Beyond Procurement

How Entur Navigated the Open Source Journey to Advance Public Transport

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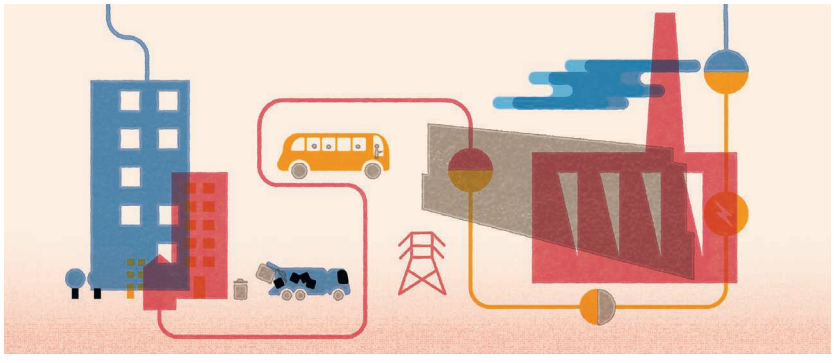
// This report describes how software professionals at the Norwegian public transport organization Entur use open source processes and tools to leverage digital transformation. Moving software acquisition from procurement to open source and in-house development can deliver value but also entails challenges.//



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DIGITAL TRANSFORMATION (DX) radically reshapes industries and societies.[1,2] A critical stakeholder group needed to bring this transformation about consists of public sector software professionals, such as those within public transport agencies. For example, mobility-as-a-service (MaaS) enables citizens to buy public transport as part of a broader bundle of transport options. On-demand services like ride-hailing, car shares, and demand-response public transport are increasingly used by citizens. Free-floating e-scooters are a new breed of connected vehicles managed via users' smartphones. This changing landscape requires public transport organizations to quickly adapt and collaborate with a changing and increasingly digitalized transport system by including these changing travel habits in agencies' travel planning systems. However, this, in turn, requires agencies to acquire software in a way that supports DX, and where we argue that open source software (OSS) can play a crucial role.

DX is going beyond being a buzzword and becoming an established topic for research. Hanelt et al.[2] recently published a thorough metareview based on 279 published articles to clarify how scholars have understood DX. At its core, this massive metareview showed that DX is a process that includes two significant shifts: 1) organizations move toward malleable organizational designs that enable continuous adaption, and 2) this change is embedded in and enabled by digital business ecosystems.

In practice, DX allows the organization to reshape itself to new challenges and opportunities rapidly (we refer to this as *organizational agility*). Also, successful DX enables an organization to have whole new collaborations with external

actors (that we call *leveraging ecosystems*). In this context, OSS has the necessary characteristics to support DX, as it is both open (and thus can be reshaped to new opportunities and challenges) and relies on collaborative communities (where organizations can leverage external stakeholders). However, while open source has provided significant productivity gains for the private sector,[3,4] the public sector is still struggling to utilize OSS fully.[5,6]

In this article, we report from the trenches of a Norwegian public transport organization, Entur AS, and discuss how they use OSS as a critical technological strategy to reap the benefits of DX. Since 2016, Entur has broken with sector conventions where a procurement-driven model of acquiring passenger information systems still prevails. Instead, Entur currently manages a development-driven software service delivery organization where OSS plays a key role. This report results from prolonged industry–academia collaboration (see "How This Experience Report Was Developed"). It intends to provide verified practical accounts of how a public sector organization could use OSS to achieve DX.

Case Organization: Entur

Entur is a public company established in 2016 and owned by the Ministry of Transport in Norway. An ambitious core objective for Entur was to create a digital infrastructure, enabling seamless data flow from all public transport operators in Norway. This backbone should help the people of Norway to reduce emissions by using the public transport network over their private cars. With this objective as a starting point, a new organization was set up. Technical design decisions were made at the group level by the travel planning team at Entur (10 people). However, these decisions needed anchoring, both within a steering committee with all CEOs of major Norwegian public transport organizations, as well as a technical reference group within the industry. Using this structure, the team made some critical choices.

