5 OpenSidewalks

OpenSidewalks is an independent specification that is managed by the Taskar Center for Accessible Technology (TCAT) at the Paul G. Allen School of Computer Science in University of Washington.

3.5.1 Organization Overview and Background

OpenSidewalks was conceived to address a critical gap in accessible pedestrian infrastructure data. The project emerged from the realization that existing sidewalk data was often incomplete, inconsistent, or unavailable, posing significant challenges for people with disabilities who rely on detailed information about sidewalk conditions for safe and independent travel. Originally, funding was provided in 2016 by the UW eScience Institute for a Summer Data Science for Social Good project. The outcome was a US-based OpenStreetMap (OSMUS) talk and the generation of the first data schema for OpenSidewalks. https://uwescience.github.io/DSSG2016//2016/07/29/sidewalks-sotmus.html

The TCAT continued to support the development of OpenSidewalks to create a standardized data model for mapping pedestrian pathways, integrating accessibility attributes such as curb ramps, surface conditions, and sidewalk width. This initiative sought to democratize sidewalk data by leveraging the OpenStreetMap (OSM) platform, enabling community contributions and ensuring the data remains open and accessible to all. By engaging local communities, disability advocates, and urban planners, OpenSidewalks not only enhances the richness and accuracy of sidewalk data but also promotes inclusivity in urban planning and navigation. This project is integral to TCAT's mission of improving accessibility and quality of life for people with disabilities, and it continues to evolve through collaborative efforts and technological advancements.

Since 2018, OpenSidewalks was adopted as the data schema by which King County Metro's Paratransit operators are required to collect their digital record for the public right of way.

In 2023, a Washington State Proviso addendum allotted funds for the Taskar Center to create a unified state-wide pedestrian accessibility data collection encompassing all Washington state public pedestrian infrastructure in the OpenSidewalks data format.

By 2024, data digitized through the OpenSidewalks data format encompassed more than 1 million paths (including sidewalks and crossings). To our knowledge, this is currently the largest single schema dataset accounting for pedestrian infrastructure and pedestrian accessibility in the world.

OpenSidewalks specification was developed by the TCAT at the University of Washington. The specification was developed as an open schema (specification) to model sidewalk representation and annotation. (uwescience.github.io/DSSG2016-Sidewalks/, extracted 2024-07-01). The schema was designed to extend the OSM, a crowd-sourced map product.

3.5.2 Governance

Presently, the TCAT is developing the standard through a governance committee and a community of practice. Changes are proposed via an annual meeting of the community of practice. The proposals are voted on by the members of the committee. The Taskar Center is intending to change the governance of OpenSidewalks with wider adoption and the WSDOT participation starting in July 2025.

3.5.2.1 Leadership

Current leaders for OpenSidewalks are the Taskar Center development team. Leadership includes the researchers and their staff.

3.5.2.2 *Membership*

Membership is composed of a community of practice that participates in their GitHub site. The community of practice will move to include the public and institutional stakeholders who maintain data in the schema.

3.5.3 Development Cycles

3.5.3.1 *Products*

The products published on GitHub (https://github.com/OpenSidewalks) include the schema, GeoJSON validation and import tools, data collection tools, and data transfer/extract tools.

3.5.3.2 *Cycle / Process*

Any community member can propose changes during weekly schema meetings and an annual meeting of the community of practice. Both are open to the public. The final adoption decision is made through a vote by the Taskar Center Development team through a clear evaluation of the changes proposed against a set goal criteria. In 2025, governance structure will expand to include votes from the community of practice. In addition, the development process will change once the Washington State provision data is made available in the OpenSidewalks schema.

3.5.3.3 *Development Support*

OpenSidewalks uses Github as the current way they support schema proposals and versioning. GitHub is also used for online collaboration.

The specification team also developed guidance for data creation using OSM (https://github.com/OpenSidewalks/OpenSidewalks-Schema/blob/main/OpenSidewalks_Mapping_Guide_P1.pdf).

3.5.4 Sustainability

3.5.4.1 *Funding*

The sustainability of the schema is based on continued funding of grants and awards from local, state and federal sources and private donations. The project recently received a significant award from the USDOT ITS4US program to build a data repository and additional tools.

The schema description and import/transfer tools are open and free with no license or license restrictions. However, the Tasking Manager, a tool to manage the collection of data input into the OSM, includes a pay-as-you-go model for resource costs including hosting, staffing, data protection and technology support.

3.5.4.2 *Deployment*

OpenSidewalks has several deployment support tools.

The Transportation Data Exchange Initiative (TDEI), an ITS4US project (https://its.dot.gov/its4us/) generated several tools including the OpenSidewalks validator, schema verification tool, editor (modeled after OSM editors -- iD and RAPiD), data quality assessment tool, and a data connectivity assessment tool. All these tools are open and freely available to any data producer pushing data to the TDEI. As a producer, access to the TDEI is free.

OpenSidewalks submitted a proposal to OSM to incorporate the schema into the OSM tag references and best practices. Since the tools are linked directly to OSM, the guidance depends on updated practices of the OSM community.

OSM editing tools were configured to follow the practices promoted by the OpenSidewalks guidance. In particular, the data collection tool is based on the OSM Tasking Manager that is configured to collect sidewalk data using the OpenSidewalks schema and guidelines.

OpenSidewalks data has been the major contributing driver for the success of TCAT's personalized pedestrian routing platform, AccessMap. AccessMap is currently available in 13 regions worldwide. In the United States, AccessMap is available in Bellevue, WA; Columbus, OH; Los Angeles, CA; Mt. Vernon, WA; Portland, OR; Raleigh, NC; Seattle WA; Toppenish WA; and Washington DC. Internationally, AccessMap is available for Quito, Ecuador, Santiago, Chile, Sao Paulo Brazil, and Valparaiso, Chile.

Source Information: The contents about OpenSidewalks were largely obtained in July 2024 from their webpage and documents and discussions with staff (with Anat Caspi on 2024 July 30).

3.6 Open Geospatial Consortium (OGC)

The Open Geospatial Consortium (OGC) is an international voluntary consensus standards organization for geospatial content and location-based services, sensor web and IoT, Geographic Information System (GIS) data processing and data sharing. It originated in 1994 and involves more than 500 commercial, governmental, nonprofit and research organizations in a consensus process encouraging development and implementation of open standards.

3.6.1 Organization Overview and Background

OGC is a consortium of experts committed to improving access to geospatial, or location information. It connects people, communities, and technology to solve global challenges and address everyday needs.

The main topic areas covered by the OGC are:

- Defense and Intelligence
- Climate and Disasters
- Marine
- Smart Cities
- Metaverse
- Cloud Native Geospatial

The scope of these topics may be found on the OGC website at https://www.ogc.org/ogc-topics/.

The OGC provides a consensus process that communities of interest use to solve problems related to the creation, communication and use of spatial information. A community of interest might be those people who are interested in ocean observation, or those who are interested in 3D modeling of urban environments, or those interested in volunteered location information during disasters. The OGC facilitates dialog within and between the ten domains of interest (aviation, built environment & 3D, business intelligence, defense & intelligence (D&I), emergency response & disaster management, energy & utilities, geosciences & environment, government & spatial data infrastructure, mobile internet & location services, sensor webs, and university and research) leading to testbeds, pilot projects and interoperability experiments that deliver candidate interface and encoding specifications and best practices. These are vetted in the OGC standards Program. After thorough review, testing, public comment and refinement, they usually pass a vote to become adopted OGC standards packaged with associated compliance tests.

Spatial data and spatial processing, both simple and complex, can be integral to the Web and other networks only through open standards. The OGC's continual growth in membership since 1994 is evidence of the value members discover in belonging to this unique, collegial and efficient networking and standards-producing organization.

3.6.2 Governance

3.6.2.1 Leadership

OGC has a 14-member BoD who are all elected. Being a virtual organization, OGC has staff located and working in many different locations around the world. The chief executive officer is located in Maryland, their chief financial officer hails from Virginia and their Chief Standards Officer is in Colorado, while their chief technology officer is located in Germany. Their key expert staff is located in different countries around Europe; however, some are in Canada and even Australia. Their webpage lists 25 staff as of July 2024.

3.6.2.2 Membership

OGC represents over 450 businesses, government agencies, research organizations, and universities united with a desire to make location information FAIR – Findable, Accessible, Interoperable, and Reusable.

The members are listed by levels:

Strategic (9 members) including European Space Agency (ESA), GeoConnections – Natural Resources Canada, Ordnance Survey, United Kingdom Hydrographic Office, US Homeland Security, US Geological Survey (USGS), NASA, US National Geospatial-Intelligence Agency (NGA), NOAA

Principal (15 members) including Airbus, Amazon Web Services (AWS), CAE, Environmental Systems Research Institute (ESRI), GIS, FCU, Google, Maxar, Hexagon, Oracle, Trimble, US Census Bureau

Voting (59 members) including governmental agencies, non-profits, for profits such as Aechelon Tech, Ansys, Autodesk, British (BAE) Systems, Bentley, Conseillers en gestion et informatique (CGI), Bureau de Recherches Géologiques et Minières (BRGM), Cubic, Dassault Systems, European Union Satellite Centre, Federal Aviation Administration (FAA), Foursquare Labs, General Electric (GE), Geoscience Australia, HERE, Hitachi, European (EU) Joint Research Centre, Korean governmental agencies, Indian Governmental agencies, OASIS (see above under 'CBDO' listing), Norwegian governmental agency, USDOT, Wuhan University

Community (390 members) including governmental agencies, non-profits, for profit organizations from around the world.

The benefits of membership associated with each level are listed in **Table 3**. As shown in the table, only 'voting', 'principal', and 'strategic' membership categories are allowed to vote on standards and attend OGC's annual meeting (see https://www.ogc.org/about-ogc/benefits/); community members are not allowed to vote on standards.

The membership application indicates the annual fees to be paid by the different membership levels (see https://portal.ogc.org/files/4779):

Strategic: $255,000 (no reductions for academia or government or non-profit).

Principal: $65,000 (no reductions for academia or government or non-profit).

Voting: $27,000 for large business, $18,000 for medium business and national government agency, $12,000 for small business, startup, sub-national government agency, university, association, and non-profit.

Community: $18,000 for large business, $12,000 for medium business and national government agency, $5,000 for small business, sub-national government agency, $2,500 for startup, university, association, and non-profit, and $1,500 for individuals.

Members can decide themselves which level of membership they desire.

Table 3. Membership Level Benefits

Member Benefits	Community	Voting	Principal	Strategic	Value
Unlimited OGC portal Accounts	X	X	X	X	Access to exclusive member-only content for an unlimited number of member's staff
Networking, business intelligence and partnering	X	X	X		Easy access to the world's leading geospatial organizations

Member Benefits	Community	Voting	Principal	Strategic	Value
Summary Report from member meetings	X	X	X		One-stop source for the latest and greatest updates
Member promoted on OGC website	X	X	Logo on homepage	Logo on homepage	Brand awareness and promotion
Participation and voting rights in working groups and activities	X	X	X	X	Influence Working Groups and the Standards Roadmap
Complimentary registrations to OGC in-person member meetings	1	2	4	20	Save on registration fees and help build the community.
Eligibility for funding to participate Collaborative Solutions and innovation Program initiatives	X	X	X	X	Member-only financial support to participate in Testbeds and Pilots
Member Discount on certification (per test)	75%	75%	75%	75%	The basic member discount
Unlimited Certification Package Option		Unlimited after 4 paid Certifications	Unlimited after 2 paid Certifications	Unlimited after 1 paid Certifications	Substantial savings for technical and above members
Voting rights in the TC		X	X	X	Influence an adoption vote
Annual meeting with OGC leadership		X	X	X	Gain focused attention from OGC senior leadership
Executive Planning Committee membership and voting rights			X	X	Influence OGC policies, positions, adoption votes, and BoD
Dedicated staff hours			24	40	Senior OGC staff hours for your organization, customized to your requirements
Assigned membership			Community: 1 business, government, nonprofit organization (NPO) / university, and 2	Community: 2 business, government, NPO / university, and 4 Individual	Amplify your voice by inviting partners to actively participate in OGC for one year (Must become paying members to continue OGC involvement beyond

Member Benefits	Community	Voting	Principal	Strategic	Value
			Individual		first year.)

OGC's community is also broken up into several additional committees, forums, and partners to ensure that the consortium can deliver on its promise of being open, transparent, and FAIR. Their committees are the core of OGC with staff and member driven groups, their forums represent an entire globe of engaged leaders, and their alliance partners help the consortium tackle issues.

The purpose of committees versus forums versus partners are:

> **Committee** - OGC standards are the result of an international consensus-based process of technical content-development followed by intense review and formal vote.
>
> **(Regional) Forums** - OGC innovations, standards, and thought leadership are truly global and are represented by multiple forums. Each forum supports a range of functions to help organizations continue to evolve with industry best practices, interoperability, and the next generation of location technologies. To better support the many different regions that use OGC standards, OGC encourages the creation of regional forums that address the particular needs and circumstances of their regions.
>
> **(Alliance) Partners** - Geospatial information is a cross-cutting requirement that is critical to many different domains. As such, the OGC mission is aligned with the missions of many different organizations.
>
> **Committees are the core of OGC**: Member and staff driven groups that shape the future of the consortium. Without committees, the consensus-based process that OGC is known for would not exist.

The process is managed by four groups:

1. Technical Committee (TC)

- Voting privileges only accessible to OGC Technical members and above.
- Provides a consensus-based forum via:
  - Standards Working Groups (SWG) – Groups that work on standards (new or revisions) through the OGC Request For Comment (RFC) process.
  - Domain Working Groups – Groups that work on technology- or domain-specific requirements for interoperability.
  - Subcommittees – Standing groups providing recommendations to the TC or Executive Planning Committee (EPC) in specific areas.
- Coordinates development, modification and adoption of OGC standards.
- Evaluates, approves, and recommends standards and documents.

For more information, download the TC Policies and Procedures.

2. Executive Planning Committee (EPC)

- Voting privileges only accessible to OGC Principal members and above.
- Approves TC recommendations for the adoption and release of OGC standards, and for specification program planning.
- Provides technology impact planning for standards development.
- Guides OGC's market outreach strategies and messaging, including review of press releases.
- Recommends and votes on appointments to the OGC BoD.
- Handles relationships with OGC alliance partners.

