WHITE PAPER

Establishing Data Standards for the Global Freight Sector: Applied Lessons Across Transportation

Rachel Aland
Isabelle Dupraz

KEY TAKEAWAYS

- **Establish data standards that are open, freely available, and accessible.** This will give industry control over their data and enable heterogeneous software vendor options and innovation.
- **Ensure regulations facilitate open data standard interoperability** with uniform and predictable regulatory frameworks that enable digitalization.
- **When developing a data standard, focus on a specific use case**—then test and iterate quickly—to improve quality and facilitate widespread adoption.
- **Alongside industry, involve software vendors** in the development process early to incorporate their expertise.
- **Create a governing structure to manage the change request process** and dedicate resources to it to maintain the data standards and continue education and engagement of users.

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Introduction

Devices that track locations using satellite technology and global positioning systems, radio frequency identification tags, and cell tower and Wi-Fi triangulation are ubiquitous and inexpensive. While these technologies generate enormous quantities of data, the data generated is only useful when collected, analyzed, and translated into meaningful insights.

Harnessing and sharing those insights can have tremendous benefits for business and society at large. The Coalition for Reimagined Mobility's (ReMo) report, *Solving the Global Supply Chain Crisis with Data Sharing*, demonstrated how harnessing information about the movement of goods would increase the efficiency, sustainability, and resiliency of global supply chains.

To achieve these benefits, data supporting the complex, multi-stakeholder transportation of goods would need to be produced, standardized, and exchanged between relevant parties. ReMo found that improved data exchange across the freight sector would reduce emissions by 22%, costs by 6% reduction, and pollution in port communities by 40% simply by increasing efficiency.

ReMo published *The Importance of Data Standards and Interoperability in Global Supply Chains*, which further details how data standards function, and the benefits of interoperability achieved by sharing a common language.

This white paper builds on ReMo's prior work, by highlighting real world examples of effective data standards in transportation. The purpose of this document is to inform policymakers and industry stakeholders who are newer to data standards with best practices that support the development, adoption, and ongoing management of data standards and how to apply these lessons to the global freight sector.

By looking at the success of the **General Transit Feed Specification** (GTFS) data standard, **electronic bill of lading** (eBL) interoperability in maritime transportation, and the **Aviation Information Data Exchange** (AIDX) standard, this white paper extrapolates lessons learned from both mature and burgeoning data standards in the transportation sector.

These three standards were selected to help inform policymakers and industry stakeholders in the freight sector as they move to develop and adopt modern data standards. All three standards are open, freely accessible standards. Two of the three, GTFS and AIDX, are examples of broadly adopted standards focused on the type of operational data exchange that is most beneficial for the global freight sector to standardize—accurate, up-to-date information about arrivals and departures. On the other hand, eBL gives insight into an ongoing data standard development initiative within the freight sector. It underscores the importance of bringing key stakeholders together with a focus on achieving interoperability.

The lessons from these three standards initiatives offer value to global freight sector data standard development efforts.

Open data standards can have tremendous economic, environmental, and security benefits for how we move goods and people. This white paper describes how to develop and maintain open, freely available, and accessible, data standards that help make our transportation systems more resilient, sustainable, and efficient.

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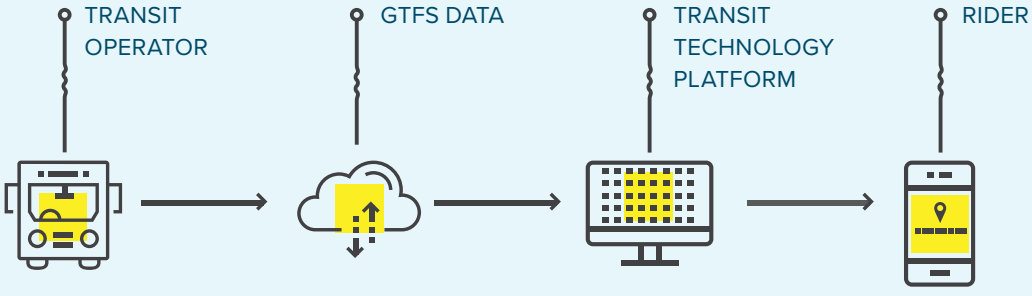
Case Studies

Lessons from Transit:
General Transit Feed Specification

General Transit Feed Specification (GTFS)

- Allows transit operators to share schedule and network information.
- Used by transit agencies and operators, who produce data, and by transit technology providers, who consume and format data within software platforms for transit riders.
- Stewarded by MobilityData, an independent non-profit, since 2019.
- 10,000 transit operators in 100 countries globally use GTFS to share schedule and real-time bus, train, and metro schedule information with millions of riders.[1]

FIGURE 1 · How GTFS Works



[1] Data Standards | MobilityData. (n.d.). MobilityData. https://mobilitydata.org/data-standards/#what-is-gtfs

TAKEAWAYS

- GTFS owes its success to its clearly defined scope, ease of adoption, and vast ecosystem of transit agencies and software providers with a shared goal.
- Coordinated, active management and upkeep of GTFS—with input from data producers and consumers volunteering their time to support the standard—is essential to upholding GTFS and ensuring it continues to best serve the community.

Today, tens of millions of transit riders need only to open any number of apps on their phone to see when the next bus, train, or metro is arriving—taking much of the guess work out of urban travel by transit, whether visiting a new city or navigating their local transit systems.