First, a key element was the importance of using open data standards for all data exchanges. Entur wanted to avoid a proprietary

HOW THIS EXPERIENCE REPORT WAS DEVELOPED

The content of this article springs from a longitudinal collaboration between researchers and practitioners concerning technology openness in the public transport sector.

The arena, Open Mobility Data in the Nordics, has hosted transport agencies in the Nordics to share knowledge and technologies relating to open data, open standards, and open source. This collaboration has yielded eight full-day on-site workshops and 73 shorter (typically 60 min) online meetings since 2018. Departing from these meetings, the researchers identified the work at Entur as especially interesting and thus performed an additional five in-depth interviews at Entur AS and two with members of OpenTripPlanner outside Entur. The interviewees were key stakeholders, including the technical and program lead, key OpenTripPlanner developers, and the OpenStreetMap lead. Using this in-depth dataset, the researchers have constructed a case study, (using systematic combining that allows for qualitative data analysis that iterates between empirical findings and theoretical concepts[S1]) having Entur's open source-based transformation as the unit of analysis (under review by an international journal). This case study primarily focused on how to leverage the ecosystems using the open data.

As a final step, the researchers and software professionals from Entur authoring this article have compared their respective views on Entur's use of OSS. Here, the researchers introduced the perspective of DX as way to understand Entur's transformational journey and explain its success (i.e., that OSS has been crucial to enable Entur to constantly reshape themselves into being more aligned with its environment and have been doing this by drawing on digital ecosystems). In close collaboration, researchers and software professionals then identified and described illustrative examples of DX, major challenges on the way, as well as the lessons learned.

Reference

S1. A. Dubois and L.-E. Gadde, "Systematic combining: An abductive approach to case research," *J. Bus. Res.*, vol. 55, no. 7, pp. 553–560, Jul. 2002, doi: 10.1016/S0148-2963(00)00195-8.

national data format and saw considerable potential in international cooperation using open data standards. To accommodate identified use cases, Entur chose network timetable exchange (NeTEx)[7]] and service interface for real-time information (SIRI)[8] as technical formats. These standards are XML-based exchange formats designed for the public transport sector. As micromobility, like e-scooters, became interwoven with the public transport network, Entur also used the general bikeshare feed specification (GBFS) standard.[9]

The second important decision concerned the use of OSS. Typically, public transport agencies in the Nordics use tenders and commercial third-party system providers of passenger information systems. However, Entur chose a different strategy. They instead based their software stack on in-house development and existing OSS components. The underlying reasoning for this decision was the belief that to reach the high ambition levels, Entur had to become much more light-footed. The conclusion was that it was not possible to rely on implementations by third-party system providers and tenders, but instead required more modularity alongside agile ways of developing, deploying, and hosting software. For this, full in-house development was assessed as necessary.

Additionally, many of the components needed for this platform overlapped those of other Norwegian countries and regions. Consequently, there was substantial potential in looking at existing OSS software projects where development and hosting could be shared (like travel planning and timetable editors). Finally, this project was creating publicly funded digital infrastructure for the public transport sector. Hence, it was natural to take responsibility for sharing both data and the code processing those datasets in an open fashion.

> An ambitious core objective for Entur was to create a digital infrastructure, enabling seamless data flow from all public transport operators in Norway.

Platform

Based on this approach, Entur has developed a platform to support Norway's entire public transport sector. This platform is wholly based on the technical data specifications of NeTEx, SIRI, and GBFS for end-to-end dataflow. Figure 1 gives an overview of the platform with its main components:

- *National Stop Place Register:* A NeTex-based master database for all 60 K stops and 120 K platforms defined for all of Norway.
- *Timetable database:* A complete validation pipeline and database of NeTEx timetable data collection from around 60 public transport data providers in Norway.
- *Self-Service Timetable Editor:* A basic editor with an interface for modeling basic timetable data and on-demand services. This editor enables the production of NeTEx data, typically for minor public transport providers that do not have a dedicated planning system.
- *Real-Time Hub:* A SIRI-based real-time hub to continuously receive, validate, and harmonize real-time data, currently for 40 feeds of real-time data from public transport agencies in Norway.
- *Mobility Hub:* A GBFS aggregator service currently aggregating 35 feeds from mobility providers of e-scooters, city bikes, and car-sharing.
- *Geocoding service:* A service for geocoding of StopPlaces, addresses, places, and points-of-interest.
- *OpenTripPlanner:* A trip planner service enabling complete multimodal trip planning for all modes of transport, including the entire public transport network, all mobility services, walking, biking, and car routing. These services harvest all data sources for input data and provide an application programming interface now serving most journey-planning apps in Norway, totaling a traffic load of close to 1 billion requests per month.

