11-6-2015

Model-Based Analytics and Processes for Transportation Investment Alternatives Analyses: From Least Cost Planning to Multi Criterion Evaluation

Jeff Frkonja
Oregon Metro Research Center

Decision Support for Transportation Investments

What to do with all those travel model outputs?

Portland State University, TREC
November 6, 2015
Jeff Frkonja, Director, Oregon Metro Research Center
Version 3b

Agenda

What are the decisions at hand?

What information is most useful to the decisions?

What analysis techniques provide useful information?

What ‘process’ elements should be in place to ensure successful decision support?

Decisions

Choose **which alternative:**

- a OR b OR c OR…

Rank **alternatives:**

- b BEFORE a, b and a BEFORE c

Design **alternatives:**

c BETTER THAN a, c & a both BETTER THAN b, therefore,

COMBINE BEST PARTS OF a and c to PRODUCE d

Decisions

Capital Investments

Policies (e.g. limited access facilities, pricing)

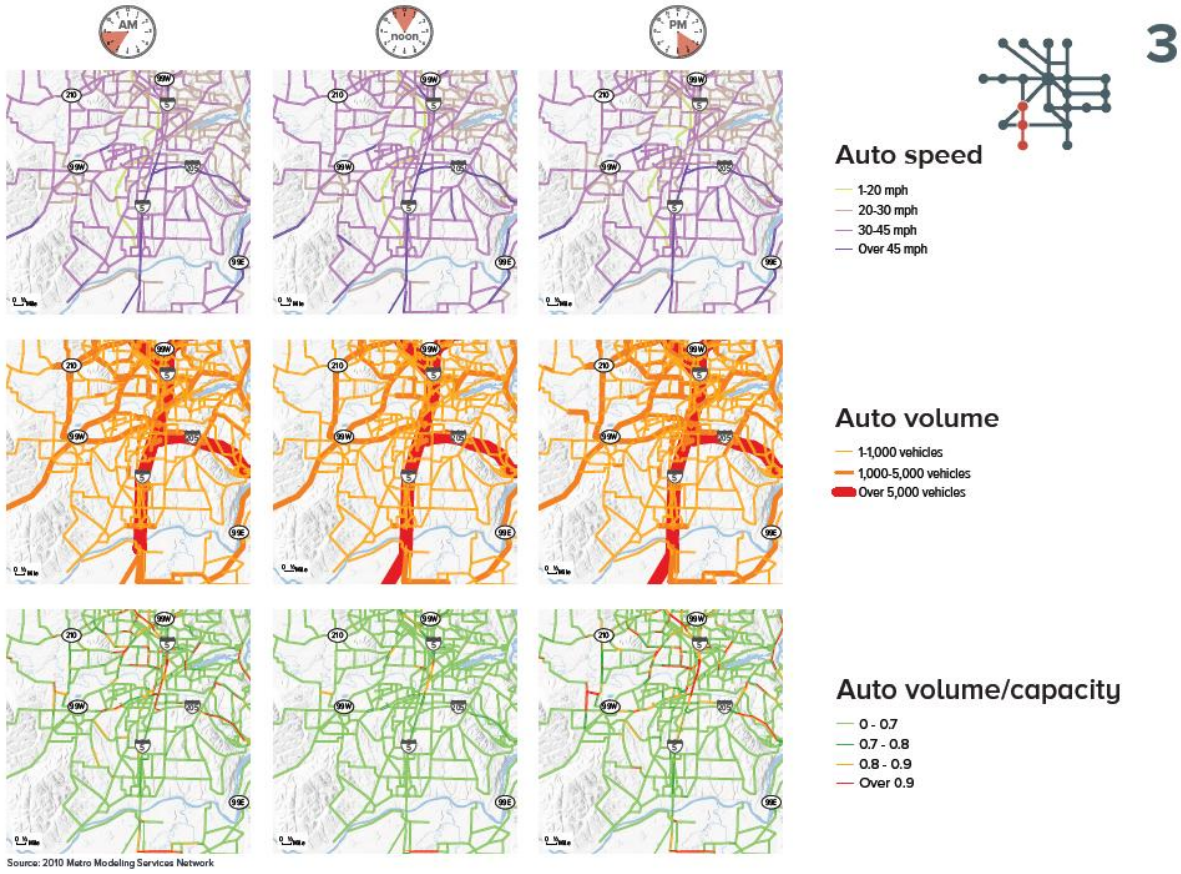
Programs (e.g. commute trip reduction, TDM, TSM)

What information?

What analysis?

How does the outcome affect ME?

e.g. corridors' travel times from travel model



Source: Metro Mobility Corridors Atlas at http://www.oregonmetro.gov/mobility-corridors-atlas

What information?

What analysis?

How does the result affect US?

e.g. total system delay, etc. from travel model

Excerpts from Plan Alternative Comparison for Metro's 2014 RTP

Vehicle Hours of Delay

Vehicle Hours of Delay (VHD)

	2010	2040NB	2040FC	2040ST
PM2	4,160	20,810	13,490	12,510
MD1	280	1,480	1,120	1,010

Average weekday, Intra-UGB

VMT per Capita

Average Week Day (AWD) Vehicle Miles Traveled (VMT) Intra-UGB

	2010	2040NB	2040FC	2040ST
VMT/capita	13.06	12.39	12.27	12.22
% Reduction		-5.1%	-6.0%	-6.4%

Number of Walk & Bike Trips

	2010	2040NB	2040FC	2040ST
Walk	505,500	814,100	835,900	823,900
Bike	178,400	293,300	306,600	302,700

(Average Weekday, Intra-UGB)

Bicycle Miles Traveled (BMT)

	2010	2040 NB	2040 FC	2040 ST
BMT	443,400	729,800	801,500	793,200
Population	1,483,506	2,080,456	2,080,456	2,080,456
BMT/Capita	0.30	0.35	0.39	0.38

Source: Metro Staff Presentation During 2014 RTP Planning Process

What information?

What analysis?

What do we get for our $ (economic outcome)?

…hmmmmm…

Benefit-Cost Analysis! (and Economic Impact Analysis too!)

What is the outcome for the environment?

…hmmmmm…

Emissions, noise, water-quality, habitat analyses!

