Interactive mapping for public transit planning: Comparing accessibility and travel-time framings

The Journal of Transport and Land Use http://jtlu.org
Vol. 15 No. 1 [2022] pp. 635–650

JTLU

Interactive mapping for public transit planning: Comparing accessibility and travel-time framings

Anson F. Stewart
Massachusetts Institute of Technology
ansons@mit.edu

P. Christopher Zegras
Massachusetts Institute of Technology
czegras@mit.edu

Abstract: As transport planners increasingly frame project impacts in accessibility terms, it is worth considering how this foundational land-use transport interaction concept can shape stakeholder attitudes. In this paper, we test whether framing the benefits of public transit projects in terms of increased accessibility better fosters enthusiasm among advocates, as compared to framing benefits in terms of travel-time savings. We test two versions of an interactive mapping tool in small workshops examining upgraded bus services. One version shows isochrones and accessibility indicators, and the other shows paths and travel time indicators. Results from pre- and post-surveys suggest that framing impacts in accessibility terms may encourage broader thinking and stronger dialog than framing impacts in time-savings terms. In particular, the accessibility version seems to mitigate skepticism and car users' predispositions against upgrading bus service. An unexpected result is that many workshop participants report decreased overall enthusiasm for the bus upgrades after using either version of the tool. This disappointment may stem from an unrealistic baseline, which assumes perfect schedule adherence not aligned with lived experiences. Future research should consider tools that help stakeholders understand and deliberate about actual service and network-level reliability, and testing such tools with wider audiences.

Article history:
Received: March 20, 2020
Received in revised form: March 5, 2022
Accepted: June 14, 2022
Available online: October 11, 2022

1 Introduction

Accessibility provides a theoretically rich way of representing metropolitan land-use and transport system performance (Geurs & Van Wee, 2004; Handy & Niemeier, 1997; Zegras, 2011). Accessibility planning can foster sustainable outcomes (Banister, 2008) and encourage interdisciplinary collaboration (Papa et al., 2016; Straatemeier & Bertolini, 2008). It is often contrasted with mobility planning, which more narrowly seeks to reduce travel time rather than increase access (Boisjoly & El-Geneidy, 2017). In project evaluation, quantifying benefits in terms of accessibility gains, rather than travel time savings, is preferable from an equity perspective (Martens & Di Ciommo, 2017). Accessibility planning has gained policy traction (e.g., UK local transport plans), providing some examples of how basic accessibility concepts can work alongside standard stakeholder engagement processes (Curl et al., 2011). While emerging digital tools that leverage rapid computation and interactive mapping may further advance the adoption of accessibility indicators (Handy, 2020; Miller, 2018), the potential of combining

http://dx.doi.org/10.5198/jtlu.2022.1760
ISSN: 1938-7849

The *Journal of Transport and Land Use* is the official journal of the World Society for Transport and Land Use (WSTLUR) and is published and sponsored by the University of Minnesota Center for Transportation Studies.

an accessibility framing with novel forms of collaborative stakeholder engagement for transport projects has not been thoroughly explored.

Allowing groups of stakeholders to modify and test scenarios iteratively and compare impacts with interactive mapping can support deliberation, mutual learning, and public involvement (Stewart & Zegras, 2016). Such spatial representation can help communicate geographic impacts, which may be unintuitive or otherwise difficult to demonstrate due to network effects inherent in transportation projects. This paper tests whether framing the benefits of public transit projects in terms of accessibility, rather than travel-time savings, encourages more influential dialog and may therefore be a stronger conceptual basis for engaging groups of stakeholders.

We use a small-sample experiment to assess the effect of accessibility framing, separate from the more general impacts of interacting with a large touchscreen map in a collaborative setting. Bus priority infrastructure (e.g., dedicated lanes) in five corridors in Greater Boston constituted the example project. In workshops, participants discussed these corridors using one of two versions of an open-source web-based mapping tool. The accessibility version showed, for a chosen origin, isochrones and accessibility indicators – the cumulative number of jobs reachable within a time limit, adjustable up to two hours. The travel-time version showed, for a chosen origin and destination, the shortest path and travel-time indicators – walk, wait, and in-vehicle time. Comparing these two versions, we measure shifts in participants' attitudes toward the example project in terms of changes in expected impacts on different groups and assess how different factors influenced changes in enthusiasm for the example project.

2 Methods

As an alternative to traditional transport modeling practice, Waddell (2011) suggests using models within a "participatory decision-making process, by making it easy for diverse stakeholders… to move through an iterative process." Literature on collaborative spatial planning support systems and other modeling tools suggests that both their substantive content and their support of quality of participatory group interactions may affect engagement outcomes (Stewart, 2017). Given these intertwined factors, evaluating the usefulness of planning support systems, and decision support tools more broadly, is a challenge (Moser, 2009).

Past studies comparing accessibility instruments (e.g., Curtis & Scheurer, 2010; Silva et al., 2017) and planning media (e.g., Stewart et al., 2018) have prioritized contextual relevance and the participation of small numbers of relevant practitioners, allowing some cross-context comparisons but limiting experimentally rigorous findings within contexts. Another approach uses larger numbers of participants to compare tools directly within a more tightly controlled context, such as the 133 student participants in Champlin et al. (2018). Recognizing "fundamental trade-offs" between contextual relevance and experimental control (te Brömmelstroet, 2017), we seek a middle ground – involving community members in a meaningful, grounded exercise while seeking to isolate the effect of the different conceptual framings.

In stakeholder workshops, a pertinent outcome is participants' intention to advocate for a project. The theory of reasoned action (Fishbein & Ajzen, 2010) holds that attitudes, perceived norms, and perceived behavioral control are strong predictors of intentions. Drawing on this theory, our premise is that multiple factors determine changes in advocacy intention as a stakeholder's awareness about a project grows.