- Provides guidance on OGC's Business Plan.
- Provides guidance on and vote for OGC Policies and Procedures documents.

The Executive Planning Committee is composed of OGC Strategic and Principal Members.

3. OGC Architecture Board (OAB)

- Membership by election
- Provides a forum to discuss OGC-wide standards architecture, OGC standards baseline lifecycle management, and consistency in architecture.
- Evaluates current technology issues and trends and identifies gaps to be addressed by OGC members.
- Uses the OGC Reference Model as guidance and reviews it when required.
- Recommends external liaisons beneficial to the consortium.
- Approves all OGC Collaborative Solution & Innovation Program Interoperability Experiments.
- Resolves consortium conflicts and appeals.
- Provides guidance and recommendations to the TC, EPC, and Strategic Management Advisory Committee (SMAC). For more information, download the OAB Policies & Procedures.

4. Strategic Member Advisory Committee (SMAC)

- Guides OGC strategy of being a:
  - Hub of technical expertise
  - Trusted forum for partnerships
  - Global authority on standards
- Participation privileges exclusive to OGC Strategic members.
- Provides a forum for strategic members to guide and influence the strategic planning processes of the Consortium, and to support the Consortium's operations aimed at achieving its mission as defined in the bylaws.
- Operates in parallel to the TC and EPC.

Acts as the approval body for the Collaborative Solution & Innovation Program Policies and Procedures.

3.6.3 Development Cycles

3.6.3.1 Products

OGC publishes a variety of documents. The different document types include:

- **Implementation Standard:** These standards are specifications that provide a basis for working software. They define the details about the interface between software components.
- **Abstract Specifications:** These standards are the conceptual foundation or reference models that provide the basis for Implementation Standards.
- **Best Practices:** These documents describe recommended use of implementation standards.
- **Engineering Reports:** These documents describe the results from pilots, testbeds, interoperability experiments and other activities undertaken in the OGC Interoperability Program.
- **Discussion Papers:** These documents enable public review of concepts.
- **Change Requests:** These documents can be submitted at any time by anyone to formally suggest changes or improvements in OGC documents.

OGC also uses and maintains a helpful standards architecture diagram called the Definition Server or OGC Rainbow (see **Figure 1**).

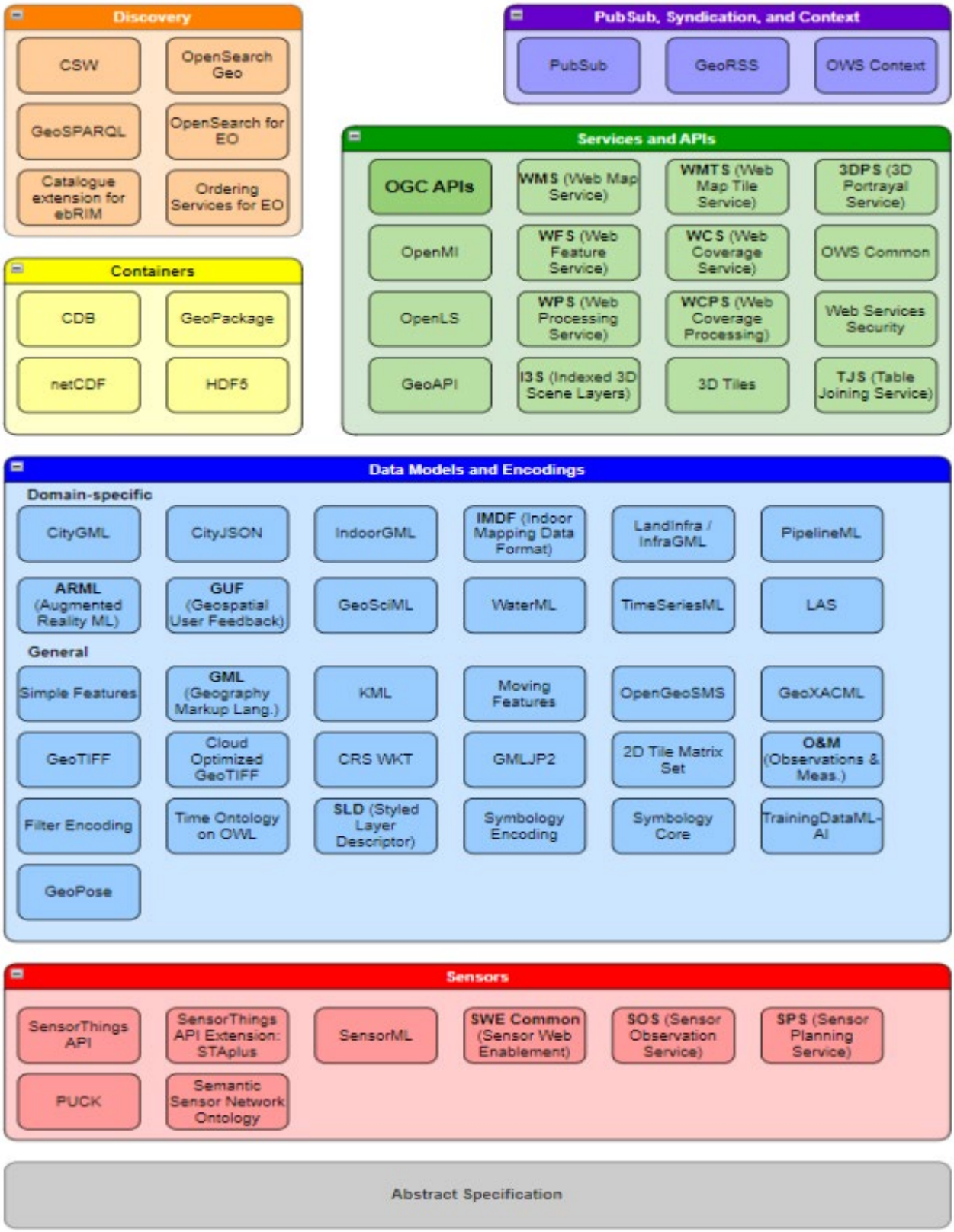

Figure 1. Standard Architecture and Domains
Source: https://www.ogc.org/standards/standards-architecture-diagram/, downloaded on 7/19/2024

OGC standards lie at the heart of FAIR geospatial information. For three decades, OGC standards have been used by thousands of organizations across the globe to ensure interoperability and maximize the value of their geospatial data. Developed through consensus, and backed by government and organizations across the globe, OGC standards provide the stable platform upon which geospatial innovation is built.

OGC's free and open geospatial standards define interoperable approaches to Data Encoding, Data Access, Data Processing, Data Visualization, and Metadata and Catalogue Services.

Developers looking to get the most from OGC standards should visit **developer.ogc.org**, the central location for any developer that uses or wants to learn more about OGC standards, including OGC APIs. The site also contains links to find information on compliance and certification, the OGC Rainbow, OGC's Discord server, OGC code sprints and other developer events, community blogs, and more.

OGC also offers free e-learning resources, such as the **Introduction to OGC standards**, which covers a number of popular and widely implemented standards, and forms one part of a wider free OGC e-learning resource that allows anyone to gain a full understanding of everything OGC.

There is also the **OGC API Workshop**, which is a free step-by-step course consisting of concepts, presentations, and exercises that enable developers to learn how to use OGC APIs to support the discovery, access, visualization, and processing of location information across the web.

Implementation standards are different from the Abstract Specification. They are written for a more technical audience and detail the interface structure between software components.

An interface specification is considered to be at the implementation level of detail if, when implemented by two different software engineers ignorant of each other, the resulting components seamlessly "plug and play" at that interface.

Any Schemas (XSD, JSON Schema, etc.) that support an approved Implementation standard can be found in the official OGC Schema Repository (see https://schemas.opengis.net/). The most important OGC standards of interest to MAT/VRU are:

- Earth Observation (EO) Dataset Metadata GeoJSON(-LD) Encoding Standard (eo-geojson)
- Augmented Reality Markup Language (ARML)
- Publish/Subscribe (PubSub) Interface Standard
- OGC API - Common - Part 1: Core Standard
- Web Feature Service (WFS) Implementation Standard
- Web Map Service Interface Standard (WMS)
- Web Map Tile Service (WMTS) Interface Standard
- Web Processing Service (WPS) Interface Standard

For more information, visit https://www.ogc.org/standards/.

Versions of OGC standards are managed using its own process and numbering schema, which is defined in https://schemas.opengis.net/VERSIONS.txt.

OGC's standards Roadmap, found at https://www.ogc.org/standards/roadmap/, is a helpful tool. The site shows the various stages of an OGC standard, ending with the "Public Release" version.

3.6.3.2 Cycle / Process

OGC, as a formal organization, has instituted and follows a defined set of policies and procedures to fulfill its vision and mission. Links to information defining these policies and procedures as well as a few of the formal texts – the bylaws and IP documents – that cover the OGC methodology for doing business are accessible via https://www.ogc.org/about-ogc/policies/.

OGC operates as a Voluntary Consensus Standards Organization. All actions that must be recorded as part of advancing work in OGC through its various review and approval stages require votes, either at the subgroup or TC level. Many of the actions that are performed to get to those vote stages, however, occur through "Rough Consensus" as described by the Internet Engineering Task Force (IETF).

OGC subgroups and the TC work through technical issues by discussion: verbally, in email, tracked in GitHub issues, etc. Such discussions may not always have unanimous agreement, however, when the chair or leaders of the discussion see general agreement, the topic can be closed, and the group can move ahead. There are no hard and fast rules to close a topic: the decision is left to the expertise of the chair or discussion leader. Ultimately, these discussions lead to a standard or other work product which is voted upon by membership. **Table 4** summarizes the voting rules for different technical groups and products.

Table 4. OGC Voting Rules
Source: https://docs.ogc.org/pol/05-020r29/05-020r29.html

Vote Type	Who can Vote	Forum	Quorum	Sufficiency	Approval
Technical Committee					
Approval of a Technical Paper, Discussion Paper, or Engineering Report	Any member	all	assumed	assumed	simple majority
Election of TC reps to the EPC	Any member	all	assumed	assumed	simple majority
Approval of a subgroup recharter	TC Voting Member	meeting	‘1/3	assumed	simple majority
Approval of a subgroup recharter	TC Voting Member	email	assumed	assumed	simple majority
Approval of a new SWG Task	TC Voting Member	meeting	‘1/3	assumed	simple majority
Approval of a new SWG Task	TC Voting Member	email	assumed	assumed	simple majority
Approval of early periodic review	Any member	all	assumed	assumed	simple majority
Approval of a periodic review action	TC Voting Member	meeting	‘1/3	assumed	simple majority
Approval of a periodic review action	TC Voting Member	email	assumed	assumed	simple majority
Approval of deprecation or retirement of Discussion Paper or Best Practice	Any member	all	assumed	assumed	simple majority
Approval to start electronic vote	TC Voting Member	all	assumed	assumed	simple majority
Recommendation for EPC approval	TC Voting Member	electronic	assumed	‘1/3	2X Yes: NO and 15% YES
Subgroup (other than SWG)					
Election of chairs	Any member	all	assumed	assumed	simple majority
Recommendation to TC	Any member	all	assumed	assumed	simple majority
SWG					
Election of chairs	Voting member	meeting	‘1/2	assumed	simple majority
Election of chairs	Voting member	email	assumed	assumed	simple majority

Vote Type	Who can Vote	Forum	Quorum	Sufficiency	Approval
Recommendation to TC	SWG voting member	meeting	‘1/2	assumed	simple majority
Recommendation to TC	SWG voting member	email	assumed	assumed	simple majority
Release of document	SWG voting member	meeting	‘1/2	assumed	simple majority
Release of document	SWG voting member	email	assumed	assumed	simple majority

For votes that require documentation, such as adoption of particular documents as standards or documents to be released for public comment, documentation supporting the vote must be available to all members in the Pending Documents list on the Portal three weeks prior to the vote. The three-week rule clause ensures that Voting TC members have adequate time to read, distribute and gather comments on documents before voting on the document at the following TC meeting. The TC may override the 3-week rule by a 2/3-majority vote of Voting TC members in attendance at a meeting.

The quorum for any meeting of the TC Members shall be 1/3 of the total Voting membership as comprised by the Strategic, Principal, and Voting members. If there is quorum, then a simple majority of the Voting TC Members present at a meeting shall constitute a positive vote for all TC Items and Issues. Electronic capture of attendance or a roll call will be held at the beginning of each Plenary where votes are to occur to ensure a quorum is present. The only exception for this Quorum rule is for a vote to issue an electronic vote for adoption of a new or revised version of a candidate standard, creation of a Working Group, a Best Practice, or a policy document. In this case, a simple majority vote of those TC Voting members present constitutes a successful vote.

"Sufficiency" is the minimum number of votes cast to have a valid vote result. In most cases, sufficiency is equal to a quorum, but for electronic votes, a quorum is assumed, and a sufficient number of voters need to participate.

Additionally, it is possible for approved OGC standards to have associated Profiles, Application Schemas, and Application Profiles. These associated Profiles, Application Schemas, and Application Profiles can be submitted to the OGC for consideration as candidates for approval as formal OGC implementation standards. For example, several Profiles and Application Schemas were developed for Geography Markup Language (GML). Some of these, such as the GML Simple Features Profile, have gone through the formal approval and adoption process. Below are the definitions for Profiles, Application Schemas, and Application Profiles (from the TC Policies and Procedures, section 7.6.1). They are derived from ISO 19109.

- A Profile is a strict subset of a standard applicable to multiple Application Schemas. An example of a profile is the GML Simple Feature Profile.
- An Application Schema utilizes an Implementation standard and adds application specific entities, e.g., feature types. An example of an application schema is LandGML or CityGML.
- An Application Profile is a profile of an OpenGIS interface standard, such as for Catalogue.

