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# **National Automated Highway System Consortium: Modeling Stakeholder Preferences Project**

**John Lathrop  
Kan Chen**

**California PATH Research Report  
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# Final Report:

## National Automated Highway System Consortium

### Modeling Stakeholder Preferences Project

November 25, 1996  
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## E. Executive Summary, with Conclusions, Next Steps

### E.1. Overview

This is the final report of the Modeling Stakeholder Preferences Project, part of Task C2 of the National Automated Highway System Consortium FY96 effort. The project consisted of three primary tasks:

1. Develop a social decision-analytic framework for evaluating AHS options, using parameters to be elicited from stakeholders in focus group meetings;
2. Convene two stakeholder focus group meetings, which were used to elicit those stakeholder parameters: concerns, anticipated benefits and impacts (including spin-offs and deployability/transition concerns), performance/impact measures (“PIMs”) that represent those concerns/benefits/impacts, and the endpoints and a relative weight for each PIM.
3. Interpret the results of those two focus group meetings in the form of useful guidance for AHS option development.

This report presents the results of the project. They consist of three very different types of results:

1. The evaluation framework. That is described in the overheads presented to the stakeholders in the first focus group meeting, summarized here in Appendix D.
2. Focus group non-quantitative findings/recommendations. The eight primary ones are presented immediately below, with backup documentation in Section III. The rest of the non-quantitative findings are presented in Sections IV and V.
3. Performance/Impact Measures (PIMs), their endpoints, rankings and weights, for each stakeholder group. We elicited a first draft of PIM/endpoint/ranking/weight information from three groups (private direct user / non-user, vehicle industry and government), and partial PIM information from three other groups (insurance, transit and trucking). Those results are presented in Section II, in particular Tables 2 through 7, and in Section IV.

### E.2. Focus Group Non-Quantitative Findings/Recommendations

The stakeholder representatives at the NAHSC Focus Group Meeting #2, held November 5-6, 1996 in Richmond, California, respectfully submit the following eight findings/recommendations to the Consortium. Eight of the nine stakeholder representatives agree with these eight points as recommendations. The ninth stakeholder representative agrees with these eight points not as recommendations, but as findings that should be considered by the Consortium. The rationale behind each of these eight points is documented in Section III.

1. AHS options should be developed in a needs-driven, market-driven process. That could involve such measures as:
  - continuing to convene focus groups or other stakeholder representative groups to elicit their preferences;
  - other efforts in market research;
  - having stakeholder representatives continue to sit on Consortium planning groups.

2. For the reasons discussed in Section III -- including marketing, acceptance, risk management, flexibility, timing, and coordination of all parties concerned -- emphasize incremental deployment of AHS options, being mindful, too, of the negative aspects of incremental deployment.
3. Institutional and legal aspects should be included as AHS concept attributes. That could involve:
  - having stakeholders and other people with specific expertise in those aspects involved in the development of AHS options;
  - specifying the “Five Who’s” (who pays, who owns, who operates, who maintains, who regulates);
  - institutional innovations, such as public-private partnerships, or private entities to set up and manage AHS options.
4. AHS options should be evaluated in terms of real-site case studies, including interfaces into the existing transportation grid/system. Those case studies should include not only urban, but also inter-urban and rural scenarios.
5. The Consortium should consider a broader range of primary benefits, to include safety, productivity, capacity, and broader economic, socioeconomic, and environmental benefits.
6. AHS options should be developed to compete with other transportation options just as they will in actual implementation: versus traditional options, in mainstream transportation planning, within budgetary constraints. That should include supporting the option comparisons conducted by implementing government agencies by presenting estimates of AHS performance on the dimensions those agencies use in those comparisons.
7. Liability and risk management are key concerns, and should be addressed in AHS option development. That could involve:
  - including people with specific expertise in liability and risk management in the development of AHS options;
  - including the setting up of a legal framework covering liability as a role of the Consortium.
8. The Consortium should become a central, proactive agency in standard setting, specifying how and when standards are to be established and implemented. It should make AHS standards a timely deliverable. It should establish an AHS presence on all relevant standard-setting committees.

These points are quite important. In a final discussion in the closing minutes of the first Focus Group Meeting, two stakeholders in particular remarked on the importance of support from the states for the Consortium, how limited that support is, and how it would be reduced even further if the Consortium does not succeed in its efforts to change in the directions specified by the above list of insights, referring in particular to issues raised in Points 1, 3, 4, and 6.

### E.3. Conclusions From Quantitative Results

The quantitative results, presented in Section II and in particular Tables 2 through 7, lead to four conclusions:

1. Significant information on PIMs, scales, endpoints and weights can be elicited from stakeholder panels.
2. PIM importance-ranking, and so weights, varies significantly among stakeholders within a stakeholder group, indicating a need for more diverse representation. This is not simply “noisy data;” It represents genuine differences in preferences. For example, the three government agencies had such predictably different perspectives that one of the stakeholders, upon seeing the three sets of importance rankings without labels as to which one was which agency’s, commented that he could tell which importance ranking belonged to which agency. This suggests that the Consortium follow the business philosophy of the 90’s: strategically market to (and develop products for) a broad array of diverse customers, tracking their very different needs separately. In turn, that calls for a “customer portfolio strategy” to reduce that plethora of information into useful guidance for AHS development, as discussed in the “Next Steps” section below.
3. The PIMs elicited are difficult to assess. There are large gaps between directly assessable performance parameters and the PIMs. That indicates a need for significant effort to bridge those gaps, linking available data to PIMs with carefully structured expert judgment and probabilistic modeling using that expert judgment. There are well-established techniques and software to do that.
4. While we have a start on incorporating the preferences and concerns of private direct users / non-users, vehicle industry and some government agencies (state DOTs and Houston Metro), we should seek representation of other stakeholder groups. We have a start on the preferences and concerns of trucking, transit and insurance, but those need further work. In addition, we need to work on other government agencies, and to consider how best to handle the other stakeholders (i.e., vehicle electronics, highway design and environmental/societal interests).

#### E.4. Next Steps

This report has presented PIMs, endpoints and weights, and so has demonstrated that information can be developed to provide quantitative guidance for AHS option development based on stakeholder issues, concerns and preferences. At the same time, the quantitative information is based on only four days contact time with stakeholders, and so should be considered only as an indication of where we can go from here.

The weights presented here are only Barron approximations (explained in Section II.B.1), based only on the importance-ranking of the PIMs. A serious look at the actual, numerical tradeoffs between PIMs requires another step in elicitation which we did not have time to do within the budget and schedule of this project.

Even if we had collected a great deal of information on weights, and could consider them sound representations of currently attainable knowledge, we would still expect the weights to change as the evaluation framework develops. Four reasons:

1. Better technical performance data will provide changed endpoints, and even suggest better scales, even with no technology development.

2. Technology development will result in better and less uncertain technical performance, and so change the endpoints, even at the same level of data quality.
3. More elicitation will result in refined endpoints and weights.
4. More representative elicitation will result in a broader basis for PIMs, scales and weights.

With the three stakeholder groups for which we obtained weight-rankings (private direct user / non-user, vehicle industry, and governments), the diversity of opinion on importance-ranking is striking. As mentioned before, we don't expect consensus on importance ranking. We don't even welcome it, in the sense that differences in importance-ranking can offer opportunities for win-win solutions, which can lead to consensus where we want it: on alternatives. However, the observed differences suggest that the current breakdown of stakeholder groups is not adequate to conduct a satisfactory performance/impact evaluation of AHS options. Rather, it seems that different stakeholder groups should be defined within the private direct user / non-user, the vehicle industry, and the government stakeholder groups. The more the diversity, the more important it is to seek broad representation, covering the range of preferences that is out there. The ideal is to identify stakeholder groups that are homogenous enough that you can average their weights within groups with assurance that the averaging is just ironing out noise to characterize an underlying preference structure. If you average over very different preferences, you are simply hiding an important part of the user situation by concealing important diversity.

This need for broader representation could lead to "information overload." That is especially true when you consider the range of possible AHS deployment "packages." The best way to handle that is to develop a "customer portfolio strategy" as part of the evaluation framework. In this case, that would mean we would develop breadth-of-interest measures out of the PIMs, cross-referencing them with AHS options, using portfolio management tools adapted to the PIM-based evaluation. Strictly speaking, the term "customer portfolio strategy" refers to maintaining a portfolio of customers just as you would a portfolio of investments. In this case we take that one step further and also have a portfolio of AHS options that we develop, again just like an investment portfolio, with all the same portfolio analysis instruments. A key part of that strategy is information management. An analogy would be the development by Digital Equipment Corporation of an expert system to support selling its computer systems. DEC found that, to best serve its customers, it had to develop and market a fairly long list of "boxes" (CPUs, servers, terminals, network management devices, etc.), where each major customer required a different subset and configuration of those boxes. To address that need, DEC developed an expert system that takes as inputs the individual customer's needs, and delivers as outputs the set of boxes, cabling and interfaces that best satisfies those needs. That expert system provides two key benefits: It ensures that the customer gets the most effective product, and it instills confidence in the customer that he or she is being well served. In the AHS case, we would have a third benefit: The system could be "run backward" to provide guidance for AHS development. As such, it would be part of the customer portfolio strategy that would take the information plethora of many different customer need-sets and AHS component combinations, and reduce it down to clearer guidance for AHS development.



## I. The Two Focus Group Meetings: Purposes, Agendas and Participants

The bulk of this report presents the results of two focus group meetings:

1. Focus Group Meeting #1 (“FGM-1”): September 10 - 11, 1996 at the Hughes facility in San Diego, California.
2. Focus Group Meeting #2 (“FGM-2”): November 5 - 6, 1996 at the PATH facility in Richmond, California.

Both meetings were facilitated by John Lathrop and Kan Chen, social decision analysis consultants specializing in stakeholder involvement.

Dr. 's Lathrop and Chen are also the editors of this report. The word “editors” is deliberate, because this report is in fact a presentation of the ideas, issues, concerns and preferences of the stakeholders. The stakeholders, listed below, were extremely intelligent and articulate, presenting many very good and well-thought-out ideas, issues and concerns. All we had to do was use our tools to elicit those ideas, then transform them into forms useful for developing guidance for AHS option development. This report sacrifices coherence for the sake of completeness, to be sure all of the stakeholder ideas that were expressed in the meetings get out on the table.

The two focus group meetings had several purposes:

1. The primary purpose was to incorporate stakeholder preferences and ideas into AHS development. More specifically, we set out to get the stakeholders’ help in developing a way to evaluate AHS concepts, to guide concept development toward a consensus solution. In order to do that, we defined six more operational purposes:
2. To present to the stakeholders a trial evaluation framework to guide AHS development, to get stakeholders’ feedback and ideas about that framework, and what they think the framework should be.
3. To set up a constructive, collegial relationship with the stakeholders, as a basis for continuing constructive interaction.
4. To elicit from stakeholders their issues, concerns, anticipated benefits and impacts of the AHS program.
5. To elicit from the stakeholders specific performance/impact measures (PIMs) that represent their issues, concerns, anticipated benefits and impacts, including a scale and endpoints for each PIM. Those PIMs (known at the beginning of the project as measures of effectiveness, MOEs) are designed to be used as a basis for evaluating the performance of AHS systems, and setting requirements for those systems, in a way that reflects the preferences and incentives of the stakeholders.
6. To elicit from the stakeholders their relative ranking of the importance of the PIMs, taking into account the endpoints.
7. To gain the stakeholders’ approval of summary findings/recommendations.

The purpose of this report is to present the results of the meetings, not to explain how the meetings were conducted. So we will simply summarize that we followed a highly structured protocol to elicit the desired inputs from the stakeholders, using several techniques from the

fields of decision analysis and meeting facilitation. Summaries of the presentations made to the stakeholders in the meetings are included here as Appendix D.

The agendas for the meetings were highly adaptive, with numerous adjustments to be responsive to the desires of the stakeholders. We deliberately switched back and forth between several activities, but designed the activities and the time spent on each one to achieve the purposes listed above:

Table 1: Participants in the Two Focus Group Meetings:

Stakeholder Group	Person	Affiliation	Attended FGM	
			#1	#2
Environmental Protection	Michael Nazemi	South Coast AQMD (Calif.)	●	
Government Agencies	John Kiljan	Colorado DOT	●	●
	Emiliano Lopez	Virginia DOT	●	●
Insurance Industry	Charles Leone	Diversified Risk Inc.		●
Insurance Ind., Private Users	Michael Appleby	Auto Club (retired)	●	
Transit Operators	Loyd Smith	Houston Metro	●	●
Trucking	Dave Barry	National Private Truck Council		●
	Hamby Hutcheson	Intelligent Transport'n Project		●
Vehicle Electronics	Wendy Williams	Frank Wilson & Associates, Inc.		●
Vehicle Industry	Damon Delorenzis	Honda	●	●
	Michael Wolterman	Toyota	●	●
National AHS Consortium	Ronald Colgin	Program Office	●	●
	Matt Hanson	CalTrans		●
	Ronald Hearne	Bechtel	●	●
	Carol Jacoby	Hughes	●	●
	Greg Larson	CalTrans		●
	Rodney Lay	Mitretek		●
	James Lewis	Hughes	●	
	Tom McKendree	Hughes		●
	Steven Shladover	PATH		●
Jacob Tsao	PATH	●	●	

## II. Performance/Impact Measures (PIMs) and Their Ranking, Weights

### II.A. Introduction

While this project, from its inception through the start of FGM-2, referred to performance measures as “measures of effectiveness (MOEs),” in FGM-2 we changed the name of the term to “Performance/Impact Measures (PIMs).” This was suggested by the participants as a term that more clearly indicated the actual nature of the scales and endpoints that we were generating. The actual term was decided by a vote of the participants in FGM-2.

This section presents the most analytic results of the FGMs. A key feature of the Social Decision Analysis approach, crucial to the development of stakeholder consensus, is the development of a scoring function, or “meter,” for each stakeholder group that generates a scalar index of the desirability of each AHS option for that stakeholder group. That function is based on the underlying theory of multiattribute utility analysis. It requires that we define assessable performance/impact measures (PIMs) to cover all important stakeholder values, concerns, impacts and issues, including a scale and endpoints for each one, then assess the relative importance weight for each PIM. (There are other considerations, concerning single-attribute utility functions and non-additivity, that we don’t need to explain here, since they would be dealt with later in the process.) We performed an initial version of those assessments of PIMs, scales, endpoints, and weights during FGM-2. This section presents the results of those assessments.

But first, we need to clarify some terms: By “PIM,” here, we mean stakeholder PIM, designed to reflect stakeholder concerns, preferences, incentives and impacts. That is as opposed to analysis PIMs, which are also designed to measure the performance/impacts of the system, but are selected on the basis of what can be assessed from available data and model runs, not based on stakeholder values.

We were able to collect stakeholder PIM information at two levels:

- 1.) With three stakeholder groups, private direct user / non-user, vehicle industry, and government, we were able to elicit stakeholder PIMs in the form of objectives hierarchies, presented in Appendix B, and elicit PIM endpoints, importance-rankings and approximate weights, presented here in Sections II. B, C, and D, respectively.
- 2.) For all nine stakeholder groups, we were able to elicit more general characterizations of stakeholder PIM information, ranging from barely a start to fairly complete, presented in Section IV.

The PIM characterizations and Appendix B hierarchies are definitely very rough drafts, work-in-progress. They are only a first cut at what should be an iterative process of defining PIMs. Often it may not even be clear at this point what, precisely, is meant by some of the terms here and in Appendix B. More precise definitions can be generated in the course of further development of PIM scales and endpoints.

As can be seen in Appendix B, an objectives hierarchy is simply a hierarchy specifying and linking an overall goal in the top box with objectives, sub-objectives, sub-sub-objectives, and so on downward through the hierarchy, until the bottom boxes, which are performance/impact

measures. So in fact, the hierarchies in Appendix B are simply ways to organize the PIMs presented in Sections II. B, C and D.

For each stakeholder group, we prepared, before the first focus group meeting, a trial objectives hierarchy, based on our limited knowledge of stakeholder concerns, preferences and impacts. That served as a starting point for our discussions in the two meetings, where we developed the hierarchies presented in Appendix B. In all cases, the hierarchies that came out of the meetings were completely different from the discussion-starting hierarchies we had prepared. That in fact is one way to demonstrate our responsiveness to stakeholder inputs.

The PIMs presented in Sections II B, C and D were developed from lists generated at FGM-1. Those PIMs were developed into scales and endpoints in two memos, totaling 21 pages, distributed to the participants shortly before FGM-2. During FGM-2, some PIMs were added to the lists, then each PIM was considered and sorted into one of three categories:

1. PIMs to be importance-ranked: PIMs where it was judged that different AHS options could score differently on those PIMs, using data that could be available during FY97. For example: Safety: There should be data in FY97 that would support different scores for different AHS options on a Safety PIM, though there may be a great deal of uncertainty about those scores.
2. “First Reserve, Technical Specs” PIMs: PIMs that couldn’t be used to evaluate AHS options using data available in FY97, though they hold definite promise of being useful in the future. That is, there was just no data that could be available in FY97 that would lead to different scores on these PIMs for different AHS options. An example: Reliability other than Safety: Security: As far as can be known in FY97, any AHS option could be designed to have the same level of performance on that PIM. It could be that, as we develop more information about the AHS options, some will be seen to perform better on this PIM than others. But for now, we can’t tell which options those would be. These PIMs were not discarded, but put in reserve, to be used as technical specifications for design guidance, and/or to be used later as more data are developed or become available.
3. “Second Reserve” PIMs: These PIMs were judged to be unlikely to be useful to evaluate AHS options. Rather than discard them, they were placed in “second reserve,” to be used if data become available that would lead to different scores for different AHS options on those PIMs.

Even for those PIMs selected for importance-ranking, for some, such as Institutional Attractiveness, there may not be a clear relationship between different AHS options and different performance on that PIM, but there are things that we can know about AHS options, such as the driver/vehicle/infrastructure allocation of components/tasks/intelligence/decision-making, that do allow us to determine that some AHS options can be assessed at a different score on that PIM than others.

The next three subsections present the PIMs, scales, endpoints and approximate weights for three stakeholder groups, respectively: Private Direct User / Non-User, Vehicle Industry, and Government Agencies (specifically state DOTs and Houston Metro). In each case, we present a spreadsheet that lists the PIMs, their importance-ranking by the participants and the corresponding approximate weights, then we discuss those rankings and findings, then we

describe each PIM in terms of its scale endpoints. Where called for, we discuss specific points about individual PIMs. The endpoints are crucial to the importance-ranking, since the discipline of the underlying theory (multiattribute utility analysis) specifies that the importance ranking must be based on the relative importance of each PIM's "swing-range" from worst endpoint to best endpoint. In fact, the ranking was elicited using a specific "litany" designed to ensure that the participants were taking the endpoints into account appropriately in their ranking.

The findings common to all three stakeholder group PIMs and importance rankings are presented in Sections E.3 (Conclusions From Quantitative Results) and E.4 (Next Steps) in the Executive Summary.

## II.B. Direct Private User, Non-User

We elicited the PIMs, scales, endpoints and importance-rankings of two stakeholder groups, direct private user and direct private non-user, as one group together, because they both consist of non-commercial drivers, differing only in the impacts upon them. While at the early deployment states there will be far more non-users than users, the main impacts on non-users were found in FGM-1 to be captured with two PIMs (Changed Congestion and General Negatives, both defined later), plus one PIM (Societal, Environmental Impacts) that affects both user and non-user groups alike.

### II.B.1. Direct Private User, Non-User PIM Ranking Discussion, Findings

Though no participant in FGM-2 was a specific representative of the direct private user / non-user stakeholder group, each is in fact a potential member of that group. For that reason, and the importance of that group, we started with that stakeholder group, asking every FGM-2 stakeholder participant (but not the Consortium representatives) to provide responses. While eight of the nine stakeholder participants engaged in essentially all of the development of PIMs, scales and endpoints, only five were in attendance when the importance-ranking was elicited.

The next page is a spreadsheet that presents the PIMs, averaged approximate numerical weights derived from the importance-ranking (using a method explained below), individual stakeholder rankings and approximate weights, then three other ways to rank the importance of the PIMs. The data on this spreadsheet are extremely preliminary. It should only be regarded as an indication of where we can go with these methods. That being said, the data on this spreadsheet can be used to develop guidance for AHS development based on private direct user / non-user preferences.

We had to make an important compromise in order to get the spreadsheet to fit on one page. That forced us to list the PIMs only by name. Strictly speaking, the PIMs should not be considered by their names alone, without their scales and endpoints, since the ranking and weighting presented in the other columns of the spreadsheet is only defined in terms of those endpoints. That is, for a given PIM, it could have a much higher importance-ranking and weight if its endpoints were further apart than the endpoints used in the elicitation, or it could have a

much lower importance-ranking and weight if its endpoints were closer together. The endpoints are specified in Section II.B.2.