Figure 1 summarizes potential interactions among these factors. As stakeholders learn about a transportation project, their backgrounds likely influence their intention to advocate for the project. Absent an outreach or engagement process, predispositions related to their customary patterns and modes of travel (arrow 1) are likely to dominate. For example, people who usually drive may be unlikely to voice support for a transit project. These predispositions may be tempered by changes in attitude toward the project (arrow 2), which arise from the interactions among backgrounds, project attributes, and engagement processes. Effective workshop tools should help individuals understand and interrogate how their mobility backgrounds interact with project attributes. Intentions may also depend on attitudes toward the engagement process itself (arrow 3), so tools should aim to prompt quality dialog and structure meaningful collaboration. Even if participants believe a transport project will benefit themselves, for example, they are unlikely to spend time advocating through engagement channels that they perceive to be a poor use of time or poorly matched with their capabilities. Other background factors may also impact participants' intentions to advocate for a project, either directly (arrow 4) or by affecting how they participate in workshops or other engagement exercises. For brevity, and because perceived efficacy is likely to depend heavily on specific institutional settings, we do not discuss changes in capability and perceptions here.

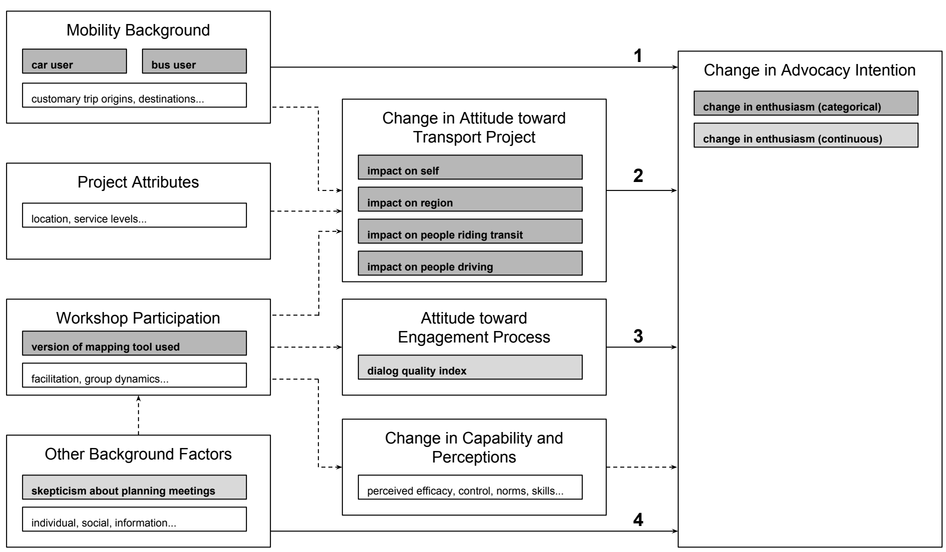


Figure 1. Factors affecting workshop participants' advocacy intention (bold items are measured in the workshops)

Drawing on the factors discussed above, two overarching hypotheses structure our analysis and discussion:

1. Participants using the accessibility version will have more positive changes in attitude toward the example project, relative to participants using the travel-time version, indicated by greater positive shifts in expectations about its impacts.
2. The core factors influencing enthusiasm, namely attitudes toward the project and the engagement process (arrows 2 and 3 in Figure 1), will have a stronger effect on enthusiasm for users of the accessibility version relative to users of the travel-time version, and background factors (arrows 1 and 4) will have a weaker effect.

These hypotheses are based on our judgement that the accessibility version employs more novel cartographic representation and presents more integrative results.

2.1 Experimental setup

To test these hypotheses, we conducted four workshops in partnership with LivableStreets Alliance, an advocacy organization in Greater Boston that has focused on active transportation and increasingly aims to build enthusiasm for campaigns promoting faster and more reliable public transit. The organization's advocacy committee helped develop the workshop agenda and recruit participants from their general membership. At the start of each workshop, participants listened to an overview of the example project, completed a pre-test survey, and separated into two groups. They then spent one hour testing bus priority scenarios and their own modifications to those scenarios in either the accessibility or travel-time version of the tool, completing a post-test survey, and reconvening for a debrief discussion. The workshops were conducted in a classroom with partitions that kept the two groups separate while they worked. Two touchscreens were used for the distinct versions (Figure 2, Figure 4). Participants were not informed of the two different framings, or that the other group used a different version of the mapping tool, until the end of the workshop. To control for facilitation style, the facilitators alternated tool versions between workshops.

Figure 2. Participant using the travel-time version on a touchscreen

2.2 Computation and user interface

The two versions of the interface were designed to be as similar as possible in terms of user interface, with the only differences tied to travel time and accessibility framings of transport impacts. For computation, both versions relied on the API of the Conveyal R5 routing engine and Analysis platform (see Conway et al., 2017; Conway et al., 2018), open-source software that accepts scenario modification and routing requests and returns accessibility and travel time results. Travel mode was fixed to walking and transit, assuming a random departure between 7 and 9 AM.

In line with the goal of enabling an "iterative process," this tool performs a rapid *ceteris paribus* analysis of changes to the transport system. Subsequent changes to traffic, land-use patterns, mode split, etc., which a project might eventually induce, are not modeled or represented. As such, expectations about impacts on other modes come from intuition and iterative exploration of first-order transit service changes. The workshops focused on five bus priority corridor segments from a government study identifying potential corridors in Greater Boston. The study selected candidate corridors for dedicated bus lanes and other priority measures to reduce delays for bus passengers, based on existing conditions of high passenger volumes and low speeds (Hart & Belcher, 2016). Users could adjust sliders in the interface, allowing them to specify scenarios as percent changes in running time, dwell time, and frequency for the bus routes traversing each of the five segments (Figure 3). After users specified a new scenario, the tool returned updated accessibility or travel-time results within approximately 20 seconds.