This is possible thanks to open data standards for transit data, and in particular the General Transit Feed Specification (GTFS), which has become the de facto standard for transit schedule data. GTFS allows people to access information that has radically improved the ease with which they can plan trips on 10,000 transit systems in 100 countries worldwide, helping encourage increased ridership.[2]

GTFS is a data specification that allows public transit agencies to publish transit data in an exchange format that can be consumed, and interpreted, by a wide variety of software applications. While it originally only created a static feed containing information about transit services schedules, fares, and routes, the companion specification GTFS Realtime later added arrival predictions, vehicle positions, and service advisories.[3]

Origin of the Standard

Google and TriMet, the transit operator of Portland, Oregon, spearheaded the creation of GTFS in 2005. A software engineer at Google was seeking a government partner to provide transit service data for Google Maps, which had launched earlier that year.[4] TriMet had a history of sharing transit schedule information with the public through its online transit trip planning tool, making the agency a good partner.[5]

Eager to boost ridership through improved access to transit schedule information, TriMet published the schedule data in CSV format on its website, for Google and other

[2] Data Standards | MobilityData. (n.d.). MobilityData. https://mobilitydata.org/data-standards/#what-is-gtfs

[3] General Transit Feed Specification. (n.d.). https://gtfs.mobilitydata.org/?_ga=2.107723393.2075155370.1643143693-1932193237.1643143693

[4] Pioneering Open Data Standards: The GTFS Story. (n.d.). https://beyondtransparency.org/part-2/pioneering-open-data-standards-the-gtfs-story/

[5] Goldstein, B., & Dyson, L. (2013). Beyond Transparency: Open Data and the Future of Civic Innovation. https://beyondtransparency.org/pdf/BeyondTransparency.pdf

third-party developers to use. By December of 2005, this data made it possible for Google to launch Google Transit for the Portland Metro Area and provide digital transit information to riders.

Several other interested agencies worked with Google and TriMet to scale the format—known at the time as the Google Transit Feed Specification—to more cities, publishing the first official version in 2006. Despite some transit agencies' initial reluctance to share data or their failure to see the value in participating, the launch of Google Transit beta received an overwhelmingly positive public response.[6]

Incentives for all parties involved in the creation and adoption of GTFS were clearly aligned: by making this data accessible to riders, transit agencies would boost ridership, delivering public value, while Google and other transit app providers would gain access to more data and expand the number of users of their software.

These naturally aligned incentives drove rapid voluntary adoption.

Phases of Governance

From its conception to the present day, the management of GTFS has changed several times. This case study explores the different phases of governance of GTFS and the impact of the different approaches to oversight and upkeep on the standard's trajectory, including:

1. Google Leads Standard Development (2006-2008)
2. Google Steps Back as an Open-Source Community Emerges (2009-2015)
3. Institutional Support and Reinvestment (2015-2018)
4. MobilityData: The Creation of a Steward (2019-present)

Google Leads Standard Development (2006-2008)

Shortly after GTFS' launch in 2006, a virtual community of software developers using the standard and public transit employees producing and maintaining GTFS data emerged.

To allow this community to get involved in the development of the standard, Google created the infrastructure to support this core group of users. A Google Group[7] was created to deliberate updates to the standard and ensure that new data fields could be added to reflect the diversity of transit systems represented by GTFS. While any transit agency or software platform included could suggest changes to the group, Google remained the gatekeeper, deciding whether to accept suggested changes.[8]

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[6] Schweiger, C. (2015). Open Data: Challenges and Opportunities for Transit Agencies. https://doi.org/10.17226/22195

[7] Google Groups support virtual discussion groups of people with common interests https://groups.google.com/g/gtfs-changes

[8] Process: How GTFS extensions are added to the main spec. (2008). Google Groups. https://groups.google.com/g/gtfs-changes/c/taR1OpnbfCI/m/yJX8Mj0wbvEJ

Google Steps Back as an Open-Source Community Emerges (2009-2015)

By 2009, Google had begun stepping back from its leadership role within the open-source community, with the aim of "working towards a more self-sufficient community process."[9] Community participants suggested a more inclusive governance structure, transitioning from a single gatekeeper to "a small collection of professional entities who cover the major uses of the specification."[10] In 2010, by Google's initiative, with the approval of the GTFS community, the standard was renamed "General" Transit Feed Specification to represent the wide array of technology platforms using the standard.[11]

The global proliferation of GTFS called for a variety of improvements to the standard to reflect a diversity of services and capabilities through new and refined data fields.

While many of these changes could be deliberated and handled through the community, in the absence of a decision-making authority, other changes were polarizing, causing some stakeholders to branch off from the standard to meet their own needs.

Stakeholders branching off from the open-source community included New York City's Metropolitan Transit Authority (MTA) and Boston's Massachusetts Bay Transportation Authority (MBTA). Both agencies created their own versions of GTFS, adding checkpoints for tracking route performance and unique station and facility information.[12] The coexistence of several variations of GTFS due to a lack of alignment in the community meant GTFS went from one cohesive standard to multiple specifications.[13]

Institutional Support and Reinvestment (2015-2018)

By 2015, in addition to the splintering of GTFS into multiple specifications, many stakeholders producing GTFS data were not implementing the standard consistently, resulting in poor quality data.[14]

Advocates from transit technology provider Trillium and the Center for Urban Transportation Research recognized the need to develop more rigorous documentation to support the transit community with implementing the standard.

They received funding from California state transportation agencies to undertake the Interoperable Transit Data project with RMI[15] as their incubator. This project

[9] proposal: remove "Google" from the name of GTFS. (2009). Google Groups. https://groups.google.com/g/gtfs-changes/c/ob_7MIOvOxU/m/3ZwU7IDg2TcJ

[10] Thoughts on GTFS Governance. (2009). Google Groups. https://groups.google.com/g/gtfs-changes/c/GyqxUNvE2xU/m/QfN9M_7vSS0J

[11] Thai, T.-T. (2021). GTFS/GBFS & NeTEx: how to interoperate? [Slide show]. data4pt. https://data4pt-project.eu/wp-content/uploads/2021/04/4-TuTho_Data4PT_MobilityData.pdf

[12] Index - General Transit Feed Specification. (n.d.). https://gtfs.org/extensions/#__tabbed_1_1

[13] *Our History*. MobilityData. https://mobilitydata.org/history/

[14] https://groups.google.com/g/transit-developers/c/JdGZY5A1srE/m/0Iq9w8LcCwAJ

[15] Formerly Rocky Mountain Institute

brought together an industry working group of 17 organizations to participate in a workshop in 2015 and culminated with the publication of the GTFS Best Practices.[16]

The GTFS Best Practices aimed to address data fragmentation.[17] This document contained guidelines for transit agencies publishing datasets and practice recommendations to support good mapping practices, among other standard implementation guidance. The GTFS Best Practices are maintained by the community with GTFS and supports its implementation by ensuring the transit data itself is published in a consistent format for transit technology providers.