All parts of this platform are developed as OSS. OpenTripPlanner,

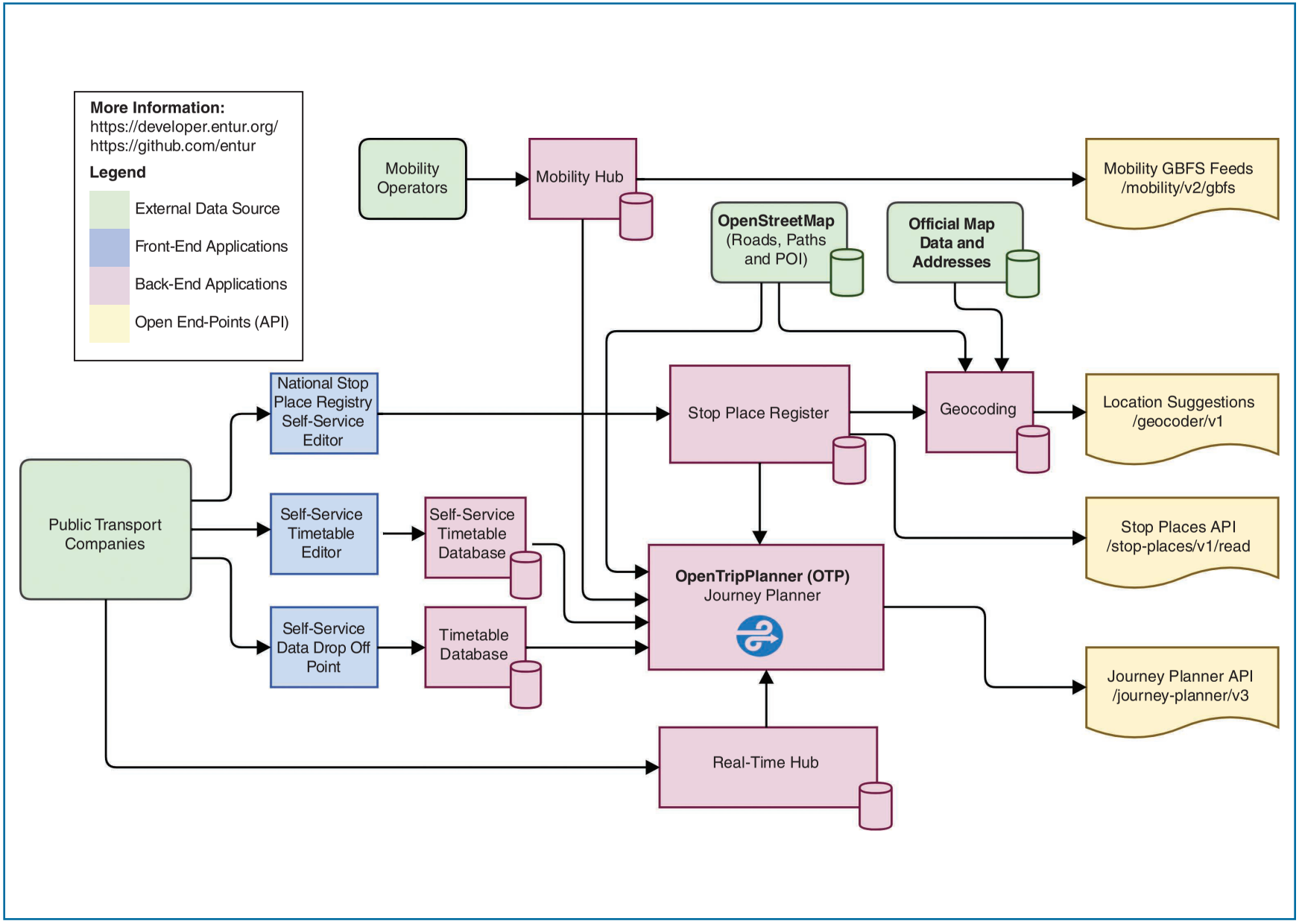

FIGURE 1. Passenger information architecture at Entur AS. API: application programming interface; POI: points of interest.