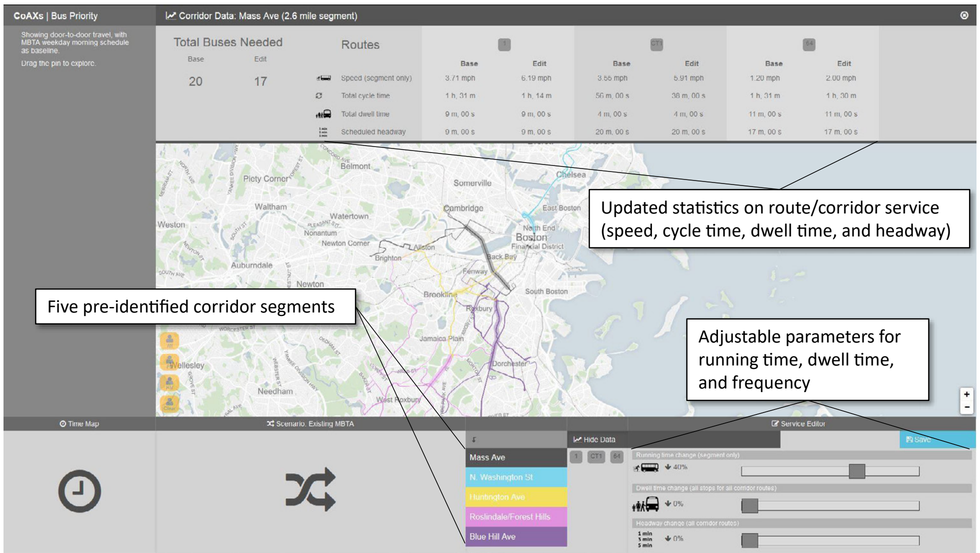
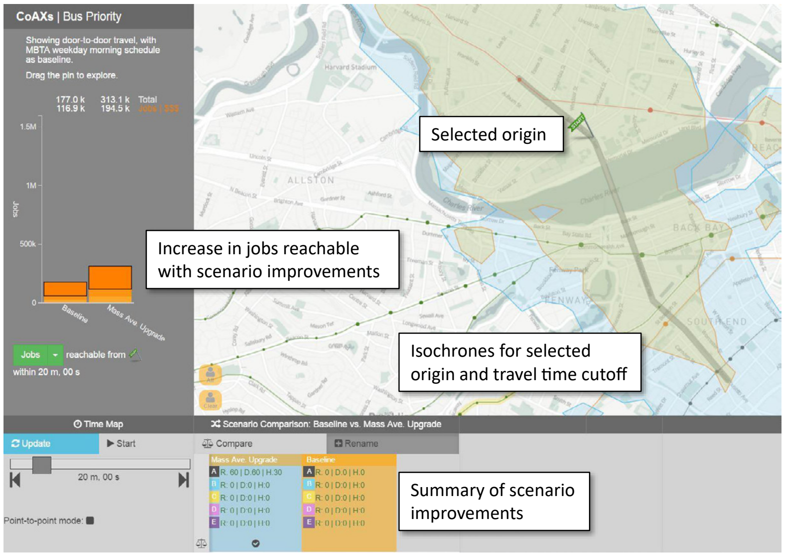


Figure 3. Scenario modification interface, with the five example corridors

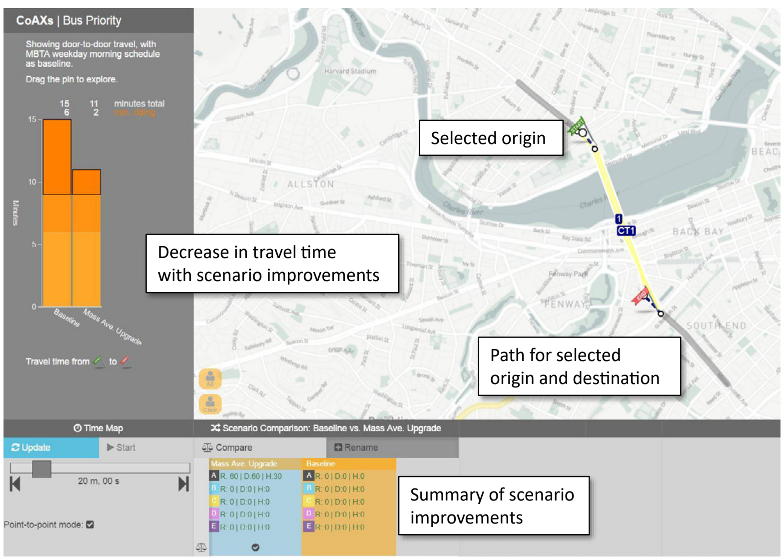
In the accessibility version (Figure 4a), in addition to selecting an origin, participants used a slider to specify a travel-time cutoff (between 5 and 120 min.), then discussed the resulting isochrones and number of jobs reachable under baseline and modified scenarios. Jobs were divided into three categories by wage level, as shown in the stacked bar charts.

In the travel-time version (Figure 4b), in addition to selecting an origin, participants used a second map pin to specify a destination, then discussed the resulting paths and required travel time under baseline and modified scenarios. Travel-time representation was divided into walking, waiting, and in-vehicle components, as shown in the stacked bar charts. Multiple paths between the origin and destination may have been optimal according to estimates from the R5 routing engine, depending on the exact departure time within the two-hour analysis window. The map shows the two paths most frequently optimal within the time window, while the bar chart displays the median of all optimal paths.

