Case Study of Digitransit

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1. Abstract

The following is a longer version of a case study included in a comprehensive report titled 'Open Source Software Adoption and Reuse in European Local Governments: A Multiple-Case Study,' available on the OSOR website.

The case study was developed through a combination of secondary research and 4-6 original interviews with individuals representing the local government, community and supplier perspectives on the open source project/collaboration. The insights in the case study were validated through workshops, and specific findings have been reviewed by people originally interviewed for the case study. Insights have been pseudonymised in the case study narrative, but a full list of organisations and individuals participating in the case study can be found in Annex C of the main report.

2. Introduction

Digitransit[1] is an open source journey planner platform that integrates multiple public transit modes, including buses, trains, trams, bicycles and e-scooters[2]. As well as being a journey planner, it provides info screen services to several cities and public sector organisations (PSOs) for public transit and other related services[3]. In addition, it provides third-party APIs to over 10,000 developers using Digitransit data and services for various apps, e.g., map and address APIs that are free to use and leverage in various apps[4].

Digitransit is utilised by multiple local governments to provide journey planning solutions. The platform is provided as a service by Helsinki Region Transport (HSL) to Fintraffic, as well as to the local governments in Finland[5]. In Finland, long-haul bus operators and national railway operators also use Digitransit, but through their own implementations of the platform, as well as being used by HSL and other regional organisations. Digitransit enables local adaptations while maintaining a shared, upstream codebase, fostering cross-border knowledge exchange and innovation. Its flexibility allows for local customisations, enabling cities to adapt the platform to their unique transit networks and user needs[6].

The Digitransit project was motivated by the need for a flexible, open source alternative to proprietary journey planners, enabling better customisability and community engagement for local governments and regions[7]. Its success can be attributed to the open and cooperative approach taken by the Nordic developers. These developers were instrumental in driving both community growth within Finland and international contributions. Since 2014, it has been jointly developed by Fintraffic[8], HSL[9] and Waltti Solutions[10]. The platform provides a user interface and application layer to the upstream open source trip-planning engine OpenTripPlanner (OTP)[11], which calculates potential routes based on input data[12]. Map data is collected from OpenStreetMap[13].

Digitransit was initially released in 2017, following the first stable release of OTP in 2016. Digitransit's financial sustainability is ensured through a state-subsidised three-way funding model between HSL, Fintraffic and Waltti Solutions, covering core development but requiring local governments to fund additional features. Long-term sustainability is also tied to the OpenTripPlanner

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[1] Digitransit. (n.d.). *Digitransit – Open journey planner platform.* Available: https://digitransit.fi/en/
[2] Ibid.
[3] Ibid.
[4] Interview with Helsinki Regional Transport
[5] Interview with Fintraffic
[6] Interview with Helsinki Regional Transport; Interview with Fintraffic
[7] Interview with Helsinki Regional Transport
[8] Fintraffic. (n.d.). *Fintraffic – Safe and Smooth Traffic.* Available: https://www.fintraffic.fi/en
[9] HSL – Helsinki Regional Transport Authority. (n.d.). *Journey Planner, tickets and fares, customer service.* Available: https://www.hsl.fi/en
[10] Waltti. (n.d.). *Waltti – Public Transport Services.* Available: https://waltti.fi/en/front-page/
[11] OpenTripPlanner. (n.d.). *Multimodal Trip Planning Platform.* Available: https://www.opentripplanner.org/
[12] Interview with Entur
[13] OpenStreetMap contributors. (n.d.). *OpenStreetMap.* Available: https://www.openstreetmap.org/#map=7/47.714/13.349

project, which faces its own financial uncertainties, although a dedicated service supplier could help with governance and cross-border adoption.