the geocoder service, and the timetable database were existing OSS components that Entur codeveloped and extended together with the community. The Real-Time Hub and the Mobility Hub were developed at Entur but much inspired by similar OSS components, and openly available technical libraries were reused. The final two components, the National Stop Place Register and the Self-Service Timetable Editor, were fully designed and developed at Entur. Here, Entur is working to cultivate a community for others to reuse and extend capabilities. All elements of this platform, developed over the last seven years, are available on Entur's GitHub repository (https://github.com/entur).

Organizational Agility

Travel planning functionality is the area within Entur where an OSS approach has been most profound. For an organization like Entur, travel planning is a mission-critical task. These algorithms provide actionable route alternatives for travelers using geospatial map data, timetables, and real-time updates. Generating travel options is a task of high complexity. A journey may include several public transport lines and other modes of connecting transport (e.g., walking, park-and-ride), creating complex trip chains. In addition, there are strict performance requirements where travel planners must be able to elicit the best—or sufficiently good—trips from a vast array of possible travel combinations, in fractions of a second.[10]

Until 2018, Entur procured such solutions from software vendors specializing in public transport passenger systems. However, as Entur 2017 was redefining its architecture, it searched for alternatives that would allow for more innovation. This decision was partly driven by frustration with commercial software vendors of travel planning algorithms that Entur had used up to this point. These frustrations were primarily connected to the unpredictability regarding change requests that Entur regularly sent to their vendor. Here, Entur found that the cost associated with the request would often substantially exceed initial vendor assessments. More importantly, however, the functionality delivered did not fully meet their needs. Given these frustrations and the centrality of travel planning, Entur explored whether insourcing travel planning functionality was feasible.

Given the complexity of travel planning, Entur assessed that they would need to collaborate with others and that the OpenTripPlanner framework was the best candidate. While the framework was open source and used by other agencies internationally, Entur has invested substantial resources to tailor the framework to Entur's needs. This investment included creating support for Entur's industry data standards (NeTEx and SIRI) and taking a lead role in replacing the core algorithm (from A* to RAPTOR to support routing in larger public transport networks, such as an entire country). Currently, two full-time developers are working with OpenTripPlanner. One is working on the main branch, adding features that require changes to the source code. The other primarily works with tailoring Entur's local instance of OpenTripPlanner, by adjusting the available routing configuration options. However, this significant change has hinged on establishing an established reputation within the OpenTripPlanner community. Gaining sufficient latitude within the OpenTripPlanner community to make such comprehensive changes has resulted from a continuous commitment to the community. For instance, Entur was active in two developer meetings per week over a longer time, as well as demonstrating through previous and less exhaustive changes that Entur was sufficiently competent to make more profound sound design decisions.

Through OpenTripPlanner, Entur now has complete control over the travel planning service, allowing for continuous alignment with new business requirements. While major changes typically require cooperation within the OpenTripPlanner community, Entur may also, using a rich set of parameters, align swiftly with a changing environment without altering the main branch. For instance, in the wake of the pandemic, demand for less-crowded journeys surged, even if that journey would take a longer time. Here, within just a few days, through their knowledge of the algorithm, Entur could elicit additional journey options that matched these unprecedented demands (which are typically not selected by travel planning algorithms).

In addition, this setup allows Entur to increase the user quality of its services continuously. Providing possible route alternatives across all of Norway entails countless possible permutations; consequently, some presented route alternatives will, in practice, be unattractive. Using the current setup, however, reported faulty route alternatives can, often within hours, be adjusted by either reconfiguring the OpenTripPlanner instance, updating the map database, or correcting the public transport datasets (such as timetables).