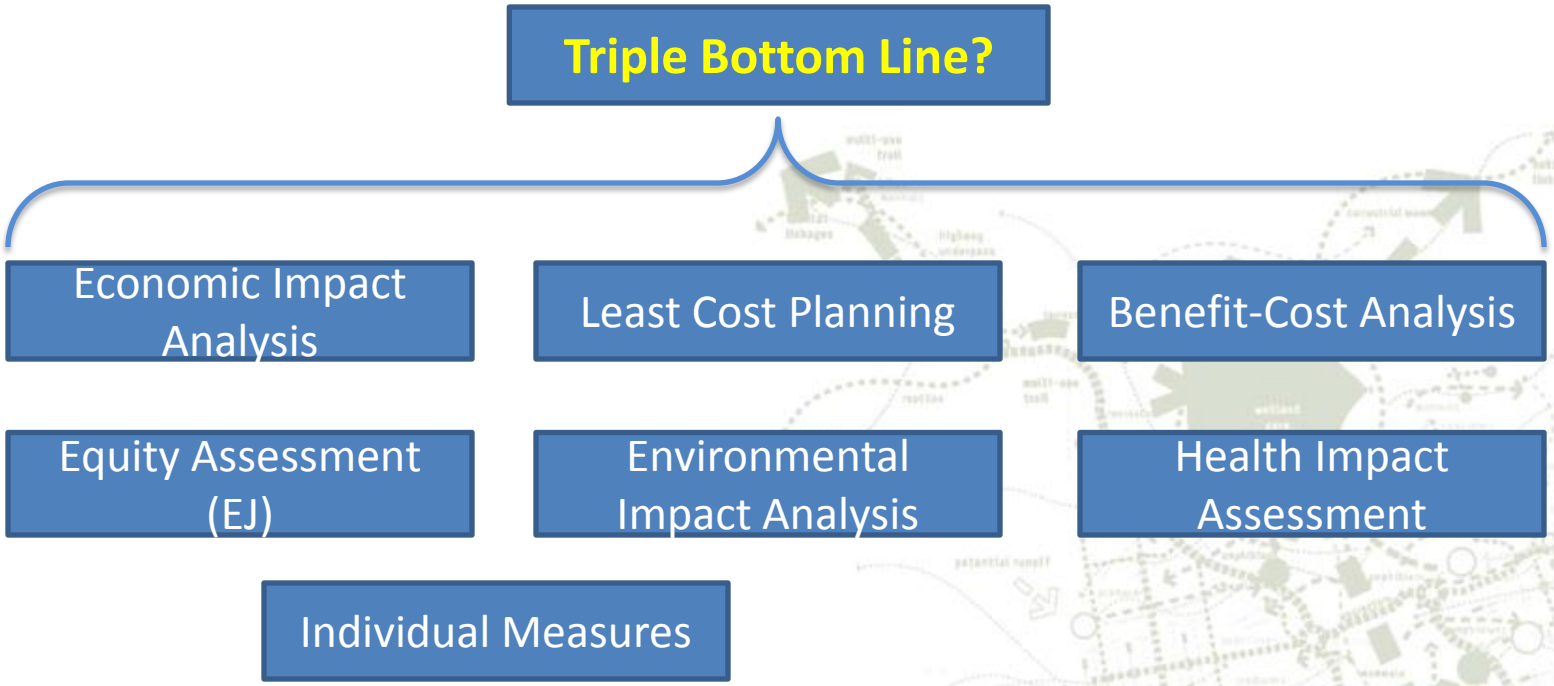
What are the social/health outcomes?

…hmmmmm…

Environmental Justice analysis, health impact assessments!

Plenty of decision/analytic frameworks

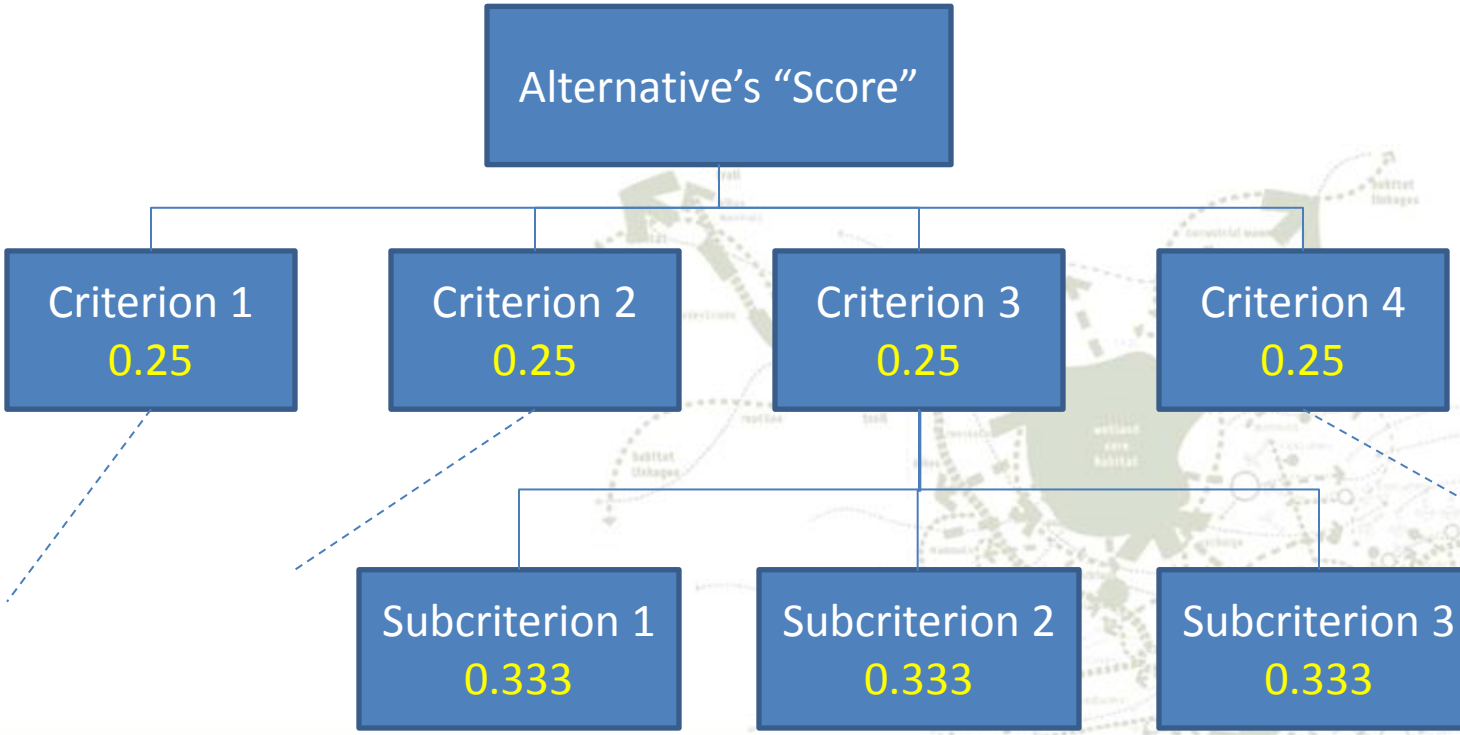
…you can probably think of several more…



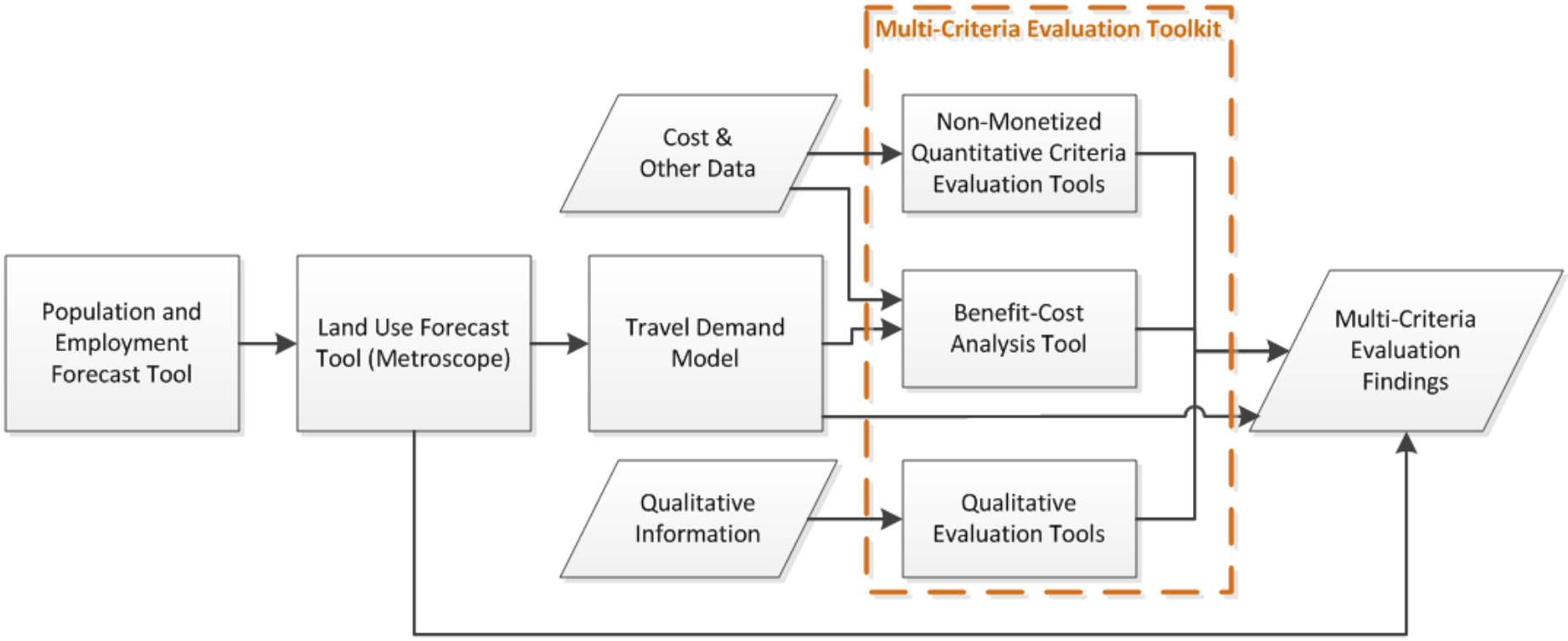
How can we make sense of all this information?

