FINAL REPORT

Mosaic Evaluation Report

Prepared for

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Prepared by

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1 Mosaic's Role in Transportation Planning

1. Background and Introduction

In 2009, the Oregon legislature passed the Jobs and Transportation Act, which called for the Oregon Department of Transportation (ODOT) to develop a least cost-planning methodology to help inform transportation decision-making. The term "least cost planning" is defined by the Act (now Oregon Revised Statutes (ORS) 184.653) as "a process of comparing direct and indirect costs of demand and supply options to meet transportation goals, policies, or both, where the intent of the process is to identify the most cost-effective mix of options." In response to this legislation, ODOT developed Mosaic, Oregon's value- and cost-informed transportation planning process in collaboration with representatives of federal, metropolitan, and local agencies, and a broad range of other stakeholders. Consultant team members from CH2M Hill and HDR Inc., assisted with Mosaic development.

Mosaic is designed to evaluate multiple bundles of transportation investments and programmatic actions (investments that are generally not infrastructure or construction, such as demand management or bike sharing). Mosaic is designed to do this as part of a larger planning process, such as the development of a complex corridor plan or a Transportation System Plan (TSP). Mosaic supports planning activities and decision-making around developing an evaluation framework, evaluating, and refining possible transportation actions and investments during the middle stages of a typical transportation planning process (see Figure 1).

FIGURE 1: Mosaic's Role in Transportation Planning

Oregon's Mosaic tool represents a new methodology for decision making during transportation system planning by offering two different methods of comparing benefits to costs. The first method is a **benefit-cost analysis (BCA)**. Taking a very broad view of the benefits and costs of transportation projects and programs, Mosaic's BCA component applies to approximately half the indicators and incorporates state-of-the-practice methods for monetizing traditional user benefits and externalities. In addition, the BCA component includes new or enhanced methods for estimating other, less traditional benefits and costs. Mosaic's BCA incorporates the latest research on the monetized value of transportation actions and offers a variety of sketch-planning tools to help the user estimate the benefits and costs of these actions at a system planning level. Mosaic helps users estimate the value of key parameters (such as the value of time or the social costs of carbon) and allows for sensitivity testing of these parameters to determine their effect on the results of the benefit cost analysis.

In addition to its BCA component, Mosaic includes a scoring and weighting framework, or **"multi-objective decision analysis" (MODA),** which applies to the indicators that are not monetized. This process is applied where it is difficult to agree on how to assign a dollar value to particular impacts or benefits and/or research is not well enough developed to support such an assignment. When that happens, MODA allows decision-makers and analysts to weight impacts subjectively. These weighed impacts generate an aggregate "score" or ranking for the bundles being evaluated. Participants may weight impacts individually, or may come to agreement on the weights through a structured, iterative process. In either approach, Mosaic allows decision makers and stakeholders to see the effects of those weights on the scoring of alternatives.

Because the tool is designed to measure the costs and benefits of transportation bundles that contain programs as well as projects, Mosaic includes a **programs guide**, covering six subject areas – Bicycle and Pedestrian Programs, Land Use Programs, Operations/Intelligent Transportation System (ITS) Programs, Pricing Programs, Transit Programs and Travel Demand Management Programs. Each subject area includes a range of programs and a discussion of benefits and costs. This enables users to select, evaluate, and incorporate the programs suited to their local conditions.

As a result of early policy decisions by Mosaic stakeholders and developers, the tool in its current form is not designed to prioritize individual projects. For the purposes of evaluating and refining bundles of investments, Mosaic highlights differences among bundles at a moderate level of detail. All assumptions are explicit and documented. Through its ability to accommodate sensitivity testing, Mosaic enables users to change key assumptions and explore the effects of that change on the relative performance of the bundles. While this is sufficient to support long-range decision-making, it is not intended to drive project-level decisions. Furthermore, in its current form, Mosaic is not designed to support the evaluation of bundles against specific performance metrics or targets. Bundles should be developed during a transportation planning process; they are scenarios for making progress toward a community's vision and goals.

This *Mosaic Tool Evaluation Report* is one of a set of publicly available materials documenting the Mosaic analysis tool and processes. The report summarizes what was learned from the Mosaic test and peer review conducted in the final phase of Mosaic development and includes recommendations for ODOT and future users. Mosaic project products and information may be found on the Mosaic website

at http://www.oregonmosaic.org/ . Further project documentation may be found on ODOT's Mosaic project website at http://www.oregon.gov/ODOT/TD/TP/pages/lcp.aspx .