To discuss each part of the spreadsheet in turn:

#### Performance/Impact Measures

The first two columns in the spreadsheet number and list the PIMs for the private, direct user / non-user stakeholder. The first eleven PIMs in the spreadsheet are ones selected by at least one stakeholder as being among his or her five most important PIMs. They are ranked in terms of relative importance, measured four different ways, as described below. The next nine are PIMs that were considered for importance-ranking, but were not selected as among the five most important by any stakeholder, and so are considered to be a tied group, tied for the bottom rank, and are listed in alphabetical order. As explained before, the remaining seven PIMs were placed in first or second reserve, since they could not be used to discriminate among AHS options in the current fiscal year. (That is, no pair of AHS options would score differently on those PIMs.)

#### Average Barron Weight

The primary basis for overall importance-ranking, across the five participants, is by average Barron weight. A Barron weight is an approximation of the numerical weight of a PIM, based on its ranking. It is generated by a calculation described in a paper to appear in Management Science this year (“Decision quality using ranked attribute weights,” F. Hutton Barron and Bruce E. Barrett).<sup>1</sup> Each of the five stakeholders participating at the time separately ranked his or her five most important PIMs. Those rankings are indicated in five columns to the right. Note that the average rank for ranks 6 through 20 is 13, so that rank is assigned to every PIM not selected by that stakeholder. For each stakeholder, the Barron weight is assigned to each PIM by its importance-rank, then we averaged those Barron weights across the five stakeholders to get the Average Barron Weight. In fact, averaging weights across stakeholders involves an unattractive assumption about interpersonal comparability of utility, so we only do that to get some aggregate guidance about the relative weights. In fact, we cross-check that weight-ranking by three conceptual sensitivity analyses, as explained below.

#### Stakeholder Rankings/Barron Weights

These columns have already been discussed above. But note how the rankings vary markedly across the five stakeholders.

#### Conceptual Sensitivity Analyses

The last columns in the spreadsheet indicate three other ways to importance-rank the PIMs. “Times in Top 5” is simply the number of stakeholders ranking that PIM in his or her five most important PIMs. “Avg. Rank” is the average of the rank numbers across the

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<sup>1</sup> That calculation starts with the fact that the weights must sum to 1.0 (or any constant), so all possible sets of the 20 weights for the 20 PIMs in this case comprise a plane in 19-dimensional space. The Barron calculation simply assumes that the centroid of that plane is the best estimate we can make of the weights, if all we know is the importance-rank of the PIMs. That makes some sense if you assume that errors are monotonic with the sum-squared distance between the estimated weight set and the true weight set. In fact, extensive sensitivity analyses on sampled data sets and decisions find that the centroid predicts the decisions of the true weights remarkably well, as discussed in the cited paper.

five stakeholders. “Pairwise Voting” is the number of votes each PIM would have gotten among the five stakeholders had it been paired with the one immediately above it or below it in the ranking. That is, the left half of the Pairwise Voting column lists the voting results of PIMs 1 vs 2, 3 vs 4, 5 vs 6, etc., while the right half of that column lists the voting results of PIMs 2 vs 3, 4 vs 5, 6 vs 7, etc. Note that, of the four ways to importance-rank the PIMs, there is full agreement on ranking, with one small exception between Flexibility and System Integrity, where we chose to allow the small difference in Average Barron Weight to be overridden by the three sensitivity analyses.

There were several points made during FGM-2 about the importance-ranking of the PIMs for the private direct user / non-user:

1. Perhaps most surprising: Remaining Driving Task was never selected as among the five most important PIMs by any of the five stakeholders. That is, the benefits, at least as perceived before deployment, of going from manual driving to “brain off” are not important relative to other PIMs. A preliminary importance ranking was performed on the first day of FGM-2, with eight of the nine stakeholder participants picking the two most important PIMs out of ten. That ranking also found that Remaining Driving Task was never picked. When challenged directly, the stakeholders stood by their rankings, maintaining that in fact, yes, the reduction in driving task was not as important as other PIMs such as Safety, Travel Time Savings, Travel Time Predictability, and Flexibility.
2. The low relative weight given to the Remaining Driving Task PIM raises the question: What is the best basis on which to “sell” (i.e., gain support for, then market) AHS? A low weight for Remaining Driving Task, at least among users before deployment, and the relatively high weight given to Safety and Travel Time Savings, suggests that effective selling points are more apt to lie with the latter two PIMs. In turn, that suggests that the initially most attractive application scenarios for AHS options are ones where the benefits in Safety and Travel Time Savings are most clear.
3. A related point: Representing the full range of benefits of AHS is a marketing challenge. In particular, to communicate the benefits of reduced driving task, they may be framed with a tag line like “electronic chauffeur.” Marketing that reduced driving task may involve supposing how the customer will use that time, and focusing on the idea of “lifestyle enhancement.”
4. A related point: The low importance-ranking of Remaining Driving Task points out the important potential differences between pre-deployment preferences, which should guide initial penetration, and post-deployment preferences, which should provide guidance related to long-term penetration. So direct private user relative importance elicitation should be performed twice: once to indicate the relative importance of benefits as they are perceived before deployment, and once as they are perceived after deployment. The problem, of course, is that the latter elicitation is quite difficult to do, since it involves very challenging “accurate imagination.”
5. Many of the direct private user PIMs will differ, at least in their weight, by application scenarios and by intermediate versus final state. There may very well be important

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differences, again at least in the relative weights among PIMs, between different driver types. With the Remaining Driving Task in particular, the lowest level of remaining driving task, i.e., “brain off,” may not be the most preferred level, and that preferred level is very apt to change with scenario and driver type.

6. The participants, though they were representing direct private users/non-users, brought different perspectives to their judgments. One participant reported tending to rank PIMs in terms of avoiding the biggest pitfalls. Another participant reported tending to rank PIMs in terms of their strength as selling points (positive and negative).





One last point was not generated by the participants, but we make as methodologists:

7. The five participants varied markedly in their importance-rankings. Consensus is not expected at the level of importance-ranking. We expect people to differ on their preferences (i.e., on their importance-ranking). We seek consensus instead on the selected/developed alternative(s) and/or the process of development. Just the same, the wide variation we observed here indicates that assessing user needs and preferences should involve extensive efforts to achieve broad representation. Also, guidance for development will involve multiple indices indicating breadth of desirability across a diverse range of users.

## II.B.2 Direct Private User, Non-User PIM-by-PIM Discussion

The next four pages list the PIMs for private direct user / non-user. They are presented in the same format as they were presented to the FGM-2 participants, as “placards” (though the placards actually used were 5” by 20” with velcro backing so that they could be physically ranked and re-ranked, and were usually heavily marked up by hand). The placards are ordered as they are in the spreadsheet, by overall importance-rank. The Average Barron Weight is also presented.

The placards should be self-explanatory. However, five additional points need to be made that are not evident from the placards:

1. The participants had a difficult time deciding on the best scale on which to measure Safety. From a normative perspective, safety could be measured as the negative of the expected value (probability-weighted sum of possible accidents) of a severity-adjusted index of loss (i.e., a weighted sum of fatalities, injuries and property losses designed to provide some measure of “equivalent fatalities” or equivalent some other standard measure). However, the participants elected instead to go with a index designed to relate more clearly to public perceptions of safety and risk: an index designed to reflect accidents per million vehicle miles, with endpoints in terms of percentage of current accident rates. In fact, according to previous guidance from the participants, when characterizing safety for a particular application, the Consortium should use whatever measure corresponds to the safety measures used by federal and local implementing government agencies, to the degree that those measures can be assessed with available data.
2. The System Integrity PIM measures an impact beyond its safety implications. In bringing it up, the participants identified a concern that is not fully captured by safety as measured by accidents per million vehicle miles. However, there is a danger that measuring both Safety and System Integrity could involve double counting, unless it is made clear that the System Integrity PIM covers impacts other than the resulting accidents per million vehicle miles.
3. The Societal, Environmental Impacts PIM started out with other impacts than mpg/air quality, specifically: land use, land use sprawl, and compatibility with electric and transit vehicles and aesthetics (road viewshed visual impacts). However, the land use and aesthetic effects had to be dropped as too difficult to link to AHS options at this stage.

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Also, the electric and transit vehicle compatibility impacts were dropped since they will be constrained to a given level. Therefore Societal, Environmental Impacts became, effectively, “Environmental Impacts.” However, as we gain a better understanding of the linkages between AHS options and land use / sprawl impacts, and if particular issues arise affecting the degree to which different AHS options may promote transit differently, those considerations should be added back in to the PIM set.

		Average Barron Weight
1	<p align="center"><b>Safety</b></p> <p align="center">index designed to reflect accidents per million vehicle miles</p> <p align="right"><b>Best</b></p> <p><b>Worst</b> <span style="float: right;"><b>50% fewer highway accidents</b></span></p> <p>equal to today</p>	.12
2	<p align="center"><b>Travel Time Savings</b></p> <p align="center">Weighted average of TTS for several door-to-door scenarios, to represent TTS of a standard scenario. In each of two applications:</p> <p><b>Worst</b> <span style="float: right;"><b>Best</b></span></p> <p>2 minutes lost    Urban 20-minute scenario "A."    5 minutes saved</p> <p>2 minutes lost    Interurban 1-hour scenario "B."    10 minutes saved</p>	.09
3	<p align="center"><b>Flexibility</b></p> <p align="center">AHS services on non-AHS freeways/highways</p> <p align="right"><b>Best</b></p> <p><b>Worst</b> <span style="float: right;"><b>full AHS, "brain off"</b></span></p> <p>no benefits</p>	.08
4	<p align="center"><b>System Integrity</b></p> <p><b>Worst</b> <span style="float: right;"><b>Best</b></span></p> <p>Hacker can cause mass accident    Tamper-proof</p>	.08
5	<p align="center"><b>Travel Time Predictability</b></p> <p align="center">Weighted average of TTP for several scenarios, to represent TTP of a standard scenario. In each of two applications:</p> <p><b>Worst</b> <span style="float: right;"><b>Best</b></span></p> <p>50% w/i 2 min.    Urban 20-min. scenario "A."    100% w/i 2 min.</p> <p>50% w/i 5 min.    Interurban 1-hr. scenario "B."    100% w/i 5 min.</p>	.07
6	<p align="center"><b>Δ Vehicle Operating Cost</b></p> <p align="right"><b>Best</b></p> <p><b>Worst</b> <span style="float: right;"><b>\$100/yr. saved</b></span></p> <p>\$1,200/yr.</p>	.07
7	<p align="center"><b>Access/Egress</b></p> <p align="center">% exits accessible</p> <p align="right"><b>Best</b></p> <p><b>Worst</b> <span style="float: right;"><b>100%</b></span></p> <p>in the regional freeway network</p> <p>1 in/out, 1%</p>	.06
8	<p align="center"><b>Δ Vehicle Capital Cost</b></p> <p align="center">('96 \$'s)</p> <p align="right"><b>Best</b></p> <p><b>Worst</b> <span style="float: right;"><b>\$0</b></span></p> <p>\$5,000</p>	.06

Table 3. Performance/Impact Measures, Endpoints and Weights: Private User / Non-

9	<b>Aesthetics</b>	Worst	Best	Average Barron Weight
		high fence, net over top	no fence or net	.04
10	<b>Societal, Environmental Impacts</b>	Worst	Best	.04
		no impact on mpg or air quality	10% reduction in mpg, with resulting air quality benefits	
11	<b>Override</b>	Worst	Best	.04
		Never	Complete, any time	
12	<b>Check Out Hassle</b>	Worst	Best	#'s 12-20 not ranked, so a tied group (alphabetically ordered), each weighted
		"wake up call" + intrusive test	None	
13	<b>Hassle: Serviceability + Certification</b> index designed to reflect servicing/certification needs	Worst	Best	.03
		.5 non-routine services/yr. 1 certification/yr	p < .05 non-routine services/yr. 0 certification/yr	
14	<b>Incrementalism</b> max difficulty of any purchase decision in sequence, timing of benefits	Worst	Best	.03
		entire cost, learning task in one purchase, later benefits	same as adding a convenience appliance, sooner benefits	
15	<b>Non-AHS User: Changed Congestion</b>	Worst	Best	.03
		stop & go	free flow	
16	<b>Non-AHS User: General Negatives</b>	Worst	Best	.03
		High relative speeds without barriers, short manual-AHS headways, perceived inequity in benefits	No anticipatable negative impacts	

Table 3B: Performance/Impact Measures, Endpoint and Weights: Private Direct User / Non-U

		Average Barron Weight
17	<p><b>Privacy - Infrastructure Knowledge</b>                      extent the infrastructure knows                      driving route, timing</p> <p><b>Worst</b> <span style="border: 1px solid black; padding: 2px;">complete knowledge</span> <span style="border: 1px solid black; padding: 2px;">without doubt , the system must be in complete ignorance</span> <b>Best</b></p>	.03
18	<p><b>Privacy - Proximity to Strangers</b>                      imposition of proximity to strangers, with no option to avoid</p> <p><b>Worst</b> <span style="border: 1px solid black; padding: 2px;">routine imposition of proximity, no option to avoid</span> <span style="border: 1px solid black; padding: 2px;">no imposed proximity</span> <b>Best</b></p>	.03
19	<p><b>Remaining Driving Task</b>                      driving tasks left to the driver</p> <p><b>Worst</b> <span style="border: 1px solid black; padding: 2px;">manual</span> <span style="border: 1px solid black; padding: 2px;">brain-off</span> <b>Best</b></p>	.03
20	<p><b>Skills Required</b>                      ... of the most challenging tasks left to driver</p> <p><b>Worst</b> <span style="border: 1px solid black; padding: 2px;">significantly more demanding recovery from anomalies</span> <span style="border: 1px solid black; padding: 2px;">removes need to manage a merge</span> <b>Best</b></p>	.03

Table 3C: Performance/Impact Measures, Endpoints and Weights: Private Direct User / Non-

21	<p><b>Controlled, Predictable Environment</b>                  degree to which controls seem directly and clearly linked to vehicle response</p> <p>Worst <span style="margin-left: 150px;">Best</span></p> <p>opaque system, unpredictable response <span style="margin-left: 150px;">intuitively clear, like a manual vehicle</span></p>	#'s 21-25 First Reserve, Tech'l Specs
22	<p><b>Government Mandates</b>                  (e.g., required to buy)</p> <p>Worst <span style="margin-left: 150px;">Best</span></p> <p>must pay \$1,500 due to AHS, no option to avoid <span style="margin-left: 150px;">no non-optional cost</span></p>	
23	<p><b>Learning Curve, Training Time</b>                  driving hours to fully learn performance</p> <p>Worst <span style="margin-left: 150px;">Best</span></p> <p>100 <span style="margin-left: 150px;">0</span></p>	
24	<p><b>Reliability other than Safety: Security</b>                  degree AHS compromises driver security</p> <p>Worst <span style="margin-left: 150px;">Best</span></p> <p>no driver control over route, no override to avoid an area <span style="margin-left: 150px;">driver-selectable route, can override to avoid area</span></p>	
25	<p><b>TechnoFear</b>                  initial resistance</p> <p>Worst <span style="margin-left: 150px;">Best</span></p> <p>VCR programming, quite unusual <span style="margin-left: 150px;">like manual, + 1 button</span></p>	
26	<p><b>Reliability other than Safety: Running</b>                  on-board components allow, cheaply:</p> <p>Worst <span style="margin-left: 150px;">Best</span></p> <p>no engine monitoring, no fault correction <span style="margin-left: 150px;">engine monitoring, fault correction</span></p>	#'s 26-27 Second Reserve
27	<p><b>Selectivity</b></p> <p>Worst <span style="margin-left: 150px;">Best</span></p> <p>All AHS features turned on by infrastructure, no driver control <span style="margin-left: 150px;">All AHS features separately selectable by driver</span></p>	

Table 3D: Performance/Impact Measures, Endpoints and Weights: Private Direct User / Non-I

4. The Non-AHS User placards involve an additional step. Overall desirability of an AHS option should be measured across both users and non-users. Those two impacted groups should be weighted differently or at least treated separately, since they represent different numbers of people in differently impacted groups. In fact, the relative sizes of the two groups will shift dramatically from the initial deployment state to the final state. While it might seem natural to weight the two groups proportionally to size of population, they may be weighted in other ways to reflect political acceptance, breadth-of-support, and equity considerations.
6. Selectivity, i.e., the ability of the private user to select automation features, should be balanced against systems control, customer information load, and liability implications.

### II.C. Vehicle Industry PIM Ranking Discussion, Findings

Below is a spreadsheet that presents the PIMs, averaged approximate numerical weights, individual stakeholder rankings and approximate weights, then two other ways to rank the importance of the PIMs. There are only two other ways, rather than the three with the private direct user / non-user data, since in this case there are only nine PIMs, not 20, so there is less of a need for the “Times in Top 5” data. The columns are as explained in Section II.B.1. The data on this spreadsheet are extremely preliminary. It should only be regarded as an indication of where we can go with these methods. That being said, the data on this spreadsheet can be used to develop guidance for AHS development based on vehicle industry preferences.

While the PIMs in the spreadsheet are ordered by average Barron weight, in fact the two stakeholder perspectives should be considered separately and not averaged together, since they represent two different perspectives, differing primarily on the importance of the Incrementability PIM. One stakeholder felt that incrementability was only of value for what it means in delivering all other PIMs, and so had no value (or weight) in itself. The other vehicle industry stakeholder felt that incrementability had several reasons for value in its own right, including customer confidence and acceptance, durability and reliability, in ways not adequately captured by the other PIMs. One reason for the difference could be that a key general value for incrementability is risk management/reduction, and one stakeholder represented a very different attitude toward risk than the other stakeholder. That is, one stakeholder was generally “risk neutral,” while the other one was generally “risk averse.” Each stakeholder was probably influenced by the culture of the company he represented.



**Table 4: Performance/Impact Measures and Rankings, Weights: Vehicle Industry**

**Note: Performance/impact measures are defined in Table 5.**

**Importance-ranking/weight information presented here depends on endpoints specified in Table 5.**

<b>Performance / Impact Measures: Vehicle Industry</b>							
						Conceptual	
		Stakeholder Rankings/				Sens'y Analyses	
	Average	Barron Weights					Pair-
	Barron	SH1		SH 2		Avg.	wise
Performance/Impact Measure	Weight	rank	wght	rank	wght	Rank	Voting
Liability	.327	1	.314	1	.340	1.0	2
Customer Objectives	.195	2.5	.175	2	.215	2.3	0 2
Marketability	.124	4.5	.097	3	.152	3.8	1 0
Image	.104	4.5	.097	4	.111	4.3	0 1
Incrementability	.088	2.5	.175	(9)	.000	(5.8)	1 1
Servicability	.061	7	.042	5	.079	6.0	1 1
Producability	.057	6	.061	6	.054	6.0	2 1
Spin-Offs	.030	8	.026	7	.033	7.5	0 2
Internal Technical Development	.014	9	.012	8	.016	8.5	0

Note: The rank “2.5” is the average rank of two PIMs tied for second rank, and “4.5” is the average rank of two PIMs tied for fourth rank. The Incrementability PIM was actually not ranked by SH 2. It is given a rank “(9)” to allow an average rank calculation. Note that it is not given a Barron rank.

The following two pages present the vehicle industry PIMs.

		Barron Weight	SH 1	SH 2
1	<p><b>veh: Liability</b> cost, clarity</p> <p><b>Worst</b> unlimited allocation, no immunity, no clarity of allocation <b>Best</b> acceptable allocation, conditional immunity, acceptable clarity of allocation</p>		.31	.34
2	<p><b>veh: Customer Objectives</b> index = weighted sum of AHS User PIMs scores, diverse weights aggregated to anticipate market penetration, separate projections of short-term vs long-term penetration</p> <p><b>Worst</b> Worst levels on all private direct user PIMs <b>Best</b> Best levels on all private direct user PIMs</p>		.18	.21
3	<p><b>veh: Incrementability</b> rating scale based on pro's / con's</p> <p><b>Worst</b> One-step deployment <b>Best</b> Best-number-of-steps: marketing, risk spin-offs, benefits-revenue timing, upgrade incompatibility, liability, etc.</p>		.18	not weighted
4	<p><b>veh: Marketability</b></p> <p><b>Worst</b> Negative AHS image; not flexible; dependent on infra or other veh.; requires changed marketing, hard-to-sell benefits, formidable learning <b>Best</b> Positive AHS image; flexible; no dependence on infra or other veh.; current marketing is fine; understandable, clear, easy-to-sell benefits; inconsequential learning</p>		.10	.15
5	<p><b>veh: Image</b> appearance of technical content</p> <p><b>Worst</b> No AHS performance <b>Best</b> Advanced vehicle AHS performance</p>		.10	.11
6	<p><b>veh: Servicability</b></p> <p><b>Worst</b> expensive replacement parts, extra training, quals for techs, 1 more routine visits/yr, .5 more non-routine visits/yr. <b>Best</b> no difference from non-AHS</p>		.04	.08
7	<p><b>veh: Producability</b> index of ease of production</p> <p><b>Worst</b> requires difficult upgrades in tolerances, QC, testing <b>Best</b> current tolerances fine, no special QC or testing needs</p>		.06	.05
8	<p><b>veh: Spin-Offs</b> index of potential for spin-off revenue, diversification</p> <p><b>Worst</b> No anticipatable spin-off revenue impact <b>Best</b> Potentially several different technologies with clear revenue</p>		.03	.03

Table 5: Spin-off revenue impact Measures, Endpoints and different technologies

9	<b>veh: Internal Technical Development</b>		Barron
	<b>Worst</b>	<b>Best</b>	Weight
	infrastructure-centered, simple vehicle AHS features, early, extensive standardization	vehicle-centered, advanced vehicle AHS features, late, minimum standardization	<u>SH 1</u> <u>SH 2</u>
			.01 .02
10	<b>Worst</b>	<b>Best</b>	
11	<b>Worst</b>	<b>Best</b>	
12	<b>Worst</b>	<b>Best</b>	
13	<b>Worst</b>	<b>Best</b>	
14	<b>Worst</b>	<b>Best</b>	
15	<b>Worst</b>	<b>Best</b>	
16	<b>Worst</b>	<b>Best</b>	

Table 5B: Performance/Impact Measures, Endpoints and Weights: Vehicle Industry

**II.D. Government Agency PIM Ranking Discussion, Findings**

Below is a spreadsheet that presents the PIMs, averaged approximate numerical weights, individual stakeholder rankings and approximate weights, then two other ways to rank the importance of the PIMs. The data on this spreadsheet are extremely preliminary. It should only be regarded as an indication of where we can go with these methods. That being said, the data on this spreadsheet can be used to develop guidance for AHS development based on government agency preferences.