3.6.3.3 Development Support

OGC offers OGC standards Compliance testing services. The OGC Compliance Program provides a free online testing facility, a process for certification of compliant products, and coordination of a vibrant community of developers. This testing can and is desired to end with a “Certified OGC Compliant” Mark, for which any organization wanting to use this Mark must pay an annual license fee that is based on the organization’s revenue and ranges from $150 to $6,250 (for OGC members) and $600 to $25,000 (for OGC non-members) - see https://www.ogc.org/resources/compliance/.

3.6.4 Sustainability

3.6.4.1 Funding

OGC seems to make all its standards available free of charge, however users of their standards must use OGC's Document License Agreement (DLA) - see https://www.ogc.org/about-ogc/policies/copyright-notice-and-disclaimers/. Additional costs incur if an organization wants to test its compliance with one or more OGC standard and for using the "OGC-certified" logo.

OGC publishes Open Standards, which are very different than Open Source, which refers to software. Most OSS use Open Standards like those from OGC. Some Open-Source implementations are also reference implementations, which can be examples of correct implementations of an OGC standard for use by developers that is free and publicly available for testing via a web service or download.

The actual work is, like with many SDOs, supported and meetings are organized by OGC staff, however the actual work is done by industry expert volunteers, whose funding is entirely provided by their respective organizations.

3.6.4.2 Deployment

The geo-location focused development of standards, best practices, certifications and feedback with the TCs and/or communities has supported more than 6,000 deployments using 1,000+ different products that are based on 100+ standards.

Additionally, OGC states that many, but not all, OGC standards have been implemented in reference implementations that are freely available from the OGC for use by developers.

OGC standards can be furnished with one or more Corridendums (i.e., addenda with corrections). As per section 9.10 of the OGC TC Policies and Procedures, a corrigendum is restricted to a bug fix to schema(s) and supporting standards document. There is a requirement for an immediate fix. When the corrigendum is published, there shall be no namespace change. The corrigendum shall be accompanied by a ReadMe file that describes the errors that were corrected.

Source Information: The contents about OGC were largely obtained in July 2024 from OGC's webpage and documents contained therein.

4 SDO Profiles

4.1 National Transportation Communications for ITS (Intelligent Transportation Systems) Protocol (NTCIP)

4.1.1 Organization Overview and Background

In 1996, AASHTO, ITE, and NEMA executed a Memorandum of Understanding (MOU) to form and operate the NTCIP Joint Committee. The MOU served, and continues to serve, as a framework to:

- develop and complete a family of communications protocols under the NTCIP umbrella
- develop, adopt, revise and maintain protocols and other standards in the NTCIP family; and
- provide expertise and training in the application of NTCIP.

NTCIP 9001 v04, *The NTCIP Guide,* provides an overview of the NTCIP family of protocols and profiles. NTCIP 9001 v04 is an educational tool, created to assist planners, specification writers, and implementers in understanding the various NTCIP standard publications and how to use them, as well as factors encouraging NTCIP implementation. NTCIP 9001 v04 includes content useful to understand and procure NTCIP; relate agency specifications to NTCIP; design, implement and test NTCIP; and many other resources. NTCIP 9001 v04 is informative, provides guidance, however does not provide requirements or mandatory information (i.e., it is not a standard). NTCIP 9001 v04 was published in July 2009.

4.1.2 Governance

The NTCIP effort is structured and governed by agreement between the 3 SDOs, AASHTO, ITE and NEMA. The resulting governance structure defines the roles and rules for developing standards and other technical reports. It also describes who participates in standards development activities (membership), how participants contribute (roles), the processes for developing technical reports and standards including the review process, access to drafts, voting rights, comment resolution, and leadership, which is further described below.

4.1.2.1 Leadership

The NTCIP Joint Committee is the most senior NTCIP group, and the NTCIP Joint Committee consists of 18 individual members, with 6 appointed from each of the three SDOs. The predecessor of the NTCIP Joint Committee was the NTCIP Steering Group. John Thai, City of Anaheim, presently chairs the NTCIP Joint Committee.

The NTCIP Joint Committee contributes to the NTCIP effort by providing oversight and general guidance for all NTCIP efforts. Specifically, the NTCIP Joint Committee reviews and accepts proposed draft documents at two stages in development: first, as User Comment Drafts, and then again as Recommended Standards. Recommended Standards are then referred to the SDOs for balloting and approval. Since AASHTO, ITE, and NEMA executed a MOU (in 1996) to form and operate the NTCIP Joint Committee, it has overseen and implemented the effort to develop, revise, and maintain the NTCIP family of standards; and to provide technical assistance and training in the application of the NTCIP.

Additional technical NTCIP Groups were established to address the technical needs authorized for development by the NTCIP Joint Committee. At present, all of these NTCIP Groups have developed one or more NTCP standards and are maintaining them. Several NTCIP Object Definition standards, which describe the functional capabilities that specific field device types such as signal controllers or dynamic message signs or Connected Vehicle Roadside Units (RSUs), are in their 2nd, 3rd or even 4th version. The NTCIP Groups that developed the NTCIP standards are:

- Actuated Signal Controller working group (WG) responsible for the object definitions for traffic signal controllers (NTCIP 1202).
- Base Standards and Profiles WG

- Center-to-Center WG – responsible for underlaying data exchange standards such as Profiles for XML Message Encoding and Transport (NTCIP 2306). Protocols on the lower layers of the OSI Reference Model stack were addressed by the Base Standards and Profiles WG.
- Closed-circuit television (CCTV) WG responsible for the NTCIP 1205 Object Definitions for CCTV
- Data Collection and Monitoring (DCM) WG responsible for data elements for the collection of long-term data for vehicle classification purposes (largely), which are defined in NTCIP 1206.
- Dynamic Message Signs (DMS) WG responsible for object definitions (NTCIP 1203) describing the functional capabilities that different types of message signs could or should be able to support.
- Electrical and Lighting Management Systems (NTCIP 1213)
- Environmental Sensor Stations (ESS) WG responsible for data definitions for roadside located weather stations (NTCIP 1204) collecting weather-related data and providing it to a central system.
- Field Management Station (NTCIP 1210) defines the data elements for a roadside-mounted field master managing directly connected traffic signal controllers with limited capabilities (controlled by the master).
- Ramp Meter Controller (RMC) WG defines the data elements for ramp metering equipment (NTCIP 1207).
- RSU WG defines the data elements for roadside units used in connected vehicle applications (NTCIP 1218).
- Signal Control and Prioritization (SCP) WG defines the data elements for traffic signal priority methodologies to transmit priority requests from a vehicle to a traffic signal controller – and that via 3 different communications paths (NTCIP 1211).
- Testing and Conformity Assessment WG developed the NTCIP 8007 – Testing and Conformity Assessment Documentation within NTCIP Standards Publications, NTCP 9012 – Testing Guide for NTCIP Center to Field Communications, and NTCIP 9014 – NTCIP Infrastructure Standards Security Assessment (ISSA)
- Transportation Sensor Systems (TSS) WG defines the data elements for sensors that detect vehicles, bicycles and even pedestrians as well as broad types of vehicle classes and provides this data to a central location (NTCIP 1209).

4.1.2.2 Membership

Appointees to the NTCIP Joint Committee are put forward by each of the 3 SDO, namely AASHTO, ITE, and NEMA. These SDOs would typically select a representative from one of their member organizations, but it is not an NTCIP-imposed requirement.

Membership within the Technical WGs is open and is often based on suggestions by volunteers already committed to working on a specific standards effort. AASHTO provides financial assistance for direct expenses to public sector volunteers, all others pay their own direct expenses.

Members are mostly volunteers but SMEs are paid consultants to expedite the effort and to perform the document editing, meeting preparation efforts, etc. Additionally, SDO staff will support each of the NTCIP WG efforts.

4.1.3 Development Cycles

4.1.3.1 Products

The NTCIP Suite of Standards covers both data exchange standards and data definition standards. It is important to understand the logical architecture of the NTCIP suite of standards, which is shown in **Figure 2** and explained in detail in NTCIP 9001.

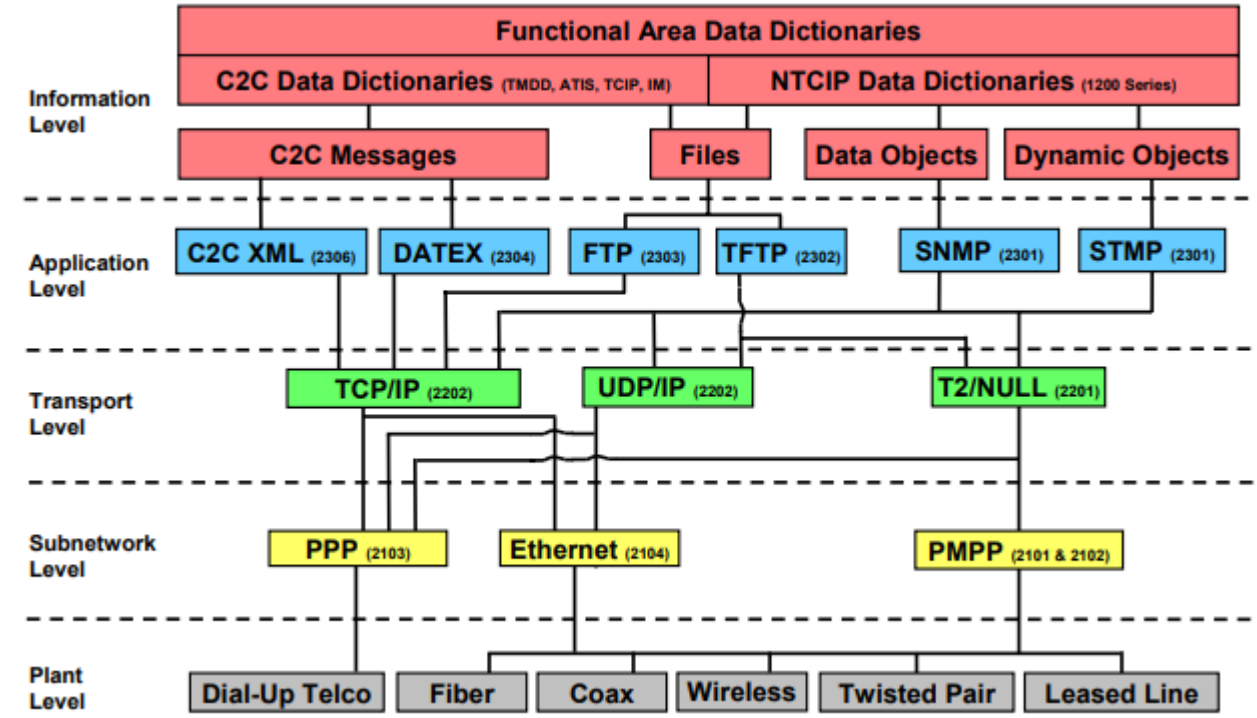

Figure 2. NTCIP Framework

Source: NTCIP 9001 v04 - NTCIP Guide, Figure 4, 2009)

4.1.3.2 *Cycle / Process*

Within the NTCIP process, new work items including updates to existing NTCIP standards are proposed to the NTCIP Joint Committee for approval. Since most NTCIP standards are USDOT funded, interest by USDOT to fund a specific NTCIP standards effort is typically obtained before voting within the NTCIP Joint Committee.

Once approved, the Technical WG responsible determines or re-confirms its membership, which typically consists of representatives from public sector (DOT or transit or other), vendors, and consultants, and liaison staff from AASHTO, ITE, and/or NEMA.

The steps for developing an NTCIP standard are:

- WG draft (as many versions as the Technical WG desires)
- Vote to elevate WG draft to a review version
- Joint Committee agrees (or disagrees) with the WG draft and allows for a wider distribution for review
- Liaison SDOs (AASHTO, ITE, and/or NEMA) follow internal procedures to perform the review among their members.
- If approved among all 3 SDOs, NTCIP standard is prepared for publication.

The different SDOs responsible for the NTCIP Standards have generally different requirements in terms of re-reviewing and re-confirming a standard. However, for NTCIP standards, they are looked at every 5 years by both the SDOs and the NTCIP Joint Committee to determine whether modifications or updates are required.

4.1.3.3 Development Support

Many installations of NTCIP standards were tested for interoperability, and sometimes even interchangeability. Documentation examples can be found online, including from FHWA and others:

FDOT DMS Purchase Specification example:
https://ops.fhwa.dot.gov/publications/tptms/handbook/app_d.htm

New York State DOT VMS Guidelines example:
https://www.dot.ny.gov/divisions/operating/oom/transportation-systems/repository/VMS%20%20Guidelines%20December%202018%20-%20FINAL.pdf

City of Anaheim, California – NTCIP 1202 and NTCIP 1218 Standards testing project:
https://local.anaheim.net/docs_agend/questys_pub/29668/29698/29699/29943/29948/3.%20Proposal29948.pdf

LA County Traffic Signal Synchronization and Bus Speed Improvements:
https://ladpw.org/TNL/ITS/i710/files/reports/Del%202.3.1.1/I-710%20Corridor%20Requirement%20Analysis%20-%20Final072007.pdf

Minnesota DOT Dynamic Message Sign report: https://www.dot.state.mn.us/its/projects/2016-2020/systemsengineeringforitsandcav/dmsse.pdf

PennDOT TSMO Guidebook, Part II: Design:
https://www.dot.state.pa.us/public/PubsForms/Publications/PUB%20852.pdf (focus here is how to reference and integrate NTCIP Standards when designing for Transportation Systems Management and Operations (TSMO).

Another source of support is the USDOT FHWA regional Resource Centers, which are well versed in supporting local deployments seeking to integrate relevant NTCIP standards (see https://www.fhwa.dot.gov/resourcecenter/) into their projects. USDOT Resource Centers also support agencies with their cybersecurity needs.

4.1.4 Sustainability

4.1.4.1 Funding

The NTCIP development efforts, since their inception in 1996, has been funded largely by USDOT both for labor of selected SMEs (typically the moderators and the document editors) and for direct expenses of SMEs and public sector volunteers. Most volunteers were sponsored entirely by their companies.

The funding provided was dispersed by the NTCIP Suite of standards-developing SDOs (AASHTO, ITE, and NEMA).

Funding requests were and still are requested every few years, after discussions within the NTCIP Joint Committee where all requests are discussed, prioritized and submitted.