Digitransit has evolved into a collaborative ecosystem of open source developers in Finland, and has been adopted and adapted by local governments in Estonia, Germany, and the United States as well[14]. For example, in Estonia, Digitransit is used by the national public transit organisations[15], and in Germany, Digitransit was adopted by the City of Herrenberg and later by Brandenburg and Berlin, inspired by its successful implementation in Finland[16]. Additionally, the U.S. City of Oklahoma deployed Digitransit with minor UI modifications, showcasing its adaptability to different urban contexts[17]. These international projects have highlighted the importance of maintaining upstream contributions to minimise the maintenance burden associated with forks.

[14] Interview with Digitransit Community
[15] Ibid.
[16] Ibid.
[17] Ibid.

3. Key Stakeholders

Helsinki Regional Transport (HSL) Authority: Helsinki Regional Transport is the public transit authority for the Helsinki region, which plays a central role in the Digitransit platform. It offers Digitransit to its customers as a tool to plan their public transit journeys. HSL initiated the Digitransit collaboration, initially alongside the Finnish Transport Agency (now part of Fintraffic), and is perhaps the most important and leading organisation in developing the solution. HSL continues to lead collaboration on Digitransit while equally sharing development and staff costs with Waltti and Fintraffic, as well as contributing other data of its own to the platform and ensuring its integration with other public transit services[18].

Fintraffic: Fintraffic is a state-owned company in Finland responsible for traffic management and control across various public transit modalities, and it acts as a National Access Point (NAP) where mobility providers are required to share their data. The mobility data, both static and real-time, can then be accessed via Digitransit, mainly targeting producers and developers of third-party mobility services. In practice, Fintraffic's data department is the main one that works with Digitransit, and they share budget and development costs for Digitransit with HSL and Waltti Solutions. Through their collaboration, Fintraffic (amongst other things) provides data, helps build info screen services, and supports data integration for local journey and route planners[19].

Waltti Solutions: Waltti Solutions Oy is a service supplier organisation that is owned by HSL and 22 urban regions and acts as a partner for IT projects related to public transit in its owner local governments. As part of its mandate, Waltti provides a unified ticketing system used across multiple Finnish cities and regions outside the Helsinki area. To do this, they integrate with Digitransit to provide complementary ticketing services for the journey planning platform. They have a jointly funded product owner and development team with HSL that helps to share costs and development[20].

Entur: Entur AS is a government-owned public transit organisation in Norway that provides the country's national journey planner. It is owned by the Norwegian Ministry of Transport and Communications and has a subdivision that functions as a service supplier for the national journey planner, through which it collaborates extensively with the OTP community, and by extension, Digitransit. They share some technological approaches, data standards, or development resources with Digitransit as part of a broader Nordic cooperation in public transit information systems. Much of the collaboration happens around Digitransit's use of OpenTripPlanner, which Entur helped to bring together and maintain the second version of[21].

[18] Interview with Helsinki Regional Transport
[19] Interview with Fintraffic
[20] Interview with Helsinki Regional Transport; Interview with Fintraffic
[21] Interview with Entur

OpenTripPlanner (OTP) Community: An open source community that develops the core journey planning software that powers Digitransit. This community consists of developers who contribute to maintaining and enhancing the routing engine that enables multimodal trip planning functionalities in Digitransit. Entur was responsible for helping to update the OTP software and released another version in 2017[22].

[22] Interview with Digitransit Community, Interview with Entur

4. Detailed Findings

4.1. Adoption and use

Digitransit has spread differently across regions, in large part due to its flexible and adaptable design that is well integrated with other open source solutions, like OTP, which are used in many other jurisdictions. Across Finland, Digitransit has become the go-to national standard for journey planning, seamlessly connecting multiple cities and public transit types, and HSL keeps the whole system running smoothly[23]. Furthermore, the open source approach and technology taken by the Digitransit community in the national government seems to have been positive for smaller local governments, letting them customise transit solutions without getting trapped in proprietary systems[24]. But despite its widespread use and adoption across Finland, there is still a lack of commercial support options outside government, which creates a real challenge for long-term sustainability.