While the PIMs in the spreadsheet are ordered by average Barron weight, in fact the three stakeholder perspectives should be considered separately and not averaged together, since they represent three different perspectives: Colorado DOT, Virginia DOT, and Houston Metro. Each stakeholder performed his ranking considering his organization, not the overall set of government stakeholders. One stakeholder consulted with three others on his staff, including expertise in engineering and architecture/planning. The three government agencies have such predictably different perspectives that one of the stakeholders, upon seeing the table, commented that he could tell which agency was which simply by its importance-ranking.

**Table 6: Performance/Impact Measures and Rankings, Weights: Government**  
**Note: Performance/impact measures are defined in Table 7.**  
**Importance-ranking/weight information presented here**  
**depends on endpoints specified in Table 7.**

Performance / Impact Measures: Government										Conceptual										
										Sens'y Analyses										
										Avg.	Pair-wise									
										Rank	Voting									
										Weight	rank	wght	rank	wght	rank	wght				
										Barron	Stakeholder Rankings/Barron Wts									
											SH1	SH 2	SH 3							
										Performance/Impact Measure	rank	wght	rank	wght	rank	wght				
1	Spin-Off Potential - Safety										.189	1	.27	1	.27	10	.02	4.0	2	
2	Δ Capital Cost										.166	5	.09	3	.14	1	.27	3.0	1	2
3	Incrementability										.151	2	.18	5	.09	2	.18	3.0	2	1
4	Upgrade/Retrofit Infrastructure										.104	3	.14	4	.11	6	.07	4.3	1	2
5	Institutional Attractiveness										.104	4	.11	6	.07	3	.14	4.3	2	1
6	Operating Burdens - Liability										.084	10	.02	2	.18	7	.05	6.3	1	1
7	Operating Burdens - Maintenance										.064	6	.07	8	.04	5	.09	6.3	2	2
8	Spin-Off - Change Existing Tasks										.047	7	.05	7	.05	8	.04	7.3	1	2
9	Δ Land Use										.045	11	.01	10	.02	4	.11	8.3	1	1
10	Operating Burdens - Detour										.024	9	.03	10	.02	9	.03	9.3	1	1
11	Spin-Off Potential - Information										.022	8	.04	10	.02	11	.01	9.7		1

Note: The rank “10” for SH 2 is the average rank of three PIMs tied for ninth rank.

The following two pages present the government PIMs, at least as they were specified by these three stakeholders. Other government agencies could have markedly different importance-ranking, and could in fact specify different PIMs.

		Barron Weight		
		SH1	SH2	SH3
1	<p><b>op ag: Spin-Off Potential - Safety</b></p> <p>Worst <span style="margin-left: 150px;">index of potential for spin-off safety benefits</span> <span style="float: right;">Best</span></p> <p>No anticipatable spin-off safety benefits <span style="margin-left: 100px;">clear spin-off safety benefits</span></p>	.27	.27	.02
2	<p><b>op ag: <math>\Delta</math> Capital Cost</b></p> <p>(assume: best AHS improves V/H from 2,000 to 3,000; worst AHS improves V/H from 2,000 to 2,200;)</p> <p>Worst <span style="margin-left: 150px;">never add high-cost infra to get less V/H</span> <span style="float: right;">Best</span></p> <p>\$70 million/L-M, to get +200 V/H <span style="margin-left: 100px;">\$0 million/L-M, to get +1,000 V/H</span></p>	.09	.14	.27
3	<p><b>op ag: Incrementability</b></p> <p>rating scale based on pro's / con's <span style="float: right;">Best</span></p> <p>Worst <span style="margin-left: 100px;">Full modularity, with interoperability, and no need to "scrap" existing components before end of useful life.</span></p> <p>One-step deployment</p>	.18	.09	.18
4	<p><b>op ag: Upgrade/Retrofit Infrastructure</b></p> <p>Worst <span style="margin-left: 150px;">None</span> <span style="float: right;">Best</span></p> <p>Extensive redesign, rebuild, scrap otherwise-useful existing infrastructure for little added capacity.</p>	.14	.11	.07
5	<p><b>op ag: Institutional Attractiveness</b></p> <p>Worst <span style="margin-left: 150px;">No government role, or flexible institutional arrangements.</span> <span style="float: right;">Best</span></p> <p>Rigid, defined government roles.</p>	.11	.07	.14
6	<p><b>op ag: Op'g Burdens - Liability</b></p> <p>Worst <span style="margin-left: 150px;">Less liability than now, through revised legal framework, contracts explicitly preclude liability</span> <span style="float: right;">Best</span></p> <p>Responsible for critical components</p>	.02	.18	.05
7	<p><b>op ag: Op'g Burdens - Maintenance</b></p> <p>Worst <span style="margin-left: 150px;">No anticipatable maintenance burden</span> <span style="float: right;">Best</span></p> <p>Important dependence on sensitive components that can't be reliably weatherproofed</p>	.07	.04	.09
8	<p><b>op ag: Spin-Off - Change Existing Tasks</b></p> <p>Worst <span style="margin-left: 150px;">Provides useful information for O&amp;M tasks, supports emergency response.</span> <span style="float: right;">Best</span></p> <p>... in operations and maintenance</p> <p>Add high-skill, critical maintenance of new infrastructure.</p>	.05	.05	.04

Table 7A: Performance/Impact Measures, Endpoints and Weights: Government

					Barron Weight	SH1	SH2	SH3
9	<b>Worst</b>	<b>op ag: Δ Land Use</b>	(assume: best AHS improves V/H from 2,000 to 3,000; worst AHS improves V/H from 2,000 to 2,200; never add high-acreage infra to get less V/H)	<b>Best</b>				
		2.9 ac/mi to get +2,200 V/H (add 1 barriered lane, +24'), or 1.45 ac/mi to get +200 V/H (convert 1 lane to barriered, +12')		0 acres (convert existing lanes) to get + 1,000 V/H		.01	.02	.11
10	<b>Worst</b>	<b>op ag: Op'g Burdens - Detour</b>		<b>Best</b>				
		Important dependence on expensive components that must be reworked for detours		No anticipatable detour burden		.03	.02	.03
11	<b>Worst</b>	<b>op ag: Spin-Off Potential - Information</b>	index of potential for spin-off info benefits	<b>Best</b>				
		No anticipatable spin-off information benefits		clear spin-off information benefits (other than for O&M)		.04	.02	.01
12								
13								
14								
15								
16								

Table 7B: Performance/Impact Measures, Endpoints and Weights: Government

### III. Insights Gained From the Stakeholders, Supporting Non-Quantitative Findings/Recs

This section presents the insights from the two focus group meetings that support the eight non-quantitative findings/recommendations presented in the Executive Summary, Section E.2.

#### Insight 1:

AHS Concepts should be developed in a needs-driven, market-driven process.

Supports points # 1 and 5 in Section E.2.

1. This calls for a particular, basic orientation for the entire Consortium AHS development process. If the existing Consortium program structure cannot adequately adopt that orientation, then the Consortium should consider reorganizing to solve that problem.
2. ITS is held as a good example of this point. It is identified in terms of transportation-user needs. ITS “fit itself into the box,” with quantified comparison with transportation alternatives. AHS has not done that. AHS thus far has seemed to be technology driven, not problem-driven.
3. Agencies like VA DOT or MPO’s identify a need, then seek ways to fill it. They must establish a need to initiate a decision. They are not oriented toward finding an application for any particular technology.
4. A needs-driven orientation will very naturally lead to different AHS configurations for the different application scenarios.
5. A market-driven orientation from the vehicle manufacturers: Their product design and introduction decisions are all keyed to the customer: The customer will buy what increases productivity, saves money and time, and improves quality of life. This follows the current management philosophy: “Satisfy customer needs and profits will follow.”  
A large-increment example: Could sell AHS on the basis of “What if you could cut your travel time in half?”  
A small-increment example: Intelligent cruise control is an incremental stress reduction.
6. Customer needs should drive both the vehicle and infrastructure sides of AHS. Market forces alone can drive vehicle-only (pre-cooperation, pre-dedicated-lane) transitions, but beyond that, you need government - vehicle industry cooperation, including in particular standards development, for an “easier sell,” from a purely market-driven perspective.
7. On the public sector side, the key here is constituents’ needs. So there is a dual perspective: AHS concepts should be market-driven on the vehicle side, and needs-driven on the government side (i.e., infrastructure and any other aspect of AHS and its implementation that is not deployed/implemented via markets).
8. Whether an incremental deployment or not, each transition from one state to another must be salable. In many cases, if not most, the initial market may be high-end, as in “Lexus Lanes.” In those cases, “market driven” should take into account the nature of that small, high-end market, and the dynamics of penetrating from there down into larger, less high-end markets.

**Insight 2:**

Incremental deployment should be emphasized, being mindful of the shortcomings that an incremental deployment brings with it.

Supports point # 2 in Section E.2.

1. Incremental deployment was generally very favored by the stakeholders. However, when we listed pro's and con's of incrementalism, the list of con's was significant (see below). Even after doing that listing, however, the stakeholders continued to favor an incremental approach. More precisely, we concluded that incremental deployment sequences should be seriously considered, being mindful of the shortcomings that an incremental development brings with it.
2. Whether incremental or not, each transition in a deployment sequence must be salable. While a non-incremental deployment may be a difficult-to-sell single transition, changing it to an incremental deployment is not necessarily a solution to that problem, since every transition in that deployment sequence must be salable, also, if the end state is to be achieved.  
One example of trying to sell a single transition: "This dedicated lane will cut your travel time in half, for \$1,500 per vehicle."  
One example of the thinking required for laying out a sequence of transitions, every transition salable: If you want to get to "brain-off" driving, then you have to figure out a state that is one salable transition before "brain-off," then you have to figure out a state one salable transition before that, and so on, or work from the current state forward, or work from both ends of the chain.
3. To make the above point more fully: Whether incremental or not, each transition in a deployment sequence must be salable, and each state must be institutionally, societally, and financially viable, including a viable liability framework.
4. Even in the most incremental deployment, it is good to lay out a "grand vision" for both planning and motivation.
5. A highly incremental deployment path must consider that, no matter how small a transition from one state to another is involved on the infrastructure side, the implementing government agency may not have money for it, so it may still have to be funded from some non-local source.
6. A highly incremental deployment path must consider that the vehicle industry will add vehicle-based AHS components and value, in some cases regardless of any longer-range deployment plan. That is specifically true for vehicle components that do not involve cooperation with other vehicles and/or infrastructure.



7. Here are two lists, first of the pro's of incrementalism, then the con's:

**Pro's of Incrementalism:**

**1. Pro:** "The Only Practical Way to Deploy AHS."

Some participants maintained that if it were possible, they would prefer revolutionary (i.e., single-transition) deployment, but that incremental deployment is the only practical way to deploy AHS.

**2. Pro:** More Easily Market-Driven

As each state is deployed, it creates opportunities for discovering market parameters (e.g., willingness to pay, demand elasticity, acceptance/penetration) that can only be found out after deployment, acceptance and use.

**3. Pro:** More Easily Needs-Driven

As each state is deployed, it creates opportunities for discovering needs that only become apparent after deployment, acceptance and use.

**4. Pro:** More Easily Coordinated Between Government and Industry

One of the biggest challenges for the Consortium is coordinating the roll-outs of vehicle advances and infrastructure. That coordination can be more feasible in an incremental approach, since deploying and operating each state is an iterative loop where information can be collected to help design the next state.

**5. Pro:** Marketability (vehicles, private sector)

Incremental changes lead to generally more easily-marketed vehicles at each incremental state than more revolutionary changes. Also, marketing could exploit early successes in particular market niches.

**6. Pro:** Acceptance by Public Sector

Intermediate transitions and states can involve little special infrastructure, deferring much of the public sector burdens that entails, and so make the AHS more palatable to the public sector.

**7. Pro:** Lower Development Risk, Better Technology Maturation

Incremental changes provide the opportunity for adjusting the technologies for the next state based on the field experience of the current state. That field experience is the only reliable way to collect information on real-world technical performance and market penetration.

**8. Pro:** Lower Deployment Risk

Incremental changes avoid the risk of a large, revolutionary roll-out that depends on coordination of multi-company vehicle roll-outs, market penetration, and multi-government infrastructure construction.

**9. Pro:** Better Development/Deployment Risk Management of Particular Challenges

For example, obstacle detection/exclusion. An incremental deployment through warning-only, then braking avoidance, then two-dimensional evasion, could have benefits in terms of iterative technical development, appraisal of the problem in the real world, and public acceptance.

**10. Pro: More Manageable Liability**

Liability and legal frameworks in general have an empirical aspect. That is, just how a liability issue is to be handled is only determined for certain after it is tested in the government / trial / appeal process. Given that, the important uncertainties concerning how liability is to be handled in each transition and state are more easily managed in an incremental deployment, where decisions about how to handle liability in future states can be informed by the liability experience of the current state.

**11. Pro: More Manageable Insurance**

The insurance industry prefers to set rates based on experience, rather than on expert-judgment estimates of accident rates in new circumstances. An incremental approach allows the insurance industry to avoid having to set rates based on expert judgment about a large change in driving operations, replacing it with the need to set rates based on a series of expert judgments about smaller changes, informed by the experience of the current state, with each set of rates then adjusted based on experience before the next change must be estimated.

**12. Pro: Early Benefits**

Incremental deployment delivers some benefits at earlier calendar dates. One example: Crash avoidance. (However, see under Con's that other benefits may be delivered at later calendar dates with an incremental deployment.)

**13. Pro: Spin-Offs**

Incremental deployment delivers some spin-offs at earlier calendar dates, both to government and to industry, resulting also in benefits to the public.

**14. Pro: Early Revenue Stream to Producers**

Incremental deployment provides opportunities for relatively early positive revenue streams for the producers of both vehicle and infrastructure components, making participation financially more attractive.

**15. Pro: Early Benefit Stream for Government**

Similarly to the above point, but in the public sector, incremental deployment provides opportunities for relatively early benefits, making it more attractive for government policy makers by shortening the time between public expenditures and benefits.

**16. Pro: Enlist Public Support, Buy-In**

Incremental deployment provides opportunities for the public to purchase, get used to, and accept incremental services, and so enlists public support and "buy-in" for future incremental transitions and the system as a whole. This can be very important, considering how governments decide how to spend their money. It can be much more important than aggregate cost/benefit performance.

**17. Pro: Easier Learning Curves, Driver Training**

From a human performance perspective, incremental deployment can provide a series of small, incremental learning curves for the users to experience, which could be easier for the user to manage than a single, larger, more revolutionary learning curve. The same point applies to

driver training, to the extent that pre-driving experiences of student drivers with current vehicles prepare them for driver training.

**18. Pro: Affordability**

An incremental approach would probably present the consumer with a series of increments in car price over a series of car purchases, which could be more affordable, or at least more easily managed in consumption behavior, than a single large increase in car price.

**19. Pro: Financeability**

An incremental approach calls for a series of financing cycles, all presumably smaller than the fewer financing cycles of a less incremental approach, both in the public sector for infrastructure, and in the private sector for vehicle components. Those smaller cycles would probably be more easily financed, because of their smaller size, because the associated risk could be less, and that risk could be more reliably estimated since it would be estimated on the basis of current experience.

**20. Pro: Better Fits Government Budgetary Process**

Incremental deployment is more compatible with a relatively even public expenditure stream from year to year, a pattern more attractive to government policy makers.

**21. Pro: Better Fits MPO Budgetary and Decision Cycles**

Incremental deployment is more compatible with MPO decision and budget cycles, which more easily deal with smaller changes.

**22. Pro: Reliability**

The vehicle industry would have an easier time maintaining reliability with an incremental approach, since adjustments could be made in the technologies of the current and next states based on field experience of the current state. This point is similar to, but not identical to, the point raised above about lower development risk and better technology maturation.

**23. Pro: Serviceability**

The vehicle industry would have an easier time maintaining serviceability with an incremental approach, since adjustments could be made in the technologies of the current and next states based on field experience of the current state. In addition, training and learning curves of the field service corps would be easier with a series of small changes, as opposed to a single large change in technologies.

**24. Pro: Sales Infrastructure, Salespeople**

The vehicle industry would have an easier time supporting its products with sales infrastructure and salespeople with an incremental approach. As with serviceability, training and learning curves of the field sales corps would be easier with a series of small changes, as opposed to a single large change in technologies.

**25. Pro: Market Development**

The vehicle industry would have an easier time developing its markets with an incremental approach, since it allows iteration and feedback loops through data collection on actual customer acceptance / market penetration.

**26. Pro: Better Timing of Standardization**

In a systems development program such as AHS, there is a most favorable time to standardize. Standardization too early tends to “lock out” advances in technology that have yet to come. Standardization too late causes wasted resources in developing technologies that are found to be incompatible, and deferral of benefits as technology-development companies defer R&D until standardization specifies a clear enough operating environment to efficiently proceed. An incremental approach allows for a more flexible timing of standardization to avoid the costs to too-early or too-late standardization. Particular industries favor particular timings for standardization. For example, to the degree that incremental deployment would defer the time when vehicles cooperate with other vehicles or the infrastructure, that is attractive to the vehicle industry, since each company has more control over its technology, and can gain experience before having to standardize.

**Con’s of Incrementalism:****1. Con: Upgradability**

Some participants maintained that it would be unlikely for an AHS car to be able to be upgraded from one version to the next version in an incremental deployment sequence.

**2. Con: Upgrading Incompatibility**

Incremental deployment leads to different versions of vehicle and infrastructure components on the road at the same time. It may be difficult to maintain compatibility among those different versions without significant performance penalties.

**3. Con: Delay in Some Benefits**

While as noted above incremental deployment can lead to some earlier benefit delivery dates than less incremental deployment, it is also true that incremental deployment could lead to deferred delivery dates for benefits related to the later states of deployment. For example, some congestion-relief benefits may not be possible until there are dedicated lanes, so sequences deferring dedicated lanes will defer those benefits.

**4. Con: Tempering Enthusiasm, Excitement**

Large, ambitious projects such as AHS depends on public- and private-sector support in advance of delivering benefits. An important part of enlisting that support can be the excitement of describing a large project and a dramatic roll-out. If AHS deployment is highly incremental, then there is no one large project and one dramatic roll-out, but instead a series of less dramatic ones. We explored what we called the “Apollo Analog,” referring to President Kennedy’s calling for the U.S. to put a man on the moon within the decade. That led to public support for one large project with one dramatic goal. At the same time, there were several Apollo missions before a man actually landed on the moon. However, the project was generally viewed and supported as having one dramatic goal. The same strategy could be taken with an incremental approach, i.e., it could be announced and presented as one large project with one dramatic goal, with several intermediate states. However, the length of time involved, and direct public experience with each intermediate state, are importantly different.

**5. Con:** Less Apt to Get to the End State

As opposed to the Apollo example just cited, each incremental transition in an AHS deployment must be sold (i.e., must penetrate its market and be accepted by the public sector) on its own merits. It could be that while a less incremental deployment may have an attractive benefit/cost ratio (broadly speaking) overall, an incremental deployment of the same general concept could have one transition in its deployment with an unattractive benefit/cost ratio. It only takes one unattractive transition to bring the deployment to a halt. That is complicated by the fact that, in the planning years of AHS development, when we must choose between concepts based in part on their deployment sequences, there is a great deal of uncertainty about the market/government penetration/acceptance of each transition, so it is difficult to determine if there are transitions in a sequence that are too unattractive for acceptance.

**6. Con:** Less Attractive to “Big-Project” Organizations

The institutional viability of AHS depends upon the desire to participate on the part of every stakeholder group. For the “participant stakeholders” (vehicle and infrastructure component producers, government agencies, insurance companies) as opposed to user/impacted stakeholders (private direct users, trucking, transit users), their participation may be contingent upon the attractiveness of the scale of the project. For some participants, their organizations may be more suited for (and attracted to) large, monolithic projects, and less attracted to a series of small projects.