Multi-Criteria Evaluation

Analytic Hierarchy Processing



Conceptual Architecture for the "Toolkit"



Tools & References

USDOT

- 2015 VOT Guidance: http://www.transportation.gov/administrations/office-policy/2015-value-travel-time-guidance
- TIGER grant BCA resource guide: https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-bca-resource-guide

AASHTO “Red Book” (project-level BCA)

- American Association of State Highway and Transportation Officials. *User and Non-User Benefit Analysis for Highways*. 2010

ODOT Mosaic MCE Tool

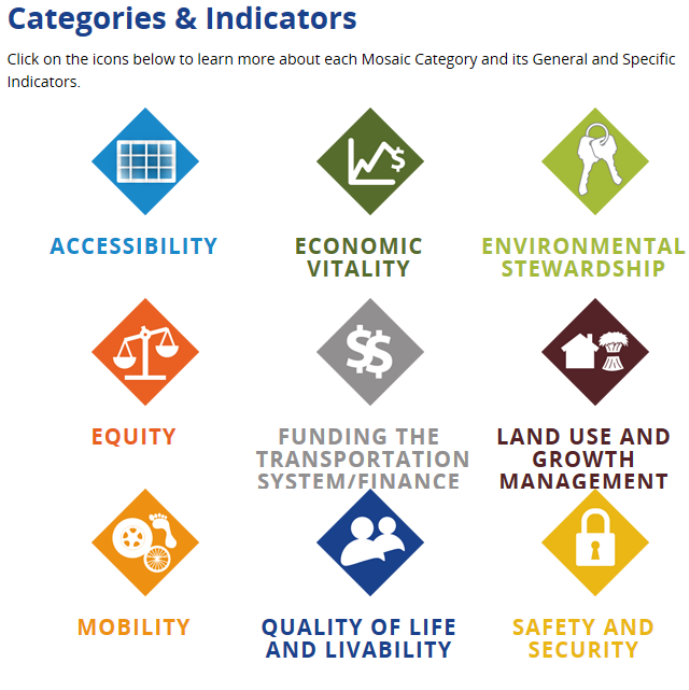
- http://www.oregonmosaic.org/

TRB Transportation Economics Committee

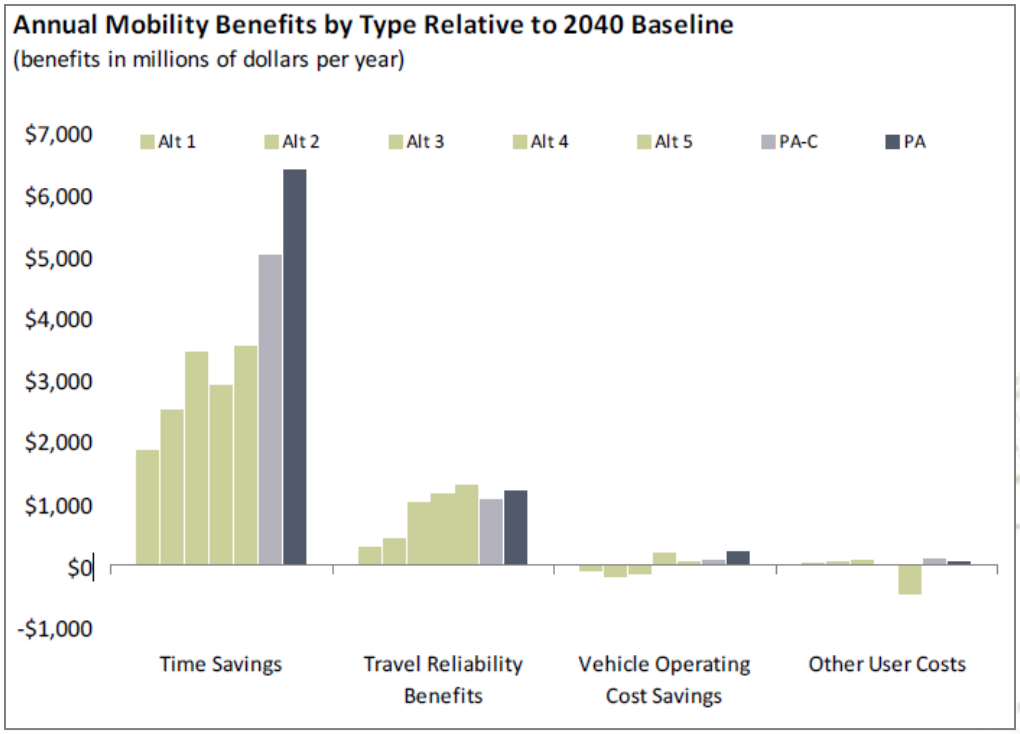
- http://bca.transportationeconomics.org/home

CALTRANS BCA Tool

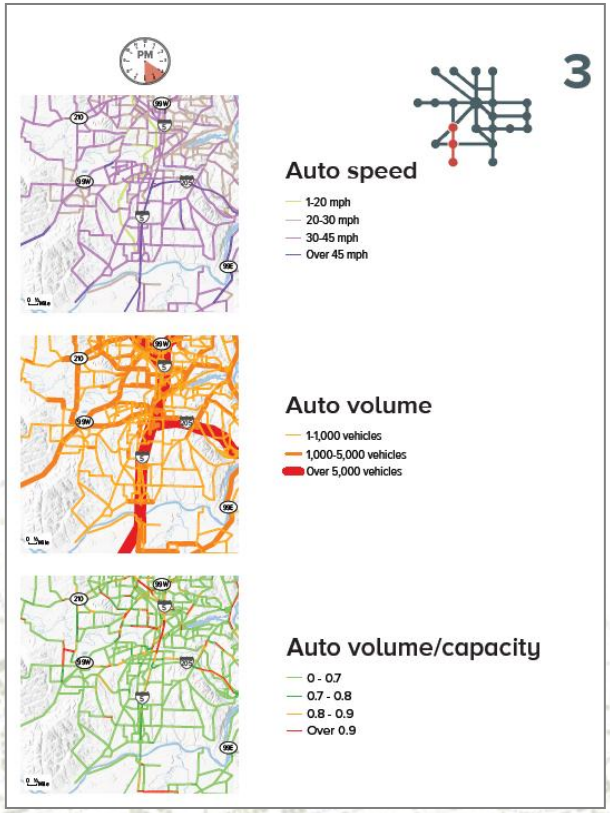
- http://www.dot.ca.gov/hq/tpp/offices/eab/LCBC_Analysis_Model.html