In 2016, GTFS standard documentation was moved from Google into a public code repository on GitHub.[18] This platform formalizes—and to some extent automates—the management of changes by allowing software developers to duplicate, edit, and validate the code before uploading changes. The change management process was further formalized, as follows:

FIGURE 2 · GTFS Change Management Process

Ideas are put forward, including how they would be implemented.	The community has a minimum of seven days to give feedback on the proposal.	Early adopters can implement and share datasets with new features to get feedback.	There is a vote by anyone producing or consuming the data passed by unanimous consent.	When the feature is voted in, it can be adopted and is added to the official specification.

This transition moved the management of GTFS from a single, corporate gatekeeper to a community of gatekeepers. The introduction of a formalized change management process ensured that the standard remained implementable by design. The process, still followed today, requires proposals to be fully tested and implemented before becoming official, and that changes support the shared interests of the community.

[16] Best Practices - General Transit Feed Specification. (n.d.). https://gtfs.org/schedule/best-practices/

[17] Stone, L. (2022). Your Transit Directions Just Got a Little Bit Better. RMI. https://rmi.org/transit-directions-just-got-little-bit-better/

[18] google. (n.d.). transit/CHANGES.md at master · google/transit. GitHub. https://github.com/google/transit/blob/master/gtfs/CHANGES.md

MobilityData: The Creation of a Steward (2018-present)

Following the GTFS Best Practices report, which called to transition the working group into a "durable and efficient consortium," MobilityData was founded in 2018 to steward the standard. It now also oversees other mobility data standards, and its mission is to maintain and improve data standards, educate users on proper implementation of standards, and drive adoption. MobilityData continues to moderate the GitHub open-source repository where updates to GTFS specifications are suggested and voted upon.

Securing reliable funding has been a consistent challenge for MobilityData. Originally solely supported by Google and Apple, MobilityData now operates a membership program, supported by almost 50 public and private sector organizations.[19] Despite this, MobilityData has struggled to raise sufficient funding to support the standards the organization manages. One contributing factor is that public sector actors who are limited by public procurement policies are hesitant to fund open-source projects.

Additionally, fundraising for the maintenance of existing standards has proven trickier than acquiring funding for the development of new standards, as funders tend to be more interested in affiliating themselves with new, innovative solutions. In the long term, MobilityData is considering transitioning to an endowment structure to develop longer-term support as well as other fundraising mechanisms such as crowdfunding.

Lessons Learned

- **GTFS was created as a solution to solve a singular, targeted use case—and that helped it move quickly through the standard development phase:** Two parties, Google and TriMet, shared a common problem—the lack of access to transit information—which could be resolved through a simple, bilateral solution. The format for sharing the data, GTFS version 0, was designed within a few weeks so that it could be implemented immediately within the technical capacities of the two organizations, respectively.
- **While developing GTFS was resource light, maintaining the standard long-term is resource intensive, requiring committed funders:** Developing the V0 of GTFS by TriMet took the equivalent of two individuals a few weeks. As the standard grew over time in complexity and reached widespread adoption, more resources were required to maintain it long-term, through MobilityData. Budgetary constraints and fundraising challenges remain at MobilityData, which is finding it difficult to raise the funds necessary to maintain the standards they steward.

[19] Per annum membership tiers are as follows: Bronze is $1,600-2,000, Silver is $2,800-$14,500, Platinum is $14,600, and Diamond >$37,500, https://mobilitydata.org/members/#MembersList

- **Institutional support, which facilitated the development of educational and implementation materials, was vital to the long-term success of GTFS:** An active and engaged volunteer-led community managed the standard for years; however, lacking a formal oversight body meant that there was no process for managing diverging views throughout the community. This misalignment caused the standard to splinter, undermining the benefits of a single specification. Support from public and non-profit entities was vital to reinvesting in the standard, with the development of technical documentation that supports compliant implementation.
- **The introduction of MobilityData, a steward with ordered processes for stakeholder input to resolve conflict, helps keep the standard focused:** GTFS' formal governance structure, supported by MobilityData, ensures that the standard continues to provide value to its community and adapt to changing conditions on the ground. Its voting system drives consensus and prioritizes issues through a democratic process of equally weighted votes. MobilityData plays a vital role in keeping things moving by facilitating discussions within the community and resolving conflict.

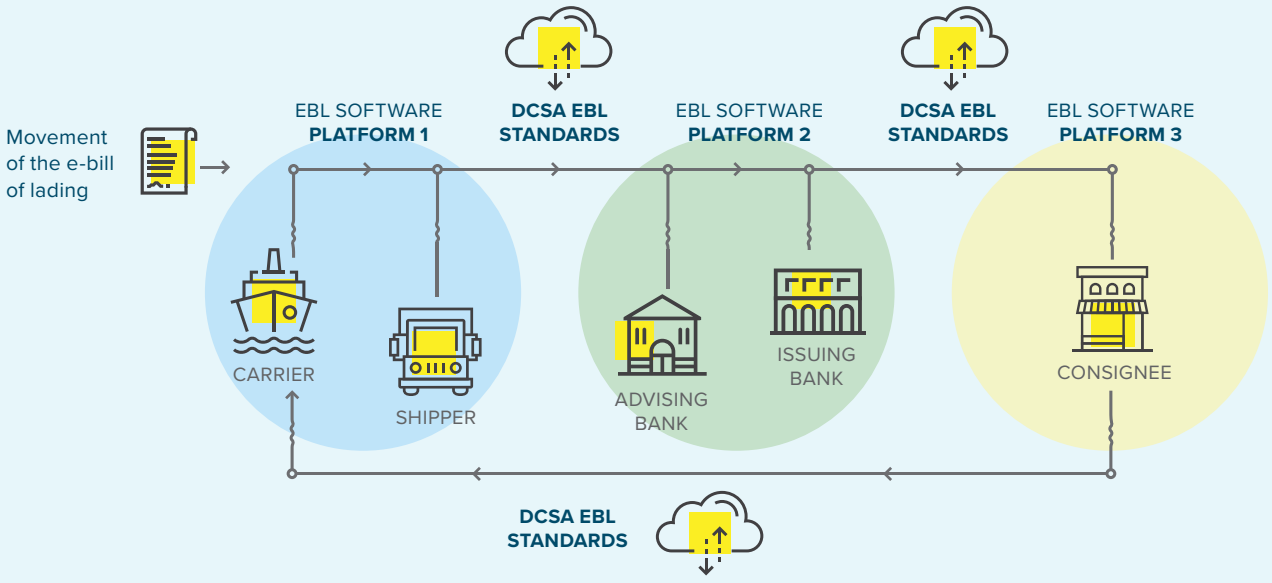
Lessons from Maritime Transportation: Electronic Bill of Lading Interoperability