**7. Con:** Less Attractive to Some Researchers

In a similar manner, the institutional viability of AHS depends upon the desire to participate on the part of key researchers. Some of those researchers, especially those from academic institutions, may be more attracted to revolutionary breakthroughs and winning peer recognition (symbolized by the Nobel prize).

**8. Con:** Less Clearly In Need of Government Support

Large, non-incremental deployment may be more obviously in need of government support, and so more able to get that support, than more incremental deployment, independent of how necessary and appropriate that government support is. That would be because of arguments that the incremental deployment could be more “pay as you go,” and so more able to be supported within the private sector. However, at least one stakeholder felt that this point (and the next point) are quite minor compared to the liability and standardization issues.

**9. Con:** Less Clearly In Need of Government Leadership

Large, non-incremental deployment may be more obviously in need of government leadership, and so more able to get that leadership and budgetary support, than more incremental deployment, independent of how necessary and appropriate that government leadership is. That would be because of arguments that the incremental deployment could be more market-driven, and so more able to be managed within the private sector. Again however, at least one stakeholder felt that this point is quite minor compared to the “enormous” liability and standardization issues.

**Insight 3:**

Institutional and legal aspects should be included as AHS concept attributes.

Supports point # 3 in Section E.2.

1. Institutional and legal aspects are an important part of AHS feasibility. If the existing Consortium program structure cannot adequately address those aspects, then the Consortium should consider reorganizing to solve that problem.
2. Financing can be key. Matching fund arrangements can be critical. The “Five Who’s” includes most critically “Who Pays.” States may insist that their budgets be “left alone,” i.e., that AHS be “revenue neutral” at the state level.
3. Financing at the government level may offer significant discrimination among technologies. For example, options requiring early high capital outlays are quite unattractive versus pay-as-you-go. This is especially true if the other, non-AHS traffic technologies being compared are pay-as-you-go.
4. Subsidies can be key. While subsidies sound attractive, on the vehicle development side, foreign vehicle companies “won’t touch” subsidies due to the perception of U.S. tax dollars going to help foreign business. They also view subsidies as risky, in that they can be cut to zero at any time. Finally, vehicle companies are oriented to customer desires, so subsidies may be viewed as pulling the companies off of that focus.
5. Another key can be the financial arrangements and responsibilities for maintenance of infrastructure. While this cuts across AHS concepts, it discriminates among them to the degree that concepts vary on the capital cost of infrastructure involved, and the expense, difficulty and criticality of its maintenance.
6. Institutional innovations for implementation can be key. For example, consider an “AHS, Inc.” to support chicken/egg deployment. It would be a private, perhaps non-profit entity, offering to set up and manage AHS in each state. It could handle liability issues. The general style could be one of “Coming soon to your state.” It would not be MPO-dependent. It would “jump out of the MPO loop,” in conventional project comparison and competition. It would require government support for only an initial fixed number of years. An analog exists: “HELP, Inc.” (Heavy-vehicle Electronic License Plate). HELP sets up a system for electronic clearance of trucks, reducing the number of weigh-ins/check-ins. It sets standards, sets up the system and network, and runs it. It was initially a government-program, but now is a public-private partnership, supported by fees it charges to the equipped trucks and by annual fees paid by the participating state governments. Its coordination between the trucking industry and governments includes provisions to avoid disclosure of truck speeds to state governments. Other analogs could be found in Information Service Providers for ITS user services in the near future.
7. How should institutional/legal aspects be incorporated?: Expand the list of attributes describing possible AHS concepts to include institutional and legal aspects. In fact, the legal aspects should include the legal framework, in particular covering how liability is to be handled. On the institutional side, each of the AHS building blocks will need to be “mainstreamed.” That is, the mechanisms need to be specified for how each building block can be handled (decided upon, deployed/sold, maintained, regulated) by normal, mainstream

institutions and operations. That should involve expertise, in institutions and law, that is not currently in the set of analysts active in the Consortium. In fact, some of the stakeholders seem to have a good deal of real-world expertise in institutions.

**Insight 4:**

Stakeholders and institutional/legal experts should be involved in concept development.

Supports point # 3 in Section E.2.

1. Stakeholders should be involved in concept development for two key reasons:
  1. That is one way to help get their concerns and insights into the AHS development process. The mechanism of these Focus Group Meetings, i.e., of eliciting PIMs, scales, endpoints and weights, is a powerful way to do that, but it may not capture all stakeholder concerns and insights.
  2. Stakeholders have particular experience and expertise in institutional and legal aspects of AHS.
2. Institutional and legal aspects of AHS concepts are quite challenging, and call for particular expertise along those lines to be involved in concept development.
3. As mentioned under Insight 3, institutional and legal aspects are an important part of AHS feasibility. If the existing Consortium program structure cannot adequately involve stakeholders and institutional/legal experts in concept development, then the Consortium should consider reorganizing to solve that problem.

**Insight 5:**

AHS options should be developed into evaluatory designs, then evaluated in terms of real-site case studies, including interfaces into the existing transportation grid/system.

Supports point # 4 in Section E.2.

1. Complying with this insight would incorporate several other insights and address other concerns. Among them:
  1. It would help the concept development process to be needs-driven and market-driven (Insight 1).
  2. It would make sure concept development addresses the systems problems of interfacing, in particular of interfacing with perhaps saturated surface grids. That could be key to characterizing the relative attractiveness of AHS for urban as opposed to non-urban application scenarios.
  3. It would help concept development address the institutional and legal aspects of deployment (Insight 3).
  4. It would help concept development incorporate Insight 6, below:
2. Some participants felt that, in order to effectively comply with this insight, the Consortium needs to continue to develop urban, intercity, and rural case studies and deployment scenarios concurrently.

**Insight 6:**

AHS options should be developed to compete with other transportation options just as they will in actual implementation: versus traditional options, in mainstream transportation planning, within budgetary constraints.

Supports points # 5 and 6 in Section E.2.

1. This is part of the “needs-driven” orientation. Local governments are not motivated to implement AHS. Their driving forces are needs for links. When a link need is recognized, then they look for a way to fill that need, and AHS is just another way to fill that need, to be compared to any other way to fill the need, using established comparison and decision-making procedures. AHS technology is simply another tool, to be evaluated on relative performance.
2. So, MPO’s want to compare AHS versus non-AHS options, such as HOV, demand management, transit. So, NAHSC should be prepared to support those comparisons, including presenting estimates of performance on the dimensions the MPO’s use in their comparisons. VA DOT volunteered to make available their decision-making procedures. One idea: Develop “shadow” alternatives to compare to AHS options, to serve as benchmarks / requirement-setting-devices.
3. Local agencies can get burned if they commit considerable financial and political capital to an AHS, then it does not perform in a popular way. Therefore, if they are to be selected, AHS options need to be presented in ways that can engender and merit the confidence of the local agency, both in terms of what dimensions the performance is presented on, and the reliability with which the system can deliver the expected performance. NAHSC must address the fact that there is considerable doubt about AHS performance forecasts.
4. Another way to word this insight is to point it out as identifying the need for a “migration path,” where each state must be explained and evaluated in such a way that the MPO understands how it will interface with the rest of its system. That is necessary for buy-in by the implementing agency. Each deployment state must also be set up to be able to optimize the performance of the MPO’s system, in the same terms and with the same analyses that the MPO uses.
5. The dimensions used for comparisons of AHS versus other local-government options are policy-laden. The Consortium should consider the policy implications of those dimensions before adopting the current dimensions. For example, a dimension like cost per new SOV is in conflict with the transit, congestion, and environmental goals of reducing the number of vehicles into urban areas. An alternative could be cost per new passenger, or cost per passenger, combined with some credit for increasing the number of passengers per vehicle and/or passengers per parking area.
6. Some stakeholders maintained that local MPO’s typically base decisions on throughput, with safety also a consideration, but often secondary or treated as a constraint.
7. The action item to bring out of this insight is that AHS options should be evaluated on dimensions used by local implementing agencies, and compared in performance on those dimensions with those non-AHS options typically considered by those agencies. A key source of data for that is the set of case studies to be conducted.



**Insight 7:****Liability is a Key, Driving Issue in AHS Development**

Supports point # 7 in Section E.2.

1. Keys:

- A legal framework that establishes confidence in the outcome of any liability question.
- Avoid complexity and lack of clarity in assigning liability.

2. Liability is such a key issue that it would be a good idea for the Consortium to take a proactive role, and convene an insurance industry committee, just as ITS America has a legal committee. That committee could be asked to do two things:

1. Identify how liability issues impact AHS development.
2. Develop a set of conditions adequate for AHS options to be insurable. Issues to be addressed would include such things as loss control, tort framework (including caps on liability), quality engineering, certainty about liability, and whatever government programs and frameworks might be called for.

These are very challenging tasks that cannot be addressed adequately without the appropriate expertise in liability and risk management.

3. Liability questions extend to the appropriate roles for the private sector and the government. Again, setting up those roles constitutes a set of strategic choices that the Consortium should be involved in, and in fact should take a proactive role in.

4. We need to consider how and when standards are to be decided upon, and then how enforced. This consideration may seem to cut across AHS concepts, but it may have some discriminating power among concepts, to the degree that concepts vary in the need for standards, the types of standards needed, and in the incremental nature of how those standards are needed and applied.

5. Liability and customer needs are among the most important concerns of the vehicle industry. That industry will not make any transitions involving a change in liability, including ambiguity in liability, until a legal framework is in place that clarifies how that liability is to be handled. The transition that is commonly considered central to a change in liability is when “brain off” operation is introduced. However, other transitions, such as lateral control or higher authorization of automatic braking, may also involve changes in liability.

6. Setting up that legal framework could be a key role of the Consortium. This is a key point. It is hard to emphasize this point enough. Frankly, that legal framework could be a make-or-break issue for AHS, so it should be a matter of primary focus for the Consortium.

7. The importance of liability means that any description of a deployment sequence should include a description of the legal/liability framework of each transition and state in that sequence. To make the point more strongly: It will be hard or impossible to evaluate a deployment sequence meaningfully without a description of the legal/liability framework of each transition and state in that sequence.

8. Liability can be a key consideration in designing an incremental deployment: The Consortium can strategically design that incremental sequence to fit in as many advances as possible before the “big steps” in liability. Specialists in liability can be consulted to advise the most attractive sequence of liability steps. Liability considerations suggest starting with

“less risky” steps, i.e., steps for which insurance rates and liability allocations can be most easily designated from experience, and deferring the steps for which insurance rates and liability allocations require larger steps away from experience. Those easier steps could include such things as ACC, then leading later to collision avoidance and finally crossing the “brain off” line.

9. At least one focus group member felt that liability concerns could actually turn out to be a “red herring” and pointed out that even greater liability issues had been effectively dealt with in other public works projects such as dams, nuclear reactors and in the development of commercial jet airplane travel. Some, but not all, states’ governmental liability limits already protect those governments very well from tort liability concerns. Extending that protection to private-sector participants may be a useful endeavor.
10. There are analogs to liability frameworks:
  - 1.) Government set up a legal framework concerning the “Extra-Safe Vehicle.”
  - 2.) The Price-Anderson Act set up a liability framework for the nuclear industry.
  - 3.) Flood risk and liability has an extensive government legal framework.
11. “Black boxes,” i.e., devices to record diagnostic parameters during a time period before a crash, may be part of the on-board suite of devices. That can have important implications for assigning liability.

## Insight 8:

Standardization / Standard Setting is a Key, Driving Issue in AHS Development.

Supports point # 8 in Section E.2.

1. There are many standard-setting committees, both inside and outside the ITS community, where decisions will be made with important impacts for AHS development. The Consortium should become a proactive member of those committees. As one key step, the Consortium should get itself invited to the Council of Standards Organizations (CSO) of ITS America. One guideline for effectiveness in this arena: “The first three rules of being effective are: 1. Presence, 2. Presence, and 3. Presence.”
2. There is a complicated system of standards and decisions that are important to AHS development, and that can restrict options available to the Consortium. For example, the February 13, 1996 “E911” FCC ruling specifies that portable phones shall be able to return location to within 150 meters by the year 2001. That in turn specifies a government-mandated infrastructure and system features with implications for state government decisions and Consortium decisions about AHS options. Other federal decisions will define frequencies available for AHS options. Out of this complicated framework, it is probably not a good idea to simply hope that the infrastructure/standards environment will remain favorable to, or even appropriate for, the most effective AHS development. The Consortium is the obvious party to represent the interests in this issue of AHS deployers and users. It follows that the Consortium should consider taking a proactive role in standard setting and in fact in any other decisions that have the effect of constraining AHS option development and use.
3. A key challenge in AHS development is the setting of standards and the integration of those standards with standards being set elsewhere, such as ITS. Standards information is being shared, but there is a massive amount of information involved, and managing it is a challenge. Action Items:
  - Ron Colgin should interact with Hamby Hutcheson.
  - The Consortium should get people on to the Council of Standards Organizations of ITS America.
4. A related point: A deliverable of the Consortium is a set of standards. However, if those standards are not delivered until the end of the Consortium’s current planned development, they will be too late, in that other standards will have been set that may constrain the options available to the Consortium. The synergy between the Consortium development work and the relevant standard-setting process should start now.
5. Before it can be started, AHS standard-setting requires a defined architecture, specifying such things as the roles of the vehicle versus the infrastructure.
6. AHS standard-setting should “use” the existing ITS “standard-setting infrastructure,” involving its existing user groups, etc.
7. AHS standards are importantly different from other ITS standards, in that AHS standards depend on the deployment of the AHS option. That presents a key challenge to AHS standard setting, since AHS options may be deployed in several very different ways.

8. The vehicle industry very much wants a clear standardization strategy, including timing, so that they can plan accordingly. Standardization is a key concern to the industry, since it is necessary for efficient delivery of AHS benefits beyond autonomous-vehicle features.
9. At least one focus group participant felt that the planned standardization efforts of the Consortium, combined with the national ITS architecture development work, may be adequate to meet the Consortium's standardization needs.

#### IV. Stakeholder Perspectives, PIM Information

These points are ones not covered in Section II or Appendix B. They were not brought up in those groupings at the meetings, and were not grouped that way by the stakeholders. They were grouped by the consultants, after the fact.

##### IV.A. Vehicle Industry (See Appendix B for an Objectives Hierarchy)

The following points are not represented, or not represented fully, in the objectives hierarchy in Appendix B or the PIM presentations in Section II.C:

1. Key motivators: Profitability is a long-term, underlying motivator, but it is not a current basis for planning. Primarily, that basis is customer needs/desires, centered on saving the customer time and money, and improving his/her productivity, including the quality of the driving experience. As for actual profitability, the implementing companies may very well lose money in the initial years. As mentioned before, this orientation follows the current management philosophy: "Satisfy customer needs and profits will follow" (perhaps in the longer term).
2. Societal Aspects, Liability: The industry is most concerned about the societal aspects of AHS, including in particular the "Five Who's" and liability, including reducing and/or defining that liability risk.
3. Generally, vehicle-intensive concepts would tend to be more attractive to this stakeholder, not only because of more AHS value-added associated with vehicles, but also because of the likelihood of more non-AHS benefits, and more opportunities for the different companies to differentiate the market.
4. Spin-off considerations may generally favor vehicle-intensive AHS concepts, and AHS concepts involving services off of dedicated or AHS-modified lanes.
5. Vehicle industry participation: With incremental deployment, the industry won't incur the risk of any intermediate state or transition between states that requires cooperation (vehicle-vehicle or vehicle-infrastructure) unless a national plan is in place.
6. The vehicle industry will seek whatever benefits it can for its customers at the autonomous or near-autonomous level. For example: reduction in run-off-road accidents (though that could involve minor infrastructure).
7. It would be good for the vehicle industry companies to work together on aspects of AHS development requiring coordination, though it will be a challenge to do that accounting for competitive pressures.

8. Internal Technical Development, Image: Several vehicle manufacturers have technologically advanced cars that represent in some cases a direct, short-term dollar loss, or at least lower-than typical return, but that are pursued for reasons of internal technical development and image. Examples include the NSX, Viper, and Prowler. Racing teams are another example of the same thing. Advanced and demonstration AHS vehicles could represent another opportunity for the same thing. That suggests two things:
- 1.) Internal Technical Development and Image are two PIMs for the vehicle industry.
  - 2.) The Consortium or some entity should lay out enough of a deployment plan that vehicle companies know which ways to advance the state of art in their advanced/demo vehicles.

#### IV.B. Government (See Appendix B for the Objectives Hierarchy)

The following points are not represented, or not represented fully, in the objectives hierarchy in Appendix B or the PIM presentations in Section II.D:

1. At least two participants maintained that institutional arrangements, partly embodied in the “Five Who’s” mattered more than throughput, or more generally the technical differences between concepts.
2. Other institutional considerations:
  - In addition to who must pay: When is it going to cost how much, and how is that to be financed.
  - How much will it require changes in local rules.
3. Planning agencies favor ease of comparison. That argues for AHS concepts presented in a way that presents clearly delineated competition with other traffic system options.
4. Planning agencies favor safety.
5. Operating agencies could favor vehicle-intensive AHS concepts, although their consultants in the highway design industry would favor infrastructure-intensive AHS concepts.
6. Air quality implications include a threshold set by the Clean Air Act requirements for “air quality neutrality,” i.e., no net decrement in air quality in certain areas.
7. One participant maintained that some state governments’ interest in AHS is primarily in its spin-offs: The technological developments needed for a fully automated AHS will address a wide variety of transportation needs -- particularly those addressing safety and communications.
8. Spin-offs not included in the hierarchy include:
  - run-off-the-road accident avoidance;
  - collision avoidance;
  - reduction of the risks of white-out driving;
  - collection of vehicle emissions performance information during check in / check out.
9. The spin-offs considered here tend to favor rural application scenarios, mixed traffic, and features that are cheap on the vehicle.
10. State differences are crucial:
  - Some states may forbid privatization of AHS control, while others may not.

- Some state operating agencies would like for operations to be handled by outside entities, while others would be attracted to expansions in their operating role, and so favor state ownership and control.

11. Two reasons some states would avoid state ownership and control:

1. The risk of being accused of “bilking the taxpayers” through expensive projects that may not deliver as much as taxpayers think it should. Those state agencies would welcome a market-driven AHS system. Obvious analogs: privately funded toll roads.
2. Anticipated problems in demands on the skills of current employees.

#### IV.C. Transit and Trucking

Several points apply equally well to transit and trucking:

1. A “slam-dunk” PIM: Compatibility with buses, and with combination trucks. The concept distinguishing PIM: Is this concept adaptable to large vehicles?
2. AHS-related decision making is concentrated at the fleet operator. Along those lines, relative to private direct users there is a clearer, more analytic orientation for evaluating transportation options in terms of “time is money,” “money is money,” and “volume is success (or at least opportunity),” and less emphasis on driver-specific PIMs. Travel time, travel time uncertainty, and reliability are more directly related to attracting business and so achieving transit goals and making money. Reduced level of driver engagement translates into reduced driver work loads, changed work rules, and reduced costs. Safety is more directly related to cost and reliability performance.
3. Travel time benefits have pronounced thresholds at the travel times of competing modes: rail for trucking and private cars for transit.
4. Costs include operator training, in addition to the usual PIMs of vehicle and infrastructure costs.
5. Both stakeholders favor incremental deployment, for several of the “pro” reasons cited in Section III.
6. Clearly, AHS planning should be coordinated with the transit system and trucking origin-destination pairs. Yet another example of the importance of interfacing AHS with the existing systems.
7. As with private direct users, transit and trucking are interested in how much AHS system benefits would spin-off onto performance on non-AHS routes.
8. An attractive feature would be convoying, with a driver in the front vehicle only, as that would enable both transit and trucking to reduce driver labor cost per “payload” delivered.
9. Desirable: Equipment compatibility: bus-truck, car-bus-truck. That can help flexibility and reduce costs due to returns to scale.
10. AHS benefits regarding throughput are not a key consideration, since buses and trucks are typically widely spaced, except for any reductions in congestion that might be realized.
11. There are location/mode specific operations that present opportunities for very targeted benefits (e.g., Lincoln Tunnel).

#### IV.D. Transit Alone

1. Transit may consider aftermarket purchases more than the other users (primary-fleet trucks, cars), though the secondary, solo trucking fleet will also be interested in aftermarket options.
2. Transit has a ready measure of negative impacts on users: number of complaining phone calls.

3. Transit enjoys a key societal norm: The farebox is typically not expected to cover more than from 20% to 40% of costs (even in Europe), the rest being subsidized by government. Thus, infrastructure for AHS can be rationally justified as subsidy.
4. A key PIM problem: If AHS success is measured in vehicles added, and those are SOV's, then AHS can induce "bad" mode-switches, and work against the interests of transit, make urban parking worse, and make urban surface grids worse. This stakeholder perspective brings up two key points:
  1. The whole systems engineering issue of interfacing AHS with the urban grid, including the surface grid and arterials, and assessing the overall impact on the overall urban transportation system.
  2. The evaluation issue of AHS impacts on broader societal impacts than simply transportation, in particular environmental and land use impacts.
5. Those systems engineering and evaluation issues cut both ways. That is, AHS presents an opportunity to help transit achieve its goals at the same time that it presents the danger of impeding those goals.
6. Spin-offs include: Spacing control for buses; coordinated train operations (which hurts trucking).