Some commercial usage is reported, but the knowledge of to what extent is quite limited. In this respect, an interviewee from Fintraffic noted: '*[T]here are some other actors who are using Digitransit functionalities in part of their commercial services, like [a few] real estate companies that are using our address and map data on their services, for example. But how those other companies or organisations are using the Digitransit capabilities and what kind of business model they have, we don't have any knowledge.*' [25]

Germany's adoption story looks quite different. Herrenberg pioneered implementation there, championed by a passionate local government employee who strongly believed in open source solutions[26]. This was not mandated from above, but instead emerged as a strategic move to avoid service supplier lock-in[27]. While initially successful, the project eventually hit roadblocks due to short-term funding cycles and not enough maintenance resources, ultimately stalling out[28]. '*In the beginning, they were a bit hesitant to merge things, especially if it wasn't exactly implemented the way they wanted. And then later, they focused more on reducing the burden on forks by also merging things that more or less fit their use case and resource. But this was a long process. And then the project finished, the Herrenberg project, and ever since, it has been there, kind of rotting because nobody really maintained it.*' [29]

Despite some issues in maintaining the project, the Herrenberg effort did spark further adoption in the State of Brandenburg, north of Berlin. In that state, local governments tried to stick close to the original code while adding necessary local tweaks, like integrating German scooter and bicycle providers[30]. As the

[23] Interview with Helsinki Regional Transport
[24] Ibid.
[25] Interview with Fintraffic
[26] Interview with Digitransit Community
[27] Ibid.
[28] Ibid.
[29] Ibid.
[30] Ibid.

same interviewee noted: '*[T]hey wanted to copy it to Brandenburg, to the local state around Berlin. They saw that one municipality in Germany could do it and then figured that they could do it too. It was a slightly different setup. It was driven by someone else, but also taking municipalities on board.*' Nevertheless, that project stalled out, and they made similar mistakes, due to, as it was described: '*… a very short-term funding-based nature of how those projects work in Germany, where[by] you can spend loads of money in a few weeks or months, but then things are over, and it's extremely hard to get money or even time after that.*' [31]

This lack of long-term planning and funding was not true in Finland, which could perhaps be attributed to a number of factors, such as a smaller population, cultural cohesion, or even a different attitude towards IT development. Similarly, while not interviewed for this case study, the Estonian use of Digitransit seems to have found more success than the German installations did, possibly for similar reasons[32]. Nevertheless, ongoing maintenance remains challenging, even in the Finnish context, as many smaller local governments simply lack the technical know-how and funding to keep things running smoothly over time[33].

Here, the community stepped up to help address some of these challenges. For example, HSL developers provide support through an active Slack channel[34]. Even in Germany, local entrepreneurs have continued to play crucial roles in customising and deploying the platform, helping to revive some work, even as it languishes in administrations Herrenberg and Brandenburg[35]. Documentation, however, continues to be a pain point, with multiple interviewees highlighting the need for better onboarding materials to help newcomers get up to speed[36].

Despite some of these challenges, it is clear that Digitransit has taken off and been adopted because its technology approach works and builds on top of an established open source community. While other local governments have not had as much success as Finland has, there are lessons to be learned from its collaboration model. It might be necessary to provide options for installing and maintaining Digitransit through a service supplier model, e.g., by HSL or commercial suppliers.

4.2. Development and maintenance

Digitransit's development and maintenance is sponsored by a core group of three actors: HSL, Fintraffic and Waltti Solutions. HSL largely drives Digitransit's development and maintenance, with a dedicated set of coordinators and an internal team working alongside coordinators and/or consultants from several external companies[37]. A representative of HSL described this development and project management approach to coordination as follows: '*... the coordinator*