2. Mosaic Testing and Evaluation

The testing phase of the Mosaic Project took approximately one year to complete, from June 2013 to June 2014. Principal activities involved 1) testing the process; 2) testing the tool; and 3) evaluating the tool. The test did not include a simulation of the use of Mosaic output for decision making.

The first two activities occurred with the participation of a Test Committee. The third included work by a Peer Review Panel in addition to the Test Committee. The Test Committee consisted of representatives from local government agencies and technical staff from ODOT. The Test Committee included individuals with both technical planning and policy analysis skills. Several ODOT staff with similar skills participated as well. **Appendix A** contains a list of Test Committee members.

2.1 Testing the Mosaic Process

The Mosaic process test was designed achieve several goals:

- Show whether the Mosaic process and tool can work and provide useful, appropriate information in a transportation planning process
- Learn what elements of the Mosaic process and tool work well or need improvement
- Learn what resources are required to successfully employ Mosaic in the future

To test the Mosaic process, the project management team (comprised of ODOT staff and consultants) led the Test Committee through the steps of using Mosaic. The team prepared materials for the meetings and brought the Test Committee the type of information that would be considered during that step in an actual application of Mosaic. Committee members were asked to imagine using the tool in an actual planning process and consider what would likely work well and what might be difficult to complete. The project management team regularly sought Test Committee feedback to improve Mosaic, identify any further guidance needed in Mosaic materials, better understand how the tool might be used, and to identify questions and concerns. The project management team recorded issues and challenges that arose, as well as advice and recommendations from the group.

Test Committee members participated actively in a total of seven meetings. The project management team regularly adapted and responded to the committee's suggestions and questions. Table 1 below summarizes the major lessons learned from the committee's participation. These lessons focus on the user's perspective as articulated by the Test Committee; other lessons from the perspective of staff responsible for data development and evaluation are addressed in Sections 2.2 and 2.3 of this report.

TABLE 1 | Test Committee: Lessons Learned
MODA and Weighting • Stakeholder values are an important element of weighting and should be made explicit at the beginning of a planning process (before initiating use of Mosaic). • MODA weighting should take place after enough data have been developed to define indicator "endpoint" values. Once Mosaic outputs are available later in the process, stakeholders should review weights and adjust them as a group in light of previously articulated values and preferences. • Skilled facilitation of the weighting process is essential.
Indicators • Users need a clear understanding of each indicator and how it is measured. • The large number of indicators in Mosaic can make weighting unwieldy. Reducing the number of indicators (potentially by combining some) could make future applications easier. (Note: the list of Mosaic indicators was developed and approved by ODOT's Statewide Transportation Improvement Program Stakeholder Committee, so future changes should be reviewed with their direction in mind). • In the MODA process, set the score of any indicator of the future base case at zero and scale other bundles' scores in a range of (-5) to (+5) relative to future base case. This makes the scoring easier to understand.
Tool Outputs • Graphical display is essential to understanding tool outputs and bundle comparisons. • The measured values of each indicator within a category must be clearly displayed and identified. • The reasons behind the measured values must be clearly explained. • The comparison of monetized results to non-monetized results (one of Mosaic's distinguishing features) helps users gain a deeper understanding of "value." • Results should be explored and discussed as some may differ from expectations, for example due to interactions among a bundle's transportation impacts.
Decision Making • Mosaic cannot "make a decision" for its users. Instead, it reveals sources of value in bundles of transportation investments and actions. This value is measured both in dollars and in terms of stakeholder preferences. • Mosaic creates a transparent record of decision-making, and of the factors and discussion that goes into a decision. • Some results may be surprising, and may challenge assumptions or preferences. Mosaic allows for discussion of these results in the context of data showing benefits and costs.

During the test, the project management team identified and fixed problems with the coding of the Mosaic tool as necessary. The team developed and maintained a list of improvements recommended by the committee (or the Peer Review Panel). **Appendix B** contains a list of improvements and enhancements made at the conclusion of the test. A discussion of additional recommended enhancements or improvements can be found in Section 3, Recommendations, below.

2.2 Data Development and Modeling

To support evaluation and decision-making, Mosaic requires a variety of data. The process of modeling and data development for the test was a partnership between ODOT, Metro (the planning agency for the Portland metropolitan region), and the consultant team. For this test, Metro furnished travel forecasts, emergency services, and GIS data. The consultant team furnished air quality forecasts, cost and schedule information and safety, quality of life, and economic data.

As would be expected for any system planning effort, the process of data development for the Mosaic test took several months and required frequent communication among Metro, ODOT, and the consultant team to clarify data requirements and Mosaic input data formats.