Example: Mobility Evaluation (part of economic leg)



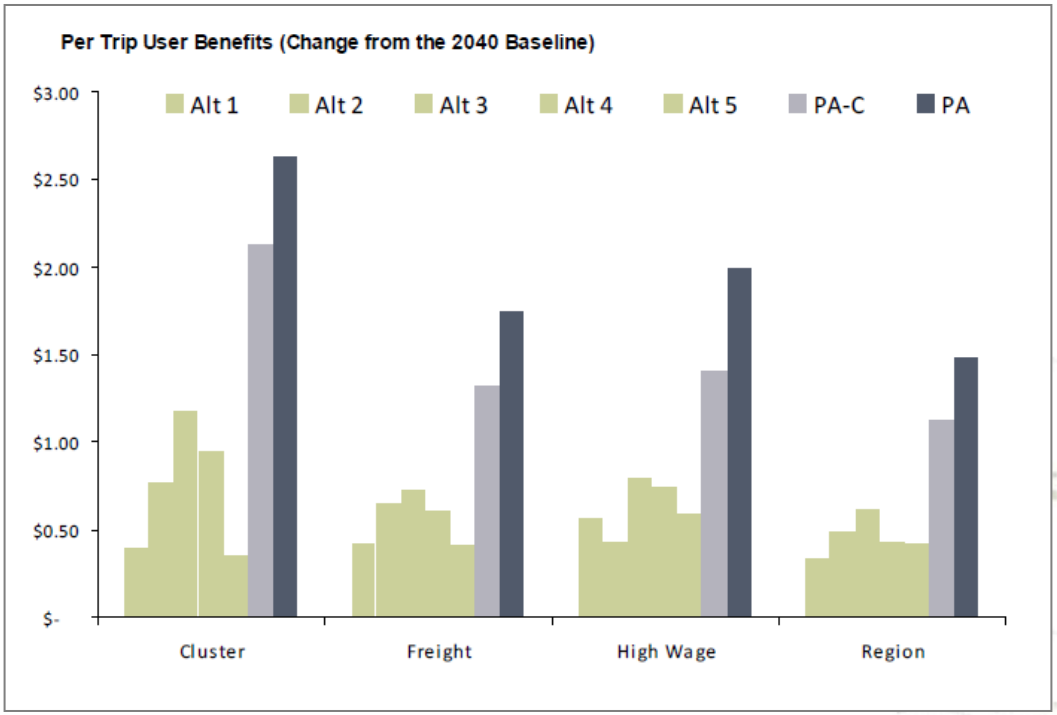
VS.



Sources:

- Transportation 2040 Final Environmental Impact Statement, Appendix D. Puget Sound Regional Council. 2010.
- Metro Mobility Corridors Atlas -- *http://www.oregonmetro.gov/mobility-corridors-atlas*

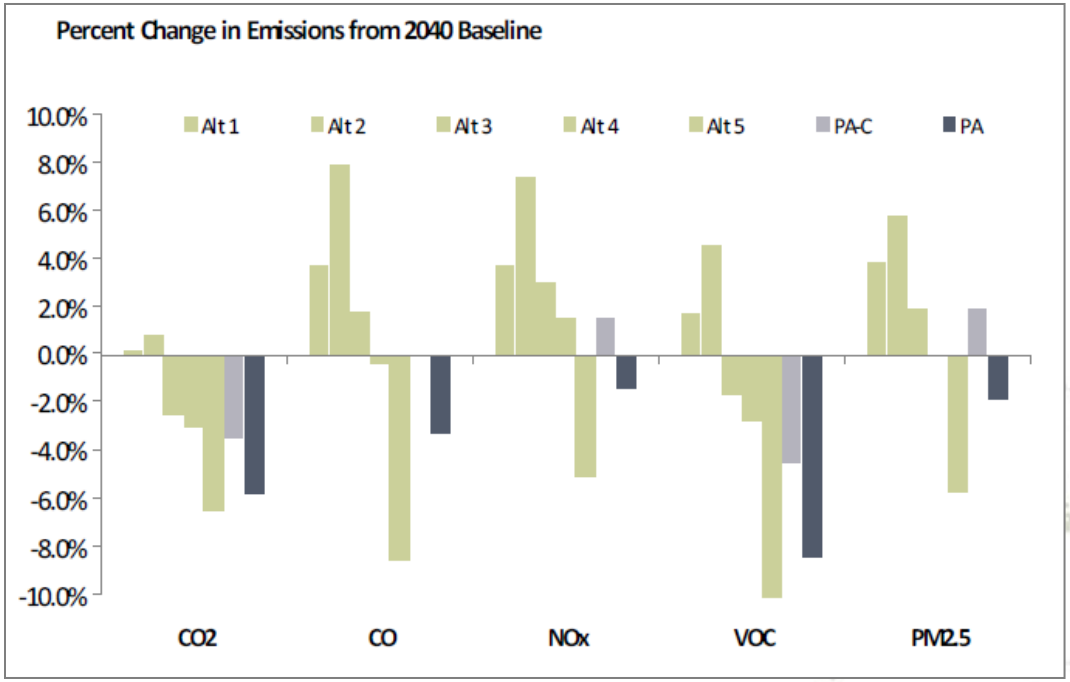
Example: Economic Evaluation



VS. $ spent in various places

Source:
- Transportation 2040 Final Environmental Impact Statement, Appendix D. Puget Sound Regional Council. 2010.

Example: Environmental Evaluation



VS. tons of pollutants

Source:
- Transportation 2040 Final Environmental Impact Statement, Appendix D. Puget Sound Regional Council. 2010.

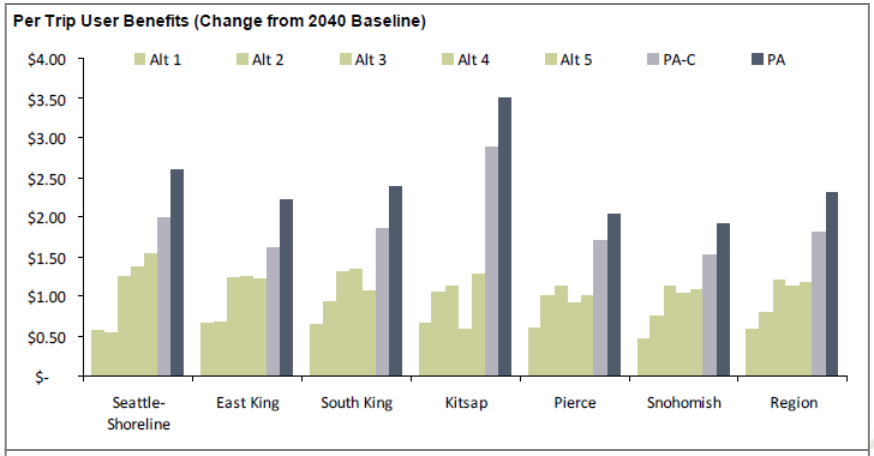
Example: "Rollup"