Today, the NTCIP standards are still being updated; however, few new standards were developed recently, one exception being the RSU standards (NTCIP 1218). Underlying communications standards are also being revised to increase cybersecurity protections and to account for more modern and more secure data exchange standards.

To participate in the NTCIP efforts (Joint Committee or Technical Working Groups) as a voting member or as a co-chair, one would have to be nominated by either AASHTO (public agency membership, but not transit agencies), ITE (individual memberships) or NEMA (company memberships). Observing members can

participate without nomination. All 3 SDOs publish all NTCIP standards and provide them for purchase.

4.1.4.2 Deployment

Extensive training and deployment examples are available – most of these examples were sponsored by USDOT's Professional Capacity Building (PCB) program. Also, requirements to include NTCIP standards in purchase specifications were added to USDOT-sponsored grants, such as the Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) program. Furthermore, in the early 2000s, USDOT-sponsored projects with specific field device types for which NTCIP standards existed demonstrated that NTCIP standards are interoperable. Also, many States have updated their standardized purchase specifications to require deployment of the applicable NTCIP standards. Most of these deployments were documented (some examples are provided in the bullets in the previous section).

The NTCIP Guide (NCTIP 9001 v04; see www.ntcip.org/standards) also contains much guidance and advice for the procurement and maintenance of NTCIP-compliant devices or interfaces.

Source Information: The contents about the NTCIP effort were largely obtained in July 2024 from the NTCIP.org's webpage, documents contained there, as well as from personal experiences and the USDOT and ITE webpages.

4.2 SAE International

4.2.1 Organization Overview and Background

SAE International (formerly the Society of Automotive Engineers) is the leader in connecting and educating mobility professionals to enable safe, clean, and accessible mobility solutions. Their core competencies are life-long learning and voluntary consensus standards development. They also champion diverse collaboration across companies and borders to engage global collaboration.

SAE's charitable arm is the SAE Foundation, which supports many programs, including A World in Motion® and the Collegiate Design Series.

Founded in 1905, SAE strives to serve its primary constituents in a variety of ways. Through its globally recognized magazines, Automotive Engineering International, Aerospace Engineering, and off-highway/heavy duty vehicles, trucks, busses, or passenger vehicle engineering, SAE informs the mobility community about the latest developments in the field. Besides automotive, aerospace, and transportation, SAE also develops and maintains (or references) cybersecurity standards and many other industry topic standards including manufacturing, automation, electrification. During the 1990s, SAE International announced the formation of SAE Brasil, an affiliate society with over 1,500 members and an annual World Congress event of its own. SAE also opened four geographic sections on the Indian sub-continent, and it established new sections in China, Russia, Romania, and Egypt, to name a few. In 2002, SAE India was formally established as an official affiliate of SAE International. As non-North American membership approaches 25%, the SAE International website has become a focal point of commerce and information exchange. As of July 2014, SAE has cooperative agreements with organizations in Japan, Germany, United Kingdom, Australasia, and India, among many others.

In terms of standards, SAE lists 49,751 standards on their standards-listing webpage (https://www.sae.org/standards).

SAE's broad array of technical, historical, and statistical publications is distributed to customers in more than 65 countries annually. SAE's Training and Professional Development capabilities have been expanded in the past 20 years - SAE now produces more than 450 separate professional development events every year.

4.2.2 Governance

Within SAE International, the governance structure defines the roles and rules for developing standards and other technical reports. It also describes who participates in standards development activities (membership), how participants contribute (roles), the processes for developing technical reports and standards including the review process, access to drafts, voting rights, comment resolution, and leadership, which is further described below.

4.2.2.1 Leadership

SAE has an elected BoD, 12 members from various companies including Rolls-Royce, Airlines for America, GM, Boing, Cummins, as well as a Leadership Team consisting of a Senior Leadership Team (7 persons) and an Executive Leadership Council (6 members). **Figure 3** provides the SAE governance organization chart.

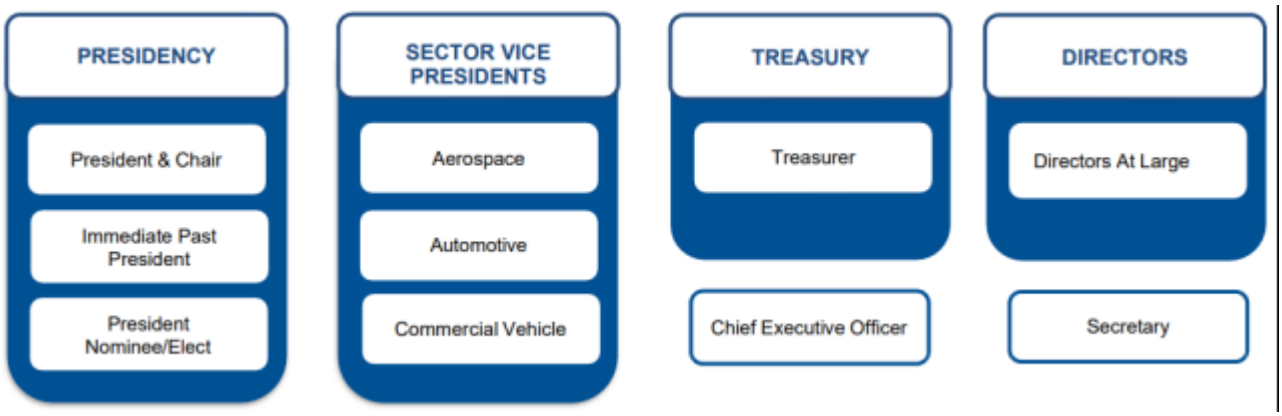

Figure 3. SAE Governance Organization Chart

Source: SAE International – Executive Standards Committee Governance Policy, App A-5, 2024

4.2.2.2 *Membership*

SAE International is the leader in connecting and educating mobility professionals to enable safe, clean, and accessible mobility solutions. SAE is a global association of more than 128,000 engineers and related technical experts in the aerospace, automotive and commercial vehicle industries.

SAE offers 2 types of membership:

- Professional membership at $125 / year
- Student membership at $ 35 / year

No company memberships are available.

SAE International Professional Membership encourages personal and professional growth by providing access to exceptional volunteer, leadership, and career-building opportunities. It also provides reduced pricing on a broad range of publications, products, and services not available to nonmembers.

Professional Membership includes:

- Member discounts on more than 100 books and 2,600 technical papers published annually
- Subscription to one of SAE's three award-winning industry magazines
- Free on-demand course: Introduction to the Automotive Ecosystem
- Access to My Standards Tracking which provides the ability to request email alerts when Aerospace and Ground Vehicle Standards are being updated
- Local and national volunteer opportunities that build leadership skills
- Subscription to SAE *Update*, our members-only digital newsletter
- Advance notice of new industry jobs through the online SAE Career Center
- Discounts on registration for SAE-owned conferences
- Advance notice of new technical papers prior to SAE conferences
- Access to SAE's partner discounts on insurance, travel services, car rental, shipping, online backup and sharing, and more

The SAE Student Membership includes:

- Ability to connect with industry professionals and engage in discussions on the latest technical topics, seek advice from experienced professionals in the mobility industry, and find volunteer

opportunities through SAE's member and volunteer online community, Connexion+

- Exposure to the job market, including access to internships and job listings via the online SAE Career Center, with members receiving a seven-day advance notice of new job posting.
- Opportunity to compete in the SAE Collegiate Design Series (CDS)™, which is known for producing highly sought-after graduates.
- Opportunity to serve in leadership positions and enhance your resume
- Ability to apply for an SAE student award or contribute to *Momentum* by writing about student topics.
- Chance to invite industry speakers to your school to learn about real-world engineering solutions.

As of July 2024, SAE has 47 SAE Local Sections in 26 states and 7 countries. Each SAE Local Section is comprised of 100 or more SAE International members in a defined technical or geographic area.

SAE TC members are volunteers, who participate with or without the support of their employers. Generally, SAE does pay for volunteers to travel to / from face-to-face meetings and/or volunteer labor time up to established maximums (see https://www.sae.org/about/legal-policies/consultant-travel).

4.2.3 Development Cycles

4.2.3.1 Products

SAE technical standards advance safety, quality and interoperability, and enable innovation across the aerospace, automotive, commercial vehicle and systems management sectors. Today, the SAE portfolio includes 10,000+ documents, driven by nearly 15,000 engineers, technical experts and leaders from industry, government and research organizations throughout the world.

4.2.3.2 Cycle / Process

Engineering standards evolve in response to advancements in technology and shifts in human behavior. SAE develops engineering standards following a committee process. **Figure 4** maps each step in this progression, which takes place through meetings organized and hosted by SAE.

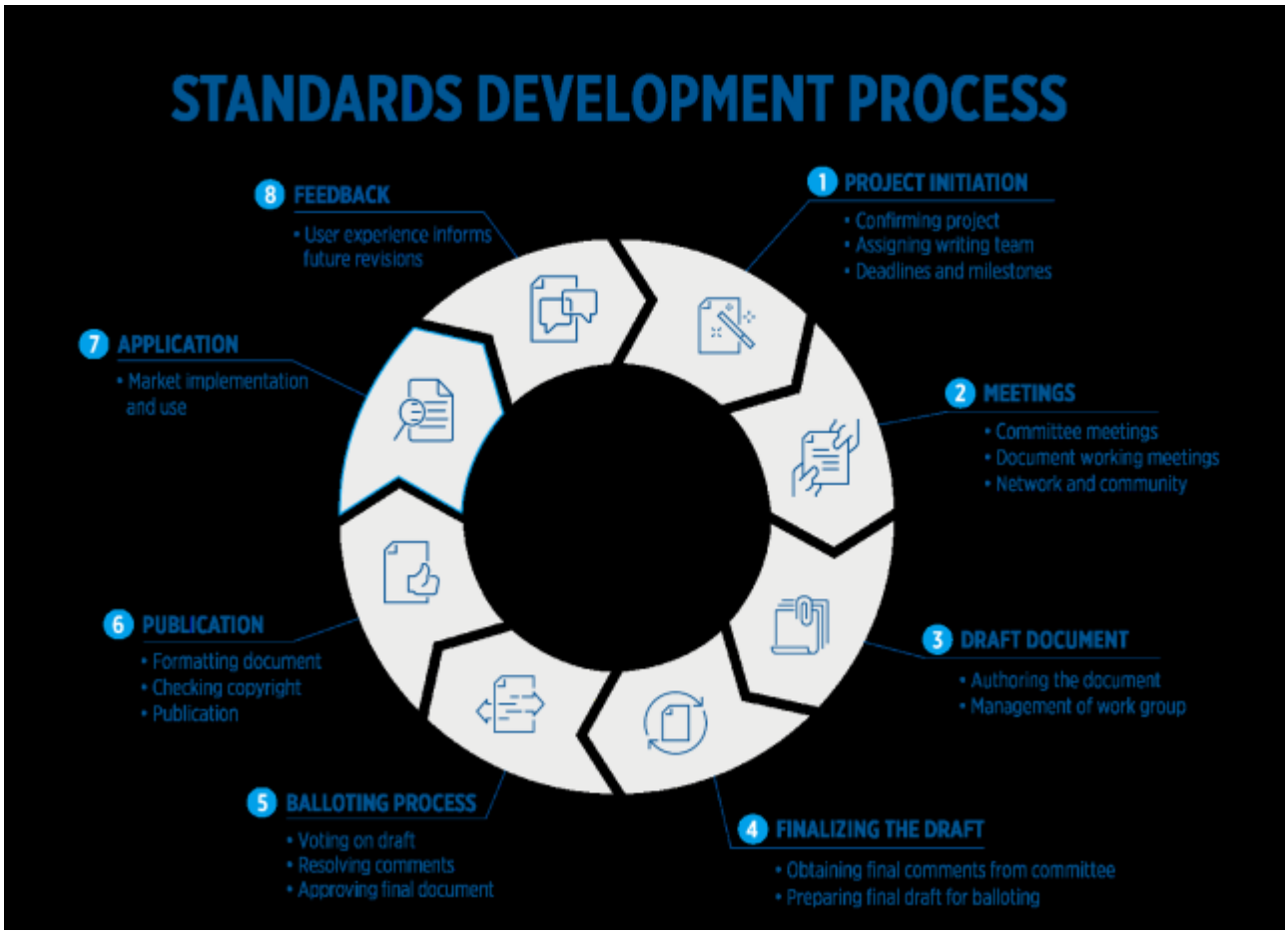

Figure 4. SAE Standards Development Process
Source: https://www.sae.org/standards/development, downloaded July 22, 2024

The standards, or Technical Reports as they are called generically, development process is further detailed in the **Table 5**, which shows the stage/phase name of a standard and the responsible party for a document at each stage/phase.

Table 5. SAE Development Process by Stage
Source: SAE Motor Vehicle Council Policy, Section IV, June 2023

Stage	SAE Technical Reports	
	Name	**Responsible/Approval**
1 Proposal stage	New work item proposal	SAE Committee/Steering Committee
2 Committee stage	Committee working draft	*SAE Committee, Task Force*
3 Balloting – 1st level	Committee draft	SAE Committee
4 Balloting – 2nd stage	Committee draft	MVC
5 Publication stage	SAE Technical Report	SAE staff

SAE has developed and maintains a Web-platform, called StandardsWorks, where volunteer collaborators can work on individual standards simultaneously. This platform is used by over 750 councils, committees, and task groups to develop technical standards. The StandardsWorks platform also offers Training Materials

on how to use the platform, guides, on-demand training, balloting, works in progress and other areas where training needs were anticipated (see https://standardsworks.sae.org/standards-committees/).

4.2.3.3 Development Support

SAE provides the frameworks to create technical groups with common goals, as long as they fit within the scope of their supported topic areas, and the desire to develop one or more standards that ease interoperability, set performance standards, and provide a platform to make the developed standards both under version control and make the standards available to anyone.

SAE also supports cross-education among different technical working groups due to its governance structure and its participation in meetings and conferences of other organizations.

4.2.4 Sustainability

4.2.4.1 Funding

Besides the membership fees from individual members, SAE does take donations for its SAE Foundation. Further funding comes from SAE creating and executing events such as SAE Annual, or COMVEC, or the Connected Vehicle-related conferences, both online and in person.