Electronic Bill of Lading Standard for Container Shipping

- Creates a standard way for preparing and issuing an electronic bill of lading for container shipping. Bills of lading are legal documents that serve as evidence of a contract of carriage, title document, and receipt for shipped goods.
- Used by global carriers, shippers, banks, and cargo owners involved in the transport and trade of container shipping.
- Governed by the Digital Container Shipping Association (DCSA), a nonprofit organization established by container shipping companies MSC, Maersk, CMA CGM, Hapag-Lloyd, ONE, Evergreen, Yang Ming, HMM and ZIM.

FIGURE 3 · E-Bill of Lading

The carrier issues the eBL, which is then passed along to various parties until the consignee finally receives the goods. The consignee then surrenders the eBL to the carrier, completing the transaction. DCSA eBL standards are employed at each exchange where the eBL transitions between platforms. Note that although in this example some of the stakeholders share software platforms, in reality, all five parties may be dispersed across five different platforms.



TAKEAWAYS

- Electronic bills of lading (eBLs) promise to reduce direct costs by $6.5 billion per year, while cutting the risk of fraud and forgery, but the lack of interoperability remains a barrier to widespread adoption.
- Software providers should be engaged in data standardization conversations recognizing that the goal of digitization can only be achieved through interoperability.
- Legal interoperability is as critical as technical interoperability. Both technical mechanisms and cross-border legal frameworks must be aligned, and these efforts can happen in parallel. Activity supporting technical interoperability can help spur policymakers to drive regulatory reform and ensure legal interoperability.

The bill of lading has supported international maritime trade since Roman times, serving as a document of title and allowing the person holding it to claim possession of the shipment. In the present day, the bill of lading remains a legal document that confirms receipt of goods and must be signed by shippers and carriers.

Bills of lading continue to be primarily issued and transferred on paper, posing a major hindrance to the efficient and secure movement of global freight. But the emergence of electronic bills of lading (eBL) promises to replace the centuries-old practice of requiring paper documentation with much more efficient digital forms that contain the same information as paper bills of lading, including names and addresses of shippers and receivers, shipment date, quantity, weight, value, and freight classification.[20]

Full adoption of eBL could save the industry $6.5 billion per year in direct costs[21] and significantly reduce the risk of fraud and forgery in transactions. And yet, only approximately 2% of containerized seaborne trade in 2022 used eBL,[22] despite the technology being available since 1998.[23]

This low level of eBL adoption is due to alack of interoperability between the different platforms. It is currently not possible to transfer an eBL from one approved platform to another, and no single platform—there are approximately ten such industry approved[24]

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[20] Tarver, E. (2023). Bill of Lading: Meaning, Types, Example, and Purpose. Investopedia. https://www.investopedia.com/terms/b/billoflading.asp

[21] The multi-billion-dollar paper jam: Unlocking trade by digitalizing documentation. (2022, October 4). McKinsey & Company. https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/the-multi-billion-dollar-paper-jam-unlocking-trade-by-digitalizing-documentation

[22] e-Bills of Lading. (2001, January 1). BIMCO. https://www.bimco.org/ships-ports-and-voyage-planning/maritime-digitalisation/ebl

[23] Can The Functions Of A Paper Bill Of Lading Be Replicated By Electronic Bill Of Lading? (2013). Public Policy and Administration Research, 3(8). https://core.ac.uk/download/pdf/234668993.pdf

[24] Electronic Bills of Lading | West P&I Club. (2022, June 29). https://www.westpandi.com/news-and-resources/news/may-2021/electronic-bills-of-lading-a-good-idea-on-paper/

platforms in operation as of this writing—has reached a critical mass of users.[25]

As a shipment changes hands, if any party is on a different platform, the document must revert to a paper format. A method of standardizing data formats used by existing software vendors would allow an eBL to transfer seamlessly between different platforms.

Origin of the Standard

The Digital Container Shipping Association (DCSA), a non-profit, non-commercial entity set up in 2019 to digitize trade and develop open data standards for the container shipping industry, quickly realized that the lack of cross-platform interoperability was creating a bottleneck for the increased adoption of eBL. In 2020, DCSA embarked on the eBL interoperability project, part of its eDocumentation initiative. As part of that project, in conjunction with carriers, DCSA published open data standards for the issuance of bills of lading, to facilitate the acceptance of an electronic bill of lading by regulators, banks, and insurers.[26]

DCSA's first version of eBL standards are aligned with the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) multimodal transport reference data model and consist of:

- Process standards, through an industry blueprint which describes the process of preparing and issuing bills of lading, and includes a standardized glossary of terms.
- Data field definitions and standards, consisting of a dataset of 80 mandatory, conditional, or optional predefined data fields that are common to containerized shipping bills of lading.
- Application Programming Interface (API) specifications and interface standards which set out protocol and programming code for data transmission.[27]

[25] F Chandler, G., III. (1989). The Electronic Transmission of Bills of Lading. Journal of Maritime Law and Commerce, 20(4). https://heinonline.org/HOL/LandingPage?handle=hein.journals/jmlc20&div=50&id=&page=

[26] DCSA members have set an intermediary goal of 50% adoption by 2028 and BIMCO members are committed to 25% adoption by 2025.

[27] Dcsa. (2023). Electronic Bill of Lading. DCSA. https://dcsa.org/standards/ebill-of-lading/

FIGURE 4 · eBL Timeline

Bringing Stakeholders to the Table for a Proof-of-Concept

To implement the standard and build interoperability into existing services, in May 2022 DCSA kicked off a proof-of-concept trial with eBL providers, banks, carriers, and cargo owners. After a pre-trial phase seeking industry feedback on the eBL process, the proof-of-concept exercise tested the standard with five[28] eBL providers participating.