Participants' interactions with each other and the touchscreen were noted by observers and automatically logged via the web browser, then reconstructed based on recorded transcripts of the workshops. Interactions and conversation topics were then aligned to the transcript timestamps for subsequent analysis.



a) Accessibility version



b) Travel-time version

Figure 4. Results shown in the two interface versions

2.3 Survey design and statistical tests

The pre-test survey contained questions on past participation in planning meetings and an open-response item about modes of travel used in a typical week. It also asked participants, "how do you think bus priority in the five corridors identified will impact" various parties, such as themselves, the region, people riding transit, and people driving. These questions allowed responses along a five-point Likert scale: "significantly positive impact," "positive impact," "no impact," "negative impact," and "significantly negative impact." Finally, the pre-test survey included three statements about participants' enthusiasm for the example project, using a five-point Likert scale ranging from strongly disagree to strongly agree:

1. This project will be effective at advancing important transportation goals.
2. This project will help advance important broader urban goals (e.g., housing, education).
3. I am more likely to advocate for this project than other projects LivableStreets supports.

The post-test survey repeated the pre-test questions and included additional ones to gauge usefulness and usability. Specifically, participants were asked whether they agreed that the tool provided a useful common ground for collaboration, raised important issues, and supported important conversations. We further assessed collaboration and usability with indices that have been applied in other planning support systems research: a dialog quality index developed by Goodspeed (2015), and a standard System Usability Scale (Brooke, n.d.; following Goodspeed et al., 2016).

The "example project" was not necessarily constant between the two surveys. In the pre-test survey, example service improvement levels were suggested for the five chosen corridors: 40% reduction in dwell time, 40% reduction in running time, and 25% reduction in headway. Over the course of the workshop, however, participants' understandings of a feasible or desirable level of improvements for each of the corridors may have changed, and their interpretation of "example project" may have changed accordingly. For example, a participant may have decided, after deliberating with their group, that a 25% reduction in headway represented an overly drastic increase in frequency, and only a 5% reduction would be appropriate. In short, using the terms in Figure 1, Workshop Participation was allowed to alter certain Project Attributes within each workshop. The potentially inconsistent interpretation of "example project" is a consequence of the trade-off discussed above, favoring contextual relevance over experimental control. It may also reflect how public understandings of projects can evolve through the engagement process, as can projects themselves (over longer timescales, if decision-makers adopt public feedback).

2.3.1 Expected impacts

For each version of the tool, we categorized each participant as having positive shift, no shift, or negative shift from the pre-test to the post-test. To assess whether expected impacts shifted systematically, a one-sample Wilcoxon signed-rank test is conducted, with the null hypothesis that the pre-test and post-test medians are equal. To test whether the distribution of participants in the three shift categories differs between tool versions, Fisher's exact test is used, with the null hypothesis that the proportion of users in each category is the same for both versions of the tool.

2.3.2 Enthusiasm

An enthusiasm index was constructed for both the pre- and post-tests by averaging an individual's responses to the three enthusiasm-related five-point Likert items. We treat the difference between pre- and post-test index values as a continuous variable with possible values ranging from -4 to +4, though this approach is debatable with only three constituent Likert items. As an alternative, participants can also be categorized as disappointed (negative change in enthusiasm) or not.

To test whether the effect of mobility background on change in enthusiasm (arrow 1 in Figure 1) differs by tool version used, we use the categorical construction of change in enthusiasm (disappointed or not) and two sets of Fisher's exact tests. The first null hypothesis is that car users and non-car users are equally likely to have a negative change in enthusiasm, and the second is that bus users and non-bus users are equally likely to have a negative change in enthusiasm (odds ratios = 1).

Summarizing the above regarding expected impacts, we categorize participants as having negative or non-negative changes in expected impact on themselves, the region, people riding transit, and people driving. We then conduct similar Fisher's exact tests to gauge the effect of changes in expected impact on enthusiasm (arrow 2).

Finally, Kendall's tau is used to assess the rank correlation between changes in enthusiasm and two other indices used in Stewart (2017). First, we use the dialog quality index discussed above as an indicator of attitude toward the engagement process. Participants who rate dialog quality highly would be expected to gain enthusiasm, leading to a one-sided test with the null hypothesis being that the correlation coefficient is less than or equal to 0. Second, a measure of skepticism is imputed from the pre-test questions about past planning meeting attendance and used as an indicator of other background factors. More specifically, participants were asked how many planning meetings they had attended in the past year (M), and at how many of these they had learned something relevant (L). A skepticism score was calculated for each participant as (M-L)/M. This score is expected to correlate negatively with enthusiasm, leading to a one-sided test with the null hypothesis that the correlation coefficient is greater than or equal to 0.

3 Results

In total, 37 people recruited by the advocacy organization participated in the workshops, of whom 33 completed both the pre-test and post-test surveys. The average number of public planning meetings participants attended in the preceding year was 12, and their average skepticism score was 0.20 (i.e., on average they reported learning something relevant at 80% of public planning meetings attended in the preceding year). Two-thirds of participants reported using the bus in a typical week. Eighteen participants used the accessibility version and 15 used the travel-time version. Group sizes ranged from 3 to 6 participants. The results and analysis below draw on the survey data, observations and recorded transcripts, and feedback from debrief discussions.

3.1 Survey results: Usefulness, empathy, and enthusiasm

Responses indicated broad agreement that both versions of the tool support meaningful conversation and collaboration. Well over 75% of participants agreed or strongly agreed, and no participants disagreed, with the statements:

- The tool provided a useful common ground for all of us to work together.
- The tool helped raise important issues for discussion.
- If the tool were widely used in the planning process, it would support the kinds of conversations that the public needs to have about transport.

For the last statement, strong agreement was more prevalent among participants who used the travel-time version (53%) than the accessibility version (22%).

The workshops prompted participants to focus on other peoples' trips. Strong majorities agreed that the tool was useful for imagining "what travel is like for others" (Figure 5). A travel-time version user described experiencing "an ability to empathize with people and trips I wouldn't usually take." In contrast, a substantial proportion of the accessibility version users disagreed that the tool prompted participants to think about alternatives for their own travel. Only 17% of accessibility version users agreed, and none participants strongly agreed, that the tool helped them think about alternatives for their own travel, versus 60% of travel-time version users who indicated (strong) agreement (Figure 5).