Additionally, SAE makes its developed Standards available for purchase via its webpage (see https://www.sae.org/standards/content/j2945/6_202310/ for a J2945/6 example). Some of the listed standards are free for download, but most have a cost associated with them.

4.2.4.2 Deployment

SAE provides publications, guidelines, and experience reports that describe the use and deployment of its standards. Furthermore, standards-describing videos, webcasts, podcasts and the SAE Smartbrief provide information. SAE has extensive learning programs tailored to PreK-12 and Professional Development, which are made available online and in person.

Source Information: The contents about SAE were largely obtained in July 2024 from SAE's webpage and documents contained there.

4.3 International Organization for Standardization (ISO)

4.3.1 Organization Overview and Background

The International Organization for Standardization, referred to as ISO, is a member organization represented by over 172 member countries. The ISO was established after World War II, in 1947 to address specific standards. Today, the ISO has published over twenty-five thousand standards and has over eight hundred TCs and subcommittees (SCs) in all areas of technologies, health, transport, management, environmental sustainability, energy, safety-security-risks, diversity and inclusion and many more. The ISO is an "independent, non-governmental organization".

4.3.2 Governance

The ISO governance structure includes the following:

General Assembly: The overarching organ and ultimate authority of ISO. It convenes annually, where members and principal officers participate to decide strategic objectives.

ISO Council: The core governance body reporting to the General Assembly. Comprising 20 member bodies, ISO Officers, and Chairs of Policy Development Committees (CASCO, COPOLCO, DEVCO), it meets thrice a year.

Technical Management Board (TMB): Responsible for managing technical work, including over 250 TCs that develop ISO standards.

Advisory Groups: These provide advice on commercial policy (CPAG) and information technology (ITSAG).

Partnerships: ISO collaborates closely with the International Electrotechnical Commission (IEC), International Telecommunication Union (ITU), and the World Trade Organization (WTO) to promote international consensus-based standards (from iso.org).

The multi-stakeholder governance model ensures public interest remains the focus, free from political or commercial interference (from International-standards.org).

The TMB oversees the TC who develops the standards, technical specifications and reports. Some TCs are organized through SC with working groups (WG). Some just have WGs. For example, TC 204 on Intelligent Transport Systems contains 20 working groups. Some TCs work with other standard organizations. For example, TC 204 includes WGs that are cooperative with the European Committee for Standardization (CEN). According to the ISO 211 business plan, (ISO_TC211_Strategic_Business_Plan_2023 https://committee.iso.org/files/live/users/fh/aj/aj/tc211contributor%40iso.org/files/Resolutions/SBP_2023.pdf) some TC 211 on Geographic Information/ Geomatics include cooperate with OGC (see **Section 3.6**) and ISO/IEC (for specific domains such as digital twin). Members of the TCs are nominated and approved by their national committees.

All technical work is confirmed and promoted for voting through the TC Plenary. The TC Plenary body is composed of member nations and the chairs of each SC / working group. Votes are restricted to one vote per delegation.

Both leaders and members ISO TCs, SCs and WGs are nominated and approved by their member states. There is typically a mirror national delegation that reviews the outputs of the TCs. The mirror organization is composed of a nations experts who review technical documents and advise the committee's delegation on how to vote on key documents. Each nation organizes their advisory groups differently.

4.3.3 Development Cycles

4.3.3.1 Products

A TC may issue several types of publications:

- Technical Standard
- Technical Specification
- Technical Report

Each development is time sensitive and subject to differing approval rules.

4.3.3.2 Cycle / Process

The development process usually takes about three years from a new work proposal to publication. The development of ISO standards involves several stages (https://www.iso.org/stages-and-resources-for-standards-development.html):

- Proposal stage: Confirming the need for a new standard.
  - The first step is to confirm that a new International Standard in the subject area is really needed. (See the Global relevance policy.) A new work item proposal (NP) is submitted to the committee for vote using Form 4. The electronic balloting portal shall be used for the vote.
  - The person being nominated as project leader is named on the Form.
  - If there are possible complications around copyright, patents or conformity assessment they should be raised at this early stage.
  - This stage can be skipped for revisions and amendments to ISO standards that are already published (as long as the scope does not change).
- Preparatory stage: Setting up a WG to complete the draft.
  - Usually, a WG is set up by the parent committee to prepare the working draft (WD). The WG is made up of experts and a Convenor (usually the Project leader).
  - During this stage, experts continue to look out for issues around copyright, patents and conformity assessment.
  - Successive WDs can be circulated until the experts are satisfied that they have developed the best solution they can. The draft is then forwarded to the WG's parent committee who will decide which stage to go to next (Committee stage or Enquiry stage).
  - The ISO/TC platform can be used for sharing documents at this and other stages of standards development.
- Committee stage: Evaluating proposed standards
  - This stage is optional. The ISO TC 204 applies this stage when the standard cuts across multiple working groups or integrates multiple mode.
  - During this stage the draft from the working group is shared with the members of the parent committee or working groups.
  - If the committee uses this stage, the committee draft (CD) is circulated to the members of the committee who then comment using the Electronic Balloting Portal. Successive CDs can be circulated until consensus is reached on the technical content.
- Enquiry stage: Seeking feedback from stakeholders.
  - The Draft International Standard (DIS) is submitted to ISO Central Secretariat by the Committee Manager. It is then circulated to all ISO members who then have 12 weeks to vote and comment on it.
  - The DIS is approved if a two-thirds of the P-members of the TC/SC are in favor and not more than one-quarter of the total number of votes cast are negative.
  - If the DIS is approved and no technical changes are introduced in the draft, the project goes straight to publication. However, if technical changes are introduced, Final Draft International Standard (FDIS) stage is mandatory.

- At this stage, the public may ask to respond to the DIS. They must first ask their national member for the draft document.

- Approval stage: Final approval of the standard
  - This stage will be automatically skipped if the DIS has been approved and no technical changes are introduced
  - However, if the draft incorporates technical changes following comments at the DIS stage (even if the DIS has been approved) the FDIS stage becomes mandatory.
  - If this stage is used, the FDIS is submitted to ISO/Central Secretariat (ISO/CS) by the Committee Manager. The FDIS is then circulated to all ISO member for an 8-week vote.
  - The standard is approved if a two-thirds majority of the P-members of the TC/SC is in favor and not more than one-quarter of the total number of votes cast are negative.
- Publication stage: process to move the publication from approval to publication
  - At this stage the secretary submits the final document for publication through the Submission Interface. But if the standard has passed through the Approval stage, the manager may submit the project leader's responses to member body comments on the FDIS.
  - Only editorial corrections are made to the final text. It is published by the ISO Central Secretariat as an International Standard.
  - Committee Managers and project leaders get a two-week sign off period before the standard is published

4.3.3.3 Development Support

Each TC provides tools supported by the convener organization to access technical and working group documents.

In addition, the ISO publishes guidelines and tool kits related to environmental sustainability and accessibility.

4.3.4 Sustainability

4.3.4.1 Funding

Funding for the ISO is contributed by national member organizations. The average cost of standards ranges between $120 and can rise as high as $1,000. The documents are typically single-user licenses, not to be shared with groups of people.

4.3.4.2 Deployment

There is no support for deployment support, tools, reference implementation, or guidance documents.

Source Information: The contents about ISO were largely obtained in July 2024 from their webpage and documents contained therein.

4.4 European Committee for Standardization (CEN)

4.4.1 Organization Overview and Background

Founded in 1961, CEN is comprised of thirty-four European countries' National Standardization Bodies (NSBs).

4.4.2 Governance

CEN's corporate governing bodies include the General Assembly (the Association's supreme body), the Administrative Board, and the Presidential Committee.

The CEN policy is established by the General Assembly, which consists of delegations from the NSBs of each member country. In addition, selected CEN partners, including Affiliates, Companion Standardization Bodies, the European Committee for Electrotechnical Standardization (CENELEC), the European Telecommunications Standards Institute (ETSI), ISO, European Partner Organizations, the European Commission, and the European Free Trade Association (EFTA) Secretariat, attend the General Assembly as observers. The General Assembly, chaired by the CEN President, convenes twice a year, with the possibility of additional extraordinary meetings called by the CEN President. Only the CEN National Members hold voting rights.

The Administrative Board is responsible for managing and administering CEN's operations. It directs the activities and coordinates the efforts of all CEN bodies with the objective of implementing the decisions made by the General Assembly. Acting on behalf of the Association, the Board takes necessary actions to achieve its organizational goals in interactions with national, European, or international authorities, as well as other organizations or individuals.

The Administrative Board, which typically convenes three times a year, includes the CEN functions (the President, three Vice-Presidents for Policy, Technical & Finance), up to nine additional Administrative Board members, and the President-Elect in an observer role. All these members are appointed by the General Assembly. The CEN-CENELEC Director General serves as the Board's Secretary. Among other responsibilities, the General Assembly empowers the Administrative Board to oversee the technical work, which is delegated to the Technical Board.

The Presidential Committee is a combined entity of CEN and CENELEC. It oversees and administers tasks related to non-sector specific issues that are of mutual interest to both Associations, including matters that fall under common administration and/or policy. The Presidential Committee consists of the Presidents of CEN and CENELEC, the President Elects of both, the six Vice Presidents, and the shared Director General. The Presidential Committee convenes on a regular basis, at least twice a year, and provides reports to the respective Administrative Boards.

Source: Structure and Governance - CEN-CENELEC (cencenelec.eu)

4.4.2.1 Leadership

The CEN Technical Board (BT) oversees the entire standards program and encourages its swift implementation by the TC, the CEN-CENELEC Management Centre (CCMC), and other entities. The primary duties of the CEN BT include providing guidance on all aspects related to the organization, operational procedures, coordination, and planning of standards work, approving CEN technical policies and strategies, and reviewing and making decisions on proposals for new projects.

Source: Structure and Governance - CEN-CENELEC (cencenelec.eu)

4.4.2.2 *Membership*

A CEN member may be either a public or private sector entity and is subject to an annual fee. To apply for CEN membership, a candidate applicant is required to submit a written application for membership of the Association to the Director General; commit itself to conform to the rules of the Association as set in the Statutes and Internal Regulations; and obtain the consent of the General Assembly, voting by secret ballot, with a three-quarter majority of the Members present or represented, an abstention not being counted as a vote.

It is important to note that there can never be more than one member per country. Members of CEN must fit the following criteria:

- Being able to adopt at the national level all European Standards and to withdraw national conflicting standards;
- Being a member (full or correspondent) of ISO;
- Adhering to and abiding by the standardization principles of the World Trade Organization;
- Being the National Standardization Body of a European state within the meaning of Article 49 of the Treaty on European Union (EU), with the following relations with the European Economic Area Single Market.

Following the exit of Great Britain in the European Union, there are three types of membership in CEN:

- Blue-type Member: National standards body in a country of the European Economic Area (EEA)
- Red-type Member: National standards body in a country which is a member of the EFTA but not of the EEA or in a country recognized by the EU as a candidate country for EU accession
- Yellow-type Member: National standards body in a country that has concluded an agreement with the EU on regulatory convergence and compatibility with the essential rules for supporting the European Single Market

All member countries (NSBs) must have a mechanism in place to facilitate voting, appropriate presentation, means to access the standardization process, allow public participation, consider all comments, nominate chairs and secretaries, and an existing Code of Conduct for leadership.

Source: Structure and Governance - CEN-CENELEC (cencenelec.eu)

4.4.3 Development Cycles

4.4.3.1 *Products*

The CEN's products include the development of European standards, technical specifications, technical reports, guides, and workshop agreements. ***European standards adopted by CEN are required to be implemented by the member countries.*** Any conflicting national standards are to be withdrawn. Technical specifications document the potential agreement of a European standard but, for whatever reason at the time, cannot get approval to become a standard, doubts regarding consensus, evolving subject matter expertise, or there is another reason precluding the immediate adoption of such standard by CEN. Technical reports are documents containing substantive material that cannot be released as a European standard or technical specification.

Guides are published for established European standards to provide regulations or recommendations on European standardization. Workshop agreements reflect the consensus of identified individuals and organizations responsible for developing a European standard, technical specification, or technical report. Prior to dissemination, most products must undergo a balloting process among CEN's members.

Source: Working Group Membership Criteria (cencenelec.eu)

4.4.3.2 *Cycle / Process*

There are effectively six phases in CEN's standardization process: 1) Proposal & acceptance; 2) Drafting; 3) Enquiry; 4) Adoption by Weighted Vote; 5) Publication; and 6) Review. A draft may automatically be adopted with adequate support (ANEC, 2017). If support does not meet the threshold, then the Working Group must address comments and make revisions to the draft before the TC subjects the standard to a vote. When a work program, product, or final results are being developed, all essential information is required to be easily accessible to all members for transparency. Participation guidance is to be effectively disseminated with adequate time and opportunities for written comments. Such essential information shall include:

- Publication of a notice at an early appropriate stage;
- Notification through established mechanisms that includes a brief description of the scope of the draft of the standard, including its objective and rationale;
- Request input and provision of the text of the draft standard;
- Provision of an adequate period of time to provide input;
- Upon adoption, prompt publication of a standard; and
- Periodically (at least once a year) publish a work program containing information on the standards currently being prepared and adopted.

Source(s): Standards-in-60-seconds.pdf (anec.eu) and Working Group Membership Criteria (cencenelec.eu)

In 2021, CEN introduced a flexible standards development process, which allows TCs to autonomously advance the delivery of a standard in two stages within a maximum timeframe (CEN Flexible Standards Development Process, 2021). The standard process has a fixed 34-week timeframe for each stage; however, the flexible process allows the TC to determine the necessary time to develop and implement the standard. The first stage involves developing a drafting standard (e.g., prEN), while the second stage includes soliciting comments to obtain consensus on the draft standard. This flexibility only applies to the first two stages of standard development. The benefit of the flexible process is that it allows TCs to fully commit to the early stages of the development process and set a shorter time than the standard 34 weeks to reduce the risk of automatic cancellation due to late delivery.