The proof-of-concept's aim was to transfer an eBL from one service provider to another. DCSA's eBL standards ensure that the flow of information between carriers and platforms is standardized amongst all platform providers. In this way, DCSA standards build interoperability between providers in, while allowing stakeholders to continue to use their preferred technology.

During the trial, the process of inputting data and transferring the eBL took only five minutes, as opposed to often multiple days required to transfer paper documentation.[29]

This proof-of-concept demonstrated that sending an eBL from one platform to another is achievable and efficient, and led DCSA members to make a pledge to commit to 100% adoption of eBL by 2030. Yet other legal and regulatory hurdles to full adoption across the container shipping industry remain.

[28] CargoX, eDoxOnline, Bolero, WAVE BL, and IQAX.

[29] Dcsa. (2023a, January 10). edoxOnline: "Interoperability will be the only way to speed up eBL adoption." DCSA. https://dcsa.org/newsroom/resources/edoxonline-interoperability-will-be-the-only-way-to-speed-up-ebl-adoption/

Legal Interoperability and Regulatory Reform

Although technical interoperability was achieved through DCSA's proof-of-concept trial, legal certainty challenges are preventing providers from adopting and operationalizing DCSA's interoperable eBL standards at scale.

The first point of friction DCSA is working to resolve is aligning the contractual arrangements between eBL platforms. Currently, each eBL provider operates under its own "rulebook," or set of terms and conditions shared between a platform and its users. As such, a contract that multilaterally bridges all providers' terms and conditions is needed.

Additionally, cross-platform liabilities and obligations, including limits of liability and user obligations, need addressing. Solutions will need buy-in from the International Group of Protection and Indemnity (P&I) Clubs, which insure 93% of the world fleet. Alongside the service providers, DCSA is working to resolve these legal interoperability issues.

The larger issue to be resolved is that many individual jurisdictions still do not recognize the validity of electronic documents, particularly as title documents. In the absence of regulation clearly designating the permissibility of using eBL, risk averse entities such as banks are hesitant to rely upon the contractual arrangements between users of the platforms to exchange eBL.

Global legal reform that recognizes eBLs across jurisdictions is underway, propelled by announcements made at the G7 summit in 2021, where G7 countries agreed to examine the barriers to adopting electronic records like eBL.[30] The Model Law for Electronic Transferrable Records (MLETR), developed by the United National Commission on International Trade Law (UNCITRAL) in 2017, aims to streamline the way in which national law recognizes electronic documents.

Singapore, a major shipping hub, passed the Electronic Transactions (Amendment) Act in 2021, becoming one of the first countries to enact a version of MLETR.[31] Many other national jurisdictions in Europe, including the United Kingdom, a precedent-setting jurisdiction for maritime law, are currently working towards legal reform. The multi-jurisdictional nature of global trade makes legislative reform highly complex, yet the adoption of MLETR will have a major impact on global trade and unlock new opportunities for streamlining information exchange.

[30] UK G7 Presidency: Roadmap to reform for electronic transferable records. (2021, December 8). GOV.UK. https://www.gov.uk/government/publications/uk-g7-presidency-roadmap-to-reform-for-electronic-transferable-records/

[31] Electronic Bills of lading - is this time different? (n.d.). HFW. https://www.hfw.com/Electronic-Bills-of-lading-is-this-time-different

Lessons Learned

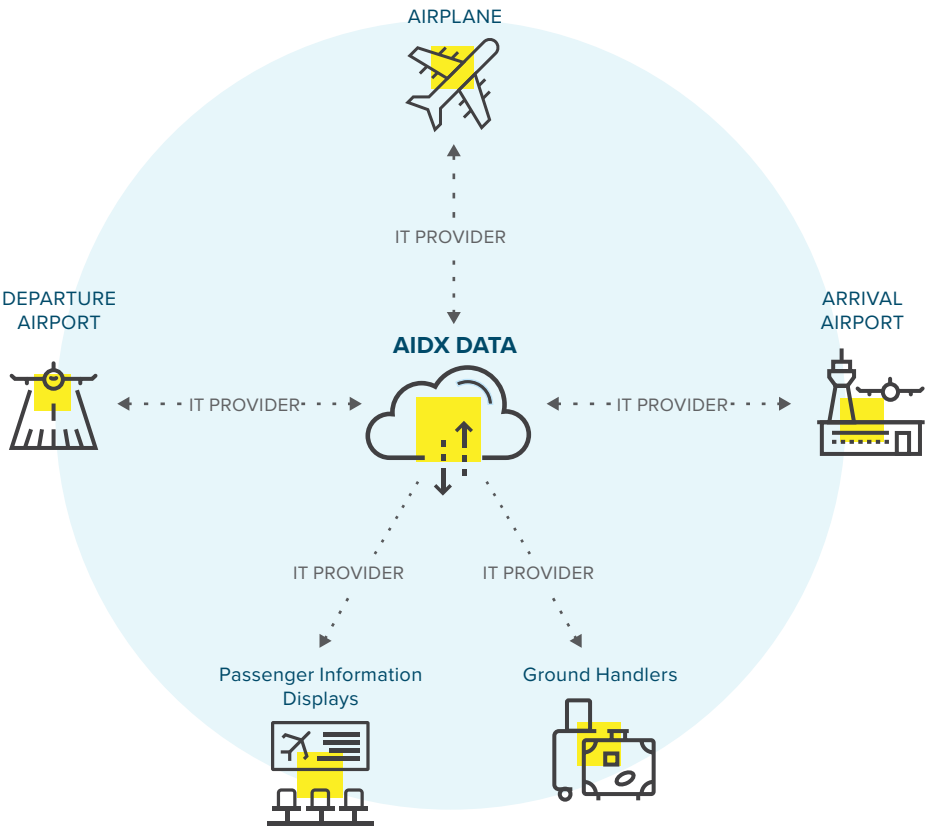
- **DCSA including software providers at the table during standards development meant all parties were working together towards a shared goal of interoperability:** In developing an interoperable solution to the electronic bill of lading problem, DCSA brought software providers to the table—alongside carriers, banks, and cargo owners—to work on a solution. This ability to bring competing software companies together was aided by a shared understanding that interoperability was the only way to increase the uptake of electronic bills of lading.
- **Frequent and early testing and iteration of the eBL improved user-friendliness of the standard while accelerating adoption and buy-in:** DCSA created a version 2.0 of the eBL standard in March 2022 and was testing the standard in a proof-of-concept by May 2022. Throughout, DCSA has been soliciting feedback from a variety of stakeholders to revise and refine the standard. An agile, iterative approach with public documentation that allows feedback from a broad swath of affected stakeholders yields a better, adoptable, and more user-friendly standard.
- **Resolving technical interoperability issues must happen in tandem with any required regulatory reform to permit the use of eBL across jurisdictions.** To achieve the goal of mass adoption of eBL globally, regulatory reform must allow for the use of a digital form of bills of lading. While countries have made commitments to enable these reforms, industry heavy hitters have made their own commitments to deploy eBL by a self-chosen time horizon. In this way, by supporting the development and committing to the adoption of a standard, industry can put pressure on policymakers to move ahead.