[31] Ibid.
[32] Interview with Helsinki Regional Transport
[33] Ibid.
[34] Interview with Fintraffic
[35] Interview with Digitransit Community
[36] Interview with Digitransit Community
[37] Interview with Helsinki Regional Transport; Interview with Fintraffic

role is shared by three different people from different companies. We are meeting weekly – or monthly, depending on the situation – on the development and coordinating [decisions]. Unanimity is the basic need for us; we have to be unanimous on doing things.' [38]

A lot of the Digitransit development is dependent on working with the OpenTripPlanner community and relies on contributions from Entur – the Norwegian state-owned transport organisation and maintainer of OTP – and others in the OTP community[39]. During the first version of OTP, there were several issues requiring extensive customisation of the Finnish Digitransit solution. Beginning in 2017[40], OTP 2.0 was released after a major revision by Entur, which had – amongst other things – a new algorithm, a different search logic, and a more modular design[41]. HSL can contribute upstream directly to the OTP project, and thereby minimise technical debt and improve HSL's ability to stay up-to-date with the latest releases of OTP[42].

For Digitransit, however, external contributions are less common[43]. One notable exception comes from Germany, where local entrepreneurs have developed features like car-sharing and multimodal public transit planning to meet specific needs in German cities. Getting these contributions merged upstream in Digitransit, however, was a challenge, e.g., due to misaligned priorities between HSL and the German use case and funding constraints[44]. *'Some [features] we have developed are really subtle, but take a lot of time [to merge] due to what the Digitransit codebase looks like. So, if you want to move one button slightly, it takes surprisingly long.'* [45]

Digitransit's development follows a structured workflow. Monthly meetings tackle key development topics, while biweekly sprint and demo sessions allow stakeholders to prioritise and review new features[46]. The product owner coordinates these efforts, making sure developments align with strategic goals[47]. The broader community can suggest features and join technical discussions via Slack, but integrating community-driven changes into the core platform tends to be a slow, resource-intensive process[48]. One interviewee from Fintraffic noted: '*We try to work as openly as possible, and if there's a new organisation [that] wants to join the development work, of course, it's free for them to do so. There's no fees or anything, [they] just join the Slack channels and read how the development is done. […] So, if you want to come and discuss these kinds of topics and [do] this very grassroots development work, [the community is] meant to be very developer-oriented, even if it takes time to get involved.*' [49]

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[38] Interview with Helsinki Regional Transport
[39] Interview with Entur
[40] Ibid.
[41] Entur. (2020). *OpenTripPlanner 2.0 is here.* Available: https://om.entur.no/aktuelle-saker/opentripplanner-2-0-is-here
[42] Ibid.
[43] Interview with Digitransit Community; Interview with Helsinki Regional Transport
[44] Interview with Digitransit Community; Interview with Entur
[45] Interview with Digitransit Community
[46] Interview with Helsinki Regional Transport; Interview with Fintraffic
[47] Ibid.
[48] Interview with Fintraffic
[49] Ibid.

4.3. Funding and sustainability

Digitransit's financial sustainability relies on a joint annual budget split equally between Fintraffic, Waltti Solutions, and HSL. Each organisation provides one-third of the total cost, ensuring baseline development and maintenance[50]. As the funding is entirely subsidised by the state and the three-way arrangement between these three actors, they have not had to give consideration to future arrangements to ensure the sustainability of the codebase. For example, they have not had to think about service suppliers or local government contributions, as everything is financed out of local IT budgets[51].

The three-way funding model between HSL, Fintraffic and Waltti is mainly dedicated to funding core functionality and main use cases. If, for example, a local government wants something beyond the agreed scope, they need to secure their own funding to cover development costs[52]. In Germany, funding constraints created serious headaches for maintaining Digitransit implementations. Cities often secure short-term grants to kickstart digital projects, but lack ongoing support to sustain them[53]. As a result, many Digitransit instances have been left to languish without active maintenance. The Herrenberg project, for example, received initial funding for just a few months, requiring a rushed implementation. After deployment, there was no real plan for continued support, leaving the system to grow outdated and neglected[54].