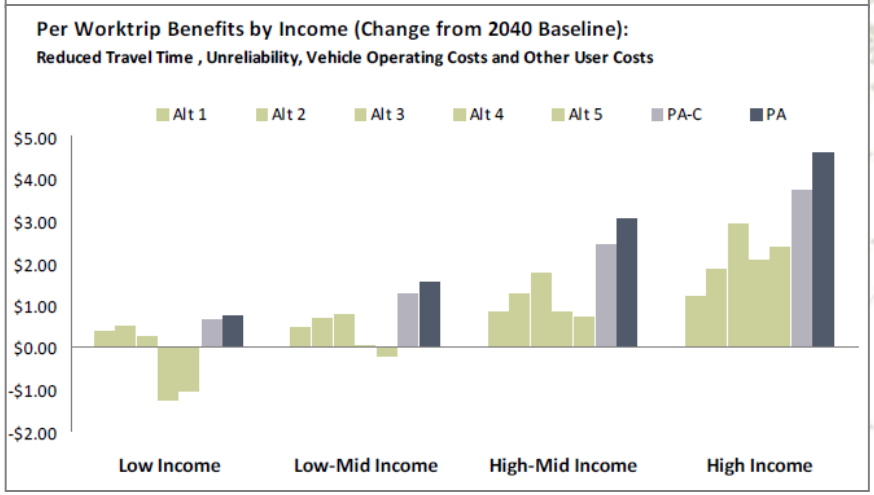
Build Scenarios Relative to Baseline (No-Build) Scenario		
Description		
Build Scenario	RC	Hypothetical
Number of years	58	58
Summary		
Lifecycle Benefits	$53,752,288,102	$63,884,869,250
Lifecycle Costs	$29,153,987,133	$42,546,985,120
Net Present Value	$24,598,300,969	$24,598,300,969
Benefit / Cost Ratio	**1.84**	**1.50**
Internal Rate of Return (%)	10.8%	7.2%
Total Lifecycle Benefits by Category for Build Scenarios Relative to Baseline		
Scenario:	**RC**	**Hypothetical**
Mobility - Residents	$33,936,027,894	$25,611,958,902
Mobility - Trucks / Commercial	$9,143,327,429	$6,337,078,938
Emissions	-$394,015,321	$2,729,979,286
Accidents	$1,523,838,864	$1,987,327,688
Reliability	$478,016,975	$678,056,799
Vehicle Operating	$6,337,078,938	$23,408,823,856
Auto Ownership	$2,729,979,286	$3,123,173,814
Physical Activity	-$1,965,964	$8,469,967
Total	**$53,752,288,102**	**$63,884,869,250**

Economic
Economic
Environmental
Health/Safety
Economic
Economic
Economic
Health/Safety

Source:
- Author's archive of DRAFT work done by RSG, Inc. for San Diego Association of Governments

Example: Equity Evaluations





VS. projects or $ in EJ communities

Source:

- Transportation 2040 Final Environmental Impact Statement, Appendix D. Puget Sound Regional Council. 2010.

Example: Equity/Social Justice Evaluation

POVERTY COC					
	Total	COC Poverty	Non-COC Poverty	COC Poverty	Non-COC Poverty
Mobility - Residents	$33,936,027,894	$12,234,571,104	$21,701,456,790	36.1%	63.9%
Mobility - Trucks / Commercial	$9,143,327,429	$6,337,078,938	n/a		
Emissions	-$394,015,321	$2,729,979,286	n/a		
Accidents	$1,523,838,864	$1,987,327,688	n/a		
Reliability	$478,016,975	$678,056,799	n/a		
Vehicle Operating	$6,337,078,938	$23,408,823,856	n/a		
Auto Ownership	$2,729,979,286	$1,089,639,193	$1,640,340,093	39.9%	60.1%
Physical Activity	-$1,965,964	-$1,171,576	-$794,387	59.6%	40.4%
Total	$53,752,288,102	$48,464,305,288	$23,341,002,496	67.5%	32.5%

Source:
- Author's archive of DRAFT work done by RSG, Inc. for San Diego Association of Governments

Summary: what can MCE do for a region like Portland Metro?

- *More apples-to-apples comparison**
- *Benefit-cost analysis findings*
  - *Summarizes region-wide outcomes ("rolls things up")*
  - *Simultaneous cost and benefit accounting*
  - *Enables geographic and market segment benefit reporting (e.g. by Council District)*
- *More robust criteria evaluations*
  - *Equity*
  - *Health & Safety*
  - *Reliability*

* To the extent methods enable.

Principles of Successful MCE

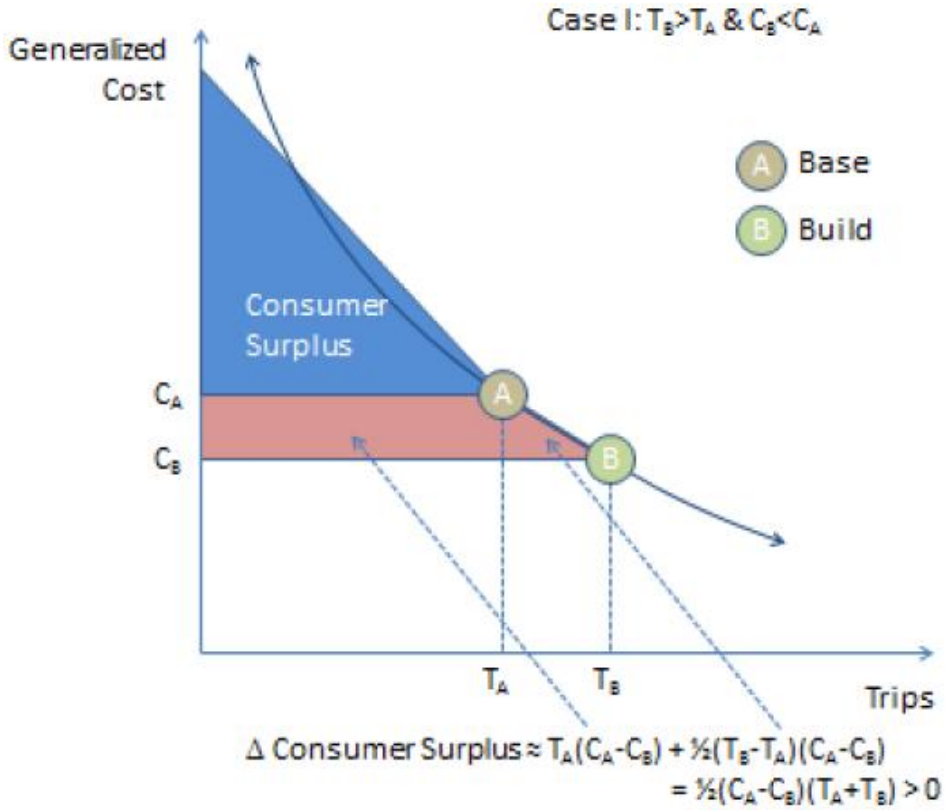
- All Criteria taken together should provide a ***comprehensive*** evaluation
- Criteria should be ***mutually exclusive***
- Weights should be set using information from the actual decision-makers (***democratic***)
- Process should be ***transparent***
  - Engage stakeholders meaningfully
  - Publish both overall and component evaluation results
  - Fully disclose all analytic methods, assumptions, and limitations
  - Fully disclose all criteria composition and weights

Potential **Analytic** Complications

- Many criteria may be relevant but not monetizable
- Some criteria may not be quantifiable at all
- *Apples-to-apples criteria comparability may not be possible **

* Best-practice principle: Even if criteria are not quantifiable or directly comparable they should still be explicitly treated in some way