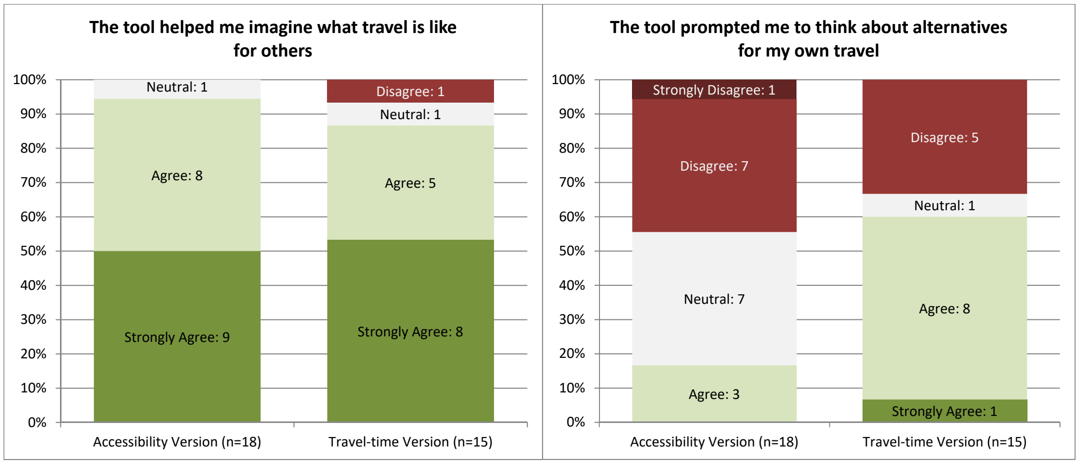


Figure 5. Distribution of survey responses – focus on others' and own travel

On the usability scale, the accessibility version received an average rating of 57, and the travel-time version received a significantly higher rating of 70 (p = .01 in a two-sided Student's t test). Participants deemed the travel-time version more appropriate for wider use in the planning process, perhaps because they found it more useable and better suited to thinking about one's own travel. These findings are unsurprising given how closely the functionality of the travel-time version matches common online trip planning tools, with which participants were likely familiar.

Figure 6 summarizes how users "expect bus priority in the five corridors identified will impact" various groups (using an adjusted scale of -2 = strong negative impact to +2 = strong positive impact). To reiterate, the indicators shown in the interface were only for travel by public transit, so expectations about impacts on users of other modes were shaped by group discussions, not the tool itself.

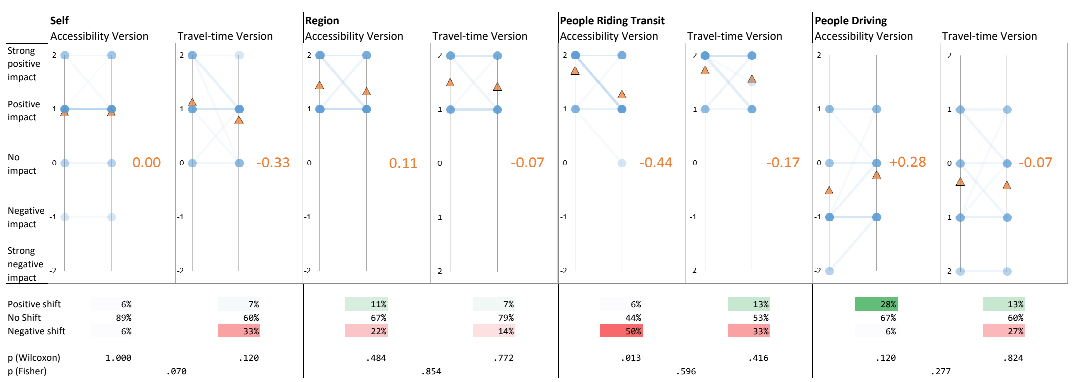


Figure 6. Pre-test to post-test shifts in participants' expected impacts on various groups, for accessibility version (n = 18) and travel-time version (n = 15) (opacity shows number of participants; triangles show mean values)

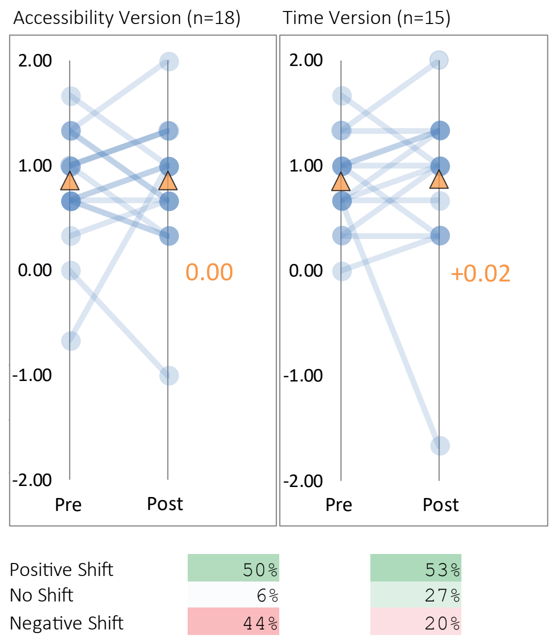


Figure 7. Shifts in enthusiasm, pre-test to post-test, separated by tool version (opacity shows number of participants; triangles show mean values)

The post-test enthusiasm index had high internal consistency (Cronbach's $\alpha = 0.79$), supporting its use as a measure of a coherent construct. Diverging responses were observed (Figure 7). Of participants who used the accessibility version, 50% had a positive shift in enthusiasm, while 44% had a negative shift in enthusiasm; only 6% (one participant) maintained the same enthusiasm score from the pre- to the post-test. In contrast, 27% of the travel-time version users exhibited no change in enthusiasm. Table 1 summarizes the effect of the four factors shown in Figure 1 on the enthusiasm index.