Another point on Digitransit's funding and sustainability relates to its dependency on the OTP project. OTP is *de facto* maintained by Entur, which provides a substantial part of the financial support for maintaining the OTP codebase, although 80% of development is today mainly coming from the broader community[55]. That said, Entur itself as a PSO struggles to create financial sustainability for OTP that could create downstream issues later for projects like Digitransit, which are dependent on it. An interviewee from Entur attributes this to procurement processes, which are often not set up in PSOs to support open source stewardship and maintenance[56].

One interviewee suggested creating a dedicated service supplier offering commercial Digitransit support – similar to OpenTripPlanner's approach – which could support work both within Finland and abroad[57]. This approach could help solve some of their challenges related to governance and organisation, which influence the development and maintenance of Digitransit. If they are to learn anything from Entur, though, it's that this can be challenging to implement in practice. The interviewee from Entur notes that: *'We find that we want to have some kind of central funding for OTP, so [that] we can hire an independent*

[50] Interview with Helsinki Regional Transport; Interview with Fintraffic
[51] Ibid.
[52] Interview with Helsinki Regional Transport
[53] Interview with Digitransit Community
[54] Ibid.
[55] Interview with Entur
[56] Ibid.
[57] Interview with Helsinki Regional Transport; Interview with Fintraffic; Interview with Entur

project leader or project manager who can manage the project day to day. And typically, we would have no problem to finance such a role together with the other organisations. But being a public organisation – which [has] a lot of laws to abide by when it comes to procurement processes – it is actually quite complex just to get hold of those funds without having to do a procurement process.' [58]

Despite recognising this gap and potential need, however, no concrete steps have materialised yet for explicitly creating or empowering an entity that can help with cross-border implementations of Digitransit. In this way, the focus remains on making the Digitransit collaboration model financially viable and sustainable in Finland. But, as Digitransit continues to establish itself as a community in its own right, some consideration will need to be given to the impact of funding on processes, and vice versa. Different arrangements may need to be explored to help the project scale and stay sustainable as it does.

4.4. Governance and organisation

Digitransit's governance structure is organised yet complex, involving multiple stakeholders across different regions. The core governance team includes representatives from HSL, Waltti Solutions, and Fintraffic. This three-way structure ensures collaborative decision-making, with each entity shaping the platform's strategic direction[59]. Each year, service coordinators from the three core organisations compile a roadmap of proposed developments, but they also meet regularly. In both the roadmap and regular meetings, representatives from each entity review proposals and ideas for ongoing work[60].

New features typically get evaluated based on their business case and alignment with Digitransit's strategic goals. One interviewee exemplified the process: *'We have to be unanimous that [external] funding doesn't hurt the main focus, which is the up-and-running service and making the minor improvements. So often it's some smaller, bigger epic that they want to do, which is not needed for us or needed for Waltti, but Fintraffic might have one that they keep funding, and then we have to decide together that it isn't hurtful for the main project.'* [61]

While designed to be inclusive, the process often involves compromise, as major decisions require unanimous agreement. As this quote demonstrates, the consensus-driven, structured approach to decision-making between multiple parties can slow down the integration of new features, as various local requirements and priorities need to be reconciled before major changes can be approved[62]. As this process was described, one gets a sense of how it might be slow and occasionally cumbersome. The whole process takes time and effort, and is rather centralised by comparison to some open source communities.

[58] Interview with Entur
[59] Interview with Helsinki Regional Transport; Interview with Fintraffic
[60] Ibid.
[61] Interview with Fintraffic
[62] Ibid.

Despite an active community of users and developers, external contributors often struggle to navigate the governance structure, which is highly centralised and focused on Finnish use cases[63]. Unlike OpenTripPlanner with its more formalised open governance model, Digitransit remains largely controlled by Finnish stakeholders. While the governance is well-suited for the needs of a PSO project – and it is part of an established open source community (in this case, the OTP community) – it is not set up to receive external contributions through open source governance.