BCA Founded in Economic Theory



Consumer Surplus

- "Good" = travel from O to D
- $ Willing to Pay
- $ Actually Paid
- Willing minus Actual = Surplus
- Build Alternative Changes Surplus
- Added Surplus has economic value

Where GenCost = (Cost of Travel Time) + (Out-of-Pocket Costs) + (Cost of Unreliability) + (Costs Related to Effects on Consumer Options)

Source: Bernardin, et. al. for Ohio DOT : "Enhancement of Economic Analysis Capabilities: Initial Review and Recommendations". 2011

Source: Ohio DOT : "Enhancement of Economic Analysis Capabilities: Initial Review and Recommendations". 2011

In-Vehicle Travel Time (auto and transit)

Trips on work tours

- c(i) = -0.15/$ / [((income(i) / 30,000 ^0.6) * (occupancy(i) ^ 0.8))]
- b(i) = -0.030/min

Trips on non-work tours

- c(i) = -0.15/$ / [((income(i) / 30,000 ^0.5) * (occupancy(i) ^ 0.7))]
- b(i) = -0.015/min

Where c(i) is the cost coefficient for user (i) in 1/$

And b(i) is the time coefficient for users in 1/minutes

In the Mode Choice logit utility expressions

Frkonja, Castiglione, and Miller. "Benefit/Cost Analysis for Project and Plan Evaluation in SANDAG's 'San Diego Forward' Plan". AMPO Annual Conference, 2014.

In-Vehicle Value of Travel Time
($/hr for trucks)

	Heavy Trucks	Light Trucks
ATRI, 2010	89.23	
Smalkowski & Levinson, 2005	58.10	
Outwater & Kitchen, 2008	53.32	42.66
Miao et al., 2011	33.94 - 57.65	
Almy et al., 2010	45.15	
Mei et al., 2013	33.29 - 52.22	26.06 - 46.14
BLA, EDRG & RSG, 2013	36.05	22.26 - 27.24
Kawamura, 1999	32.25	
Kawamura, 2003	21.96 - 34.94	
Cal-BC	28.70	
USDOT*	26.43	

***Driver's time only, USDOT acknowledges there is value to commodities' time**

Travel Time Reliability (auto & freight / truck)

Calculate “Total Equivalent Delay”

Link-level calculation

- Segmentation limited to assignment classes
- Trucks / auto

Set VOR equal to IVTT VOT

Source: SHRP2 L05

Frkonja, Castiglione, and Miller. “Benefit/Cost Analysis for Project and Plan Evaluation in SANDAG’s ‘San Diego Forward’ Plan”. AMPO Annual Conference, 2014.

Collisions

- Segmented by collision type
- Link-level calculation
  - Facility type segmentation only
  - SANDAG staff updating VMT-based rates using SWITRS
- Auto only
- Source: USDOT Memo (2/28/2013) on the value of statistical life, Cal-B/C

Collision Type	Value
Fatality	$9,100,000
Injury	$427,700
Property damage only	$10,200

Frkonja, Castiglione, and Miller. "Benefit/Cost Analysis for Project and Plan Evaluation in SANDAG's 'San Diego Forward' Plan". AMPO Annual Conference, 2014.

Emissions

Pollutant	Monetization
CO2	$55.35 / ton
PM2.5	to be imputed from MTC monetization factors and SANDAG weighted distribution of PM2.5 by type
NOx	$7,800 / ton
ROG	to be imputed from MTC monetization factors and SANDAG weighted distribution of ROG by type
SO2	$40,500 / ton

Segmented by pollutant

Link-level calculation

Source: BAAQMD

Frkonja, Castiglione, and Miller. "Benefit/Cost Analysis for Project and Plan Evaluation in SANDAG's 'San Diego Forward' Plan". AMPO Annual Conference, 2014.

Auto Ownership Costs

- MTC = $6,290 / year
- AAA = $6,000 / year
- Household-level calculation
- Source: MTC

Frkonja, Castiglione, and Miller. "Benefit/Cost Analysis for Project and Plan Evaluation in SANDAG's 'San Diego Forward' Plan". AMPO Annual Conference, 2014.

What does the **Process** look like?

Multi-Criterion Evaluation (or pick your label…)

- Identify the ***actions*** that will be decided
- Choose ***criteria*** that inform the decision
- Devise ***evaluation methods*** that ***make the criteria comparable ****
- Engage decision-makers to ***weight the criteria***
- ***Apply the evaluation*** to the actions
- ***Report the evaluation findings*** to the decision-makers

* To the extent feasible

Some **Process** Observations

A few lessons learned…

- "Rollup" intended to simplify discussion but still need to ensure participants understanding & trust methods
- People care about different things: transparently report every criterion even when you report the "rollup"
- Be forthright about assumptions, methods, and analytic limitations
- Have a communications plan—MCE produces a lot of information
- Stakeholders will always disagree about validity of analytic methods for both tangible and tactical reasons

Suggestion: if someone values it then address it

Discussion

Are MCE techniques valuable for regional stakeholders?

What technical features are particularly important to this region?

What outreach, education, and information should regional stakeholders be given to best understand and participate in this type of decision-support process?

Background

Least Cost Planning:

- ***Originated in power generation*** industry, based on ***benefit-cost analysis***
- A structured planning ***process*** that provides ***decision support information*** to the decision-makers
- ***Analytic tools are necessary but not sufficient***. Decision-maker consultation and stakeholder involvement are also required
- ***Has evolved since its inception*** and during its applications to transportation decisions
- Proven ***successful applications*** in transportation are better described in current terminology as ***multi-criteria evaluation (MCE)***
- Technical and best-practice ***successful transportation examples exist***

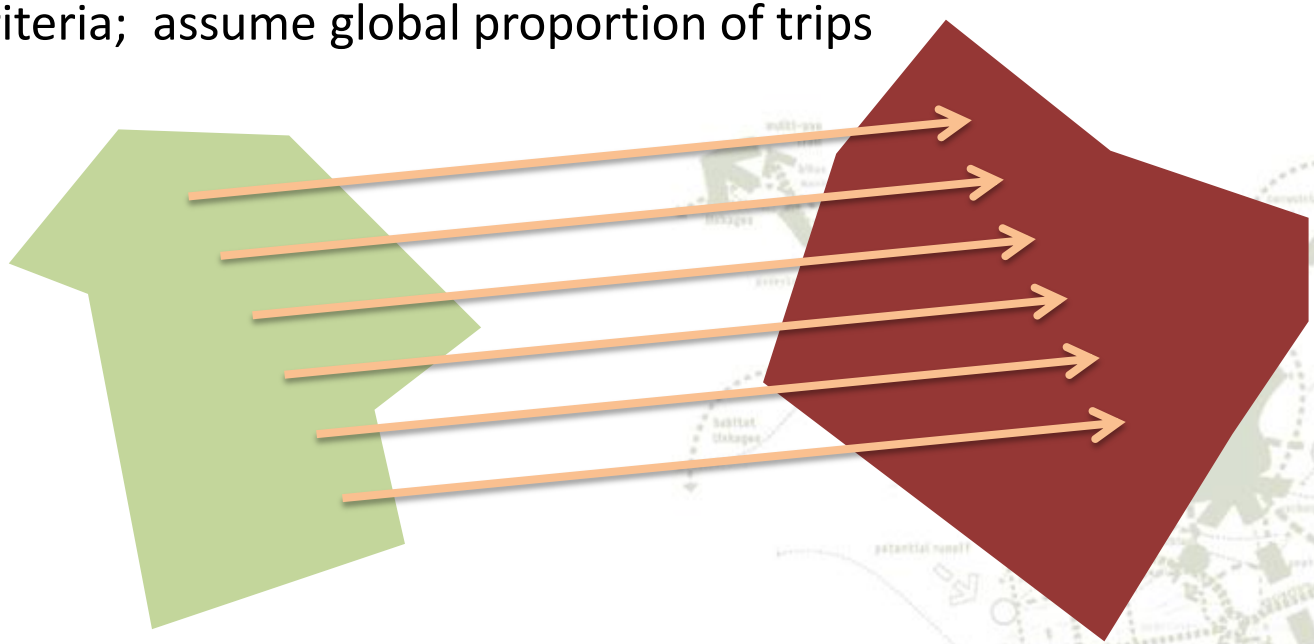
Aggregate vs. Activity-Based Analysis

- Aggregate potential level of detail:
  - Zone
  - Market Segment (e.g. Home-Based-Work-Low-Income)
- Activity-based potential level of detail:
  - Person, along any characteristic (e.g. HH income, age, etc.)
  - Person-trips