#### IV.E. Trucking Alone

1. Trucking is not monolithic. The different application scenarios involve different user needs and different competitive situations for trucking, and so different opportunities for AHS value-added.
2. What is behind the lack of participation by trucking stakeholders? Perhaps AHS is perceived as having too long-term delivery of benefits to be attractive to an industry based on a short-term market and short product-development cycle. Yet the first implementers of AHS benefits could be trucking. Also, note that trucking was quick to adopt a new technology once it demonstrated an attractive cost/benefit: GPS. We could consider what appropriate incentives could make AHS options attractive. Also note that incremental deployment sequences could be arranged to deliver benefits to trucking in a relatively short term. However, the biggest benefits for trucking could lie in dedicated-lane options, which could be difficult to implement in any short term.
3. There are many important differences between the trucking and the passenger car industry:
  - The lag between introduction of a component and when it is on the road:  
car: 3 to 5 years; truck and bus: 6 months.
  - vehicle components of trucks and buses are much more modular, and a truck owner can specify components made by different manufacturers.
  - trucks and buses are more systematically managed by fleet managers. That means that "customer needs" may differ quite a bit from private car customers. Most notably, the fleet manager could put a much higher weight on cost, reliability, travel time savings and predictability, and so much lower weight on every other PIM, and would attend to Quality of Driving Experience PIMs only as they relate to driver productivity. As an example of that systematic management, large trucking fleet owners have developed



- instantaneous and thorough diagnostic systems, and so can gain economic advantage by purchasing without warranty at a discount, making use of their own service centers.
4. Trucking will purchase a component as soon as it is cost-effective. The motivation for accepting AHS technologies is easier to understand for the trucking industry than for private users: The industry is favorable to adopting any technology that lowers operating costs or gives the implementor a competitive advantage.
  5. At least one participant felt that some of the disappointment felt by the trucking industry with ITS has to do with its failure to establish what could be considered to be an appropriate level of standardization.
  6. ITS benefits will have cycled out into the primary trucking fleets within 3 to 5 years. After that, those components will cycle out into the solo fleet. Those benefits include:
    - “seamless” border clearances (electronic one-stop permitting, with no stateline stops).
    - weigh-in-motion (though note that the federal government saves more with that than do the trucking companies).
    - cargo tracking
    - automatic vehicle location (AVL)
    - driver management
    - crash recording
    - possible reductions in blind-spot accidents.
  7. There are reasons for trucking to participate in AHS. AHS could help with regard to:
    - “co-habitation” problems between trucks and cars, with help through, among other things: driver management (logs); regulation of high-speed, long-distance traffic; ABS and closure braking.
    - standardization.
    - communication with infrastructure.
    - electric vehicles for staging, i.e., positioning and coupling trailers.
    - driverless trucks, though logistical problems could limit this, and three-trailer rigs could have a similar benefit.
    - AHS could help prevent or mitigate runaway truck incidents.

#### IV.F. Insurance Industry

1. A first cut at PIMs (this is just the start of a list, thought-starters):
  - clarity of liability;
  - engineering uncertainty;
  - financial strength of all of the AHS implementing participants;
  - incrementability, especially with regard to managing liability, and maximizing the degree to which insurance rates can be experience-based;
  - willingness to risk-share among participants;
  - standardization, in particular with regard to underwriting comfort;
  - conservative field deployment, i.e., using only technologies proven in field applications;
  - redundant safeguards.

2. Mixed-traffic operations raise enough questions about liability and coverage, it may be difficult or impossible for the insurance industry to provide coverage. That is a stronger statement than saying simply that the insurance industry would need a clear legal framework before coverage could be provided.
3. Generally, the attractiveness of an AHS concept to the insurance industry is a function of:
  1. Expected value of actual losses per year and per customer, functions of accident frequencies per year, rates per VKT, and severities.
  2. The allocation of the liability of those losses among drivers, vehicle industry, vehicle electronics industry, infrastructure designers, builders, and maintainers, and other government agencies. Specifically, the amount of business the industry would realize is a function of how that liability is allocated between self-insured entities and entities who would use the insurance industry to cover risk.
  3. How clearly the liability is allocated among the parties just listed. The less clear that allocation, the higher the difficulty of predicting loss rates, and the higher the overhead in legal actions.
  4. The predictability of the risk. The industry wants to avoid situations where it must set rates based on expert judgment, as opposed to actual risk experience, and to avoid situations where that expert judgment must involve predicting risk for new situations more greatly different from current experience. This breaks down into two related subconcerns:
    - 4A. Incrementalism: The more incremental the deployment, the more attractive to the industry, since then rate-setting for new driving environments would involve expert judgment (as opposed to actual risk experience) on smaller changes from current experience, and could be based in part on experience in the current state. A related point: The more revolutionary the change, the higher the insurance rates, at least initially, since the industry would be setting rates based on expert judgment under higher uncertainty, and would be financially conservative (i.e., erring on the side of higher rates) in setting those rates.
    - 4B. Novelty: The more different the situation, the less attractive. For example, a platoon-intensive concept is less attractive than one without platoons, because that is such a different situation than current experience.
  5. The degree to which the risk can be pooled among insurance industry entities.
  6. Legal overhead due to factors other than clarity of allocation. This is a point related to Point 3 above, but different. Regardless of how clearly the liability is allocated, if it is allocated to one party alone, litigation will involve fewer lawyers than if it is allocated among several parties. Also, the degree to which the liability situation is set up as “no-fault” of course matters a great deal.

In addition to this general framework, the following points apply:

4. Another factor affecting the attractiveness of an AHS concept to the insurance industry is size of market. That is, if a deployment sequence results in a small number of drivers in a particular risk situation, that is unattractive from the point of view of risk pooling, and is more unattractive the longer it lasts. It is unclear which deployment sequences would result in that situation.

5. Generally, the insurance industry would favor AHS, because to the extent that it increases the VKT, and improves quality of driving experience, it increases the general use of liability coverage.
6. Generally, vehicle-intensive concepts would be apt to be more attractive to the insurance industry.
7. States vary importantly in legal frameworks, so AHS liability and insurance industry concerns about AHS vary from state to state.
8. It is unclear whether risk would increase or decrease with AHS. For example, increased miles driven could increase risk, yet some AHS features (like preventing run-off-road accidents) could reduce risk per mile driven.
9. AHS could change the distribution of accident severity, which in turn would change patterns in co-payments.
10. For most of the points raised here, it is unclear how they vary among AHS concepts. That linkage will require careful analysis by credentialed expertise.

#### IV.G. Vehicle Electronics Industry

##### 1. Vehicle Electronics Industry as a Stakeholder:

While an important participant, vehicle electronics is not seen as a proactive “driver” of the development process. Vehicle manufacturers have been transferring more product development over to the electronics industry, e.g., having that industry propose how to manufacture to a particular concept. But typically the electronics industry follows specs provided by the vehicle manufacturer. AHS technologies related to vehicle electronics are generally available. That industry’s main role, then, is in the understanding of production. The main way that vehicle electronics industry performance affects AHS development is simply in the time lags between specification and delivery. In those cases where the electronics industry has taken the initiative in product development (e.g., radar), the results have not been satisfactory, in terms of an implemented product. At the same time, we should keep in mind that there are a number of Japanese and European companies that will be supporting other AHS developments overseas. Their potential for affecting the development of the American program should not be underestimated.

2. There was some discussion as to whether or not any differences between AHS concepts would be “crucial” for the vehicle electronics industry. That is, would some concepts be so unattractive to that industry that it would not participate, and refusing to participate would prevent deployment. No solid conclusions were drawn - it was left as an open question.
3. It was unclear whether AHS would lead to an increase or decrease in the vehicle electronics aftermarket.
4. Generally, vehicle-intensive concepts would tend to be more attractive to this stakeholder, not only because of more AHS value-added associated with vehicle electronics, but also because of the likelihood of more non-AHS benefits (i.e., off of dedicated or AHS-modified lanes).

5. Spin-offs could include radar development, sensors, and communications technology.
6. The vehicle industry is the customer of the vehicle electronic industry. Therefore, the main criterion for AHS participation of the vehicle electronics industry is the determination of the vehicle industry to participate.

#### IV.H. Environmental Protection

1. AHS development and deployment needs to be considered within a broader evaluation framework than simply increasing transportation capacity and performance, and serving transportation user needs. Other societal impacts are important, and could be key. For example: induced transportation demand, induced growth in general, and induced land use patterns in particular (i.e., sprawl, or concentration along dedicated lanes or transit enhancements) could be major impacts, as important as any other impacts of AHS.
2. AHS offers opportunities for environmental protection. Not only possible reduced emissions, but also other possibilities, e.g., monitoring and enforcement of environmental performance (see Insight 8 above).

#### IV.I. Highway Design Industry

1. This industry serves the same function as government design agencies, and does not involve crucial distinctions among AHS concepts. That is, the concepts will not vary in ways that would cause the highway design industry to decline to participate in some concepts, and so prevent those deployments.
2. Generally, the highway design and construction industries should of course like new infrastructure, though it is unclear how that differs among AHS concepts, since one concept might involve more expensive infrastructure, but fewer miles of it. We should not assume that state highway design agencies would favor new infrastructure - some might favor less, though their consultants would probably favor more new infrastructure.

#### V. Concerns, Guidance for the Consortium, Case Studies, Sundry Topics

These points were not brought up in these groupings at the meetings, and were not grouped that way by the stakeholders. They were grouped that way by the consultants, after the fact, and in some cases the groupings are a little on the arbitrary side.

#### V.A. Concerns, Guidance for the Consortium

1. General guidance for AHS option development: Don't necessarily design an "optimized," "best" option. Rather, concentrate on satisfying user needs. This is a fundamental point. AHS options can be developed to optimize some engineering aspects of performance, but that won't necessarily result in an attractive product.
2. A key point is that AHS must be flexible in deployment, to meet the very different needs of, for example, Houston versus Colorado. That flexibility must also be communicated effectively. Flexibility must always be balanced against interoperability. The main constraint of interoperability is that, of course, a national-range vehicle (i.e., private,

national commercial, national bus) must be able to operate effectively in both Houston and Colorado.

3. The PIMs for AHS options should be based on the “agenda’s” involved. Those include:
  - the management of the transportation network;
  - the management of the national “fleet” of vehicles (cars, trucks, buses, etc.);
  - safety considerations;
  - environmental quality.The latter two are directly covered by PIMs in the existing set: Safety and Societal, Environmental Impacts (see Section II.B.2). The first two involve a systems orientation for the AHS development process, which can be guided by the other PIMs identified in this focus group meeting. However, they do imply a wider scope for the evaluation than has often been supposed. That is, the first two “agenda’s” listed above suggest a development process guided by the anticipated performance of the entire transportation network, as opposed to focusing on the performance of the AHS components within that network.
4. In a more general sense than standardization alone, AHS should “build on” other ITS applications. That is, it should recognize the interfaces, and pay particular attention to ITS decisions that may have the effect of “locking in” particular transportation features that limit future AHS decisions.
5. AHS development should maintain consistency with the Precursor System Analysis (PSA) work. Bill Stevens can be identified as a “PSA conscience” for AHS.
6. AHS PIMs related to congestion call for a systems approach, in that the interface with existing traffic networks has to be considered.
7. Yes PIMs are an effective first step in specifying system requirements, but those requirements must include specifying the conditions under which the requirement applies.
8. There are a lot of considerations surrounding AHS that may not be easily fit into a PIM framework.
9. We should be more clear that “AHS” could mean very different things, and could operate very differently, in different application scenarios.
10. We may need to identify different PIMs for different application scenarios.
11. AHS should be represented as offering other things than throughput (such as travel time and safety), especially in cases such as urban application scenarios where AHS must be interfaced with the urban streets, and in rural areas where safety and peace of mind may be the benefits of most interest.
12. Roles of the Consortium:
  - Key role: integration of infrastructure and vehicle.
  - Related role: Coordinate roll-out plans between vehicles and infrastructure. The vehicle industry has and is developing long-term roll-out plans for a sequence of vehicles. There is a need for coordination between those plans and infrastructure roll-outs, as well as coordination among companies where vehicle-vehicle cooperation is involved. Roll-out planning should involve stakeholder inputs.
  - Develop standards.

13. The Consortium should develop “Straw Dogs,” and consider doing some of that development in the Focus Group Meetings, which would be an expanded role for those meetings. A “Straw Dog” is a concept that is fleshed out, including institutional features, answers to the “Five Who’s,” and a deployment sequence, as well as the attributes currently considered. We should make a systematic effort and process to key each Straw Dog to user requirements.
14. The PIMs related to “Quality of Driving Experience” may need to be developed with specific focus groups and other market research techniques.
15. Of the three deployment sequences presented to the meeting, the only one considered attractive was the one that deferred a dedicated lane to the latest state, chiefly because of that fact. Specifically, that sequence was viewed as most closely matching the preferences of the vehicle industry and the DOT’s, because, to those stakeholders, a dedicated lane was viewed as very challenging to introduce.
16. The other timing consideration elicited by presenting those three sequences was that the transition into the “Fully Automated” state was considered especially significant, since that is when a legal framework addressing liability would be a necessity for participation by some stakeholders (certainly the vehicle industry and probably others). Though as noted before, other transitions could also call for a revised legal framework. The fact of the matter is, the determination of need for a revised legal framework requires specific legal expertise, and even with that, would involve significant uncertainty.
17. We should consider a decision tree format for planning Consortium development and deployment sequences. One reaction from a stakeholder (paraphrasing): “That’s the way it should be done, if people can understand it.”
18. Market-driven development and deployment is key, and the vehicle industry has highly developed mechanisms and expertise for evaluating markets for new products, involving focus groups, test markets, consultants and organizations like J.D. Power, and proving out in other countries. Therefore the Consortium should consider ways in which those mechanisms and expertise can be tapped. Stakeholders acknowledged the difficulty of using corporate marketing information, since most of it is proprietary and strategic. But perhaps some information, mechanisms, and/or procedures could be developed or made available at an industry-wide level. At the same time, stakeholders pointed out that concerning markets for new products, “nobody really knows until you introduce it.”
19. We should consider that the current mechanism for stakeholder involvement (i.e., these Focus Group Meetings, Forums, and Workshops) does not bring all relevant stakeholders to the same table the same way. The more obvious examples are those stakeholders on the Consortium stakeholder list that were not represented at the Focus Group Meeting, but more generally, we should recognize that some stakeholders, e.g., certain environmental interests, may want to operate at a political level outside of the Consortium process. That presents problems as to how best to incorporate those interests in a balanced, consistent way.
20. There needs to be more clarity in the general federal/state/local agency / public’s mind about what, exactly, an AHS is. For example, in some cases an AHS is considered hands-off/feet-

off/dedicated lane. If we are considering broader options, it is important to communicate that. In general, we need to communicate what we are considering as AHS options, and we need to do that quickly and clearly to a broad public/government audience, not just our immediate supporters/members. There needs to be more communication to clear that up. One confusion: Tests conducted on dedicated lanes may create the expectation that you have to have dedicated lanes to have AHS. If mixed-traffic operations are to be considered after dedicated-lane tests, that should be made clear.

21. We need to consider special users, such as elderly drivers, handicapped drivers, and other drivers with special needs. In fact, perhaps we need to do a survey to characterize the spectrum of driver types and driver needs.
22. AHS will require changes in local rules. Those changes can be made, but we need to consider what those changes will be, and how they will come about. There is an interaction between this consideration and funding mechanisms, since federal funding can make possible the circumvention of certain state laws.
23. Virtual barriers may involve psychological burdens. That is, if the only thing separating manual and AHS lanes is an invisible barrier, then one or perhaps both sets of drivers may be uncomfortable with the differences in flow in adjacent lanes (e.g., relative speed, spacing, platooning).
24. A very reality-based look at incremental deployment including mixed traffic forces us to face the fact that mixed traffic includes mixed with trucks, with all that entails.

## V.B. Case Studies

1. Key motivations of case studies:
  - to operationally test AHS concepts
  - to communicate AHS concepts and benefits/impacts
  - to help internal selection of concept attributes
  - to promote discussion
  - to provide a more easily visualized basis for providing stakeholder feedback on the desirability of various attributes.
2. Case Studies will include comparison with non-AHS options, including a “shadow MIS (Major Investment Study).”
3. Case study PIMs are to be developed in the course of the case study. A key idea along that line: Ask Case-Study-Site local stakeholders for PIMs. Then present the results of each case study in terms of those PIMs.
4. Another idea for a case study focus group: Participants should include people with expertise in bringing projects through complete implementation.
5. In case studies, it is not necessarily a good idea to involve the local government as an active partner in the design of the case study. That local government may have a different agenda from the Consortium’s, which is of course to carry out the most effective case study it can. It may be better to keep the division of labor clear: The Consortium is the sole party designing the implementation of the case study. At the same time, it is a good idea for the Consortium to seek “local champions” to help carry out the case study.

## V.C. Sundry Topics

### Participation in future focus groups.

1. In general, of course, seek representatives from stakeholder groups not yet well represented in the two focus group meetings reported on here. In particular: environmental protection, highway design and government agencies not yet represented.
2. In addition, there is a need to seek broader representation from the stakeholder groups already represented.
3. We should seek diverse opinions from other quarters besides the stakeholder groups.
1. Suggested participants for a Focus Group for implementing government agencies:
  - operations and maintenance (O&M) (One pitfall of AHS can be that its O&M can call for skills different from those of current O&M employees. This may call for special measures, including institutional innovations such as a new institution for AHS O&M.)
  - Attorney General’s Office. There are several questions to be resolved concerning possible legal agreements, public-private institutional relationships, contracts, obligations, legal frameworks, etc. For example, a key question: Is the government allowed to make money related to AHS?
  - MPO and/or transportation planning representatives, being sure that includes representation of the involved transit agencies, other local government agencies, etc.



- Traffic engineering design representatives, who are familiar with the existing infrastructure, and with project planning experience.
  - I-95 representatives.
  - (secondary importance): Highway Patrol, regulatory agencies.
2. Suggested participants for a Focus Group for vehicle industry:  
Need representation from a large U.S. company, such as GM. Recommendations for the experience of that representative included both a “guru” of advanced technology and somebody with experience with a platform, specifically not from R&D (which is represented directly within the Consortium). Perhaps the group should include both types of expertise.
  3. Suggested participants for a Focus Group for trucking:  
Lloyd Henion, Bill McCall, Tom Mays, CVISN (including recent awardees of CVISN model deployment).

#### Other Sundry Topics

1. AHS raises a clear need for coordination between government and the vehicle industry.
2. The vehicle industry can continue to develop technologies without standardization until the car must communicate with other cars and/or the infrastructure. That is the critical point.
3. Linked point: Some stakeholders maintained that you need to interact with the infrastructure in order to address urban traffic problems. So urban problems cannot be addressed without standardization on information transfer.
4. There is a need for vehicle industry participation broader than current members of the Consortium. We can expect that the other companies (e.g., Chrysler, Ford, BMW, Daimler-Benz) will begin to participate once standardization becomes an issue, which happens once the system goes beyond autonomous vehicles. However, that may involve other standardization agencies, such as SAE. This is another set of considerations where there may be an advantage to incremental deployment.
5. On the vehicle market side: If the buyer buys a capability, he or she will want to use it.
6. A key value tradeoff concerns performance/impacts in different time periods, i.e., in each of any intermediate states and in the end state. For some or many stakeholders, and for the political decision making process, that tradeoff may be very different from some normative time discounting rate, in the direction of a very high weight for the near term versus intermediate term and long term.
7. The split in operating costs, between direct and indirect, is affected by “the stroke of a pen” (e.g., tolls versus taxes), and so we can only consider total operating cost in evaluation at this stage.
8. We shouldn’t lose sight of the fact that the current infrastructure needs work. So AHS plans should be compared versus transportation improvements including infrastructure maintenance.
9. There are technical solutions that should always be considered in assembling options. For example: electronic toll collection.