One interviewee notes of this approach to governance and organisation: *"Yeah, I mean [with Digitransit], it's kind of de facto governance; like, it's their project, and they say that they are open to contributions, which is actually true, but it's not as open as OpenTripPlanner where they have a governance document and where there's votes happening and open calls and so on. It's more [of] an HSL project, I would say.'* [64] The limited amount of external contributions coming from the community can, hence, to certain extents be explained by the relatively closed governance model the project has adopted.

Where they do happen, international contributions to Digitransit mainly flow through the official community channels on Slack and occasional meetings[65]. Some interviewees suggested that greater transparency and streamlined contribution processes could enhance international collaboration and broaden the platform's accessibility[66].

Despite these challenges, through its three-way governance, Digitransit maintains a strong commitment to open source principles, enabling local governments to leverage and customise the platform for their needs. For long-term success, though, stakeholders may need to explore new governance approaches that allow for greater flexibility and inclusivity, particularly as the platform expands beyond Finland. They will also need to consider what more structured and inclusive contribution models look like.

[63] Interview with Digitransit Community
[64] Interview with Digitransit Community
[65] Interview with Digitransit Community; Interview with Fintraffic
[66] Interview with Digitransit Community; Interview with Entur

5. Lessons Learnt

1. **Multi-stakeholder governance models without clear ownership structures can create challenges for governance of open source development.**

The Digitransit case study reveals how a three-way governance structure between HSL, Fintraffic, and Waltti Solutions introduced complexity that limited external contributions. While decisions required unanimous agreement from all three organisations, this consensus-based approach created bottlenecks in the development process, with interviewees noting that municipalities often provided requirements rather than code contributions. The contrast with OpenTripPlanner's more streamlined governance, which featured weekly developer meetings, clear contribution processes, and a dedicated release committee. This highlights how governance structures directly impact project sustainability and external participation.

The difference in external contribution levels between OTP and Digitransit demonstrates how governance affects community growth. While OTP successfully attracted contributions from Norway's Entur, U.S. cities, and other international participants, Digitransit struggled to cultivate a similar contribution ecosystem despite its usefulness. As one interviewee noted regarding the German implementation, they pushed as many changes as possible upstream, but there was not much responsiveness from HSL's side[67]. This suggests that complex governance can create high barriers to entry, discouraging potential contributors and ultimately limiting a project's long-term sustainability compared to communities with more accessible participation pathways and clearer decision-making structures.

2. **Cross-border collaborative development requires proactive engagement with, and contribution to, upstream communities and dependencies.**

The Digitransit case study demonstrates how open source solutions can create thriving ecosystems that transcend national boundaries. The relationship between Helsinki's Digitransit platform and the upstream OTP project illustrates a broadly successful model of collaborative development across international communities. While the German municipality implementations offer important insights into adoption challenges, the broader significance lies in how OTP serves as a foundation for other such public transit solutions worldwide. The Norwegian experience with OTP, as described by Entur's representative, shows how the professionalising of open source governance – through regular developer meetings, clear contribution processes, and consensus-based decision making – has strengthened the entire ecosystem, benefiting all downstream implementations, including Digitransit[68].

[67] Interview with Digitransit Community
[68] Interview with Helsinki Regional Transport; Interview Fintraffic; Interview with Entu

In this way, the case study highlights the value of investing in a project's upstream communities and dependencies rather than maintaining isolated forks, as well as the importance of community support between projects more broadly. Finland's HSL, Norway's Entur, and other international partners actively contribute to OTP's core functionality, ensuring the platform evolves to meet diverse needs while maintaining interoperability. This collaborative approach has enabled the adoption of OTP-based solutions in cities across the United States, Germany, Estonia, and beyond[69]. The ecosystem's success demonstrates how local governments and other PSOs can leverage shared development resources to create sophisticated transit solutions that would be prohibitively expensive to build independently, while simultaneously fostering innovation through open standards and data exchange frameworks mandated by regulations like Finland's 2017 mobility data law.