Source: flex_process_operational.pdf (cen.eu)

In 2022, CEN published the European Standardization Strategy to guide prioritizing, enhancing, accelerating, and streamlining their standardization process. The following five actions were cited in the European Standardization Strategy:

- **Identification of several strategic areas** of standardization needs, which include sustainability, such as critical raw materials recycling, chips certification, and data standards.

- **Mandating a peer review process** among its member states to improve the governance of European standards, maximize inclusivity, and enhance evaluation.

- **Establishing a High-Level forum** as a new collaborative mechanism to disseminate information and bolster coordination among EU member states and other similar organizations to enhance CEN's leadership in global standards. This document outlines the desire to fund standardization projects in Africa and neighboring countries.

- **Advancing innovation** in standardization by tapping into the potential of EU-funded research and anticipating early standardization needs. This includes developing a Code of Practice to underpin linkages between the standardization process and innovative research.

- **Better support of the next generation of standardization experts** by raising academic awareness of standards through outreach and training in European universities.

Source: DocsRoom - European Commission (europa.eu)

4.4.3.3 Development Support

To share products created by CEN members, implementers may utilize a dynamic database, post on their website, notify members of the CEN Management Centre and other members, or reference the availability of such information in the Member's bulletins, newsletters, or annual report.

Furthermore, members are to have a non-discriminatory procedure to accept new experts. To ensure that all stakeholders of varying capabilities and capacities are involved, information is expected to give access to related activities without SMEs becoming members of the NSB at a discounted or free rate.

Drafts of standards are expected to be available free of charge on member websites. Once a standard has been adopted, special rates or reduced prices can also be offered to SMEs to maximize their participation and access to information.

CEN monitors and tracks the number and quality of initiatives that support stakeholder engagement and statistics on the categories of participating stakeholders (e.g., SMEs, national authorities, social organizations, etc.). Each NSB must also have a mechanism in place to garner consensus and an appeal process. Coordination and cooperation with other relevant international bodies is essential to ensure that there are no conflicts between international standards; CEN members are to avoid duplication or overlap with the work of other standardization bodies. CEN members are expected to take a due diligence approach during the planning stage to ensure a proposed product is not in conflict.

Source: Working Group Membership Criteria (cencenelec.eu)

4.4.4 Sustainability

4.4.4.1 Funding

While some workshop agreements can be downloaded for free, CEN standards and other products require a fee. Each member is required to pay their dues. CEN is also funded by donations obtained from national and European Union grants.

4.4.4.2 Deployment

As mentioned, each member country must adopt and implement all CEN standards without modification. As a result, each member is expected to recognize the law in their respective country as an officially competent organization to mandate the adoption of standards and adherence to other products.

Additionally, members must demonstrate that it has the physical infrastructure, which includes an IT system that meets CEN's requirements and enables the organization to participate in the voting process, manage a high volume of data, and capture communications within the CEN system. In order to ensure stability, the member country must have two levels of IP rights protection (e.g., copyright) and commercial policy at the national level and the member level. For the latter, the member's commercial and legal policies must comply with CEN.

In addition, many standards include pilot deployments prior to adoption. Member organizations can also access guidance documents and training.

Source Information: The contents about CEN were largely obtained in July 2024 from CEN's webpage and documents contained therein.

4.5 Connected Transportation Interoperability Standards Committee (CTIC)

4.5.1 Organization Overview and Background

In October 2019, the USDOT ITS JPO sponsored the development and publication of a connected signalized intersection standard that defines the key capabilities and interfaces that a connected intersection must support to ensure nationwide interoperability with production vehicles for state and local IOOs. Although JPO contracted with the ITE, the following associations are involved with ITE in ensuring balanced and effective stakeholder representation and adherence to a formal standards development process administered as SDOs: SAE, AASHTO, NEMA, and the Institute of Electrical and Electronics Engineers (IEEE)'s 1609 Working Group.

Upon publication, it was determined that there was a need for a series of documents that are jointly developed by stakeholders across the connected vehicle spectrum, including IOOs, the automotive industries, device manufacturers, mobility data providers, and systems integrators. These stakeholders and many others are represented by the SDOs listed above.

The SDOs working with USDOT agreed to create a new, jointly created family of standards, the Connected Transportation Interoperability (CTI) standards. Sponsored by the USDOT, the documents in the CTI family may be approved and published by any of SDOs mentioned but are developed and maintained by representatives across the connected vehicle spectrum. The documents in the CTI family include standards and technical reports (guides, test plans and procedures, etc.) that provide guidance to develop and maintain an interoperable connected vehicle environment. Three documents have been published to date:

- 1 CTI Standard: CTI 4001 – Roadside Unit Standard incl. v01.01 (Amendment 1)
- 1 CTI Guide: CTI 4501 – Connected Intersections Implementation Guide
- 1 CTI Technical report: CTI 4502 – Connected Intersections Validation Report

Additional reports were prepared leading up to these 3 documents, which can be found on ITE's Connected Intersection webpage (https://www.ite.org/technical-resources/standards/connected-intersections/).

4.5.2 Governance

There was no formal agreement or memorandum of understanding between the four primary SDOs (AASHTO, ITE, NEMA, SAE) during the development of the first three CTI documents (Phase 1). ITE was the lead SDO for an ITS standards development contract with USDOT and already had a MOU with AASHTO and NEMA to co-develop standards documents (See **Section 4.1.1**). SAE International had a separate Intelligent Transportation Systems (ITS) standards development contract with USDOT and served as a partner SDO throughout the development of the three documents. SAE International represents the interests of many stakeholders including the automotive industry. A joint SDO committee was formed to guide the development of two of the documents, with representatives from each of the partner SDOs, including Mr. Roy Goudy (SAE) and Mr. John Thai (ITE), who served as co-chairs of that committee. SAE International also assigned Justin McNew as a liaison to the CTI Committee (CTIC) who participated in all the committee meetings. Through this liaison, the SAE Infrastructure Applications TC was kept informed of the activities and progress of this CTI Implementation Guide. The publication of the first three CTI documents were published following the process established in the MOU among AASHTO, ITE, and NEMA.

In the current new phase of the CTI development (Phase 2), SAE International is the lead SDO for the development of the CTI documents. SAE International used its standards development process (See **Section 4.2**) and created a CTIC. The four partner agencies are currently negotiating on a MOU, which will be a framework for the cooperation of the four SDOs in publishing future CTI documents.

4.5.2.1 Leadership

Following the SAE standards development process (see **Figure 4.** SAE Standards Development Process),

SAE International formed a CTIC during Phase 2, which is responsible for developing the CTI documents. The CTIC has a chair and a vice-chair to preside over the committee meetings.

4.5.2.2 Membership

SAE TC members are volunteers, who participate with or without the support of their employers. Current committee rules allow anyone to participate in any of the meetings. Voting on ballots is restricted to voting members. To become a voting member, a prospective member must attend three consecutive committee meetings, then send an application to the committee chair requesting voting membership, and the application must then be approved by the committee chair.

Working groups, also called task forces, may be created by the TC, to develop a proposed document. Anyone may participate in any of the task force meetings.

4.5.3 Development Cycles

4.5.3.1 Products

The products of the CTIC are Technical Reports. SAE Technical Reports are classified as either SAE standards, SAE Recommended Practices, or SAE Information Reports. The MOU currently under negotiation is expected to define how these documents will be published. The seven documents currently under development by the CTIC are described below:

- J4501 – CI Implementation Guide v2.0
- J3305 – Assured Green Period (AGP) to Support Red Light Violation Warning
- J3258 – V2X Infrastructure Support for GNSS Corrections
- J3238/1 – Testing & Validation of SPaT information broadcast
- J3238/2 – Testing & Assessment of MAP using RTCM information broadcast
- J2945/B – Recommended Practices for Signalized Intersection Applications
- J3295 – Cooperative Perception Services Concept of Operations

4.5.3.2 Cycle / Process

ITE managed the CTI effort in Phase 1; therefore, the standards development process and cycle for the CTI standards developed in Phase 1 is the same as the one AASHTO, ITE, and NEMA have established and used for the NTCIP standards development process. That process can be reviewed in **Section 4.1.3.2**.

Technical reports such as CTI 4501 and 4502 are not standards and do not need balloting approval. They were approved by the responsible Phase 1 CTI committee.

The Phase 2 standards development process is under negotiation among the 4 SDOs but is expected to either follow SAE's process or continue to use the current Phase 1 process.

4.5.3.3 Development Support

The development support is provided in the form of funding for SMEs and for SDO coordination of task force and committee meetings. The support also includes publication and reimbursement for the published documents (the documents are free to the public, but USDOT reimburses the SDO for the cost).

4.5.4 Sustainability

4.5.4.1 Funding

The development of CTIC documents is funded by USDOT through the ITS standards contracts. ITE and SAE International each have a separate ITS standards Development and Support contract with USDOT.

Both are task orders to existing contracts, i.e., an Indefinite Delivery, Indefinite Quantity (IDIQ)/task order for ITS Connected and Automated Vehicle Standards Support contract with SAE International, and a task order for Connected Intersections Phase 2 with ITE.

The existing 3 CTI documents are openly available, free of charge, to all interested parties via an ITE webpage. ITE is reimbursed by USDOT for each download.

While not yet finalized, it is to be expected that both the funding mechanisms as well as the "free download, reimburse for each download" approach will be retained in Phase 2.

4.5.4.2 Deployment

The CTI 4501 Guide and the CTI 4502 Validation report were both used in the ATCMTD Grant deployment by Utah DOT (see https://transportationtechnology.utah.gov/wp-content/uploads/2023/07/Blaine-Leonard_UDOT-Transportation-Technology-Manager-compressed.pdf, slide 21). The first version of CTI 4001 RSU standard was also developed, and hardware updated to comply with this CTI standard.

Recently, two of the standards, CTI 4501 and CTI 4001, are consistently referenced in procurement documents seeking Connected Vehicle technology deployments. Several agencies are working towards conforming to CTI 4501, e.g., conformance to CTI 4501 is the subject of several projects including several Connected Vehicle Pooled Fund Studies and the Utah DOT SMART Grant. No RSU vendor has yet claimed conformance to CTI 4001; however, several vendors are working towards conformance.

5 Framework for Comparing Governance Characteristics

This paper describes a framework for comparing CBDO and SDO governance characteristics. Through reviewing organizational profiles, it was clear that the different types of organizations have considerable differences, but even more similarities. This section is divided into six groups related to the comparison categories (**Section 2.2**). These groups include:

- Governance and membership (**Section 5.1**)
- Standards development cycle (**5.2**)
- Development environment and publication process (**5.3**)
- Deployment support (**5.4**)
- Sustainability (**5.5**)
- Other factors in standard development (**5.6**)

Each group includes a set of categories by characteristics with which organizations are associated. For example, other factors include categories such as privacy and security framed by their inclusion in the development process – none, pre-development, during development period, and post-development. Although some SDOs and CBDOs have different characteristics that differ by working group or standard, each organization is assigned to a category by framework element.

The final section, **Section 5.7**, is a summary of how the organizations fall within the framework.

5.1 Governance and Membership Comparison

The Governance comparison is divided into two categories – SDO and CBDO that are organization or association driven versus body driven. SDO and CBDO Governance structures are described as follows:

The *organization or association driven* SDO or CBDO relies on its member organizations or associations to nominate their staff to leadership and membership positions. They also put forward technical experts to participate in activities. Finally, any voting is restricted to one organization – one vote.

The *body driven* SDO or CBDO organizations rely on the body to vote on leadership, are open to all individual participating in voting, and allow support for the technical work without restriction. The membership body driven approach may enforce diversity by basing leadership and voting by affiliation to public, private, or another sector (e.g., non-profit, academic). **Table 6** provides a description of the governance categories and **Table 7** classifies organization by governance categories.

Table 6. Description of Governance Categories

Category	Organization Driven	Body Driven
Leadership	Leadership is assigned or appointed by member organization	Leadership positions are nominated by the membership body. They are voted in using a democratic process.
Leadership Diversity	Proposed leadership personnel are not based the type of member organization (e.g., public, private) or stakeholder group, rather it is based on the agreement of key leadership positions (e.g., agreement of leadership).	Proposed leaders may be based on the sector or stakeholder group, for example, public, private, academic, non-profit, other.
Membership	Member status and its associated benefits/rights are restricted to organizations or individuals that join through a fee-based rate schedule.	Members and their associated benefits/rights are open to all interested parties. Members may need to comply with certain requirements such as attendance,

Category	Organization Driven	Body Driven
	An individual may also be considered a "member organization".	representing certain sectors, etc.
Participation in Technical Activities This includes -- development of standards, report, practices, recommendations for priorities/changes, and participation in coordination tools (e.g., Slack)	Participation in technical activities is restricted to members.	Participation in technical activities is open to any interested party.
Voting rights	Voting is restricted to one vote per member organization.	Voting is open to any interested individual. Sometimes it is restricted to one vote per participating organization.

Table 7. Organizations Classified by Governance Categories

Standards/Specification Organizations by Category	Association Driven	Body Driven
Leadership	**CBDO:** OASIS, OGC, OMF **SDO:** NTCIP, SAE, ISO, CEN,	**CBDO:** MobilityData, WZDWG **SDO:** CTIC
Leadership diversity	**CBDO:** OGC **SDO:** ISO, CEN	**CBDO:** OASIS, WZDWG *[Note 1]* **SDO:** NTCIP, SAE, CTIC
Membership	**CBDO:** OASIS, OGC, MobilityData **SDO:** NTCIP, SAE, ISO, CEN	**CBDO:** WZDWG **SDO:** CTIC
Participation in TCs	**CBDO:** OASIS, OGC **SDO:** NTCIP, SAE, ISO, CEN	**CBDO:** WZDWG, MobilityData, OMF **SDO:** CTIC
Voting rights	**CBDO:** OASIS, OMF, OGC **SDO:** NTCIP, SAE, ISO, CEN	**CBDO:** WZDWG **SDO:** CTIC

Note 1: Although individuals participated in WZDWG, leadership was voted on by the body assembly, within their own swimlanes – public and private sectors.

OpenSidewalks is not a formal organization and as a consequence it is not classified in the Governance categories. It is an academic-led specification at this time.