Lessons from Aviation: Aviation Information Data Exchange

Aviation Information Data Exchange (AIDX)

- A global messaging standard for communicating operational flight data between airlines, airports and third parties.
- Used by airlines, airports, data aggregators, software vendors, and ground handlers.[32]
- Governed by the International Air Transport Association (IATA).[33]

FIGURE 5 · How AIDX works (operational air transportation data exchange)



[32] IATA & Airlines for America. (2022). Aviation Information Data Exchange (AIDX): XML Implementation Guide. In IATA. https://www.iata.org/contentassets/cfe998bcf9214859afda9c8bf4ff75c3/aidx-xml-imp-guide-v22.1.pdf

[33] About us. (n.d.). https://www.iata.org/en/about/

TAKEAWAYS

- Coordinating aviation demands precise, real-time information, with little room for error.
- In solving a pressing need to share operational flight information, AIDX has enriched and extended operational data exchange standards in aviation that address a range of applications.
- In highly complex operating environments, such as airports, a multitude of standards are needed to address different operational needs. As such, semantic interoperability is key to aligning and harmonizing overlapping data standards and technologies.

Aviation is a time-sensitive industry that has always demanded high levels of coordination to orchestrate the movement of aircraft.

As new technology platforms providing electronic and digital solutions to transmit critical information about flight operations began to arise, airlines and airports alike found themselves having to support many different proprietary systems and data formats.[34]

Airports each began implementing their own protocols, and airlines had to maintain different interfaces with airport systems. The result was costly, complex, and inefficient.[35]

The creation of the Aviation Information Data Exchange (AIDX) standard allowed airlines and airports to exchange operational flight data in a consistent format.

AIDX is used to efficiently coordinate the movement of planes through airports and synchronize resources, while also streamlining the experience for passengers through for example, real-time flight information displays.

Origin of the Standard

In 2003, Airlines for America (A4A) and Airports Council International (ACI) called for a unified approach that would make different vendors and systems interoperable. Together, A4A and ACI established a subcommittee of ACI-North America, dedicated to defining a flight data interface specification. The subcommittee focused on the specification included three airlines, two airports and three IT providers[36] and met over

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[34] [PDF] Business Requirements Document (BRD) for. Aviation Information Data Exchange (AIDX) message - Free Download PDF. (n.d.). https://silo.tips/download/business-requirements-document-brd-for-aviation-information-data-exchange-aidx-m

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[36] Aviation Information Data Exchange (AIDX) ACI – Europe IT Conference November, 2009 Yngvar Sundsfjord, COWI. (2009). https://slideplayer.com/slide/10341335/

the course of two years with other government and the aviation industry stakeholders.[37]

The precursor standard to AIDX was released in 2005. It identified 103 flight-specific data elements and 34 elements for ground handling in Extensible Markup Language (XML),[38] a flexible format that can be used with virtually any operating system. The new standard was further developed with the participation of over 80 airlines, airports, and vendors.

In 2007, the new standard was named Aviation Information Data Exchange (AIDX) and adopted by an IATA working group. Denver International Airport was one of the first airports to deploy AIDX in partnership with Frontier Airlines and software vendor FlightView in 2007.[39] In 2008, the new AIDX standard was adopted as a Recommended Practice by IATA, meaning a non-binding protocol passed with the support of the airlines.[40,41]

AIDX data are shared to both arrival and departure airports during a flight's operational window: before, during, and after a flight. The standard grew to cover 180 distinct data elements such as aircraft detail, flight identification, airline codeshare, operational times, flight status, and airport resource requirements.[42] These data consist of timestamped activities, and different event types (actual, planned and scheduled) can be sent at planned intervals or triggered.

Integrations & Adaptations

After its launch in 2008, AIDX was rapidly adopted, gaining momentum with U.S. airlines piloting the standard at select airports. By 2009, ten airlines, 12 airports, and 12 software vendors had committed to adopting the standard. By 2015, AIDX had a global reach and was implemented by over 100 airlines, airports, and vendors.[43] AIDX is still in widespread use today at airports around the world.

[37] IATA & Airlines for America. (2022). Aviation Information Data Exchange (AIDX): XML Implementation Guide. In IATA. https://www.iata.org/contentassets/cfe998bcf9214859afda9c8bf4ff75c3/aidx-xml-imp-guide-v22.1.pdf

[38] IATA & Airlines for America. (2022). Aviation Information Data Exchange (AIDX): XML Implementation Guide. In IATA. https://www.iata.org/contentassets/cfe998bcf9214859afda9c8bf4ff75c3/aidx-xml-imp-guide-v22.1.pdf

[39] Aviation Information Data Exchange (AIDX) ACI – Europe IT Conference November, 2009 Yngvar Sundsfjord, COWI. (2009). https://slideplayer.com/slide/10341335/

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[41] FAA & Eurocontrol. (n.d.). Aviation Information Data Exchange (AIDX) [Slide show]. Air Transportation Information Exchange COnference, Silver Spring, MD, United States of America. https://www.aixm.aero/sites/aixm.aero/files/imce/library/ATIEC_2015/34_day3_aviation_information_data_exchange_aidx.pdf