Moving through the testing process, it was necessary to clarify on several occasions that the level of detail at which Mosaic analyzes investments is most appropriate for bundles of investments rather than individual projects. The tool is designed to evaluate bundles of projects and programs (also known as investment scenarios or alternatives) in support of the system-level decision-making used in Oregon TSPs and other regional planning efforts.

2.3 Tool Testing

The tool testing phase included two broad types of Mosaic Tool tests.

The primary test involved generating and displaying data with Mosaic. These activities focused on Test Committee participation. ODOT staff determined the overall geography of the study area used in the test with Metro's advice. The test bundles (including both projects and programs) were developed by the project management team and informed by a Test Committee discussion about the issues currently characterizing the study area. The purpose of the test was to learn how well Mosaic works. Thus, bundles were designed using many hypothetical projects, in order to test the reliability of specific indicator calculation methods. Bundles were not designed to show what projects and programs were needed or desired by the study area, or to replace any current or future planning process.

The test involved three bundles, titled "Roadway and Capacity," "Transit," and "Active Transport and Programs." The team designed the bundles to maximize the ease of evaluating the categories and indicators of impacts in the tool. Specific projects and actions were taken in most cases from scenarios that Metro has modeled in the past, although the project management team created a few hypothetical projects to test particular elements of Mosaic. The team then sorted projects into three mode-emphasis bundles for purposes of analysis. Programmatic actions were included to test Mosaic's ability to respond to project goals that Mosaic should be able to evaluate both infrastructure and program investments.

Using mode-based bundles is not typical when developing Transportation System Plans. In “real-life” system planning, bundles are likely to be multimodal, responding with balanced investment strategies to identified needs and stakeholder values. Throughout the Mosaic test, the project management team reminded the Test Committee that the thematic bundles were hypothetical, designed to illustrate tool functionality rather than predict actual outcomes. Nevertheless, the modal nature of the bundles led some Test Committee members to react strongly when results seemed to “favor” or “disfavor” a particular mode.

The team explained the need for this approach to the Test Committee, and the test demonstrated that the tool works as intended. However, all participants agree that generalizations should not be made based on the modeled results from the test. Further, the test showed that using modal bundles created some confusion – and it suggests that multimodal bundles responding specifically to project area needs are likely to be more appropriate for actual Mosaic applications.

The second set of tests occurred within the project management team, including ODOT and its consultants. This testing included a review of the reasonableness of results.

All but six indicators in Mosaic were measured successfully at the level of desired performance designated in the default settings for the tool (monetized, quantified, or qualitative, as appropriate). **Appendix C** lists all indicators and their planned vs. tested method of measurement. Table 2 displays a list of indicators whose method of estimation was other than planned, as well as a brief explanation of the reasons for that outcome.

TABLE 2 | Changes to Indicator Estimation Methods

Indicator		Notes
MO.3	Reliability—Recurring congestion	The data needed to estimate this indicator as originally anticipated were not available. The indicator was instead estimated qualitatively.
MO.4	Reliability—Nonrecurring congestion	The data needed to estimate this indicator as originally anticipated were not available. The indicator was instead estimated qualitatively.
AC.1	Transportation Cost Index	The Transportation Cost Index is estimated with an external tool. It is currently under development and was not ready for use at the time of the Mosaic test.

TABLE 2 | Changes to Indicator Estimation Methods		
	Indicator	**Notes**
QL.4	Noise Impacts	The original method used to monetize this indicator proved to be very difficult. The project team developed an alternative monetization method, using USDOT methodology. The original method, while technically feasible, is more laborious and could not be evaluated within the time available.
SA1/SA2	Crashes and property damages	The sketch model originally designated for these indicators proved inadequate. Instead, the team built a spreadsheet tool based on the Highway Safety manual that proved suitable for estimating crash rates on different facility types. The Mosaic tool monetizes the resulting outputs.
EQ.1	Transportation Cost Index, in different geographic areas (e.g., urban vs. rural) and/or for different population groups	The Transportation Cost Index is estimated with an external tool. It is currently under development and was not ready for use at the time of the Mosaic test.

A review of the reasonableness of measured results identified several formula errors in the tool. For example, errors were found in the formula for calculating the monetized benefits or disbenefits from greenhouse gas emissions. These corrections to the tool have been made.

In a much larger number of instances, staff or Test Committee members raised questions about the measured values of certain indicators in certain bundles, and after discussion and investigation, the values were determined to be reasonable. As a state-of-the-practice tool that considers a range of indicators not traditionally measured, Mosaic's impact estimations may yield surprising results. The formal and informal discussions with Test Committee members resulted in valuable insights that can inform future decision making, as shown in Table 1.