3. Cross-border open source communities need to be responsive and helpful to both new and existing users and contributors.

Active communication and responsiveness are crucial for sustaining an open source community, especially in cross-border projects. In the case of Digitransit, its early success was heavily influenced by the proactive engagement of Finnish developers, who were committed to fostering a collaborative environment. Their responsiveness to requests from other local governments in Finland[70] highlights the importance of consistent and clear communication channels within open source projects, as it helps resolve immediate issues and also fosters a sense of community ownership. While their engagement was possible in Finland, aided by a similar culture and working dynamics, their collaboration across borders highlighted the complexities of being responsive and collaborating actively. This is common for open source collaborations originating from PSOs, particularly at a local or regional level, but is notably absent in Digitransit, which is a relatively mature collaboration already.

As Digitransit scales internationally, a more robust governance model, perhaps with tiered support structures or funding mechanisms for smaller local governments, might be necessary to help alleviate and remediate some of these challenges. The Herrenberg experience suggests that even with enthusiastic individuals and helpful communities, structural support and guidance for contributions is essential for long-term success[71]. A good model for this is OTP, though they have their own sustainability challenges as well[72]. But by providing support, guidance, and resources, open source communities can lower the barrier to entry for newcomers and encourage active participation. This collaborative spirit not only aids in growing the project but also enriches it with diverse perspectives and expertise, driving innovation and ensuring its relevance in a global context.

[69] Interview with Helsinki Regional Transport; Interview Fintraffic
[70] Interview with Helsinki Regional Transport
[71] Ibid.
[72] Interview with Entur

4. **Developing documentation and onboarding processes that lower barriers for newcomers, particularly local governments, is vital for adoption.**

Lowering barriers for new contributors, particularly local governments, is essential for adoption. In the case of Digitransit, some new contributors to the software struggled to become active due to limited documentation, leading to challenges in cross-border implementations[73]. The challenges faced by Herrenberg[74] suggest potential gaps in these areas. In those cases, rapid implementations – driven by the limited funding period – seemed to prioritise speed over thorough documentation and training[75]. This could have contributed to the project's eventual abandonment, as the local government lacked the internal expertise to maintain the system.

One interviewee's comments about Finnish adaptations to OpenTripPlanner struggling to be integrated into the main branch hint at a broader issue with contribution processes[76]. Even if documentation is excellent, there is not always a clear pathway for contributing back to the core project, which can lead to fragmentation and duplicated effort. Local governments, like the City of Herrenberg or the State of Brandenburg, often lacking dedicated development teams, may be particularly vulnerable to this issue[77]. Local governments, typically the end-users or beneficiaries of open source projects like Digitransit, may have limited technical expertise or resources to navigate complex platforms[78]. Therefore, providing comprehensive documentation, tutorials, and support can significantly ease their onboarding process.

By creating means to streamline the initial engagement with the project, upstream developers and maintainers can help downstream users, such as local governments, more effectively utilise and customise the open source solution to fit their specific needs. These dynamics are complicated depending on where the local government is in the ‘stream’. In any case, while strong documentation and onboarding are essential, they must be complemented by a clear and accessible contribution process. Such processes should not only guide local governments on how to use the software but also empower them to contribute their own adaptations and improvements back to the community, fostering a sense of shared ownership and reducing the risk of isolated implementations.

5. **Standards enable broader adoption and reuse of solutions in other contexts or migration to a different platform.**

The use of open standards facilitates the reuse of solutions in various contexts, as they can be easily adapted and customised to fit specific needs without requiring extensive modifications. In the Digitransit case, the use of OpenTripPlanner clearly demonstrates the benefits of open standards, which

[73] Interview with Digitransit Community; Interview with Entur
[74] Interview with Digitransit Community
[75] Interview with Digitransit Community; Interview with Helsinki Regional Transport
[76] Interview with Entur
[77] Interview with Digitransit Community
[78] Interview with Digitransit Community; Interview with Helsinki Regional Transport

help to enable cross-border sharing and interoperability[79]. This flexibility is crucial for local governments with diverse existing systems and data sources. In addition to OTP, Digitransit's use of other open standards, like OpenStreetMaps – which has a broad international community – also seemed to enable broader adoption and reuse across different contexts, as it facilitated easier migration between platforms and supported international scalability[80].