Another unexpected agility benefit that emerged from moving from

procured solution to OSS concerned more efficient onboarding of new employees. Onboarding developers is costly and getting new developers up to speed is critical. OSS projects need to onboard new developers rapidly but have limited human resources. To this end, OSS code repositories typically contain detailed and updated installation instructions, dependency descriptions, and other forms of documentation that help new developers leapfrog the OSS onboarding process. This OSS style of releasing software has substantially lowered onboarding time also for new Entur employees. For example, the Self-Service Timetable Editor is essential to Entur's software architecture. It allows nontechnical users to create timetables graphically and subsequently export them into NeTEx. However, the instructions for this project, initially targeting external developers, have also proven efficient in onboarding new internal developers at Entur. This way, an OSS approach has decreased the onboarding compared to previous and less open initiatives within the team (as internal projects seldom invest this extra time to minimize onboarding time).

Leveraging Ecosystems

In addition to organizational agility, leveraging resources outside the organizational boundaries is crucial for DX. The second transformational aspect of Entur concerns how involvement in OSS communities and other open technologies enabled Entur to acquire IT resources and otherwise unattainable knowledge.

Even though public transport is differently organized worldwide, travel planner use cases are surprisingly aligned: an end-user enters the departure and destination alongside optional trip preferences (like acceptable transfer times and transport mode preferences). Based on this input, the service retrieves matching trips. However, as trip planning algorithms are complex, even minor changes to the main branch can introduce ripple effects for journey planner results and hurt performance significantly. Fortunately, the OpenTripPlanner community includes several world-class experts in travel planning. Using this community, Entur gains access to expertise unattainable through a public tender in Norway. These experts often offer to review use case designs suggested by Entur and perform code walkthroughs and debugging efforts. This way, Entur has received numerous and invaluable feedback on how to implement a local business requirement.

Moreover, through the OpenTripPlanner community, Entur has been able to draw on contributions from actors outside the public transport industry. Within the public transportation industry, the MaaS concept has been put forward as a new business concept in recent years. Through MaaS, commercial brokers sell mobility packages encompassing both public transport and on-demand transportation (such as taxis and ride-hailing services). As OpenTripPlanner primarily has been used by public transport agencies, this functionality has not been prioritized by the community and was rudimentary for a long time. Resulting from MaaS firms' engagement, however, the support for on-demand services on OpenTripPlanner has been significantly improved. This way, with minor additions, Entur has been able to add enhanced routing support, e.g., flexible transportation services from public transportation agencies (https://www.transitwiki.org/TransitWiki/index.php/Flexible_transportation_services).

Third, geospatial data on road networks, bike lanes, and footpaths are another area where Entur leverages external ecosystems. Such map data are an essential asset for public transport agencies to help travelers navigate the best route for mass transit journeys (as public transport journeys' attractiveness often depend on correctly assessing connecting walking/cycling segments). Using updated map information as a foundation for correct travel suggestions is thus a key concern for mobility service developers. Here, Entur collaborates closely with the OpenStreetMap community, which operates under an organizing logic similar to OSS. OpenStreetMap relies on voluntary contributions from private citizens and organizations, and any user can make updates to OpenStreetMap. The community around the map plays a key role by ensuring map edits follow conventions and curates edits that do not conform with the conventions (when spotted). Using this ecosystem of contributors, Entur experiences little time between when a change occurs on the ground and when the map is updated (as projected by previous studies on voluntary mapping[11]). This difference in speed is especially notable when comparing OpenStreetMap to official maps maintained by the government. In addition, Entur found that OpenStreetMap is mapped with additional details, typically not found in other maps. These data includes widely used preferred paths (https://en.wikipedia.org/wiki/Desire_path), wheelchair ramps, and detailed road surface information, enabling more precise and accurate journey options.

However, while OpenStreetMap's network quality is typically detailed, minor deficits are regularly spotted. Several Entur employees, therefore, frequently make minor updates to OpenStreetMap: for instance, when a customer reports a faulty journey suggestion and the source is traced to erroneous map data. In both of these cases, Entur reports having much help from the OpenStreetMap community to ingest edits aligned with OpenStreetMap standards. In rare cases, when important infrastructure objects lack necessary details, Entur has even formally engaged influential members to map such objects.

At Entur, the developer responsible for the code to be deployed is also accountable in this process, which has created a greater sense of ownership at the individual developer level.