[42] IATA, "Aviation Info. Data Exchange (AIDX)", Available at: https://www.iata.org/en/publications/info-data-exchange/#tab-2

[43] FAA & Eurocontrol. (n.d.). Aviation Information Data Exchange (AIDX) [Slide show]. Air Transportation Information Exchange COnference, Silver Spring, MD, United States of America. https://www.aixm.aero/sites/aixm.aero/files/imce/library/ATIEC_2015/34_day3_aviation_information_data_exchange_aidx.pdf

Integration into Software Systems

The rapid adoption of AIDX was in part supported by the standard's quick integration into software products already used by airlines and airports. IATA has a long history of working with IT providers, and many contracts between software vendors and airports or airlines are contingent on IATA standards being used in products. IT providers can therefore serve as a critical vehicle for bringing standards to market. The relationship between IATA, an overseer of aviation standards, and software companies helps accelerate adoption and reduces the impact on industry. By integrating seamlessly into existing software, airlines and airports can maintain their existing software systems which incorporate the standard and avoid having to change their business processes.

Integration of AIDX into Other Standards Initiatives

Over time, through integrations into other data standardization initiatives overseen and supported by IATA, the reach of AIDX has grown considerably. As a mature standard supporting a broader suite of initiatives, AIDX is being integrated to support IATA and ICAO-led process improvement and environmental decision-making standard development initiatives.

In 2012, AIDX was used to support Airport Collaborative Decision Making (A-CDM), an initiative to optimize air traffic at European airports.[44] A-CDM improves the efficiency and resilience of airport operations by optimizing resource utilization—particularly fuel consumption—through focusing on aircraft turn-round and pre-departure processes.[45,46] In this way AIDX contributes to another system of data standards to support broader sector-level goals.

Whereas in the past data domains were isolated from one another with information being defined differently from one domain to the next, IATA is currently overhauling data management, with the development of a centralized semantic data model. This data model, Airline Industry Data Model (AIDM), aims to become a single point of access for industry-agreed vocabulary, data definitions and their relationships, and business requirements for generating airline data exchange standards.[47] As such, AIDX, along with other airport and airline standards are being incorporated into AIDM, which will create greater consistency, and allow different standards to be used in tandem.

[44] IATA & Airlines for America. (2022). Aviation Information Data Exchange (AIDX): XML Implementation Guide. In IATA. https://www.iata.org/contentassets/cfe998bcf9214859afda9c8bf4ff75c3/aidx-xml-imp-guide-v22.1.pdf

[45] Airport collaborative decision-making (A-CDM). (2017, March 31). EUROCONTROL. https://www.eurocontrol.int/concept/airport-collaborative-decision-making

[46] ICAO. (2021). AIRPORT COLLABORATIVE DECISION MAKING (A-CDM) IMPLEMENTATION GUIDE FOR THE CAR/SAM REGIONS (No. 1). https://www.icao.int/GREPECAS/Documents/CARSAM%20ACDM%20Impl%20Guide-01ed_EN.pdf

[47] AIDM Project and CR Templates - Additional Resources. (n.d.). https://guides.developer.iata.org/docs/aidm-templates

In addition to aligning with IATA standards, AIDX must also reach cross-domain alignment and harmonization with data models outside of IATA's scope. Additional data covering air navigation and approach falls under the umbrella of Air Traffic Management (ATM) and is shared via a flight plan, overseen by the Flight Information Exchange-Model (FIXM) change control board, governed under ICAO. FIXM is an emerging[48] standard that contains all flight and flow information needed between aircraft operator and air navigation service provider. The overlap of ICAO's flight plan data with AIDX has called for a connector – currently under development – that would link the two standards through common data fields. Connecting the two standards, which function on two separate systems, would be hugely beneficial to stakeholders, who would stand to gain from deeper insights.

Next Steps in Aviation Data Standardization

The aviation industry has come a long way in the past 20 years since the first conversations about how to standardize operational information between airlines and airports which led to AIDX. By making sharing operational information broadly part of the culture of the industry, the aviation industry, with the support of organizations like IATA and ICAO, has embraced the many applications of data standards of operational processes and is now in a phase of ensuring consistency and alignment between the standards.

Lessons Learned

- AIDX has been foundational to driving a broader ecosystem of standards and continuous process improvements: In developing AIDX, stakeholders were responding to a push from airlines and airports to streamline messaging of operational flight data to improve communication. Initially developed as a bilateral messaging system from airline to airport, AIDX may now be used for multi-lateral communications. In supporting critical operational data, AIDX constitutes a fundamental data input to other standards and decision-making frameworks that improve processes in aviation. AIDX is incorporated into broader ambitions by IATA and ICAO to build upon operational insights to reach broader environmental and sector-level goals.

[48] FIXM has been around since 2013 and is in final review stages through the end of 2024 and is expected to come into use from 2025 onwards.

- AIDX created a marketplace of vendors, while also giving airlines greater control over their data: Prior to AIDX, airlines were dependent on costly, proprietary data systems. AIDX and other IATA standards have given airports and airlines control over their data and distribution channels. At the same time, IATA standards have created a marketplace of software systems for airports and airlines to choose from, reducing over-reliance on a limited number of data aggregators and the risk of vendor lock-in.

- IATA's long-established reputation and industry relationships drive high rates of adoption: As a long-standing industry association, IATA's industry relationships facilitate standards adoption. Software providers work with IATA to develop standards, providing industry insights, and help standards achieve higher adoption rates by seamlessly incorporating updates. IATA's long-standing culture of standardization of processes, protocols and information flows drives trust in the community to accept and adopt standards.

Summary

Developing a successful, adoptable data standard can happen quickly, but the work of maintaining a standard that meets industry needs is ongoing. Standards require regular maintenance and a democratic governance process that gives space for regular feedback.

GTFS, DCSA's eBL project, and AIDX share the common features that make them successful, adoptable standards.

A summary of the best practices from the development, adoption, and governance of data standards informed by these three examples can be found below:

Best Practices: Data Standard Development

Clear use cases, iteration, and early testing improves standard user-friendliness

When starting to develop a data standard, the standard should be focused on solving a specific use case. In complex operational environments, though it may be tempting to try to build a standard that can solve many operational needs, keeping a standard focused means it can be developed and tested early and often.