However, as the interviewee also notes, even with open standards, challenges remain. The difficulty in integrating Finnish adaptations into the main branch of OpenTripPlanner shows that using open standards is not a silver bullet[81]. Variations in implementation and customisation can still create significant barriers to collaboration and code reuse. Therefore, while open standards are a crucial foundation, they must be complemented by strong community governance and clear contribution guidelines[82], and they may not be appropriate or useful in all circumstances. A better consideration of the context appropriateness of open standards (and APIs) will ensure that local adaptations, while leveraging the flexibility of openness, can also contribute back to the broader project, rather than creating isolated and incompatible implementations.

Regardless of the challenges, open standards are vital for the portability and reuse of open source solutions, particularly for PSOs, who often benefit from economies of scale and tapping into established communities of practice. They play a crucial role in ensuring interoperability and compatibility across different systems and platforms. By adhering to such standards, open source projects like Digitransit open up the possibility of more easily integrating with other software, services, and communities, enhancing their functionality and expanding their potential user base while also providing benefits to code quality and reuse[83]. This not only saves time and resources but also promotes collaboration and knowledge sharing among different communities and projects. Additionally, standards enable easier migration between platforms, allowing users to switch to different systems or upgrade their infrastructure without facing significant challenges in transferring data or functionalities.

6. Scalability and localisation are important to make open source projects easily adaptable to local contexts and requirements.

The Digitransit project, by its very nature, needs to be both scalable and localisable. Scalability ensures that the project can grow and adapt to increasing demands without compromising its performance or stability, while localisation is about ensuring the project can be adapted to the specific needs of different local governments, while also maintaining a core codebase that is manageable and sustainable. In this way, balancing scalability and localisation is critical for the success of open source projects – especially when they aim to serve diverse communities with varying needs and contexts – but hard in

[79] Interview with Helsinki Regional Transport; Interview with Entur
[80] Interview with Helsinki Regional Transport
[81] Interview with Helsinki Regional Transport; Interview with Entur
[82] Workshop Discussions
[83] Interview with Entur

practice. One interviewee's comments about trying to have OpenTripPlanner 2.0 as clean as possible suggest an awareness of the challenges of balancing these competing demands[84]. The experience with Finnish adaptations struggling to be integrated into OpenTripPlanner highlights the tension between local customisation and maintainability[85].

While local adaptations are essential for meeting the specific needs of each local government, they can also lead to a fragmented codebase if not properly managed. For example, Digitransit scaled to Germany, but perhaps failed to be localised properly into a different cultural context, leading to forks that increase maintenance complexity and were ultimately left to languish, as seen in Herrenberg and Brandenburg[86]. A modular architecture might help to address this challenge. By allowing for independent updates and customisations, a modular design can enable local governments to tailor the system to their needs without compromising the integrity of the core project. However, this modularity must be coupled with a strong governance model to ensure that valuable local adaptations are shared and integrated back into the main codebase.

For this reason, developing a more modular architecture could enhance scalability and localisation while reducing those maintenance burdens and allowing for more collaboration between upstream and downstream developers. This is a frequent challenge as open source projects scale, and can be seen as especially acute for the private sector, which has less capacity to absorb maintenance and customisation costs. In this way, as projects like Digitransit scale, taking such factors into account can promote the long-term sustainability of the project.

[84] Interview with Entur
[85] Interview with Helsinki Regional Transport; Interview with Entur
[86] Interview with Digitransit Community