OSS Transition Challenges

However, being a public sector organization diverging from the procurement paradigm and instead using OSS, has created several challenges within Entur that have been necessary to tackle.

The most tangible challenge emerging within Entur concerns addressing the added responsibility that follows from using OSS. When Entur was procuring passenger information software, and software faults or outages occurred, software vendors could be held accountable for fixing the error. As Entur started to use, e.g., OpenTripPlanner, they needed to shoulder this responsibility internally instead. To this end, Entur has been developing DevOps capabilities that enable them to, in a managed way, roll out and roll back solutions in production. At Entur, the developer responsible for the code to be deployed is also accountable in this process, which has created a greater sense of ownership at the individual developer level.

Another challenge relates to relying on external actors. In some cases, new functionality is delivered by the community and can be reused with little additional effort (e.g., like on-demand transportation mentioned above). However, in other cases, OSS community members may start (or signal that they might begin) the development of a feature. Still, it is unclear when it will be put into production (or what additional work will be required by Entur). One such example concerns travel planning that includes e-scooters. While basic functionality for these vehicles exists, OpenTripPlanner has yet to include important routing aspects, like geofencing: i.e., zones where e-scooters are not allowed to drive or are subject to speed limitations. Entur has thus far refrained from adding such functionality to OpenTripPlanner, as it has a global scope and therefore is likely to be developed by other actors at some point. However, the question of how long to wait before the situation requires Entur to lead the development of this functionality becomes the subject of internal and occasionally heated discussions. These discussions are caused by difficulties in establishing clear roadmaps with OSS components and highlight a key difference compared to procurement practices (where new functionality simply can be procured). To mitigate this, the developer team continuously needs to stress the benefits of the OSS approach and how the platform helps Entur reach its ambitious goals.

Finally, and contrary to some common arguments regarding OSS within the public sector,[12,13] moving software acquisition from procurement to OSS has not been a short-term cheaper strategy for Entur. For instance, being heavily involved in OSS projects means that everything from use case implementations to documentation must be implemented to a standard that allows reuse by others. Connecting to the different communities around relevant OSS projects requires extensive time investments to establish efficient dialogue and processes to ensure fruitful cooperation. Finally, assessing actual OSS maturity has proven complex and projects with, e.g., seemingly credible institutional support, have in practice turned out to be withering. Taken together, these tasks entail more effort than if they were to be executed for internal purposes only. However, these extra efforts have proven necessary to ensure that the used OSS project's health is sustained and for Entur to be considered a trustworthy community partner within these projects. Here, the development team within Entur has had to continuously explain and convince decision makers of the benefits

of organizational agility and how Entur can leverage external ecosystems through this OSS approach. A key to convincing management to allow these extra costs is to continuously deliver unexpected value in a fast manner, as in the case of querying less-crowded journeys during the pandemic.

Lessons Learned

The principles Entur has adopted as an organization, together with the technical platform, have made Entur an international showcase in the public transport sector. The key to this position lies in the synergy of the platform design and the ways of working. As a public organization, Entur has established an agile culture focusing on in-house product development, combined with the platform's extensive use of OSS, a modular technical platform, and open standardized data formats. This approach has enabled Entur as a public organization to become better abreast with societal changes and resolve constraints related to public procurement (such as becoming less dependent of external suppliers[11] and having access to highly specialized competencies).

We hope this experience report can inform other public sector agencies to navigate similar transitions successfully. We thus end this report by offering some actionable advice based on Entur's journey.

- *Moving from procurement to open source and agile development is a cultural journey.* Make sure you have the right resources and spend time teaching all team members and decision makers these new principles. This education has been necessary, e.g., for the new ways of dealing with roadmaps, schedules for new functionality in production environments, and iterations with continuous improvements instead of detailed requirement specifications. The effort this journey requires from an organization should not be underestimated.
- *Ambition levels matter.* It is difficult to compare the

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performance/cost of an agile/OSS approach with procurement. Following Entur's example, an engaged OSS approach works well in projects/organizations with high ambitions, as it enables you to be more agile and to draw on the knowledge of others. However, it might not be worth the investment (e.g., generalizing use case implementations and becoming a trusted OSS community member) in an organization and in people if you only have a medium/low ambition level.