Table 1. Summary of effects on enthusiasm

		Fisher Exact			
		Accessibility Version		Travel-time version	
		Odds Ratio	p	Odds Ratio	p
1. Mobility Background	Use Car	1.27	1.000	†	**0.077**
	Use Bus	†	**0.069**	0.72	1.000
2. Attitude toward project:					
Non-negative change in expected impact on…	Self	†	0.444	1.00	0.736
	Region	4.90	0.206	†	1.000
	People riding transit	**6.18**	**0.077**	1.00	0.736
	People driving	†	0.444	8.07	0.154
		Kendall τ			
		Correlation	p	Correlation	p
3. Attitude toward process	Dialog Quality	**0.55**	**0.002**	**0.31**	**0.078**
4. Other background factors	Skepticism	0.00	0.500	**-0.35**	**0.064**

† N/A due to empty cells in contingency table

3.2 User interactions

Participants interacted with the touchscreen differently depending on the version used. As shown in Table 2, the average user of the accessibility version touched the map or controls 5.4 times, while the corresponding figure for the travel-time version is 3.3 times. The indicator stacked bar chart (showing either accessibility or travel time values) was touched relatively infrequently, but more often for the travel-time version. Touching the screen, to drag map pins or sliders or tap the controls, was often in response to facilitator instructions. Pointing at the screen, in contrast, was more likely to occur organically in discussions, without explicit facilitator instruction. Participants pointed at the map much more frequently when using the accessibility version (4.1 times per participant, vs. 1.3 times per participant when using the travel-time version), suggesting the accessibility version was more naturally integrated with participants' dialog.

Table 2. Average number of device interactions per user

Interaction	Component	Accessibility Version	Travel-time version
Touching screen	Map/Controls	5.4	3.3
	Indicator chart	0.2	0.5
Pointing at screen	Map/Controls	4.1	1.3
	Indicator chart	0.3	0.3

4 Discussion

Before discussing findings in relation to the main hypotheses, two caveats are worth mentioning. First, the findings offer an assessment of the relative performance of these two versions of the tool, but the workshops lacked a true control treatment. Second, participants in these workshops were recruited from one specific advocacy organization, which also limits the generalizability of these findings to broader public engagement exercises.

4.1 Changes in attitudes toward project

Overall, the prevalence of downward shifts in expected impacts (Figure 6) was a surprising result. This disappointment may stem from the limited scope of the example project – modest interventions in five short bus corridor segments. It may also reflect a tempering of expectations about the corridors from unrealistically positive ones generated by the introductory presentation. As one participant remarked, "After playing with the tool, I think I overestimated the positive impacts of these specific corridor improvements on transit users." This comment provides anecdotal insight, but it is beyond the scope of this analysis to predict the "true" long-term impact of the example project, or how closely participants' expectations align with actual impacts.

A strong majority (89%) of participants who used the accessibility version exhibited no shift in expected impact on themselves (Figure 6). This result, and the finding that the accessibility version did not prompt people to think about their own travel to the same extent that the travel-time version did (Figure 5), do not align with the hypothesis that the accessibility version would compellingly persuade participants that the project would benefit themselves. A greater proportion of travel-time version users, however, had a negative shift in expected impact on themselves, and the overall distribution of shifts was significantly different (p = .070, Fisher's exact) between the two versions.

Half of accessibility-version participants indicated a negative shift for impact on transit riders, and there is strong evidence that this shift was systematic (p = .013, Wilcoxon); the corresponding value for participants who used the travel-time version was only 33%. If participants consistently overestimated positive impacts in the pre-test survey, perhaps the systematic negative shift for the accessibility version suggests it did a better job of calibrating expectations to more realistic levels. But as noted above, and given the potential shifts in interpretation of "example project," it is beyond the scope of this analysis to assess whether estimated impacts were realistic. Other potential explanations for the negative shift in expected impact on transit riders include the limited scope of the example project, and limitations of the interactive mapping tool. Because the interactive tool showed scheduled, rather than actual, travel times and accessibility (e.g., it ignored unscheduled congestion delays that impact many of the routes considered), important speed and reliability benefits of bus priority may have been overlooked. A participant's comment in the debrief discussion highlights this issue:

"One of the issues we came across was believability of the travel-time boundaries [isochrones] because of known congestion on those existing routes... It didn't feel very satisfying to tweak the levers and see the boundaries move only a block or two in some parts; but at the same time the initial time boundary didn't feel accurate."

For driving, the accessibility version saw a negative shift for only 6% of participants, while the travel-time version saw a negative shift for 27%. While the difference between the versions' effect on shifting expected impacts on driving may not be statistically significant (p = .277, Fisher's exact), there were notable qualitative differences in the groups' conversations. Groups using the accessibility version spent more time deliberating about longer-term wider impacts and changes in travel behavior (e.g., mode shift from cars to transit), while the groups using the travel-time version tended to limit discussion to immediate impacts in the corridors considered. The latter's focus would naturally prompt greater concern about spatially constrained rights-of-way and how bus lanes might delay cars, leading to more negative shifts in expected impacts on drivers.

4.2 Effects on enthusiasm

The results in Table 1 suggest that workshop participation reinforced predispositions based on regularly used modes, in ways that differed between the tool versions. For accessibility version participants, being a regular car user had little effect on the change in enthusiasm for advocating for the example bus priority project; car users were nearly as likely to report a decrease in enthusiasm as non-car users (Odds ratio = 1.27, p = 1.00). None of the three accessibility version bus users showed a decrease in enthusiasm, while 67% (10/15) of the non-bus-users did; this split is strong evidence that, for accessibility version participants, being a bus user had an effect on change in enthusiasm (p = .069). Results for travel-time version participants were the opposite. Being a car user had a strong negative effect on enthusiasm (p = .077), but being a bus user had negligible effect.