11. Every technological transition and state, e.g. going from cruise control to adaptive cruise control, suggests new bases for evaluating the AHS system, and suggests new features of application scenarios.
12. Obstacle detection/exclusion is key. Some stakeholders felt that highway infrastructure can't fully manage obstacle risk, either through exclusion or infrastructure-based detection. Also, state governments will differ on how they will want to handle obstacles. Those considerations favor vehicle-based obstacle detection/avoidance. Incremental deployment could be key, here (e.g., warning-only, then braking avoidance, then two-dimensional evasion), for iterative technical development, appraisal of the problem in the real world, and public acceptance.
13. We have to consider realistic societal learning curves, i.e., the time we can expect it to take for people to get used to using new technologies, and to significant changes in the driving task. For example (this example from Workshop #3), now, with "fully brain-on" driving, it is estimated that it takes about seven years for a person to fully "learn" to drive a car. How long will that process take if it includes periods of "brain-off" driving? Also, what does that tell us about how long it will take for AHS-related significant changes in the driving task to be fully learned?
14. A related point, crossing over to institutional implications: What are the implications of AHS for driver training? ... for licensing?
15. AHS can be considered fundamentally a human factors / human performance challenge. We should consider organizing at least certain aspects of deployment sequences and options in a way centered on the human performance tasks involved. For example, obstacle exclusion/avoidance sequences might be organized and timed in a way guided by arranging that as the most effective (or most painless, or quickest) sequence of driving learning states, tasks, and requirements.
16. The focus for evaluation should remain spread across the several major PIMs, avoiding too narrow a focus on any one PIM, such as throughput. In certain application scenarios, real-world delivered throughput is not going to be a major selling point, but other PIMs will be selling points. In keeping with the vehicle industry's focus on driver desires, we need to make sure the focus for evaluation includes PIMs that fully capture quality of driving experience.
17. The application scenario of feeding a saturated surface grid is a thought-starter. Several started thoughts:
  1. The attractiveness of AHS for that application scenario may not be fully captured unless it is measured on other PIMs as well as throughput.
  2. That scenario suggests that more compelling arguments for AHS might be made with other application scenarios, such as inter-urban, rural, and transit-urban.
  3. On the other hand, if the implementing agency is comparing AHS to more lanes, or to increased bus service, then yes, throughput remains an important PIM on which to make such a comparison.
  4. This application scenario is a good example of the advantages of addressing the needs/concerns of the implementing MPO.

18. Once you have a dedicated lane, you shouldn't limit yourself to simply normal-like cars going down a normal-like lane. It has already been suggested that such lanes can be built as a "single-class-vehicle" lane (i.e., no heavy trucks), and so save considerable money (with lower weight-bearing requirements) and space (with a narrower lane). But why stop there? Why not consider cars with power pickup from the lane? Or public cars? Or special buses? Or ...?

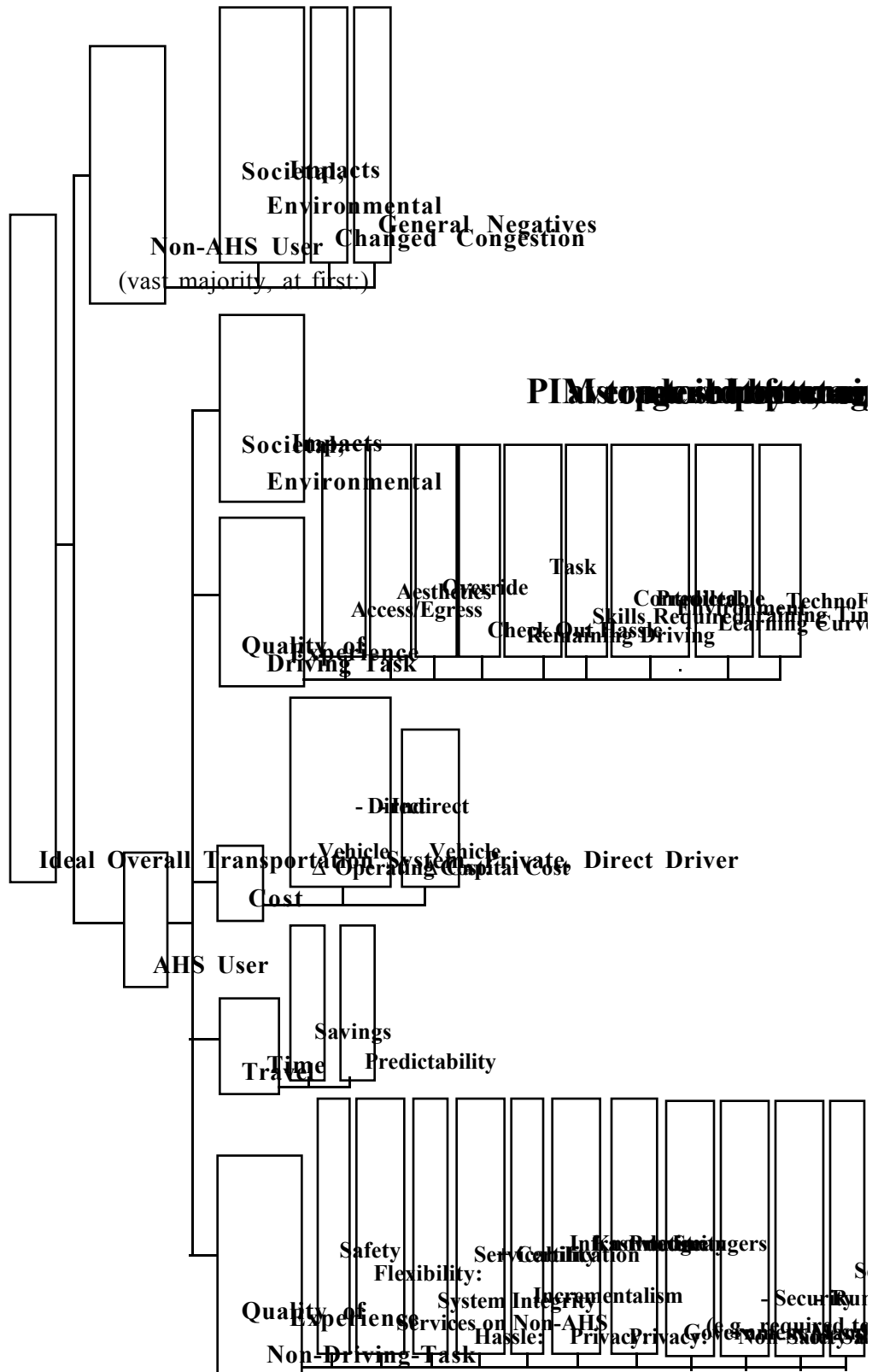
Appendix A: Acronym Glossary
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$\Delta$	Difference, Incremental
ACC	Adaptive Cruise Control
AHS	Automated Highway System
ac/mi	acres per mile
DOT	Department of Transportation
DOD	Department of Defense
FCC	Federal Communications Commission
FGM	Focus Group Meeting; FGM-1 = FGM # 1, September 10-11, 1996, Hughes, San Diego. FGM-2 = FGM # 2, November 5-6, 1996, PATH, Richmond.
GPS	Global Positioning System
ITS	Intelligent Transportation System
L-M	Lane-Mile
MOE	Measure of Effectiveness, later changed to Performance/Impact Measure (PIM)
MPO	Metropolitan Planning Organization
O&M	Operating & Maintenance
op ag	operating agency
PIM	Performance/Impact Measure, originally termed Measure of Effectiveness (MOE)
SAE	Society of Automotive Engineers
SH	Stakeholder
V/H	Vehicles per Hour
veh	vehicle industry
VKT	Vehicle-Kilometers Traveled

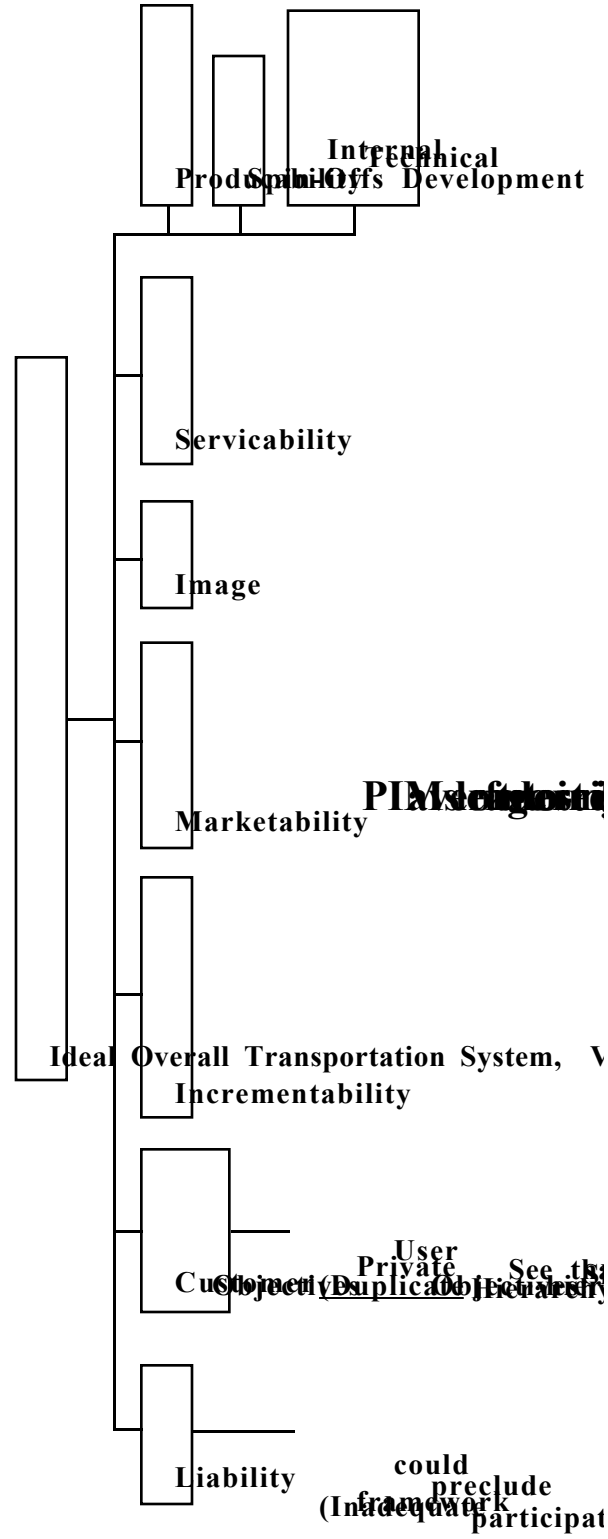
Appendix B: Objectives Hierarchies

The following pages present objectives hierarchies for three of the stakeholder groups. While information was collected that could be used to develop objectives hierarchies for other groups, these three are the only ones we had time to review with the stakeholders for their approval.

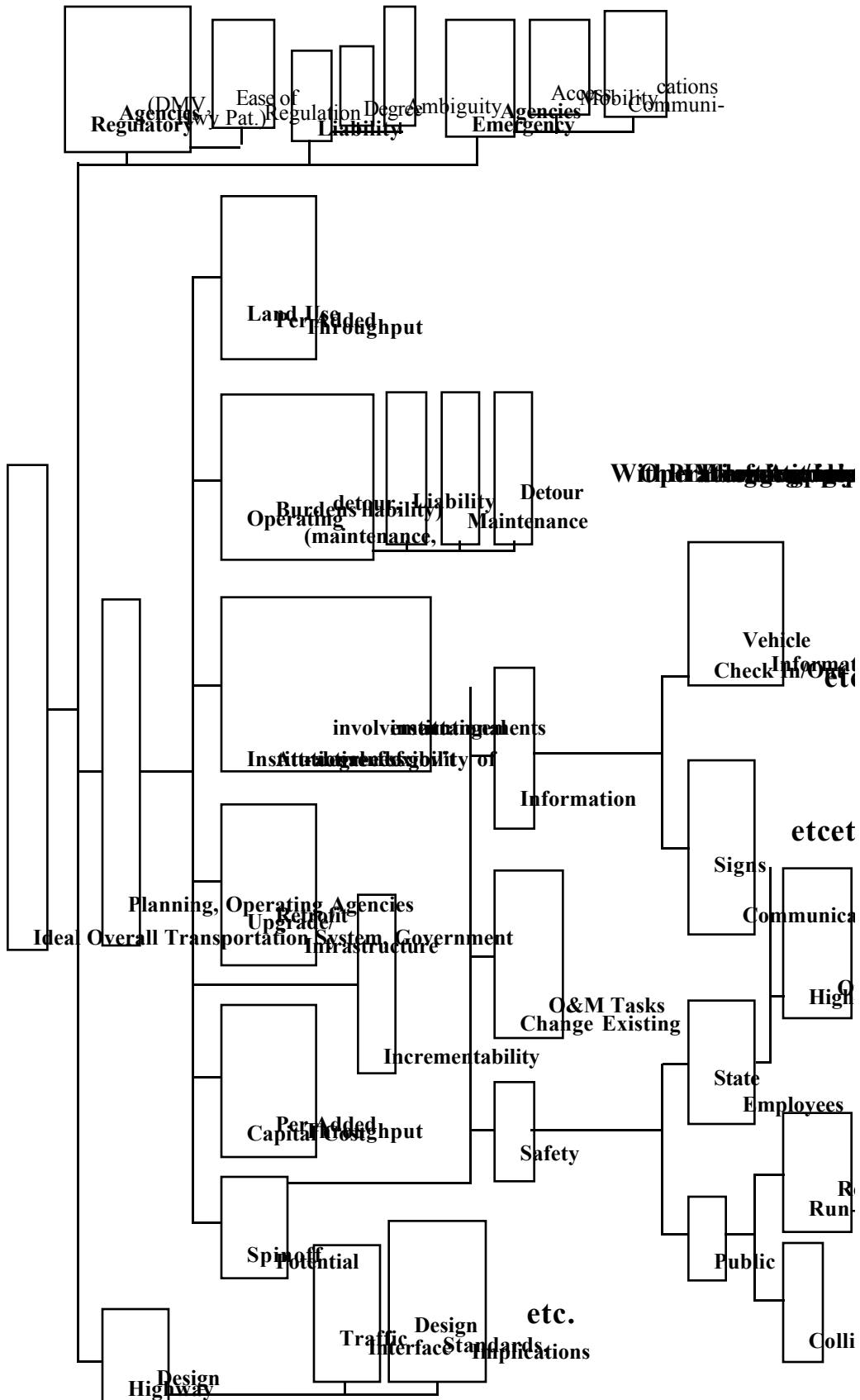
Objectives Hierarchy for Private, Direct Driver.



Objectives Hierarchy for Vehicle Industry.



Objectives Hierarchy for Government.





Appendix C: Summaries of Evaluation Forms

Responses are coded by respondent code number. Stakeholders are #'s 1 through 7. Consortium representatives are #'s A through C. "1-1b)" means the answer to 1b) by respondent #1.

**1. Social Decision Analysis (SDA) evaluation framework**

Please indicate whether you agree with the following statements:

- a) There is an appropriate place in the evaluation framework for each major substantive issue of concern to my stakeholder group.

5	3,6,4,A	2	C	7	1	B
Strongly Agree			Neutral			Strongly Disagree

- b) With further improvement, the framework can be useful for incorporating stakeholder inputs to AHS concept development.

2	3,4,6	A	7,B,5	C	1
Strongly Agree			Neutral		Strongly Disagree

- c) The framework shows potential for facilitating consensus building among stakeholders on major decisions regarding AHS.

3,4,6	A	7	5	C	2	1	B
Strongly Agree				Neutral			Strongly Disagree

(Optional) Please expand your opinion with comments below:

- 1-1b) Need more stakeholder involvement in the process, Vehicle Industry and State DOT / Transit input is not enough.
- 1-1c) Not enough input, may not get buy-in.
- 1-1all) Overall, I think the SDA process is a good method, however, I think more input is needed from the other stakeholder groups (Trucking, Vehicle Electronics, etc.) to realize benefits.
- 1-1all) Final results from FGM may affect the above opinions.
- 2-1c) Answer depends on whether the products of this meeting are carried forward to next round of stakeholder presentations. If stakeholders look at the material without seeing the PIMs/issues of interest to them (as opposed to AHS technical PIMs), they will be turned off and less likely to understand, therefore less likely to form consensus.
- 2-1all) SDA framework is appropriate in drawing out stakeholder issues and concerns. Potential not fully realized due to volume and complexity of materials presented at the meeting.
- B-1all) A concept should be an idea about how to solve a set of customer (or user) requirements. All customer requirements have not yet been identified, so today's concepts are incomplete. But this process has helped in determining what the customer (user) wants from an AHS.

C-1all) Best discussions were less structured, stakeholders telling what key issues and needs are.

**2.. Focus Group Meeting (FGM)**

Please indicate whether you agree with the following statements:

a) I have been able to follow the presentations at the FGM easily.

3,B A 4	C 7,6	2	1	5
Strongly Agree	Neutral			Strongly Disagree

b) I am satisfied with my participation in this FGM.

3,6 A 4,7	B,2 C	1	5	
Strongly Agree	Neutral			Strongly Disagree

c) My inputs at this FGM will likely have an impact on the AHS program.

5	3,6,A	2	B 4	1	C 7	
Strongly Agree	Neutral				Strongly Disagree	

(Optional) Please expand your opinion with comments below:

5-2c) I hope.

7-2c) Facilitators for this FGM listen well, but that does not mean that the FHWA and Consortium members will.

A-2c) I would like to think so.

**3. Future Steps**

Please give your opinion regarding future steps:

(a) whether a 2nd FGM should be held soon:

2,4,C- Yes. 7- Nov.

(b) if so, who should be invited to the 2nd FGM:

2,C- Same attendees, if possible, but also add Stakeholders not present in September.

4- Add additional private interest user and insurance representative.

(c) what roles, if any, the SDA Evaluation Framework should or could play in future stakeholder group workshops (like the one to be held next week in Minneapolis):

2- Bringing the technical concept development and deployment strategy development (e.g. social, institutional, etc) closer together is vitally important. Technical not sufficiently far along to provide meaningful basis ...

3- Continuing

C- Keep PIMs at high level, Key issues, non-tech

(d) what roles, if any, the Evaluation Framework should or could play in the next phase of AHS concept development:

4- Participate in development.

7- Modify our purpose for reality check, forgotten issues.

C- Non-tech attributes and their options defined.

Development of evolutionary path, alternatives, describe and assess the means to get from one step to next.

Answers to Question 3 in general:

3- A second FGM should be held, hopefully in S. Calif., and one has to make sure that the environmental sides are presented.

However, the group should bring forward the new concept of AHS, so that a lot of time and effort is not wasted “bashing” the dedicated lane / platooning issue.

5- Yes. Ensure insurance industry (practitioners) are there to explain what they can really do to affect deployment. Also invite MPO's. Vary invitees to either confirm concerns or introduce new ones. Regarding SDA, drop it. It would be more beneficial if a “strawman” is developed for T.E. people to touch, taste and smell.

6- The SDA is very important to incorporate the realities of each stakeholder's environment into the plan for AHS deployment. Without the SDA it will be very difficult to get a realistic plan for AHS deployment.

6- Stakeholder viewpoints on PIMs and deployment issues should be incorporated as soon as possible, or NAHSC credibility is at stake.

A- Need wider participation of other stakeholders.

A- Need to incorporate real world (PIMs) into SDA.