The project management team's commitment to sensitivity testing led to enhancing the tool with a function that automates the sensitivity testing process, as noted above. The enhancement determines the effect of a percentage change in any of the tool parameters on the benefits of any bundle. These data offer the user two benefits: it identifies the parameters that had the greatest impact on the benefit-cost ratios, and it also affords an opportunity to discuss whether it is appropriate to test a different value for a parameter (e.g., the value of time or the cost of carbon). Currently, the tool offers

a recommended value and a likely range of values for key parameters based on published guidance and research; users can change the default value to any other within the range.

2.4 Peer Review

In addition to the Test Committee, the Mosaic test phase also engaged a peer review panel comprised of experts in decision science, travel forecasting, and economics. Peer reviewers were asked to evaluate certain innovative components of the Mosaic tool. Over the course of five meetings, the peer review panel found the Mosaic approach valuable and innovative, due to its ability to compare monetized with non-monetized impacts. They focused extensively on the MODA section of the tool, and made recommendations to ensure its consistency with multi-objective decision analysis best practices. They reviewed the Mosaic indicators and identified several gaps, some of which the project team was able to address easily and some of which were noted and identified as potential future improvements or enhancements to Mosaic. In addition, the panel reviewed and advised the team on the use of travel data in Mosaic. The Peer Review Report will be posted on ODOT's project website in late 2014.

2.5 Summary of Key Issues

Of the numerous issues discussed during the tool testing process, the following may be the most enduring.

2.5.1 Study Area Definition

Typically, this issue is moot; system plans are generally defined by jurisdictional boundaries, for example. However for special studies such as corridors, the study area definition should be large enough to capture the vast majority of affected travel behavior, but not so large that differences are difficult to measure. At a minimum this means the area needs to be larger than the facility itself; how much larger should be determined by regional expert knowledge.

2.5.2 Bundle Definition

For the test, the management team built bundles of programs and actions designed to highlight the functionality of the tool. In the future, users will build bundles as part of a planning process. The composition of the bundles will relate to their values, stated goals and visions for the study area, as well as their understanding of current conditions. Bundles will be developed by staff and groups of participants uniquely tailored to the study area.

Many users will be developing multimodal investment strategies. Some may wish to vary the level of investment across bundles. Some may choose to build bundles with different geographic emphases. Some may use Mosaic in a visioning process in which land use and modal investment strategies are key variables. (Land use was held constant in the test.) Others may choose to emphasize roadway or time of day pricing strategies to a far larger extent than was done in the test. Still others may use Mosaic for decisions about a complex travel corridor in which there are multiple segments at issue, and multiple treatments available for each. This is an incomplete list of possibilities. Mosaic can accommodate any of the above. Data limitations or stakeholder preferences may affect the methods used to measure the indicators; but in all cases, the tool itself should not be a limitation. Ultimately, however, Mosaic does

not direct actual choices. Decision makers will remain responsible for evaluating bundles and considering their different expected impacts, with community input.

2.5.3 Trip Capture

Every study area not only contains trips that have origins and/or destination inside it but also through trips. Planners need to determine whether through travel is substantial enough to be included in the analysis and/or to be affected by programs or investments being studied.

2.5.4 Aggregate vs. Disaggregate Travel Data

Mosaic offers analysts two options for importing travel data into the tool. The modeler either can export trip and travel time data by bundle, mode, origin/destination pair and time of day (disaggregated), or intermediate results estimated within the travel demand model and loaded directly into Mosaic (aggregated). This was also thoroughly discussed during peer review of Mosaic. Mosaic is intended to use data that is disaggregated to reflect different modes, peak and off peak travel, and also origins and destinations. While Mosaic can accept aggregated data, the Mosaic team's research determined using disaggregated data is a better way to estimate changes in consumer surplus, and felt that it is necessary to effectively evaluate the equity indicators in which the distribution of the impacts are considered. The group agreed that sensitivity testing (enabled within the Mosaic tool) will be important to see how Mosaic reacts to changes in these data.

2.5.5 Travel Model Availability

The Portland region has developed several enhancements to its models not otherwise available in Oregon, such as the ability to forecast bicycle and pedestrian travel and freight (commercial vehicle) movement. The test was well served by these enhancements. Other regions may not have equivalent tools available, nor will all places have a transit mode choice model at their disposal. The Mosaic tool includes several sketch tools for estimating non-motorized demand. For the test, the included bicycle demand sketch tool was employed, and results were compared with those generated by Metro's travel demand model. Sketch tool results showed similar levels of bicycle demand to those predicted by the Metro model. It should be noted that the Mosaic sketch tool is sensitive to the supply of cycling facilities, while Metro's model considers land use – so the two models estimated similar demand based on different parameters. Mosaic's use does not require a travel model. See Sections 3 and 4 for further discussion and recommendations about this issue.