On balance, the effect of change in expected impacts on enthusiasm (arrow 2 in Figure 1) was stronger for the accessibility version than for the travel-time version. For example, accessibility participants who were disappointed in the example project's impacts on transit riders were six times more likely to exhibit decreased enthusiasm than accessibility participants who were not. While the travel-time version led some participants to exhibit negative shifts in expected impact on themselves and transit riders (Figure 6), these negative shifts had essentially no effect on the enthusiasm outcome (p = .736). The exception was for impact on drivers; the travel-time version generated a marginally significant (p = .154) effect, which corroborates the qualitative observations discussed in the previous section.

Differences in the estimated effects of dialog quality (arrow 3 in Figure 1) and initial skepticism are striking. Dialog quality is more strongly correlated with enthusiasm when using the accessibility version ($\tau = 0.55$) than when using the travel-time version ($\tau = 0.31$). Participants using the accessibility version pointed at the map more frequently (Table 2), suggesting that it was connected more closely and organically with group dialog than the travel-time version was. When using the travel-time version, individuals testing their own trips of interest tended to stand in front of the screen, blocking it, and testing different destinations with limited interaction with other participants. In contrast, an individual using the accessibility version tended to move the origin marker to an origin of interest, step back, and discuss the resulting isochrones with the other participants. These other participants would then be more inclined to join a conversation referencing a representation of travel times that spans much of the region, rather than only a single trip with which they might not be familiar. Participants with a skeptical predisposition toward learning in planning meetings were significantly less likely ($\tau = -0.35$, $p = .064$) to be enthusiastic about the project after using the travel-time version. In contrast, the accessibility version mitigates the effect of initial skepticism on change in enthusiasm ($\tau = 0$).

5 Conclusions

To support stakeholder engagement for transportation projects, interactive maps can be designed to allow participants to compare project impacts from different locations and for different scenarios. Innovative computation allows many such combinations to be displayed on-demand, in rapid-succession. This research assessed the usefulness and usability of one such tool and how it might lead participants to shift expectations about the impacts of transport projects, and the effect of dialog quality and other factors on changes in enthusiasm for an example bus project.

In general, both the accessibility and travel travel-time versions were deemed useful for stakeholder engagement. With an expanded framing that encouraged discussing the wider land-use system, the accessibility version seemed to mitigate skepticism and car users' predispositions against upgrading bus service. It also fostered greater focus on others' travel, perhaps because the familiar user experience of the travel-time version felt simplistic or too similar to individual trip-planning tools. In short, the workshops provided evidence in support of our second hypothesis, that attitudes toward the project and the engagement process would have a stronger effect on enthusiasm for users of the accessibility version relative to users of the travel-time version, and that background factors would have a weaker effect. Of course, both representations rely on the same underlying data and could be superimposed in a single version of the tool, which makes the distinction somewhat artificial; nonetheless, this research helps illuminate advantages of the two distinct ways of framing transport project impacts.

The primary implication of this research for transportation planning practice is that the conceptual framing of accessibility, and related cartographic representations such as isochrones, can make dialog in stakeholder engagement for transit projects more meaningful. This experiment suggests that interactive accessibility mapping tools prompt stakeholders to engage more fully with a project and other stakeholders by broadening their focus beyond narrow self-interest, fostering more effective dialog, and mitigating background factors that might impede engagement. These potential advantages over a more limited travel-time framing, along with the advantages discussed in the introduction, come with some costs, including lower usability implied by the more complex information conveyed. Testing such tools with more broadly representative audiences, and different types of transport projects, could provide insights into this tradeoff, and show how well these results hold in other stakeholder engagement and broader public participation processes.

Negative shifts in expected impact, especially on transit riders, were unexpectedly prevalent. Many of the decreases in enthusiasm reflect expectations about impacts of bus priority that were initially high, and subsequently not met, after using the tool. These decreases may be explained by the tool's inadequate representation of delays and unreliability. For the unexpected negative shifts for users of the accessibility version, the initial discussion of the example project's delay reduction goal may also play a role – the accessibility framing was central to the interactive mapping tool, but not a central concept in the background materials or participants' past engagement with transit advocacy. This finding illustrates another aspect of inertia potentially slowing the adoption of accessibility indicators; while academics have advocated the adoption of such indicators for decades, stakeholders and advocates may be accustomed to traditional time-savings goals and be underwhelmed when project impacts are not presented in these terms.

Future work includes extending these digital engagement tools to show actual travel times, rather than scheduled service alone (e.g., extending the approach of Wessel & Farber, 2019). Other aspects of user experience, such as safety and comfort, may be salient for stakeholders but are ignored by both the travel-time and accessibility implementations tested here. Research on perceived accessibility (e.g., Curl et al., 2015) could guide the design of tools to support deliberation about these more qualitative impacts. Future research could also consider the usefulness of interactive accessibility mapping in more distributed applications like standalone online tools that do not rely on in-person interaction and collaboration. Such applications would be straightforward technical extensions of the web-based tools tested here, but obviating in-person dialog would raise additional questions related to digital engagement more broadly. Such engagement may favor stakeholders with more ready access to digital platforms, raising concerns about representativeness and equity. Whether engagement and collaborative design of transportation projects occur virtually or in person, broader concerns about who has access to power in the transportation planning process still stand (Karner et al., 2020).

References

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy, 15*(2), 73–80. https://doi.org/10.1016/j.tranpol.2007.10.005

Boisjoly, G., & El-geneidy, A. M. (2017). How to get there? A critical assessment of accessibility objectives and indicators in metropolitan transportation plans. *Transport Policy, 55,* 38–50. https://doi.org/10.1016/j.tranpol.2016.12.011

Brooke, J. (n.d.). SUS—A quick and dirty usability scale. Retrieved from http://www.usabilitynet.org/trump/documents/Suschapt.doc

Champlin, C., te Brömmelstroet, M., & Pelzer, P. (2018). Tables , tablets and flexibility: Evaluating planning support system performance under different conditions of use. *Applied Spatial Analysis and Policy, 12*, 467–491.