- *Analyze the actual maturity level of any OSS project you are considering in your stack* (assessing contributors/recent pull requests/backing organizations but also by actively engaging in the community). You can expect much more investment in projects with a lower maturity level.
- *Keep your architecture modular when working with open source.* All modules should be as loosely coupled as possible, since OSS components must work in several organizations. Hence, make your component tasks even more clearly defined than in a non-OSS architecture. Consequently, if you consider extending a component for new tasks, contemplate whether instead to develop a new component.
- *Follow standards and principles when creating a digital infrastructure with OSS.* Like Entur's passenger information systems, the use of international standards, both for data models and the exchange of data, makes your platform more relevant for cooperation. Done together with established practices for open source development and investments in dialogue toward the community of codevelopers, you are much more likely to succeed. Do everything properly and do not cut corners.

References

1. G. Doukidis, D. Spinellis, and C. Ebert, "Digital transformation - A primer for practitioners," *IEEE Softw.*, vol. 37, no. 5, pp. 13–21, Sep./Oct. 2020, doi: 10.1109/ms.2020.2999969.
2. A. Hanelt, R. Bohnsack, D. Marz, and C. A. Marante, "A systematic review of the literature on digital transformation: Insights and implications for strategy and organizational change," *J. Manage. Stud.*, vol. 58, no. 5, pp. 1159–1197, Jul. 2021, doi: 10.1111/joms.12639.
3. F. Nagle, "Open source software and firm productivity," *Manage. Sci.*, vol. 65, no. 3, pp. 1191–1215, 2019, doi: 10.1287/mnsc.2017.2977.
4. G. Robles, I. Steinmacher, P. Adams, and C. Treude, "Twenty years of open source software: From skepticism to mainstream," *IEEE Softw.*, vol. 36, no. 6, pp. 12–15, Nov./Dec. 2019, doi: 10.1109/ms.2019.2933672.
5. T. P. Scanlon, "Critical factors for open source advancement in the U.S. Department of Defense," *IEEE Softw.*, vol. 36, no. 6, pp. 29–33, Nov./Dec. 2019, doi: 10.1109/MS.2019.2933769.
6. J. Linåker and P. Runeson, "Public sector platforms going open: Creating and growing an ecosystem with open collaborative development," in *Proc. 16th Int. Symp. Open Collaboration (OpenSym), Virtual Conf.*, 2020, pp. 1–10, doi: 10.1145/3412569.3412572.
7. "Network timetable exchange," European Commission, Brussels, Belgium, CEN TC278 Working Group 3 Sub Group 9, 2019. [Online]. Available: http://netex-cen.eu/
8. "Standard interface for real-time information," European Commission, Brussels, Belgium, CEN TC278 Working Group 3 Sub Group 7, 2019. [Online]. Available: http://www.transmodel-cen.eu/standards/siri/
9. "General bikeshare feed specification: MobilityData." GitHub. [Online]. Available: https://github.com/NABSA/gbfs
10. D. Rudmark, "Open data standards: Vertical industry standards to unlock digital ecosystems," in *Proc. 53rd Hawaii Int. Conf. Syst. Sci.*, 2020, pp. 2063–2072, doi: 10.24251/HICSS.2020.252.
11. H. Senaratne, A. Mobasheri, A. L. Ali, C. Capineri, and M. M. Haklay, "A review of volunteered geographic information quality assessment methods," *Int. J. Geographical Inf. Sci.*, vol. 31, no. 1, pp. 139–167, Jan. 2017, doi: 10.1080/13658816.2016.1189556.
12. S. Freeman, "User freedom or user control? The discursive struggle in choosing among Free/Libre open source tools in the Finnish public sector" *Inf. Technol. People*, vol. 25, no. 1, pp. 103–128, Feb. 2012, doi: 10.1108/09593841211204362.
13. O. Jokonya, "Investigating open source software benefits in public sector," in *Proc. 48th Hawaii Int. Conf. Syst. Sci.*, 2015, pp. 2242–2251, doi: 10.1109/HICSS.2015.268.