2.5.6 Use of Sketch Models

In order to better inform decision making, Mosaic developers have included sketch models in the tool. These models generate estimates of the value of certain indicators, based on the best available data and science. All these models have been published and undergone some level of peer review. The consulting team has selected from available models those that best suit the needs of Mosaic's future users. Full documentation and links to source material is provided within the tool. In some cases, alternative models are presented, enabling the user to compare results.

The sketch models' developers typically gathered data from multiple locations, and by applying several statistical techniques, they generalized a set of relationships that may be applied to other locations,

subject to uncertainty. In the short period of time since Mosaic was first developed, new methods for calculating several indicators have been published. We note them in Table 2 and recommend their incorporation into the tool (see Section 3, below). While the consultant team recommends using the models included in the Mosaic tool, future users are free to assess indicators with newly-developed tools – or qualitatively if they prefer. If the sketch models are employed, it is appropriate to acknowledge the uncertainty associated with their statistical estimation techniques, because many of the sketch tools are based on national or international data or limited sample size. While these represent the best research available, the values of key dependent variables are typically subject to estimation errors, which are noted in the original published research results. See Section 3 for recommendations for further work on this topic.

2.5.7 Evaluation of Programmatic Actions

Mosaic includes a Programs Guide that summarizes a variety of programs and strategies shown to help manage vehicular demand in general and automobile demand in particular. In all, the benefits and costs of twenty programs that fall in these subject areas are included:

Bicycle and Pedestrian Programs

Land Use Programs

Operations/ Intelligent Transportation System (ITS) Programs

Pricing Programs

Transit Programs

Travel Demand Management Programs

This guide is a core component of Mosaic and vital to achieving the fair evaluation of many kinds of investments that was Mosaic's original goal. The guide includes costs and ranges of estimates for the effectiveness of these programs on a number of key indicators. Specific sources for these conclusions are included. However, the literature is not extensive on many of the programs (many are studies of one or two locations). Professional judgment is required to identify appropriate inputs to Mosaic. The programs guide includes this explicit direction. If used, the estimates of impacts should be expressed as a range, to incorporate the effects of uncertainty.

2.5.8 Scaling of Impacts of Programmatic Actions

The Mosaic Programs Guide contains information on the range of costs and impacts associated with the programs. Typically these estimates are from a few places, where careful study was possible. Future users of the guide will want to take care in applying these estimates to their geography by noting the extent to which the places studied resemble their own. Users should select an estimate that best suits their local conditions from those available and described in the Programs Guide where appropriate.

3. Recommendations

3.1 Recommendations for Oregon Department of Transportation

3.1.1 General Recommendations

After over a year of testing, staff and peer reviewers agree that Mosaic represents an advancement in the state of the art. Staff recommends that Mosaic is ready to move into uses in pilots. Thus, the principal recommendation at this time is to **identify several opportunities to use Mosaic for decision-making and support local agencies in those efforts**.

In this next phase the key question will no longer be, "Does the tool work?" Questions for the next phase will be the following:

How well does Mosaic work *in the planning process*?

How helpful is it in informing decisions?

How can Mosaic be improved to work better and be more informative?

One such opportunity is expected with the Albany Area Metropolitan Planning Organization, during their coming work to develop the MPO's Regional Transportation Plan. Ideally, other pilot opportunities, in different geographies and situations, would occur in the near future following Albany's effort.

3.1.2 Recommended Improvements to the Mosaic tool

Appendix B contains a list of improvements completed during the test phase and several others that were recommended but deferred. The Test Committee and peer reviewers have identified several improvements that would enhance Mosaic's performance for the professional community, including the following:

- Introduce methods to calculate the benefits and costs of improved reliability. This refers to both recurring and nonrecurring congestion, which benefit both passenger and commercial vehicles. Recent work completed for the SHRP2 program offers methods that may be incorporated into Mosaic.
- Related to the above, add a method to measure the benefits specifically of supply chain reliability as an indicator of economic vitality. Identify methods to evaluate the impact of land use on travel efficiency. The preferred methods, ODOT's Transportation Cost Index, is still under development.
- Update the programs guide at regular intervals, perhaps biannually, by adding results from new studies of the effects of the programs and by adding new program descriptions as needed.
- Review the set of Mosaic sketch tools at the same interval as the programs guide. Cite or substitute new tools as needed.