# **Slides of a Stakeholder Focus Group Meeting:**

---

## **The Point of This Meeting:**

**We need your help to figure out  
how to evaluate concepts,<sup>1</sup>  
to guide reconception<sup>2</sup>  
toward a consensus solution.**

<sup>1</sup> **A feasible combination of concept attributes.**

<sup>2</sup> **Combining concept attributes into desirable concepts.**

## **Our Key Goal:**

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- **Get your insights / concerns / issues / preferences into Consortium decision making.**
- **Get your insights / concerns / issues / preferences into the most usable form to advise/affect Consortium decision making.**

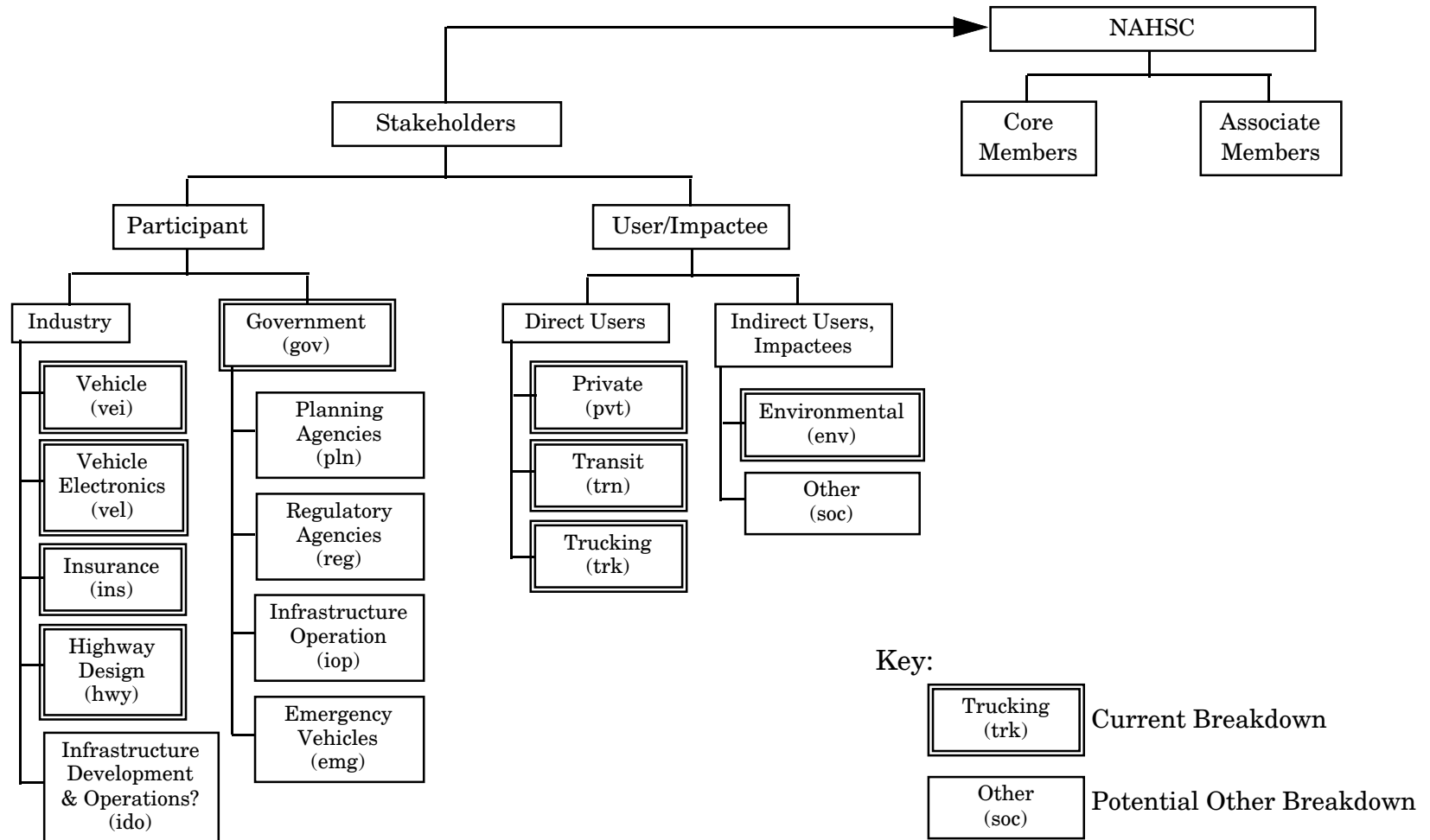
# **The Role of Stakeholders**

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- 1. Any sound systems analysis needs evaluation measures to use as a basis for guiding system development. We have to “know which way is up” for stakeholders. Those measures are  
“Stakeholder Measures of Effectiveness” (MOEs)**
- 2. The MOEs used here are designed to reflect Stakeholder preferences,  
and so incorporate those preferences directly in the development/reconception process.**



# Stakeholders, Players



## **So Here's Our Plan for This Meeting**

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**I. Introduce Evaluation Framework**

**II. Elicit Stakeholder Concerns, Anticipated Benefits and Impacts,  
Including Spinoffs and Deployability/Transition Concerns**

**III. Identify How to Capture Those With  
Stakeholder Measures of Effectiveness (MOEs)**

**IV. Identify Stakeholder Criteria for Participation in Development,  
Including Strategies to Maximize Participation**

**V. Evaluate and Suggest Improvements In**  
**- Evaluation Framework**  
**- Focus Group Meeting Process, Including Invitees**

## **Now Let's Start In On Our Agenda:**

### **I. Introduce Evaluation Framework**

**Map Current Stakeholder Issues Into Framework**

### **II. Elicit Stakeholder Concerns, Anticipated Benefits and Impacts, Including Spinoffs and Deployability/Transition Concerns**

### **III. Identify How to Capture Those With Measures of Effectiveness (MOEs)**

**Identify an Assessable Unit Scale for Each MOE**

**Estimate Endpoints for Each MOE Scale**

**Elicit Relative Importance of MOE Scales**

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**Identify Concept Features Important for Decisions to Participate, and Affecting Relative Attractiveness of Concepts, Including Spinoffs**

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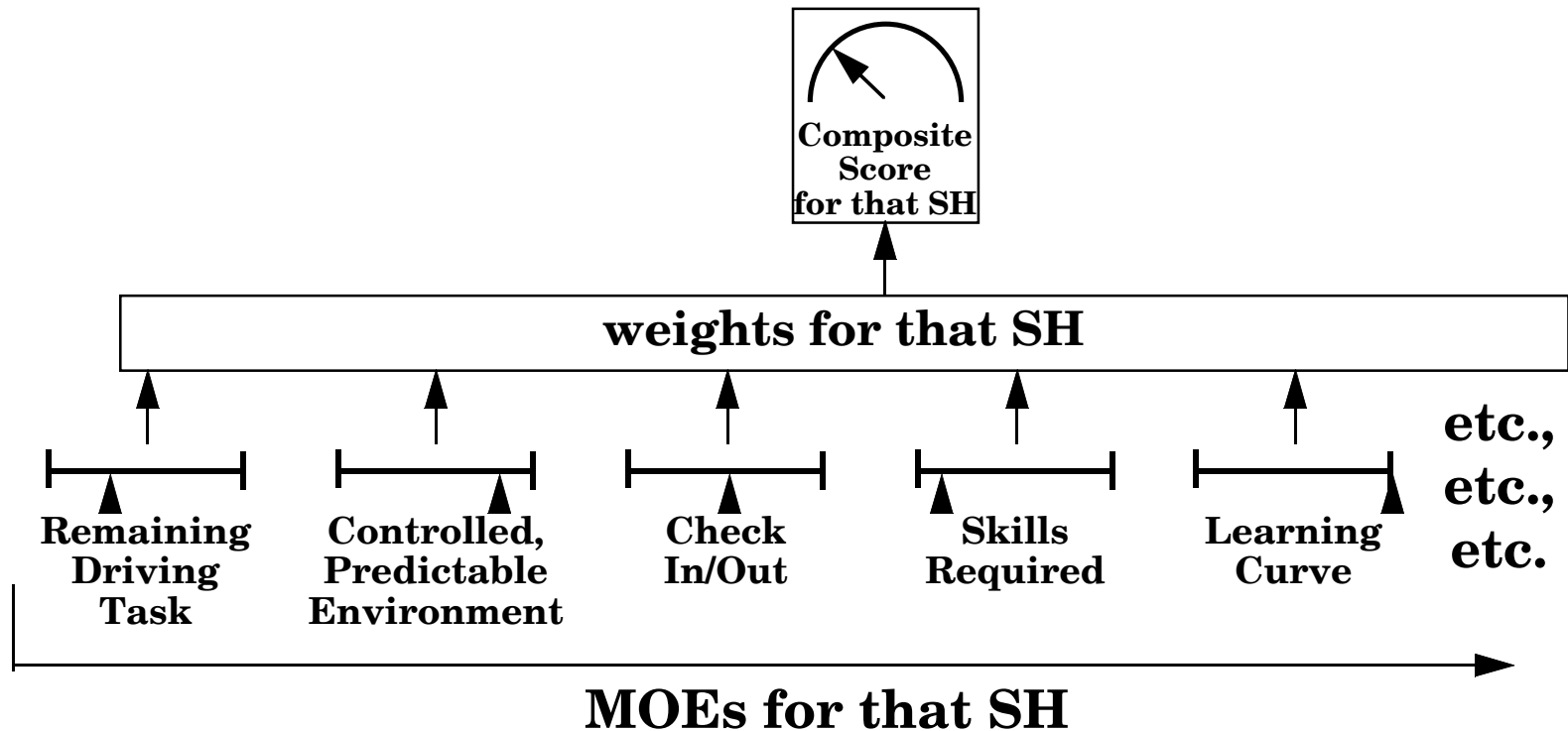
**- Evaluation Framework**

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# How MOEs Lead to Stakeholder Consensus /

## Involvement

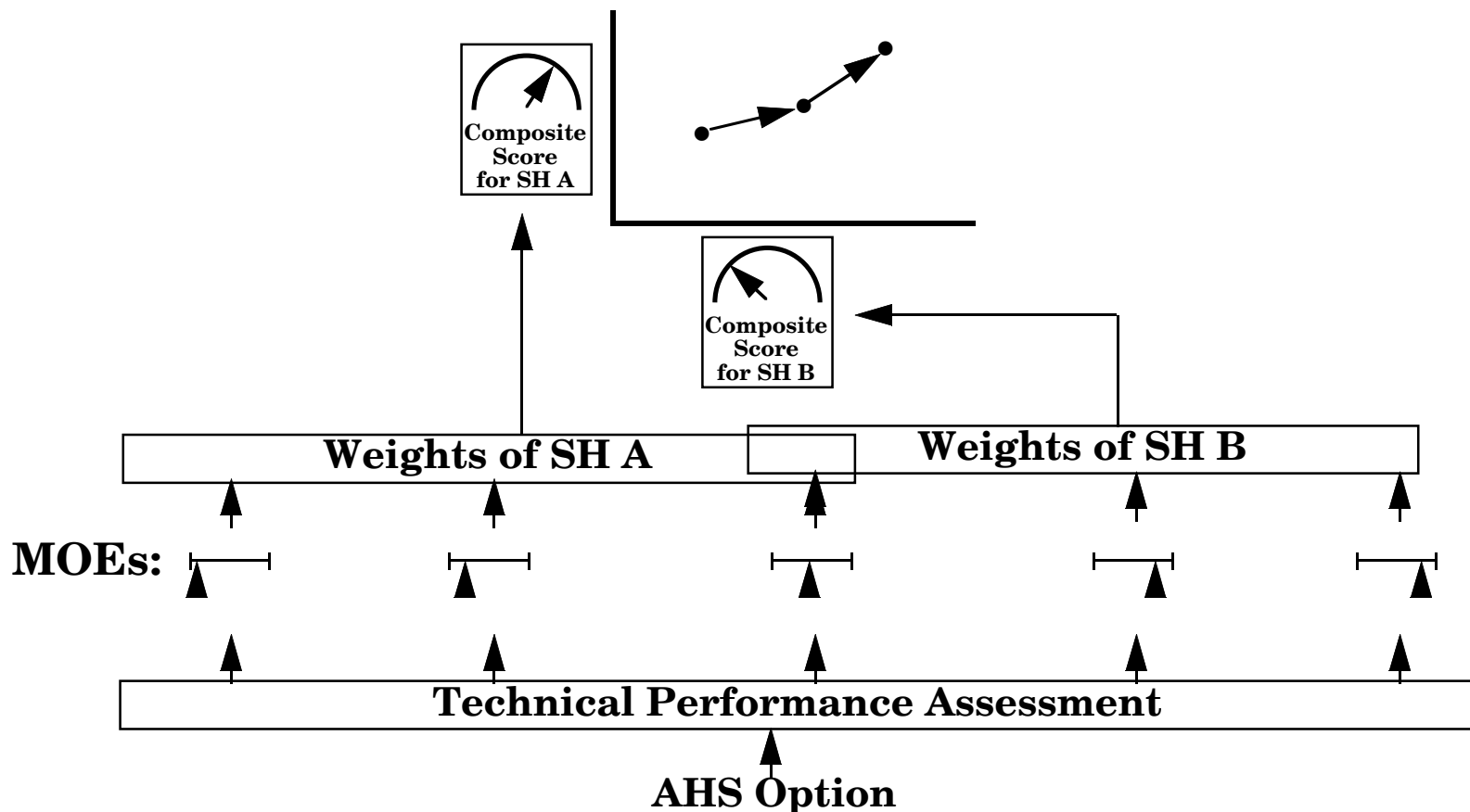
**Two Steps: First Step** build a “meter” for each SH,  
that delivers a composite score  
of the desirability of an AHS



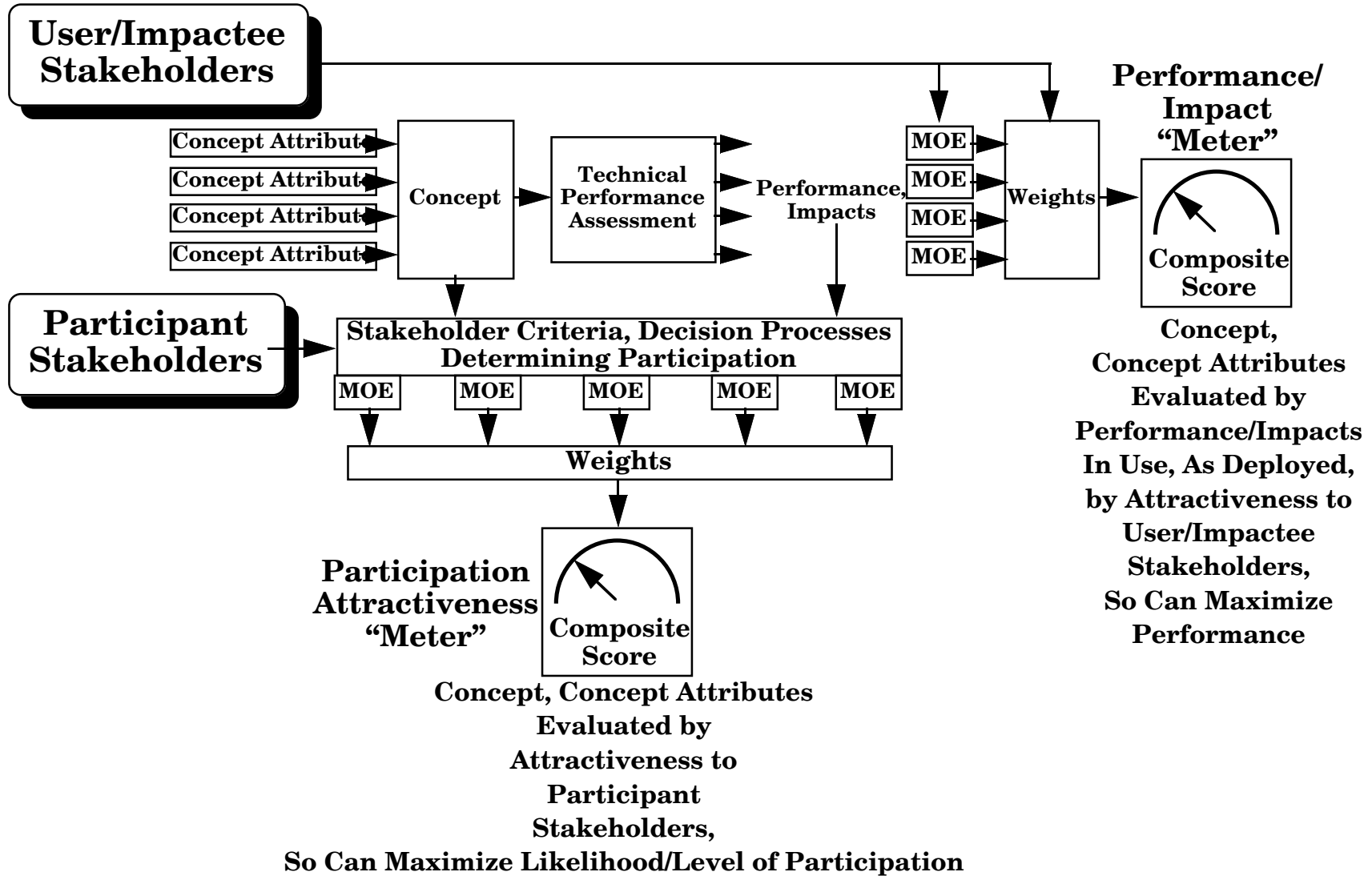
# How MOEs Lead to Stakeholder Consensus /

## Two Steps: Second Step

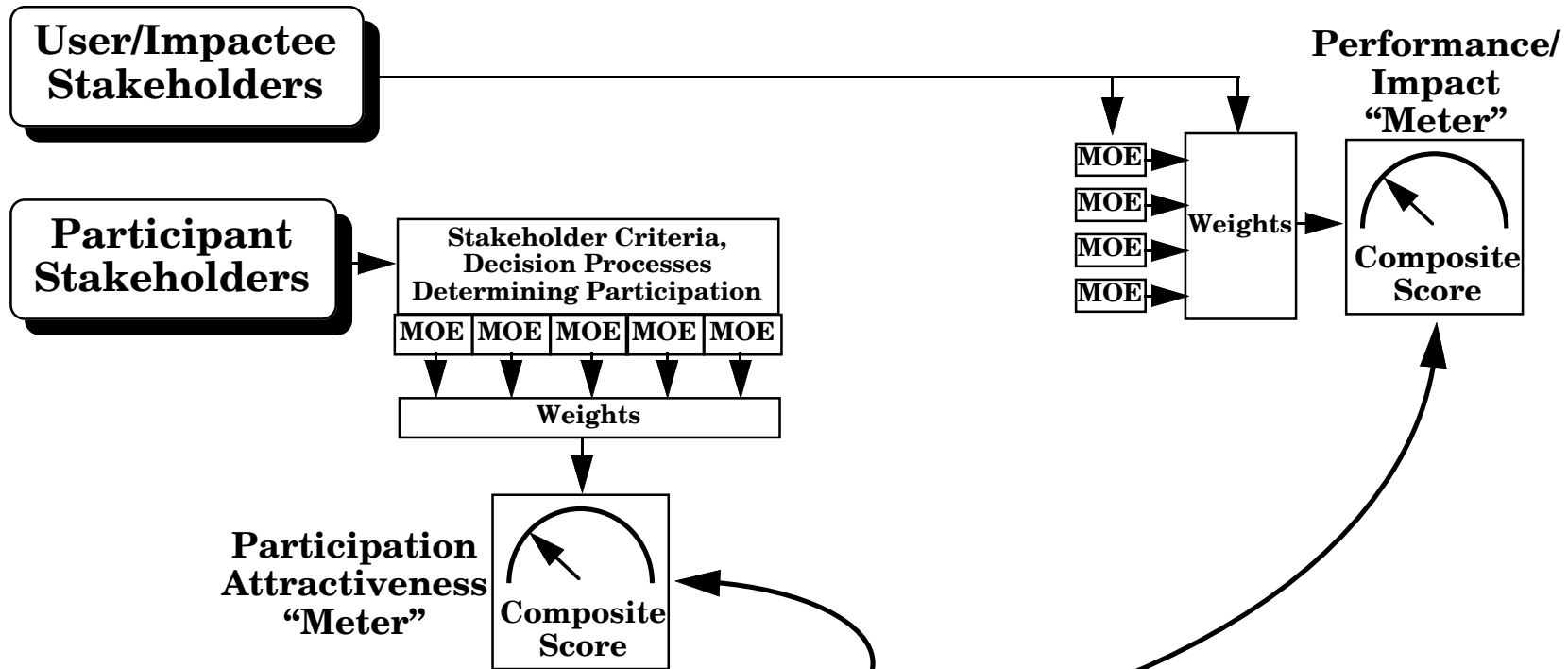
We can use those “meters,” one per SH,  
to identify “win-win” development of AHS options



## Two Roles for Stakeholders in This Process

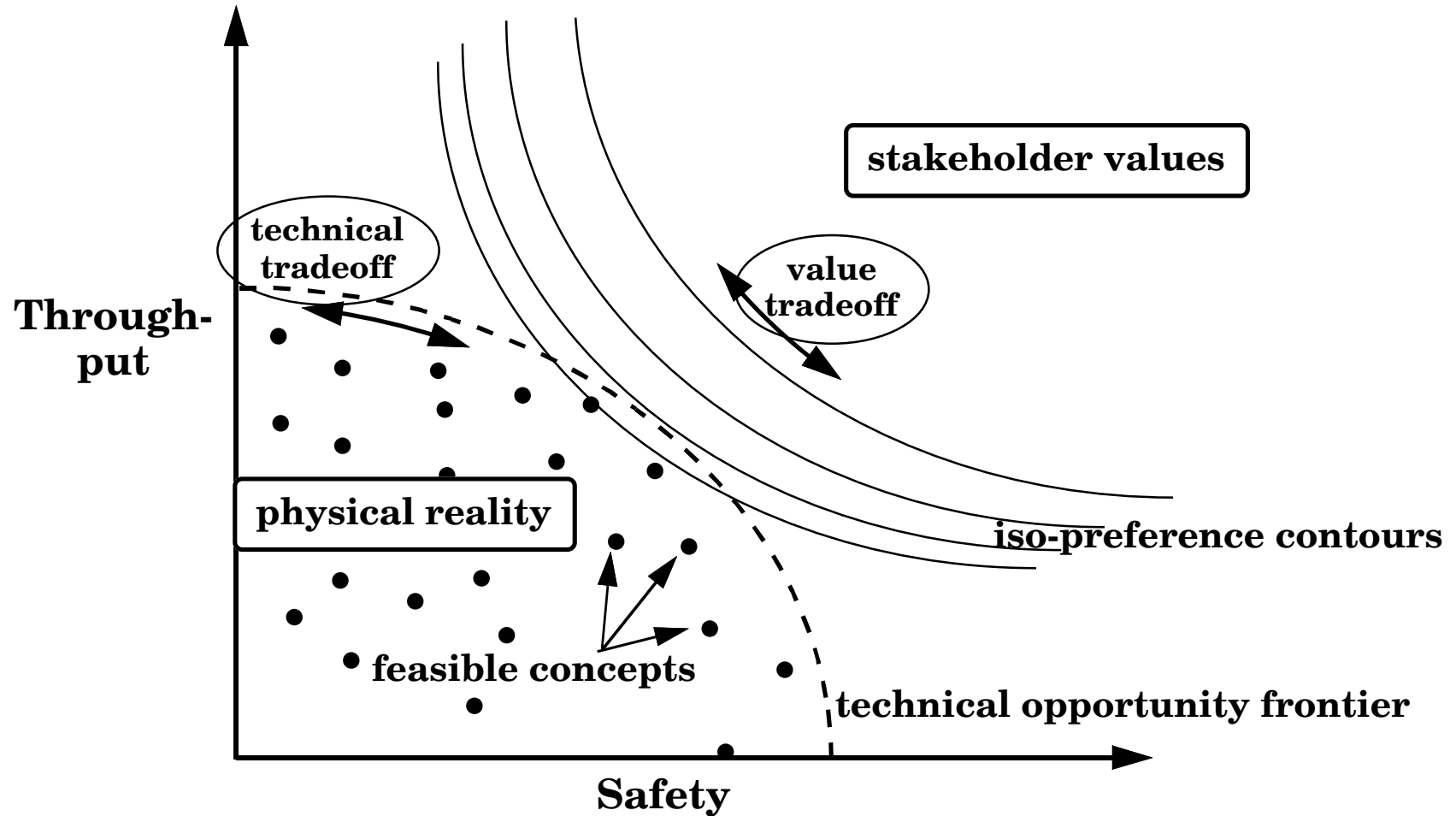


# Key Idea: Focus on Values, Not Alternatives



**We are here to build meters,  
a separate meter for each stakeholder,  
to use to evaluate concepts,  
to develop concepts  
in a way that reflects your preferences.**