5.2 Standard Development Cycle

The development process is subject to milestones and provisions prior to balloting or adoption. The entire process may be subject to a formal development or review methodology. All organizations that we reviewed include an open, consensus-based review process for standards; however, some organizations require additional development activities prior to balloting and promotion as an "official" standard or specification. **Table 8** classifies organizations by the types of standards development processes.

Formal SE Process – applies a formal system engineering process to development standards from developing a Concept of Operations, Requirements, and Test Compliance documents with stakeholder walkthroughs.

Use Case Process – identifies needs and use cases and requires that the proposed or provisional

standard be piloted in a reference implementation. Additional support tools or guides are also developed during the development cycle.

Standard Compliance Testing Process – in addition to the open review process for reviewing the standard, the technical specification or standard also requires verification from a testing compliance tool prior to promotion as a standard / specification.

Standard Review Process – all standards are subject to only a review process by voting members and/or stakeholders (depending on the stage of balloting).

Table 8. Organizations Classified by different types of Standards Development Processes

	Formal SE Process	Use Case Process	Standards Compliance Testing Process	Standard Review Process
Standard / Spec Development Process	**SDO:** NTCIP, CTIC	**CBDO:** OMF, OpenSidewalks	**CBDO:** MobilityData, WZDWG	**CBDO:** OASIS, OGC **SDO:** SAE, ISO, CEN

The Standards Development Cycles of various organizations vary based on their goals, scope, and processes with the key differences of:

Focus: Each organization has a different focus, ranging from geospatial data (OGC) to intelligent transportation systems (NTCIP) to public transportation data (MobilityData).

Process: While all follow a consensus-based approach, the specific steps and stages can vary significantly. For instance, ISO and CEN have more formalized processes with multiple review stages compared to more flexible, iterative approaches in organizations like Open Mobility Foundation.

Public Participation: Most organizations involve public review stages, but the level of openness and the extent of stakeholder involvement does vary.

Adaptability: The CBDO process is more agile as it allows for rapid innovation compared to SDOs.

The update and review cycles in the standards development processes of various organizations differ based on their specific methodologies and processes. The **Update and Review Cycles** for each organization are provided in **Table 9**.

Table 9. Organizations Classified by Standards Update and Review Development Cycles

Organization	Updates, as Needed	Periodic Updates	Regular Updates	Comment
OASIS	✓			Updates as needed; review includes public reviews and committee evaluations.
OMF		✓		Periodic updates based on feedback; collaborative review process.
MobilityData			✓	Regular updates; review includes working group and community feedback.
WZDWG	✓			Updates as needed; review includes stakeholder feedback and public comments.
OpenSidewalks	✓			Updates driven by needs and feedback; review involves public and community feedback.
OGC		✓		Periodic updates; review includes public comment periods and working group reviews.
NTCIP		✓		Periodic updates or as necessary; formal review processes and public comments.

Organization	Updates, as Needed	Periodic Updates	Regular Updates	Comment
SAE			✓	Regular updates based on industry needs; review includes committee and public input.
ISO			✓	Review and update every 5 years; formal proposal, draft, public review, and approval stages.
CEN			✓	Review and update every 5 years; involves proposal, draft reviews, public consultations, and approval.
CTIC	✓			Updates as needed; review includes community feedback and public reviews.

5.3 Development Environments and Publication Process

The development environments support technical discussions and guidance enabled by members and community outreach. These tools and support materials may be characterized as tools and publications. The development environments and artifacts may be described by the following:

- Collaborative technical tools
  - Example of collaborative technical tools include GitHub, Slack, and other modeling tools
- Document repository
  - Storage of products and draft documents for technical reviewers or developers to use. These may include a document repository and configuration tool such as Microsoft Sharepoint/Teams or Google Docs.
- Testing tools
  - Simulation or tools to validate engineering specification (e.g., XML) or to test an API.
- Open source software (OSS)
  - Site to store and access OSS that may include a reference implementation such as an app that implements the standard, or a dashboard that displays the results of data collected using the standard. The OSS may also be an API or schema used to transmit, receive or store a "message".

Limited implies that the organization has few resources that are available within each category, while *extensive* implies that the organization provides typical tools that meet the content of each category.

Table 10. Development Environment Categories

Categories	Limited to None	Extensive
Collaborative technical tools	**SDO:** ISO	**CBDO:** OASIS, MobilityData, WZDWG, OGC **SDO:** NTCIP *[Note 1]*, SAE, CTIC
Document repository	**SDO:** ISO	**CBDO:** OASIS, WZDWG, OGC, MobilityData **SDO:** NTCIP, SAE, CTIC, CEN
Testing tools	**CBDO:** OASIS *[Note 3]*, WZDWG, **SDO:** CEN, ISO, NTCIP *[Note 2]*, SAE, CTIC *[Note 2]*	**CBDO:** MobilityData, OGC
Open source software	**CBDO:** OASIS *[Note 3]*, WZDWG ***SDO:*** ISO, CEN, SAE, NTCIP, CTIC	**CBDO:** MobilityData, OGC

Notes:

- Note 1: As of 2024, NTCIP standards are now managed; prior to this year, NTCIP would have been designated as 'limited'.
- Note 2: Although limited, all updated and new NTCIP and CTI standards have test procedures defined.
- Note 3: Does not support testing tools or OSS

In addition, support materials include publications that may be available to access including the standard or specification, testing conformance, guidance, and training materials.

Publications categories include:

- Cost describes whether the standard/specification is free or purchased
  - *Open* implies that the standard / specification is free without or with limited license restrictions
  - *Restricted* implies that the standard is not free but requires the recipient to buy the document and it is restricted to share with others (e.g., outside your organization). Some engineering specifications may be available for free but without the explanations and context typically included in a standard document.
- Publication Review implies that the transition from acceptance to publication entails several reviews.
  - The review might include a legal review, editor and copy editor reviews, or the addition of supplemental documentation.
  - This category differentiates the review of the draft document (*open*) versus the balloted document *(restricted*). The review of the balloted document may delay the publication.
- Copyright describes the usage rights applied to the product
  - Open implies a Creative Commons License, exclusive of Creative Commons Zero (CC0), or free reproduction of the publication material with a citation of its source
  - Restricted implies that the republication of the material is restricted. The restricted does not imply restricted use of the standard, just its reproduction of the standard document is restricted.
- Publication Format describes the formats in which the publication is available.
  - Open implies that the products and other materials are available on-line and in editable or native formats such as engineering specifications (e.g., management information base (MIBs), JSON, XML), word processor (e.g., Google Docs or Microsoft Word), etc.
  - Restricted implies that the products and other materials are restricted to non-editable formats such as Portable Document Format (PDF).

Table 11. Publication Process Categories

Categories	Open	Restricted
Cost	**CBDO:** OMF, MobilityData, WZDWG, OpenSidewalks, OGC, OASIS **SDO:** CEN (free for member countries), NTCIP	**SDO:** ISO, CEN (for the public), SAE
Publication Reviews	**CBDO:** WZDWG	**CBDO:** OASIS, **SDO:** ISO, NTCIP, CEN
Copyright	**CBDO:** OMF, MobilityData, WZDWG, OGC, OASIS *[Note 1]* **SDO:** CEN, NTCIP	**CBDO:** OpenSidewalks *[Note 2]* **SDO:** ISO, CEN, SAE
Publication format	OMF, MobilityData, WZDWG, OpenSidewalks, OGC, NTCIP, CEN, OASIS	**SDO:** ISO, SAE

Notes

- Note 1: OASIS TCs determine which one of four types of Intellectual Property Rights (IPR) the developed products will have. A TC cannot change the IPR of its deliverables once established (see https://www.oasis-open.org/policies-guidelines/ipr/).
- Note 2: OpenSidewalks is copyrighted under Creative Commons Attribution-Sharealike 4.0

5.4 Deployment Support

Standards and specifications often include the generation of deployment support products, collaboration environments, and tools to develop as well as support deployment. Deployment support includes the following:

Training tools may be in the form of workshops, online modules, videos, or webcasts. Training may be synchronous (i.e. real-time, scheduled meetings) or asynchronous (i.e. training materials can be accessed at any time for use). Skills and knowledge gained may include background information on the standard topic, the purpose of the standard, and/or instructions on how to implement the standard.

Best practice guides are documents that provide advice for implementing a standard. They may address the entire process or focus on specific use cases (e.g. GTFS guides provide examples of how to implement fixed route vs. flex service).

Test tools and certification provide support for testing and then certifying the standard implementation. Test tools may be created to assist deployers in ensuring that the "interface" or "design" met the requirements of the standard (e.g., data and content were verified) and that their canonical form is tested to ensure it can be Integrated with other systems. Certification provides deployers with approval based on passing specified tests or by a third, independent party conducting standardized testing.

Engineering specifications, as defined in Section 2.1, **"**[is a] file that is encoded using an open file format and interface standard such as JSON, XML, or CSV." The engineering specification is verified using a testing tool that the content meets specific requirements of the encoding format.

Reference implementations are pilot implementations that deploy the standard in an open format (sometimes publishing the code as open-source software). Specifically, as defined by *the National Institute of Standards and Technology (NIST) (reference implementation, extracted September 19, 2024)* "the implementation of a standard to be used as a definitive interpretation for the requirements in that standard. Reference implementations can serve many purposes. They can be used to verify that the standard is implementable, validate conformance test tools, and support interoperability testing among other implementations. A reference implementation may or may not have the quality of a commercial product or service that implements the standard."

Active online communities are collaborative platforms such as chat forums to facilitate discussions related to issues, modifications, or implementation of a data specification or standard.

Most products generated by a standard or specification development group do not need the group to ballot to approve them. However, some support products such as test procedures (a type of test tool) included in some NTCIP standards require the working group to ballot for approval. **Table 12** provides a list of deployment support categories denoting whether or not a ballot is needed. This table is not an exhaustive table of Deployment Support products; some information is not known or easily accessible.

Table 12. Deployment Support Categories

Category	Products Generated	Ballot Needed
Training Tools	**CBDO:** OASIS, **SDO:** NTCIP, SAE, CEN	None *[Note 1]*
Best Practice Guides	**CBDO:** OMF **SDO:** NTCIP, SAE, CEN	None *[Note 2]*
Test Tools / Certification	**CBDO:** OMF, MobilityData **SDO:** CEN	**SDO:** NTCIP *[Note 3]*

Category	Products Generated	Ballot Needed
Engineering Specifications	**SDO:** NTCIP *[Note 4]*, SAE *[Note 5]*	**CBDO:** OMF, MobilityData, WZDWG *[Note 6]* **SDO:** CEN, NTCIP, SAE
Reference Implementations	**CBDO:** OMF, OGC **SDO:** CEN	None *[Note 1]*
Active online communities	**CBDO:** OMF, MobilityData **SDO:** CEN	
ISO does not generate deployment support products.		

- Note 1: Training tools, best practice guides, and reference implementations usually do not need balloting to be published.
- Note 2: Best practice guides usually do not need balloting to be published.
- Note 3: Some NTCIP standards include test procedure documents.
- Note 4: NTCIP MIBs (https://www.ntcip.org/how-to-get-mibs/)
- Note 5: SAE ASN.1 (https://www.sae.org/standards/content/j2735asn_202309/)
- Note 6: WZDWG JSON schema (https://github.com/usdot-jpo-ode/wzdx/tree/main/schemas) is the primary product of the specification. Therefore, the WZDWG is needed to ballot to approve the product.

5.5 Sustainability

Sustainability of standards and standard organizations is achieved through a variety of channels. The most important may be the deployment and use of the standard. To that end, acquisition of the standard and other deployment support tools, applications using the standard, and ease of deployment of the standard are critical elements. The categories used to frame specific standards developed by SDOs or CBDOs may be characterized by whether the category is voluntary (e.g., free, commercially widespread) or mandated (e.g., required by government organization).

- Product costs – entails costs for acquiring an organization's products including standard document, engineering specification, tools, validation tools, guidance, etc.
  - Voluntary implies that the cost is free or with limited license restrictions
  - Mandated implies that the product acquisition is purchased
- Standard adoption – includes the authority or drivers for adopting the standard.
  - Voluntary implies that the standard is not mandated by an authority (like a state or federal policy)
- Funding of programs for deployment – includes awards, grants or other sources of funds from outside organizations to pilot or deploy the standards in projects.
  - Voluntary implies that all deployments are self-funding.
  - Mandated implies that there are government subsidies, grants, awards or mandates that require procurement of equipment, data, or other project elements that contain the standard.