- Add a feature to Mosaic that enables users identify how well bundles meet performance standards (established outside Mosaic) that local policy makers may set for their region or community as part of their planning process.
- Update recommended ranges provided for the various parameters included in Mosaic as better or Oregon specific information is researched and becomes available.

While all the above are desirable improvements to Mosaic, the short- to medium-term issues associated with the tool are not related to the breadth of impacts it measures. Mosaic already has more computational power than likely users have experienced in prior system plans. The more pressing short-term issue, cited above, is how to best use the tool's ability to inform decision-making at the system level—and how to explore tradeoffs among the impacts associated with different mixes of programs and investments.

In the longer term, the major recommendation for Mosaic is to migrate the tool to a web-based platform. This is consistent with best practices for many products of this kind. Web-based development will offer the opportunity to streamline the tool and display fewer screens, since many of the current pages contain intermediate calculations only. In addition, there would be opportunity to significantly improve and increase Mosaic's graphic capabilities.

3.1.3 Recommendations on Maintenance and Future Development of Mosaic Tool

Achieving the goals of the enabling legislation and the process of continuous improvement identified above requires that the Mosaic program have a clear institutional home. ODOT offers this today. However, in the future, ODOT may wish to consider involving the Transportation Research and Educational Consortium. Placing the tool in an academic setting may enable economical maintenance and upgrades and the implementation of an annual research agenda.

Recommendations for Users on Required Skills, Training and Technical Assistance

The following skills, already present in the training and experience of Oregon's planning professionals, are necessary for the application of Mosaic:

- A broad understanding of travel behavior and how it responds to changes in networks, policies, and programs
- For those places where travel models exist, the ability to use existing models to generate travel forecasts.
- Familiarity with geographic information system software and with the data layers available in the study area
- The ability to estimate planning-level costs of transportation improvements

- Familiarity with socioeconomic data (e.g., population, household, employment) commonly used in transportation planning
- Familiarity with the terminology of travel behavior, spatial data, and economic analysis
- Experience in using Microsoft Excel-based analytic tools

With these skills, a planning professional is able to understand the intent and content of Mosaic. Nevertheless, to embark on a first-time use of Mosaic, agency planners will need training in the details of using the tool and managing the Mosaic process. One set of in-depth introductory materials for the Mosaic tool has been produced by ODOT and its partners. See the ODOT project website to look through these.

In addition to these materials, first-time Mosaic users will need access to other professionals who can offer technical assistance, answer questions, and support the work of populating the workbook with data, as well as coaching the first-time user in how to interpret outputs, understand relationships among impacts, and use the information for decision-making.

ODOT has built an understanding of Mosaic through tool development and regular outreach. Continued outreach will be critical to maintaining support and building a base of users. In addition, below are several specific ideas for consideration and implementation.

- The agency could consider opening discussion about the use of Mosaic to a wider audience, through a Wiki group or project sharing software framework, which would allow users to keep up on progress, provide advice, and ask questions. Whatever the method, the agency should continue regular information sharing with its stakeholders and partners regarding Mosaic lessons learned and best practices.
- Videos on the website or other sites could be useful to ensure that interested parties are able to understand the tool and receive continuing training on how to use it. Videos could be short and related to different topics or steps in the process to provide guidance to practitioners. For example, topics could include a primer on Benefit-Cost Analysis, economic analysis and MODA. This subject typically is not part of the training received by many professional planners.
- An online library of Mosaic case studies might be useful to summarize the test as well as future applications. As new case studies are completed, they would be added to the library. This could be a good way for people to see how Mosaic can be used.

4. Conclusion

Broadly speaking, what was proposed to be done with Mosaic in 2010 has been accomplished with the new Mosaic tool, User Guide, and other information. The test and peer review process has confirmed that Mosaic is a fully working version of what was anticipated:

- A tool and process that supports value- and cost-informed transportation planning that fits completely within Oregon's approach to transportation planning
- A common framework that any and all geographies can use, that incorporates all Oregon Transportation Plan goals
- A menu of indicators that all can use now and refine and improve over the coming years as models and data evolve.
- Transparency that documents the logic of decisions and that comes from a process that openly explores tradeoffs among investments and their consequences
- Ability to level the funding playing field by evaluating costs and benefits of all modes using the same set of metrics, thus avoiding selective justifications

Work remains to disseminate, calibrate, and refine Mosaic to help realize its potential to inform Oregon planning processes. The next, and most important, step will be to apply the tool in an upcoming planning process, and begin to build on ODOT's investment in developing the tool.