Activity-Based Analysis

Environmental Justice ("Communities of Concern"): In aggregate modeling the zone becomes a proxy for the people

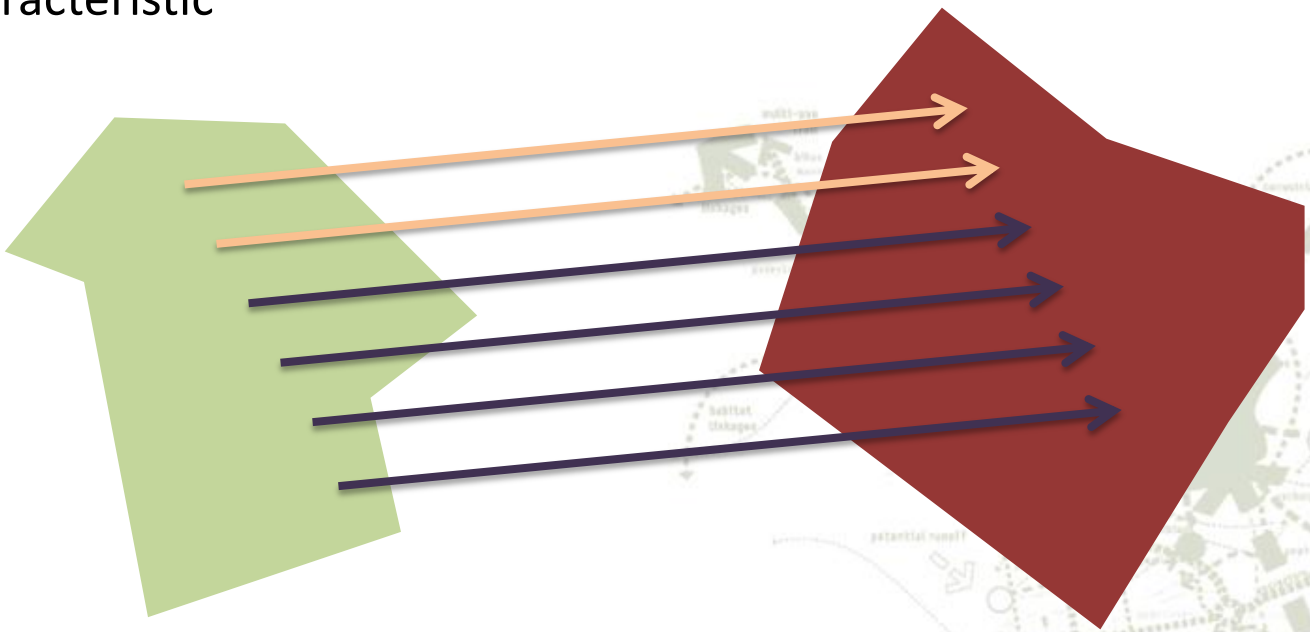
Typical: Green is an "EJ" zone because threshold percent of residents meet EJ criteria; assume global proportion of trips



Frkonja, Castiglione, and Miller. "Benefit/Cost Analysis for Project and Plan Evaluation in SANDAG's 'San Diego Forward' Plan". AMPO Annual Conference, 2014.

Activity-Based Analysis

Environmental Justice ("Communities of Concern"): In ABM modeling we know exactly who the EJ individuals are (dark green arrows) because model simulates individual characteristics: ABM enables more-precise accounting by person and characteristic

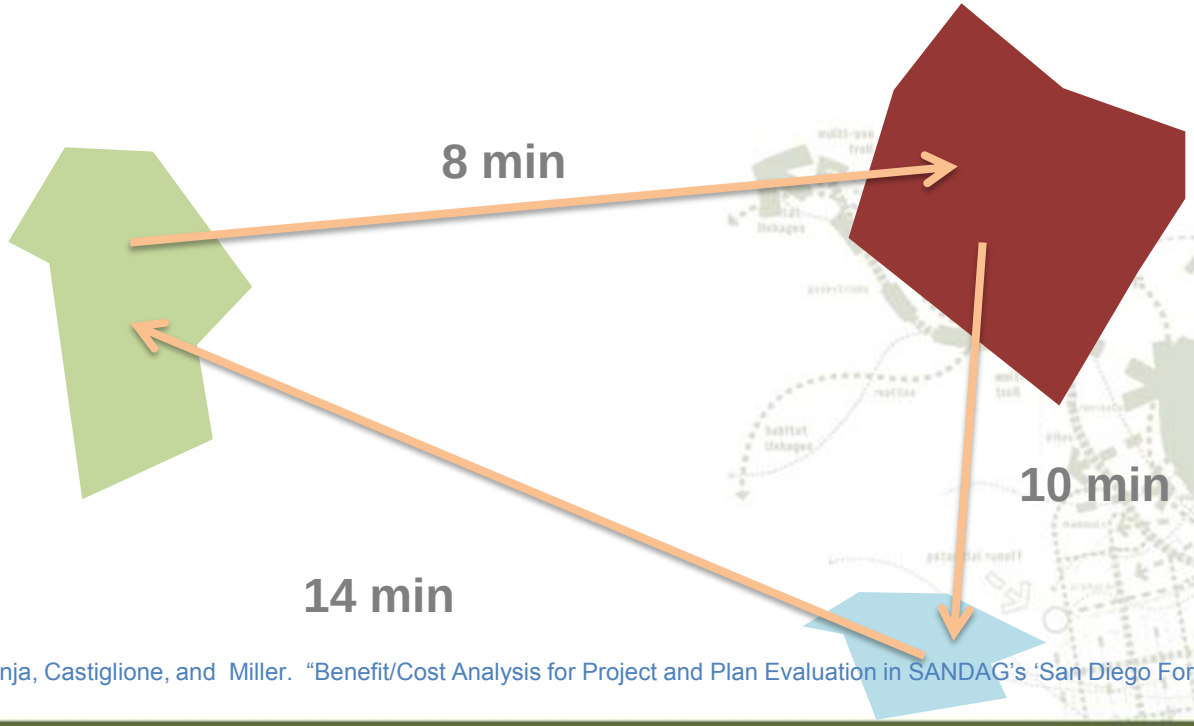


Frkonja, Castiglione, and Miller. "Benefit/Cost Analysis for Project and Plan Evaluation in SANDAG's 'San Diego Forward' Plan". AMPO Annual Conference, 2014.