Conway, M. W., Byrd, A., & van der Linden, M. (2017). Evidence-based transit and land use sketch planning using interactive accessibility methods on combined schedule and headway-based networks. *Transportation Research Record: Journal of the Transportation Research Board, 2653,* 45–53. https://doi.org/10.3141/2653-06

Conway, M. W., Byrd, A., & Van Eggermond, M. (2018). Accounting for uncertainty and variation in accessibility metrics for public transport sketch planning. *Journal of Transport and Land Use, 11*(1), 541–558. https://doi.org/10.5198/jtlu.2018.1074

Curl, A., Nelson, J. D., & Anable, J. (2011). Does accessibility planning address what matters? A review of current practice and practitioner perspectives. *Research in Transportation Business and Management, 2*(March), 3–11. https://doi.org/10.1016/j.rtbm.2011.07.001

Curl, A., Nelson, J. D., & Anable, J. (2015). Same question, different answer: A comparison of GIS-based journey time accessibility with self-reported measures from the National Travel Survey in England. *Computers, Environment and Urban Systems, 49,* 86–97. https://doi.org/10.1016/j.compenvurbsys.2013.10.006

Curtis, C., & Scheurer, J. (2010). Planning for sustainable accessibility: Developing tools to aid discussion and decision-making. *Progress in Planning, 74,* 53–106. https://doi.org/10.1016/j.progress.2010.05.001

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior.* New York, NY: Psychology Press.

Geurs, K. T., & van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: Review and research directions. *Journal of Transport Geography, 12*(2), 127–140. https://doi.org/10.1016/j.jtrangeo.2003.10.005

Goodspeed, R., Riseng, C., Wehrly, K., Yin, W., Mason, L., & Schoenfeldt, B. (2016). Applying design thinking methods to ecosystem management tools: Creating the Great Lakes Aquatic Habitat Explorer. *Marine Policy, 69,* 134–145. https://doi.org/10.1016/j.marpol.2016.04.017

Handy, S. (2020). Is accessibility an idea whose time has finally come? *Transportation Research Part D: Transport and Environment, 83*(April), 102319. https://doi.org/10.1016/j.trd.2020.102319

Handy, S., & Niemeier, D. (1997). Measuring accessibility: An exploration of issues and alternatives. *Environment and Planning A, 29*(7), 1175–1194. https://doi.org/10.1068/a291175

Hart, N., & Belcher, J. (2016). *Prioritization of dedicated bus lanes.* Boston, MA: MassDOT. Retrieved from https://www.massdot.state.ma.us/Portals/49/Docs/BusLane20160513 .pdf

Karner, A., London, J., Rowangould, D., & Manaugh, K. (2020). From transportation equity to transportation justice: Within, through, and beyond the state. *Journal of Planning Literature, 35*(4), 440–459. https://doi.org/10.1177/0885412220927691

Martens, K., & Ciommo, F. Di. (2017). Travel time savings, accessibility gains and equity effects in cost – benefit analysis. *Transport Reviews, 37*(2), 1–18. https://doi.org/10.1080/01441647.2016.1276642

Miller, E. J. (2018). Accessibility: Measurement and application in transportation planning. *Transport Reviews, 38*(5), 551–555. https://doi.org/10.1080/01441647.2018.1492778

Moser, S. (2009). Making a difference on the ground: The challenge of demonstrating the effectiveness of decision support, *Climatic Change, 95*, 11–21. https://doi.org/10.1007/s10584-008-9539-1

Papa, E., Silva, C., te Brömmelstroet, M., & Hull, A. (2016). Accessibility instruments for planning practice: A review of European experiences. *Journal of Transport and Land Use, 9*(3), 1–20.

Silva, C., Bertolini, L., te Brömmelstroet, M., Milakis, D., & Papa, E. (2017). Accessibility instruments in planning practice: Bridging the implementation gap. *Transport Policy, 53*(July 2015), 135–145. https://doi.org/10.1016/j.tranpol.2016.09.006

Stewart, A. F. (2017). Mapping transit accessibility: Possibilities for public participation. *Transportation Research Part A, 104,* 150–166. https://doi.org/10.1016/j.tra.2017.03.015

Stewart, A. F., & Zegras, P. C. (2016). CoAXs: A collaborative accessibility-based stakeholder engagement system for communicating transport impacts. *Research in Transportation Economics, 59*, 423–433. https://doi.org/10.1016/j.retrec.2016.07.016

Stewart, A. F., Zegras, P. C., Tinn, P., & Rosenblum, J. L. (2018). Tangible tools for public transportation planning: Public involvement and learning for bus rapid transit corridor design. *Transportation Research Record: Journal of the Transportation Research Board, 2672*(8), 785–795. https://doi.org/10.1177/0361198118797462

Straatemeier, T., & Bertolini, L. (2008). Joint accessibility design. *Transportation Research Record: Journal of the Transportation Research Board, 2077*, 1–8.

te Brömmelstroet, M. (2017). Towards a pragmatic research agenda for the PSS domain. *Transportation Research Part A: Policy and Practice, 104*, 77–83. https://doi.org/10.1016/j.tra.2016.05.011

Waddell, P. (2011). Integrated land use and transportation planning and modelling: Addressing challenges in research and practice. *Transport Reviews, 31*(2), 209–229. https://doi.org/10.1080/01441647.2010.525671

Wessel, N., & Farber, S. (2019). On the accuracy of schedule-based GTFS for measuring accessibility. *Journal of Transport and Land Use, 12*(1), 475–500.

Zegras, C. (2011). Mainstreaming sustainable urban transport: Putting the pieces together. In H. Dimitriou & R. Gakenheimer (Eds.), *Urban transport in the developing world: A handbook of policy and practice* (pp. 548–588). Cheltenham, UK: Edward Elgar Publishing.