Appendix A: List of Test Committee Members

Rich Arnold, ODOT
Terry Cole, ODOT
Tim Collins, Metro
Larry Conrad, Clackamas County
Andy Cotugno, Metro, STIP Stakeholder Committee
Chris Deffebach, Washington County
Angus Duncan, STIP Stakeholder Committee
Brian Dunn, ODOT
Abbot Flatt, Clackamas County
Kyle Hauger, Metro
Eric Hesse, TriMet
Mike Jaffe, Mid-Willamette Valley Council of Governments
Stephanie Millar, ODOT
Kirsten Pennington, ODOT
Bud Reiff, Metro
Paul Thompson, Lane Council of Governments
Dick Walker, Metro
Denise Whitney Dahlke, ODOT
Molly Vogt, Metro

Appendix B: List of Improvements to Mosaic Tool after Test

The following improvements were completed following the test and are included in the Mosaic tool, version 2.

Category or Topic	Worksheet(s) affected	Improvement Completed
QUALITY OF LIFE	QUALITY OF LIFE	Allow estimation of mortality risk reduction from walking (QL.1).
QUALITY OF LIFE	MULTIPLE	Combine QL.1 and QL.2 into a single specific indicator (renamed, *Health Benefits from Active Transportation*).
ECONOMIC VITALITY	SKETCH MODELS	Direct users to external tools for the estimation of EV.4 (agglomeration economies).
SAFETY & SECURITY	MULTIPLE	Build ability to estimate Property Damage Only (PDO) accidents.
GRAPHICS	MULTIPLE	Enhance graphic options to display Mosaic results in new and different ways in the CONTROL PANEL and OUTPUT CHARTS sheets.
NPV CALC	NPV CALC	Add ability to estimate a second B/C ratio where cost is defined as *Net Agency Expenditures.* This metric shows the B/C ratio for only those costs incurred by the agency and not other entities (e.g., state or federal government).
ENVIRONMENTAL STEWARDSHIP	MULTIPLE	Combine ES.2 and ES.3 into a single specific indicator (Air Toxics).
RESULTS	OUTPUT TABLES	Add a "Consequences Table" which allows for easy and quick visual comparison of Mosaic results by bundle.
ACCESSIBILITY & EQUITY	MULTIPLE	Change indicator for EQ.1 to *User Benefits for Different Groups*; Leave AC.1 *Transportation Cost Index* as is. This change for EQ.1 allows for estimation of user benefits across population groups without access to Transportation Cost Index data.
MOBILITY	INDICATORS	Change Reliability indicators MO.3 and MO.4 to Qualitative or Report Only. The previous quantitative method proved unworkable.
ECONOMIC VITALITY	SKETCH MODELS	Add inventory costs to value of time for freight travel.
SENSITIVITY	MULTIPLE	Restructure SENSITIVITY and MODA SENSITIVITY worksheets to make interpretation of results easier.
GENERAL	HELP	Add ability to send email and tool directly from the tool.
GENERAL	HELP	Add ability to "Save As" from last step of HELP worksheet.
GENERAL	WELCOME	Add ability to Lock / Unlock the tool.

Category or Topic	Worksheet(s) affected	Improvement Completed
LOAD TRAVEL DATA	LOAD TRAVEL DATA	Relocate input data for loading travel data to OTHER INPUT DATA worksheet and adjust code accordingly.
NPV CALC	NPV CALC	Modify estimation of undiscounted benefits and costs.
MODEL PARAMETERS	MODEL PARAMETERS	Modify structure and formatting to enhance readability.
INDICATORS CALC	MULTIPLE	Revise worksheet structure (estimation of quantitative scores) to simplify layout and improve usability.
XY CHARTS	MULTIPLE	Add automatic update of labels in XY charts (CONTROL PANEL and OUTPUT CHARTS).
QUALITY OF LIFE	SKETCH MODELS	Add sketch tool for estimating number of walking trips based on trip length (Row 55).
MOBILITY	TRAVEL DATA CALC	Revise estimation of changes in business transportation costs used in calculation of EV.5.
GENERAL	CONTROL PANEL	Expand list of parameters under "ARE ALL MODEL PARAMETERS WITHIN RECOMMENDED RANGE?" to reflect recent additions to MODEL PARAMETERS worksheet.
ENVIRONMENTAL STEWARDSHIP	MODEL PARAMETERS	Add placeholders for social costs of ozone and lead emissions to MODEL PARAMETERS worksheet and adjust formulas as needed.
MODEL PARAMETERS	MODEL PARAMETERS	Revise "Restore Default Values" macro to reflect changes to MODEL PARAMETERS worksheet (addition of parameters and re-formatting).

The following Mosaic improvements were deferred for future consideration.