Over time, GTFS grew in complexity and functionality, but it started as a simple, lightweight solution built in a few weeks.

Starting small and focused increased the usefulness of the standard and the ability for additional transit agencies to successfully apply the standard according to recommended guidelines.

Keeping a standard specific and focused also helps drive iterative development and testing within shorter timelines. Frequent and early testing improves standard quality and accelerates buy-in.

By focusing the development of eBL on container shipping, DCSA brought together the right stakeholders to the table to test the standard—which still included 11 participants and 16 observers.

Software providers should be at the table

Including IT and software vendors in the conversation early in the process of building standards allows for higher rates of adoption.

In GTFS's open-source community, managed by MobilityData, software providers participate alongside transit operators in the democratic process of proposing and voting on modifications to the standard. Software providers similarly work with IATA to help shape standards and seamlessly incorporate AIDX updates.

Software providers offer insight into existing processes around data exchange. With the participation of software providers in data standards development, standards can reach higher rates of adoption by being integrated into existing systems.

Best Practices: Data Standard Adoption

Resolving technical interoperability issues must happen in tandem with any required regulatory reform Interoperability means both technical and regulatory alignment when the adoption of a standard is dependent on legal frameworks permitting standard use. In the context of digitizing trade documentation such as the development and testing of the eBL standard, DCSA worked to engage stakeholders under a shared goal of increasing interoperability to support further digitization of trade documentation. While the ongoing work of the eBL initiative has demonstrated that technical interoperability is feasible at the proof-of-concept phase, the global regulatory landscape remains a barrier.

Most critical maritime trade nations do not yet recognize the validity of electronic documents as title documents. Many global trade finance banks and other major trade stakeholders therefore remain reluctant to go paperless because of a lack of certainty around institutional bylaws, national laws, and other regulatory frameworks.

This illustrates the significance of digital interoperability driven both by technical interoperability—achieved through the development and adoption of data standards—and legal interoperability enabled by regulatory frameworks that enable the application of these standards. Regulators have an important role to play in standards adoption.

Open data standards give industry control of their data and software solution options

Open data standards can support the needs of industry stakeholders of different sizes and with differing technical competences. The creation of a shared language helps shift the digital tools available to industry from expensive, custom-built proprietary software to a marketplace of software options built upon a shared language and available to industry at a lower cost.

Both GTFS and various IATA standards can be implemented directly by industry players, or by a software provider. This allows stakeholders with more advanced technical capabilities to implement the standard in house, and in so doing benefit from more control over their data and more industry insights. Stakeholders with fewer technical abilities can outsource their data management to a software provider, hence facilitating new software marketplaces.

Open data standards create more options for organizations of all sizes, driving more balanced data distribution and competitive marketplaces.

Best Practices: Data Standard Governance

Inclusive and democratic governance structures support necessary ongoing maintenance

Standards oversight organizations need to prioritize stakeholder engagement, democratic processes for change management, and sufficient technical expertise to ensure that standards meet evolving user needs.

First, an organization dedicated to the ongoing maintenance and management of a standard needs to have sufficient relationships with industry and software vendors using the standard. For that reason, a good fit for caretaker of a standard can be a well-regarded industry association (such as IATA in the case of AIDX) or dedicated third-party organization (such as MobilityData overseeing GTFS) who understands the standard's value, can advocate for increased adoption of the standard, and can interface with regulators.

Second, organizations should oversee the democratic process of both building and maintaining the standard. Governance protocols should ensure that standards remain backward-compatible, and that they are tested in the field before changes are voted upon for inclusion. GTFS' change management processes resolved conflict in the community and were successful in driving consensus-based decision making. Industry is best suited to make up the bulk of the community giving feedback on standards, but centralized leadership is needed for the standard to avoid fragmentation.

Third, oversight organizations, although serving primarily as conveners of industry and standard users, need technical expertise in house. IATA's continuous improvement and iteration of data standards is thanks to its technical teams which oversee standards. This technical expertise has allowed IATA to develop data models which bring together and aggregate all standards into a common lexicon in a comprehensive way.

Data standard maintenance requires long-term funding and oversight to ensure they remain effective

Developing minimum viable standards that respond to clear use cases can happen quickly and at low cost. The more resource-intensive phase of standards, particularly for standards built for complex operating environments, is the ongoing long-term maintenance.

GTFS was developed on a shoestring budget. However, GTFS began to splinter into different specifications until MobilityData stepped in to oversee a structured process for approval and integration of updates to the standard, which it still does today.

Beyond overseeing updates, MobilityData works to ensure standards are implemented correctly. This requires written documentation, including implementation guides, educational materials such as seminars and webinars, and technical support staff. Developing comprehensive resources is labor and time intensive. For this reason, institutional support is essential to ensure these materials remain relevant and support various adoption methods and technologies.

All three standards rely on a large number of stakeholders volunteering their time to give the feedback needed to build and maintain a worthwhile standard. It takes a significant amount of human capital to not only first develop a standard, but to keep it relevant.

Conclusion

Harnessing the power of seamless and reliable real-time data sharing in transportation requires a better understanding of how the open data standards that underpin reliable and accurate data exchanges are developed and adopted.

Well-developed and maintained data standards can translate the substantial amount of information generated every minute by the transportation sector into useful insights. Whether it's the tens of millions of people who can track, in real time, the arrival of their bus or train on their smart phones, or shipping companies being able to save millions by tracking and transferring cargo through electronic records, or the aviation industry coordinating the complicated ground movements of planes, data standards can vastly improve the way we do business and move through the world.

To get the recipe right and successfully implement functional, high quality data standards, policymakers and industry must look to what has worked.

The examples detailed here for transit (GTFS), maritime shipping (eBL), and the aviation industry (AIDX) provide essential lessons. As policymakers and industry grapple with how to build data standards for the freight sector, the best practices reflected in this white paper are intended to help inform those efforts by demonstrating, through real-world examples, how a successful data standard is developed and maintained. Data standards that are open, freely available and accessible lead to higher quality data, and better data has a real impact on shaping more sustainable, efficient, and resilient systems that move people and goods around the world.

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