Activity-Based Analysis

Physical Activity Threshold=22 min/day

- Aggregate model sees three trips below threshold

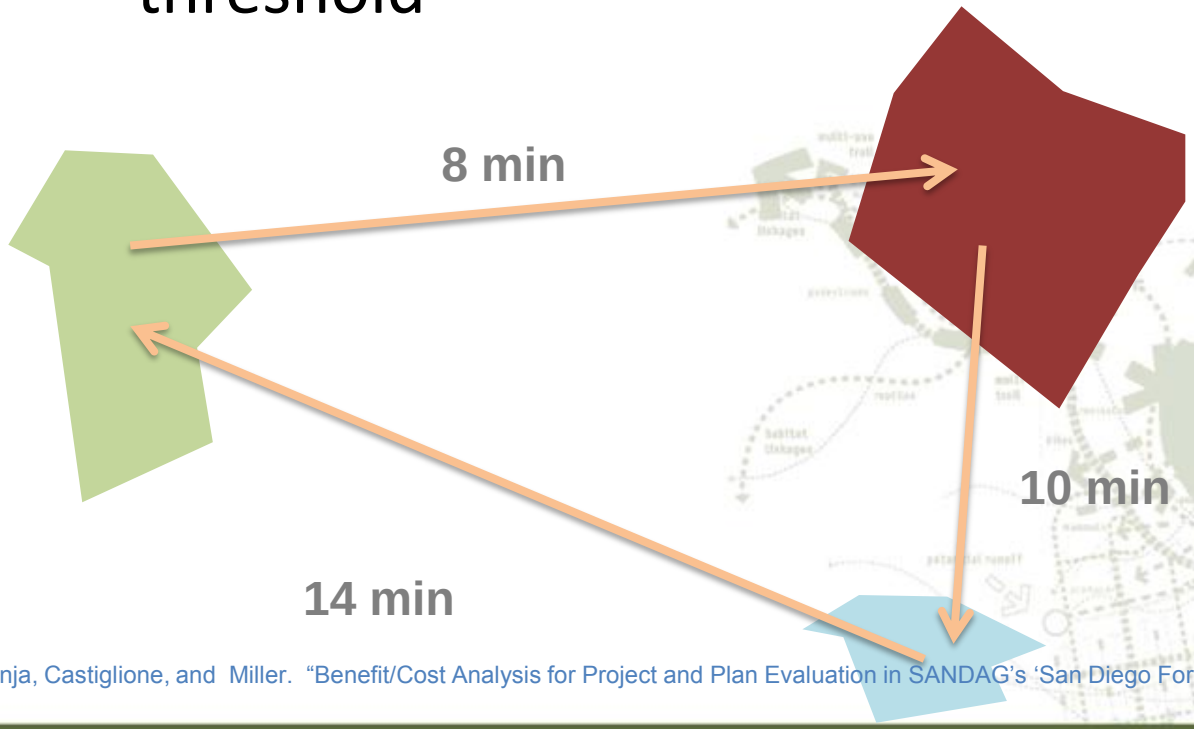


Frkonja, Castiglione, and Miller. "Benefit/Cost Analysis for Project and Plan Evaluation in SANDAG's 'San Diego Forward' Plan". AMPO Annual Conference, 2014.

Activity-Based Analysis

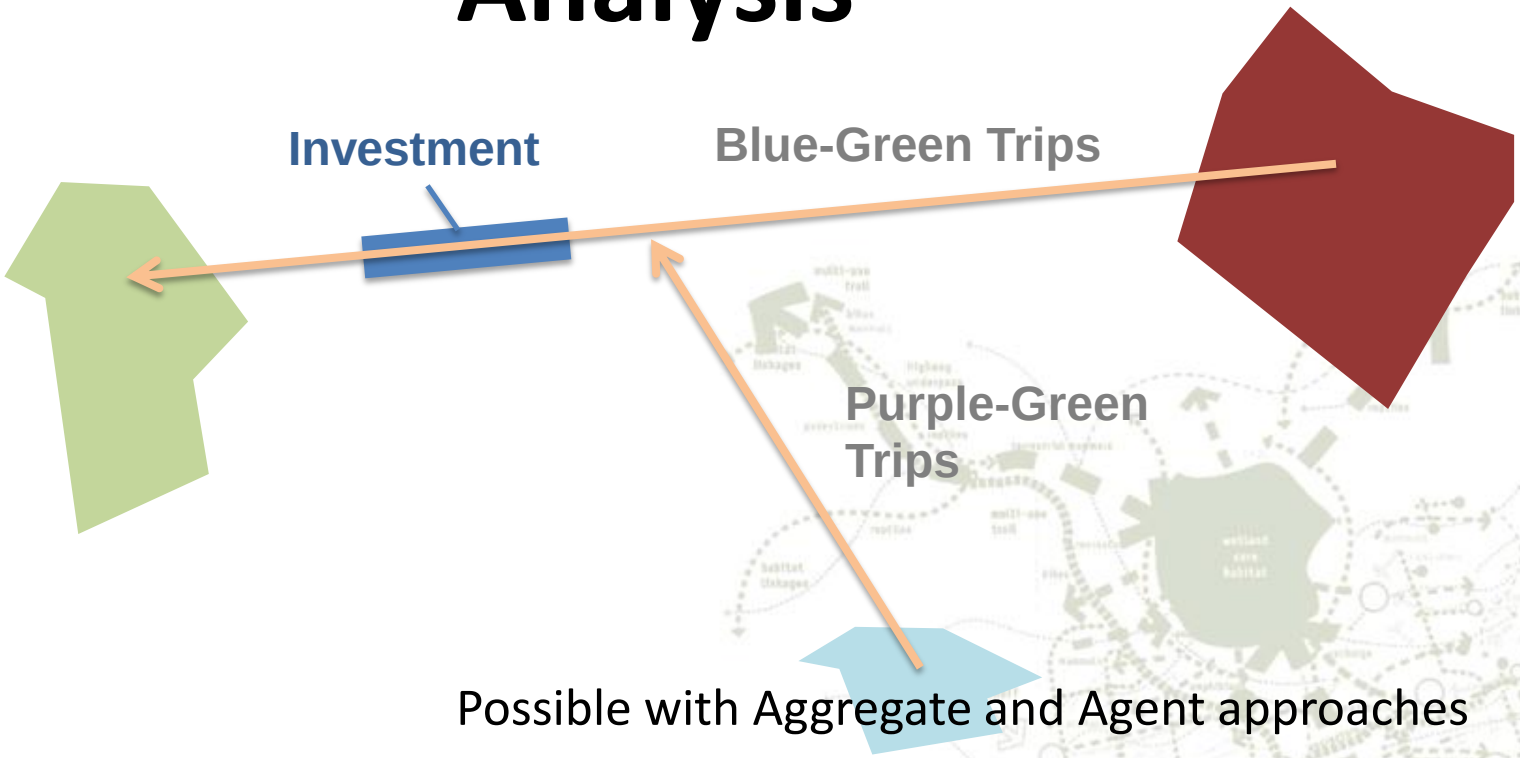
Physical Activity Threshold=22 min/day

- ABM sees one daily activity that in total crosses threshold



Frkonja, Castiglione, and Miller. "Benefit/Cost Analysis for Project and Plan Evaluation in SANDAG's 'San Diego Forward' Plan". AMPO Annual Conference, 2014.

Geographic Subarea Analysis



Possible with Aggregate and Agent approaches

Frkonja, Castiglione, and Miller. "Benefit/Cost Analysis for Project and Plan Evaluation in SANDAG's 'San Diego Forward' Plan". AMPO Annual Conference, 2014.