Improvements deferred
Add an indicator related to business attraction.
EV3 (Changes in Employment by Industry and Associated Income Metrics) currently has no secondary effects included as it is based on a basic sketch model. Consider including effects of congestion relief on factors other than economic activity. Possible sources for the future may include a look up table from SWIM output or SHRP2 reports.
Varying value of time by trip length or by large vs. small time savings
Allow users to input both the value and their confidence level in the estimated value of the indicators.
Display the effects of uncertainty (in the value of parameters, and in the output of sketch tools) graphically.
Refine safety tool developed by CH2M HILL.
Add an indicator of option value for transit and other modes if possible.
Enable use of other equity indicators as desired by Mosaic users.
Consider extracting look-up tables/parameter values from SWIM/SWIM runs to help in estimating several economic vitality indicators.
Add a feature to output tables or charts that enables a user to click on the values and “find out why” through hyperlinks to specific part of the tool.
Incorporate a freight intermodal connectivity indicator.
Consider broader effects for programmatic actions. Programmatic actions currently only affect vehicle miles travelled calculations.
Review and enhance indicators as needed to make sure each treats all modes equally.

Appendix C: List of Indicators used in Test (planned vs. actual)

The table below lists each Mosaic indicator and describes in the "Used as planned?" column whether the indicator was estimated as originally conceived or whether the indicator was estimated in a different way (or not used at all).

Category	Indicator	Used as planned?	Notes
Mobility	Travel Time	Yes	
	Hours of Congestion	Yes	
	Reliability – Recurring congestion	No	Quantitative method proved unworkable. Evaluated qualitatively instead.
	Reliability –Non-recurring congestion	No	Quantitative method proved unworkable. Evaluated qualitatively instead.
	User Costs	Yes	
	Mode Split	No	Concerns over double-counting with this indicator. Converted to "report only" statistic.
	VMT / Capita	Yes	
Accessibility	Transportation Cost Index (TCI)	No	TCI not ready for use
	Population within 45 minutes between work and home	No	Calculation method is workable; did not receive needed data to estimate this indicator for the test.
	Location of industrial jobs in relation to the regional freight network	Yes	
	Population and employment within ¼ mile of a transit stop served by at least 30 vehicles per day	Yes	
	Amount of multi-use paths and bike boulevards	Yes	
	Sidewalk coverage	Yes	
Economic Vitality	Number of jobs associated with plan or bundle of actions, and associated income metrics	Yes	

Category	Indicator	Used as planned?	Notes
	Changes in transportation costs by industry (business travel and freight)	Yes	
	Changes in employment by industry, and associated income metrics	Yes	
	Changes in productivity from increased connectivity (agglomeration effects)	No	Original method only accounted for agglomeration benefits from rail transit projects. Evaluated qualitatively instead.
	Changes in the total value of exports and imports	Yes	
Environmental Stewardship	Criteria Air Contaminants	Yes	
	Mobile Source Air Toxics	Yes	
	Non-Mobile Source Air Toxics	Yes	
	Life-cycle CO2e	Yes	
	Natural, built, and cultural resources at risk	Yes	
Funding and Finance	Capital Costs	Yes	
	Other Lifecycle Costs	Yes	
	Total Revenue	Yes	
	Share of lifecycle funds that are “new” or “recycled”	Yes	
	Net impact of program on State and Local fiscal balance	Yes	
Safety	Fatal, Injury A, and Injury B Crashes	No	Original tool anticipated for this indicator (PLANSAFE) proved unworkable for Mosaic purposes. Developed alternative tool to evaluate indicator.

Category	Indicator	Used as planned?	Notes
	Emergency Management Systems (EMS) Response Times	Yes	
	Resiliency of the Network	Yes	
Land Use	Population and employment change and distribution	Yes	
	Relative land value change compared to base case or no action	Yes	
Quality of Life	Lives saved due to active transportation	Yes	No method for estimating benefits for pedestrians.
	Reduced incidence of diseases due to active transportation	Yes	No method for estimating benefits for pedestrians.
	Quality of the travel environment	Yes	No method for estimating benefits for pedestrians.
	Noise Impacts	No	Original monetized method was data-intensive. Utilized alternative monetization method from USDOT.
Equity	Transportation Cost Index, in different geographic areas (e.g., urban vs. rural) and/or for different population groups	No	TCI not ready for use during the test.
	Distribution of PM and PM Diesel emissions across population groups	No	No data for quantitative method; no qualitative method either.
	Reduced incidence of disease due to active transportation	Yes	
	Distribution of accident rates (fatalities and injuries) across population groups	Yes	