Table 13. Standard Organization Categories

	Voluntary	Mandated
Product Costs	**CBDO:** OASIS, OMF, MobilityData, WZDWG, OpenSidewalks, OGC **SDO:** NTCIP, CEN, CTIC	**SDO:** SAE, ISO, CEN *[Note 1]*
Standard adoption	**CBDO:** OMF, MobilityData, WZDWG, OpenSidewalks, OGC, OASIS *[Note 2]* **SDO:** CTIC, SAE, ISO *[Note 2]*	**CBDO:** MobilityData *[Note 3]*, **SDO:** CEN *[Note 4],* NTCIP *[Note 5]*
Funding for deployment	**CBDO:** OASIS, OMF, OGC **SDO:** SAE, ISO, CTIC	**CBDO:** MobilityData, WZDWG *[Note 6]*, OpenSidewalks **SDO:** CEN

Notes:

- Note 1: CEN has a limited number of products, primarily in the ICT field, available free of charge under certain circumstances.
- Note 2: OASIS and ISO include different types of standards that are subject to different industry drivers. For example, many ISO standards are mandated by the European Union but not in other countries. Many OASIS standards are de facto standards accepted and used throughout certain industries. Although both are identified as "voluntary", there are strong drivers to imply that they are necessary.
- Note 3: Effective in 2023, GTFS, the major specification maintained by MobilityData, is required for federal reporting by the Federal Transit Administration
- Note 4: Mandated for member states (CEN)
- Note 5: NTCIP, though not federally mandated, is required for capital funding by the USDOT. Many states also mandate equipment that is NTCIP compliant.
- Note 6: USDOT offered microgrants for piloting the WZDWG

5.6 Other Factors in Standard Development

Although not necessarily described in the development process, some standards development activities require consideration of other factors prior to initiating a standards effort, during the development effort or as part of the deployment effort. These factors associated with the standard may include:

- **Security and privacy** protections consider security and privacy issues for accessible transportation and VRUs as part of the development process.
    - Cybersecurity is the practice of protecting systems, networks, and programs from digital attacks. These attacks are typically aimed at accessing, changing, or destroying sensitive information, extorting money from users, or interrupting normal business processes. *With respect to standards development, cybersecurity focuses on addressing security policies and protocols to the standard. Cybersecurity also involves deployment activities such as regular updating and patching of systems, user education and training, and the implementation of robust security policies and protocols.*

    - Privacy is the right of individuals to control or limit the collection, use, and dissemination of their personal information. It involves safeguarding personal data from unauthorized access, ensuring that individuals have the autonomy to make decisions about who can access their information, and under what circumstances. Privacy encompasses various aspects such as physical privacy, informational privacy, and communication privacy. *With respect to standards development, this involves limiting the exposure of personal data, describing functions that enable individuals to make decisions about sharing personal data, and ensuring the protocols used to convey privacy data include cybersecurity provisions.*

- **Environmental Sustainability Impact** defines how the standard / specification may support sustainability. Sustainability is defined by the United Nations (UN) Sustainability Development Goals. For example, a proposed New Work Item for an ISO product requires a Form 4 that includes the following question:

  "Please select any UN Sustainable Development Goals (SDGs) that this proposed project would support (information about SDGs is available at www.iso.org/SDGs)

  ☐ GOAL 1: No Poverty
  ☐ GOAL 2: Zero Hunger
  ☐ GOAL 3: Good Health and Well-being
  ☐ GOAL 4: Quality Education
  ☐ GOAL 5: Gender Equality

☐ GOAL 6: Clean Water and Sanitation
☐ GOAL 7: Affordable and Clean Energy
☐ GOAL 8: Decent Work and Economic Growth
☐ GOAL 9: Industry, Innovation and Infrastructure
☐ GOAL 10: Reduced Inequality
☐ GOAL 11: Sustainable Cities and Communities
☐ GOAL 12: Responsible Consumption and Production
☐ GOAL 13: Climate Action
☐ GOAL 14: Life Below Water
☐ GOAL 15: Life on Land
☐ GOAL 16: Peace, Justice and strong institutions
N/A GOAL 17: Partnerships for the goals"

The question asked during review of the application for a new work item implies the pre-review of environmental sustainability impact.

Many standard/specification development organizations may not address these considerations, or they address the consideration factor to move forward (pre-development) or rely on deployment feedback. Even fewer require that the draft standard or reference implementation involve advocacy and stakeholder groups to review the requirements inherent in the product. These other factors that are considered by the standards/specification organizations may fall into the following:

- **No Review:** organization does not consider other factors when initiating or developing a standard
- **Pre-development and Throughout:** organization includes activities that classifies work prior to development. This may impact the priority of the development. This may include identifying needs, reviewing associated goals, or providing guidance to developers on considerations.
- **During development:** organization not only considers impact of other considerations but may also involves advocacy groups and/or stakeholder SMEs to participate and/or review the proposed standard content.

Table 14. Consideration of Other Factors during Standard/Specification Development

Standards / Specification Organizations by Category	**No Review *[Note 1]***	**Pre-Development Only**	**During Development / Throughout**
Security / Privacy	**CBDO:** OASIS *[Note 2]*, MobilityData, OpenSidewalks, OGC **SDO:** ISO *[Note 2]*		**CBDO:** OMF **SDO:** SAE, CEN, CTIC
Environmental Sustainability	**CBDO:** OASIS, MobilityData, WZDWG, OpenSidewalks, OGC **SDO:** NTCIP, SAE, CTIC	**SDO:** ISO, CEN	

Notes:

- Note 1: Many of the SDOs apply different processes for different domains.
- Note 2: for standards/specifications that do not deal with security

5.7 Summary of Framework Comparison

The Framework Comparison is summarized in **Table 14**. The summary framework table assigns a framework category value for each organization. The rows identify each organization while the columns represent the framework categories. Each cell lists the and highlights the category value so that the chart presents a visual depiction of the variety of framework category values. **Table 15** describes the colors used to visualize each category value.

Table 15. Summary of Framework Comparison

Org \ Framework Categories	Governance	Development	Dev Environment	Deployment Support	Sustainability	Other Factors
CBDOs						
OASIS	Association Driven	Standard Review	Limited	Products Generated	Voluntary	No Review
OMF	Association Driven	Use Case Process	Limited	Products Generated	Voluntary	Throughout
MobilityData	Body Driven	Standards Compliance	Extensive	Products Generated	Mandated	No Review
WZDWG	Body Driven	Standards Compliance	Limited	Products Generated	Voluntary	No Review
OpenSidewalks	Not applicable	Use Case Process	Limited	Products Generated	Voluntary	No Review
OGC	Association Driven	Standard Review	Extensive	Products Generated	Voluntary	No Review
SDOs						
NTCIP	Association Driven	Formal SE Process	Limited	Needed to Ballot	Voluntary	No Review
SAE Int'l	Association Driven	Standard Review	Limited	Products Generated	Voluntary	No Review
ISO	Association Driven	Standard Review	Limited	Products Generated	Voluntary	Pre-development
CEN	Association Driven	Standard Review	Limited	Products Generated	Mandated	Pre-development
CTIC	Association Driven	Formal SE Process	Limited	Products Generated	Voluntary	No Review

Table 16. Legend Colors for Framework Comparison Table (Table 14)

Legend	Category 1	Category 2	Category 3	Category 4
Governance	Association Driven	Body Driven		
Development	Formal SE Process	Use Case Process	Standards Compliance Testing Process	Standard Review Process
Dev Environment	Limited	Extensive		
Deployment Support	Products Generated	Ballot Needed		
Sustainability	Voluntary	Mandated		
Other Factors	No Review	Pre-development Only	Throughout	Post development Only

In developing the organization profile descriptions, it became clear that there were no consistent practices that drove SDOs versus CBDOs. The most diverse category is the development category where the diversity of development approaches within the CBDO is significant (includes three types of development approaches), while the traditional SDOs (SAE, ISO, CEN) use a typical standard review process while the USDOT sponsored SDOs (NTCIP and CTTIC) use a system engineering approach.

Most organizations are governed by associations (organizations, company affiliation or sector). Most CBDO and SDO development environments are limited, although they are starting to use tools to collaborate and manage document configuration. Although there are more types of products generated by CBDOs including open source software, most organization produce engineering specifications that can be used as a programming template. Most organizations rely on their standards or specifications becoming de facto, industry standards versus required. However, some specifications have become accepted by the Federal government as the required reporting data format (e.g., GTFS). Finally, few organizations adopt other factors such as review for security as a requirement for development although some international SDOs have implemented a pre-review need for one or more of these considerations.

6 Summary of "Best" Practices

This section reviews the framework paradigms that support moving standards to deployment. Based on the comparison of Governance Characteristics the following practices seem to support not only expeditious delivery of standards but moving standards to deployment and use in commercial products. Four sets of practices that produce standards and specifications that are common or expedite concept-to-deployment are categorized below:

Governance Practices

- ✓ Open, Un-tiered Membership
  - Open membership with leadership diversity representing key stakeholders
  - Open membership in technical working groups, meaning that participation does not require membership fees or certain membership tiers.
  - Leadership, voting rights, and participation is not based on tiered membership
- ✓ Formal Rules and Procedures
  - Voting rights restricted to one vote per organization
  - Formulas for passage of different types of organizational products: standards, technical reports, policies/procedures, etc.
  - Develop strategies and prioritize tasks for standardization activities

Development Practices

- ✓ Transparent, Collaborative, Consensus-driven Standards Development Process
  - Consensus based where community/membership resolves all the issues raised about the proposed standard/specification
  - Collaboration and transparent environment to develop standards, i.e., GitHub
  - Rigorous standards development process to ensure high quality and deploy-ability for end-users.
- ✓ Utilize Deployment Support Tools
  - Develop standards/specifications with testing specifications
  - Ballot with validated engineering specifications
- ✓ Establish Time Frames
  - Formal review cycle to engage key stakeholders in reviewing and validating provisions of draft standards / specification
  - Mandatory review/refresh period for standards
- ✓ Consider Other Factors
  - Consideration and input of "other factors" into the development of standards/specifications including privacy, security, and environmental sustainability

Deployment Support Practices

- ✓ Free Access
  - Free standard / specification documents accessible through on-line portals
- ✓ Enhance Standards Usage and Viability Through Tools and Interactive Opportunities
  - Deployment of support tools to sustain deploying standards including training, best practices, OSS and on-line collaboration groups
  - Reference implementation, engineering specifications, and OSS repository to help data producers and consumers jump start deployment
  - Support user feedback to improve standards through the deployment.

Sustainability Practices

- ✓ Provide Practitioner and Academic Training

- Professional capacity building program to train developers and leaders in standards, standard development processes and standard implementation
- Outreach programs in academia and for other stakeholder groups (e.g., OEMs, government agencies, deployment organizations, and professional organizations)

✓ Mandate Standard Usage

- Federal requirement to use standards

7 Acronyms and Definitions

Table 16 defines the acronyms present throughout this document.

Table 17. Acronyms and Definitions

AASHTO	American Association of State Highway Transportation Officials
ANSI	American National Standards Institute
API	Application Programming Interface
ARML	Augmented Reality Markup Language
ATCMTD	Advanced Transportation and Congestion Management Technologies Deployment
AWS	Amazon Web Services
BAE	British Aerospace
BoD	Board of Directors
BRGM	Bureau de Recherches Géologiques et Minières
BT	Technical Board
CAE	*Name of a company*
CBDO	Community-Based Specification Development Organizations
CCMC	European Committee for Electrotechnical Standardization (CENELEC) Management Centre
CCTV	Closed-Circuit Television
CD	Committee Draft
CDS	Curb Data Specification
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CGI	Conseillers en gestion et informatique
CISA	Cybersecurity and Infrastructure Security Agency
CPAG	ISO's Commercial Policy
CS	Central Secretariat
CSV	Comma Separated Values
CTI	Connected Transportation Interoperability
CTIC	Connected Transportation Interoperability Standards Committee
CWZ	Connected Work Zones
DCM	Data Collection and Monitoring
DHS	Department of Homeland Security
DIS	Draft International Standard
DLA	Document License Agreement
DMS	Dynamic Message Signs
EEA	European Economic Area
EFTA	European Free Trade Association
EO	Earth Observation
EPC	Executive Planning Committee
ESA	European Space Agency
ESRI	Environmental Systems Research Institute
ESS	Environmental Sensor Stations
ETSI	European Telecommunications Standards Institute
EU	European
EU	European Union
FAA	Federal Aviation Administration
FaaS	Foundation-as-a-Service
FAIR	Findable, Accessible, Interoperable, and Reusable
FBI	Federal Bureau of Investigation
FCU	*Name of a company*
FGDC	Federal Geographic Data Committee

FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GBFS	General Bikeshare Feed Specification
GDPR	General Data Protection Regulation
GE	General Electric
GIS	Geographic Information System
GML	Geography Markup Language
GTFS	General Transit Feed Specification
HPE	Hewlett Packard Enterprise
IBM	International Business Machines
IDIQ	Indefinite Delivery, Indefinite Quantity
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IFB	Invitation for Bid
IOO	Infrastructure Owners and Operators
IoT	Internet of Things
IP	Intellectual Property
IRP	Intellectual Property Rights
ISO	International Organization for Standardization
ISSA	Infrastructure Standards Security Assessment
ITB	Invitation to Bid
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
ITS JPO	Intelligent Transportation Systems Joint Program Office
ITSAG	ISO's Information Technology
ITU	International Telecommunication Union
ITU	International Telecommunication Union
JSON	JavaScript Object Notation
MAT	Multimodal Accessible Travel
MDIP	Mobility Data Interoperability Principles
MDS	Mobility Data Specification
MIBs	Management Information Base
MOU	Memorandum of Understanding
MSP	Mobility Service Providers
NEMA	National Electrical Manufacturers Associations
NGA	US National Geospatial-Intelligence Agency
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPO	nonprofit organization
NSB	National Standardization Bodies
NTCIP	National Transportation Communications for ITS (Intelligent Transportation Systems) Protocol
NTD	National Transit Database
NWS	National Weather Service
OAB	OGC Architecture Board
OGC	Open Geospatial Consortium, Inc.
OGC	Open Geospatial Consortium
OMF	Open Mobility Foundation
OSM	OpenStreetMap
OSMUS	US-based OpenStreetMap
OSS	Open-Source Software
PCB	Professional Capacity Building
PDF	Portable Document Format

PubSub	Publish/Subscribe
RC	Release Candidate
RESO	Real Estate Standards Organization
RFC	Request For Comment
RFP	Request for Proposal
RMC	Ramp Meter Controller
RSU	Roadside Unit
SAE	SAE International
SC	Subcommittee
SCP	Signal Control and Prioritization
SDG	Sustainable Development Goal
SDO	Standards Development Organizations
SGML	Standard Generalized Markup Language
SMAC	Strategic Management Advisory Committee
SME	Subject Matter Expert
SWG	Standards Working Groups
TAGs	Technical Advisory Groups
TC	Technical Committee
TCAT	Taskar Center for Accessible Technology
TDEI	Transportation Data Equity Initiative
TIDES	Transit ITS Data Exchange Specification
TMB	Technical Management Board
TODS	Transit Operational Data Standard
TSC	Transportation Subcommittee
TSMO	Transportation Systems Management and Operations
TSS	Transportation Sensor Systems
UML	Unified Modeling Language
UN	United Nations
URL	Uniform Resource Locator
USDOT	US Department of Transportation
USGS	US Homeland Security, US Geological Survey
VMS	Variable Message Sign
VRU	Vulnerable Road Users
WD	Working Draft
WFS	Web Feature Service
WG	Working Group
WMS	Web Map Service Interface Standard (WMS)
WMTS	Web Map Tile Service
WPS	Web Processing Service
WTO	World Trade Organization
WZDWG	Work Zone Data Working Group
WZDx	Work Zone Data Exchange
XML	eXtensible Markup Language
XSD	XML schema definition