# Value Tradeoffs and Technical Tradeoffs



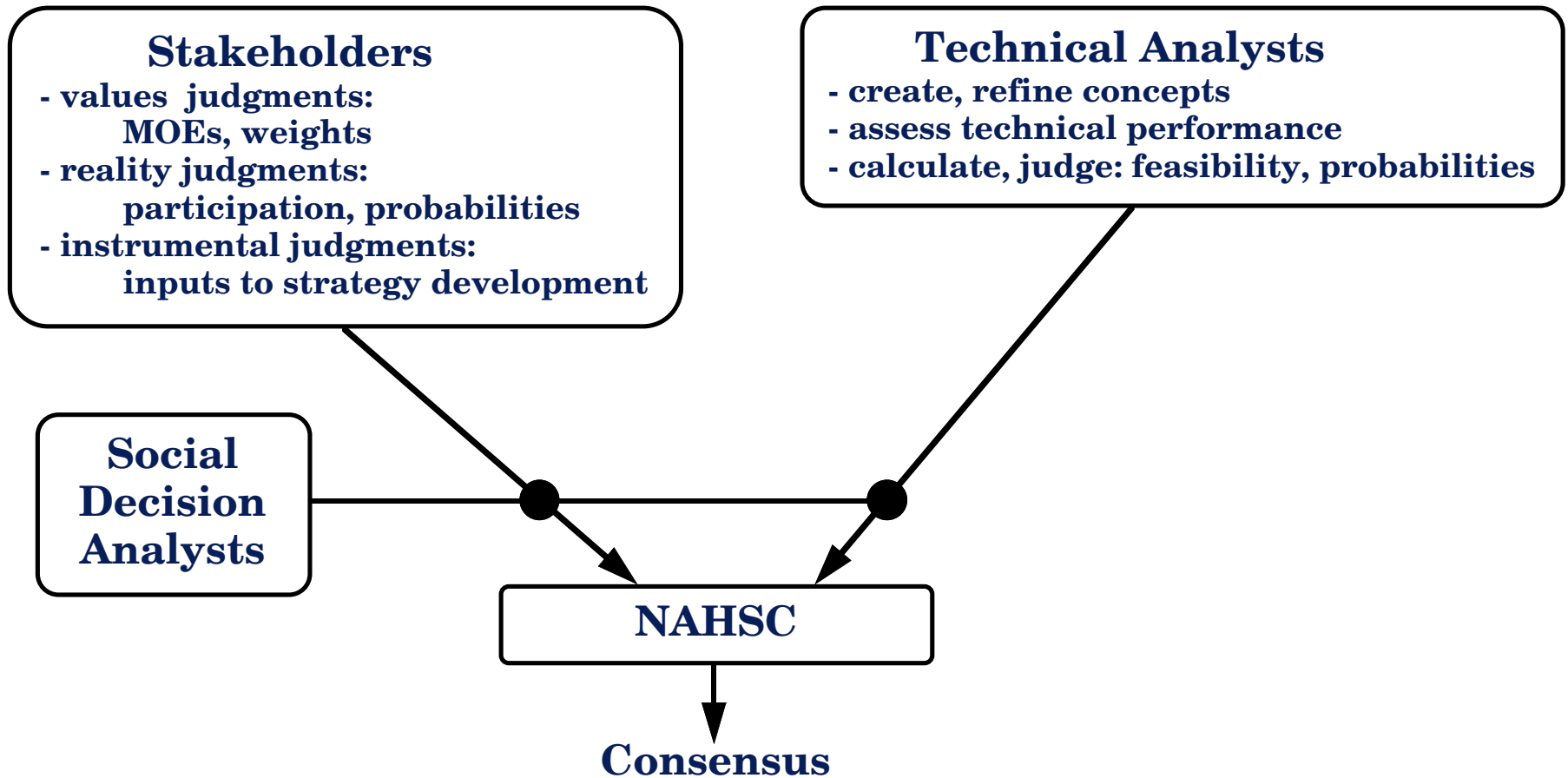
**Key Challenge:**

**Must present technical tradeoffs in same units as value tradeoffs.**



# Division of Labor

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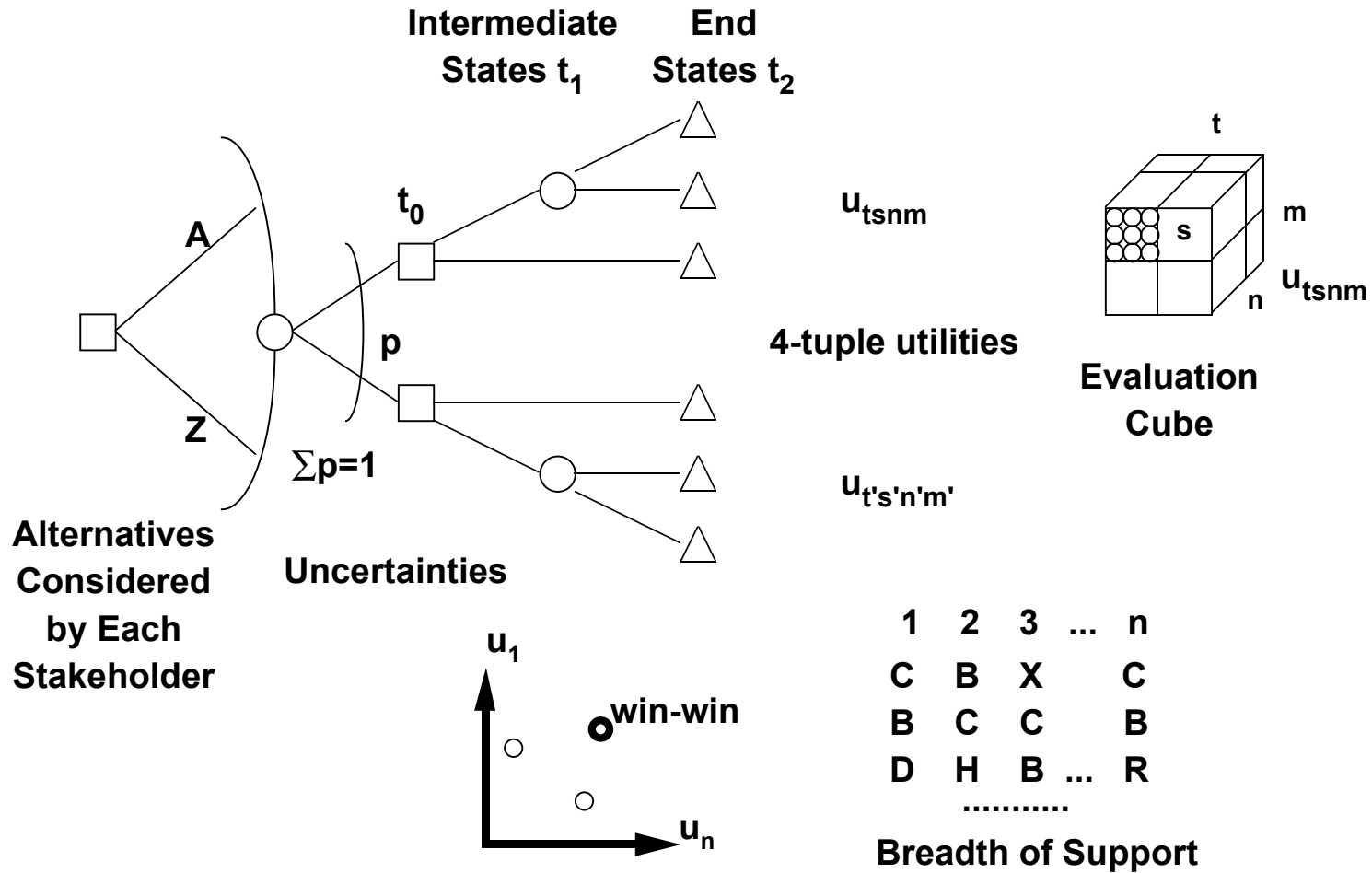
# Decision Support Tool: Social Decision Analysis (SDA)

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## Five Dimensions:

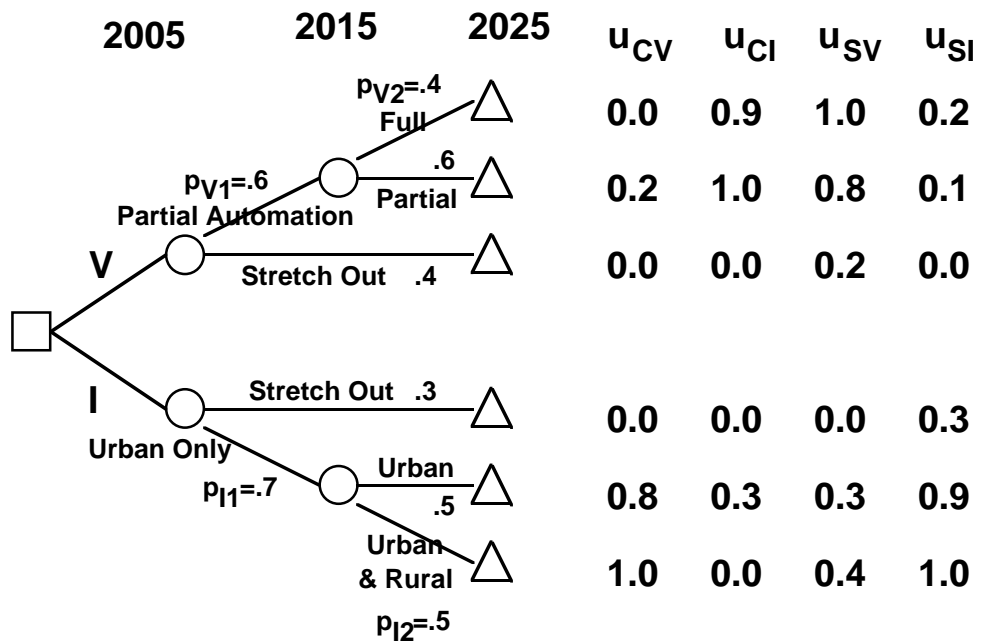
- p - Uncertainties of Crucial Variables**  
(e.g., stakeholder participation)
- t - Intermediate and End States**  
(e.g., spinoffs & progression to end states)
- s - Scenarios**  
(e.g., urban, interurban & rural)
- n - Different Stakeholder Groups,  
Different Weights on  $\Delta(\text{MOE})$ s**  
(e.g., private user, transit user,  
vehicle manufacturer, etc.)
- m - Distinguishing MOEs**  
(Drop out of non-distinguishing MOEs)

# Evaluation Framework

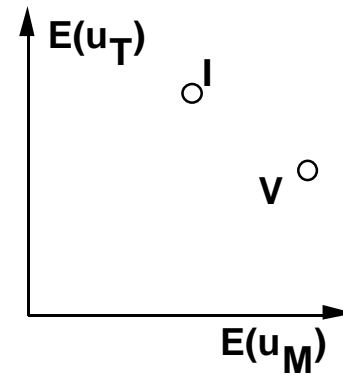


# A Simple Example

V-Based & I-Based  
 Concepts Considered by  
 Motor Vehicle Industry M &  
 Transportation Authorities T.



	V	I
$E(u_M)$	0.501	0.322
$E(u_T)$	0.333	0.444



M's Weights	0.2	0.0	0.8	0.0
T's Weights	0.0	0.4	0.1	0.5

$\Sigma w=1$

## **Now On to the Next Step On Our Agenda:**

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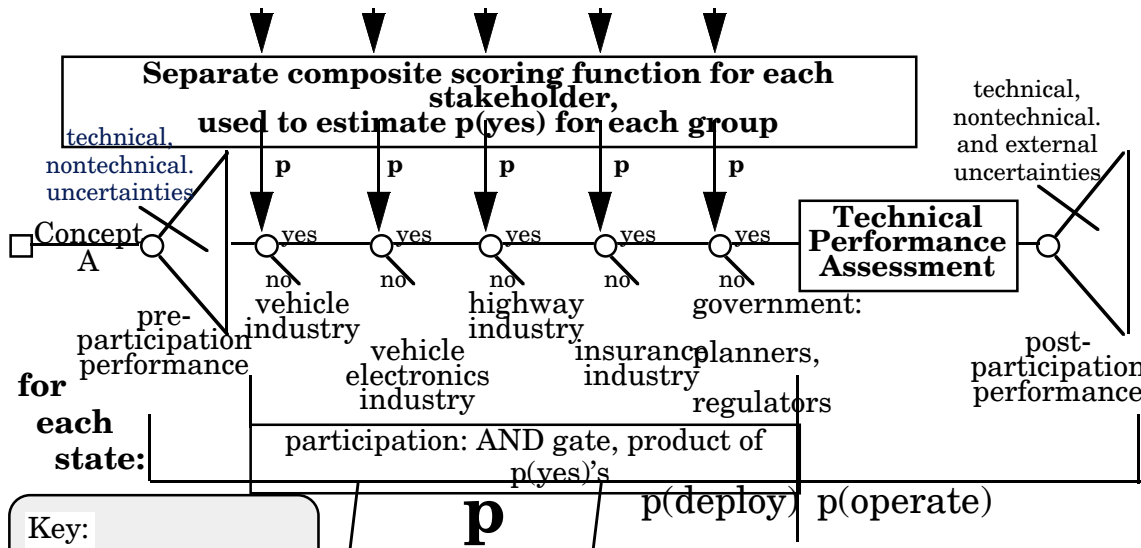
**- Focus Group Meeting Process, Including Invitees**

# Basic Evaluation Framework

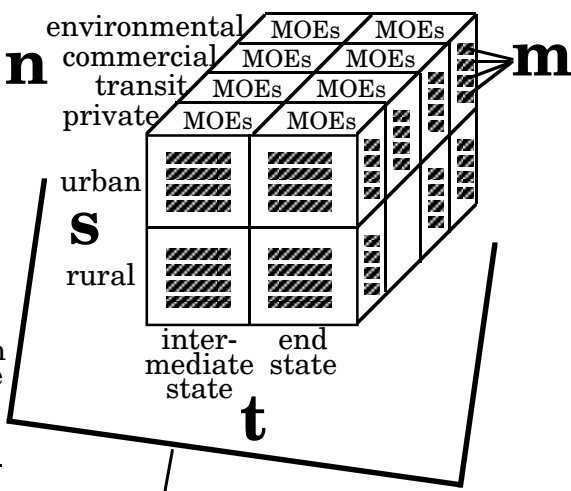
**p, t, s, n, m:**

## Participant MOEs

Separate MOEs for each stakeholder group



## Evaluation Cube: User/Impactee MOEs



**Key:**

- Decision Node
- Event Node

a composite scoring function for each stakeholder

scenario:	urban			rural		
time:	private	transit	comm'l	private	comm'l	societal
intermediate	↓	↓	↓	↓	↓	↓
end	↓	↓	↓	↓	↓	↓
present value	—	—	—	—	—	—

**a few numbers summarize performance of a concept**

# Issues Spreadsheet, 1 of 3

Stakeholder	#	Issues	Location in SDA
		<i>Numbered Issues from Consortia Spread Sheet</i>	
		<i>Additional Issues from Boston Forum Summary (ref. by page numbers)</i>	
<b>VEL</b>	1	PMOC Rep's effort level	<i>Procedural</i>
(Vehicle Elec.)	2	AHS requirements	p-criteria for participation m-MOEs affecting participation
	3	Intermediate goals needed (fast payback)	t-spinoffs
	4	Outsiders' technology ideas	p-technical probabilities m-MOE for tech. performance
	5	Manufacturers' liability	p-probability for insurance p-industry participation
	6	Champion for liability issues	<i>Procedural</i>
	7	Liability reduction via NHTSA involvement	p-probability for insurance p-industry participation
	8	Liability during manual-auto transition	p-probability for insurance p-industry participation
	9	Platoon accident perceived as airplanes	p-probability for insurance p-industry participation
	10	NAHSC accepting single source technology	<i>Procedural - YES</i>
	11	Technology research/Component specs	<i>Procedural - research management</i>
	12	One-paragraph component spec	<i>Procedural - research management</i>
	13	Performance matrix	<i>Procedural - research management</i>
	14	Concepts A-E not focused on technology	n,m-value tradeoffs v. tech tradeoffs
	15	Obstacle detection too hard to accomplish?	p-technology uncertainty
	16	Limited benefits in urban congestion?	p,m,s-uncertain MOE in urban
	17	Best vehicle/roadway cost division	n,m-value tradeoffs v. tech tradeoffs
	18	Rural roads?	m,s-MOEs in rural scenario
<b>GOV</b>	1	Stakeholder group communications	<i>procedural + SDA Eval Framework</i>
(Govt. Agency)	2	Who pays for AHS?	n,p-probability of n's participation
	3	Who owns, operates, & maintains?	n,p-probability of n's participation
	4	Who regulates	n,p-probability of n's participation
	5	Evolutionary deployment	t-progression over time
	6	How is AHS defined	t-building blocks over time + def.
	7	Interface between AHS & non-AHS	Concept attributes & tech perf study
	8	Political consensus	A main objective of SDA
	9	Services provided by concepts?	t-building blocks

## Issues Spreadsheet, 2 of 3

<b>HWY</b>	1	Will highway design aspect fall into place?	t-infrastructure building blocks
(Hwy Design Industry)	2	Standards for AHS	m,p-affecting cost, safety as MOEs
	3	MOEs needed before criteria developed	Yes, using MOEs in SDA framework
	4	Role of HWY design in 97 demo?	p-probability of HWY's participation
	5	Safetv of people standing in AHS vehicles	p-safetv probabilities
	6	Who owns AHS?	n,p-probability of n's participation
	7	Check-in check-out for trucks	m,p-effect on safety and costs
	8	Check-in check-out in general	m,p-effect on safety and costs
	9	Effects on surface streets	m-total travel time as MOE
	10	Freeway-to-freeway connections	p-tech & non-tech probabilities
	11	Visible facilities with limited investment	p-tech & non-tech probabilities
	12	Express lanes vs. AHS lane	m-MOE comparison for alternatives
	13	Justification with small initial usage	t-progression & time discount
	14	Resistance to giving up lane/land	t-progression & time discount
	15	AHS benefit to the elderly, sight impaired?	n-increasing # of stakeholder qps.
	16	Feasibility of narrower lanes	m,p-uncertainty in performance
	17	Learning from the Demo	Opportunity for multi-stage decision
	18	Check-in delays?	m,p-delays & space use alternatives
	19	How to handle magnetic marker failure	p-uncertainty in performance/safety
	20	Driver intervention	p-uncertainty in performance/safety
	21	Problems with each concept family	SDA to help reconcepting
p.22	22	Need case study	Evaluatory design used in SDA
p.32	23	What is in it for me?	Answer from SDA
	24	Unquantifiables	m-Use constructed scale for MOEs
<b>TRN</b>	1	Hard to realize AHS Transit concept	SDA to help reconcepting, incl.transit
(Transit Opnr)	2	Transit-oriented Associate Participants	<i>Procedural</i>
	3	Travel funds for stakeholders	<i>Procedural</i>
	4	Labor union problem in driverless bus	n,p-transit participation likelihood
	5	AHS competes with transit?	n,p-transit participation likelihood
	6	Demand for AHS?	p-uncertainty in ridership
	7	Local demand for AHS?	p-uncertainty in various scenarios
	8	Transition from manual to automatic?	p-technical p's affecting MOEs
	9	Merging into a parked lane?	p-technical p's affecting MOEs (NO)
	10	Concerns about infrastructure costs	p,m-uncertainty in perf., cost, safety
	11	Concerns about mixed mode	p,m-uncertainty in perf., cost, safety
	12	Incremental approach	t-progression over time
	13	Summary comparison of 5 concepts	SDA to help reconcepting
p.38	14	Start with Lincoln Tunnel	Instrumental judgment

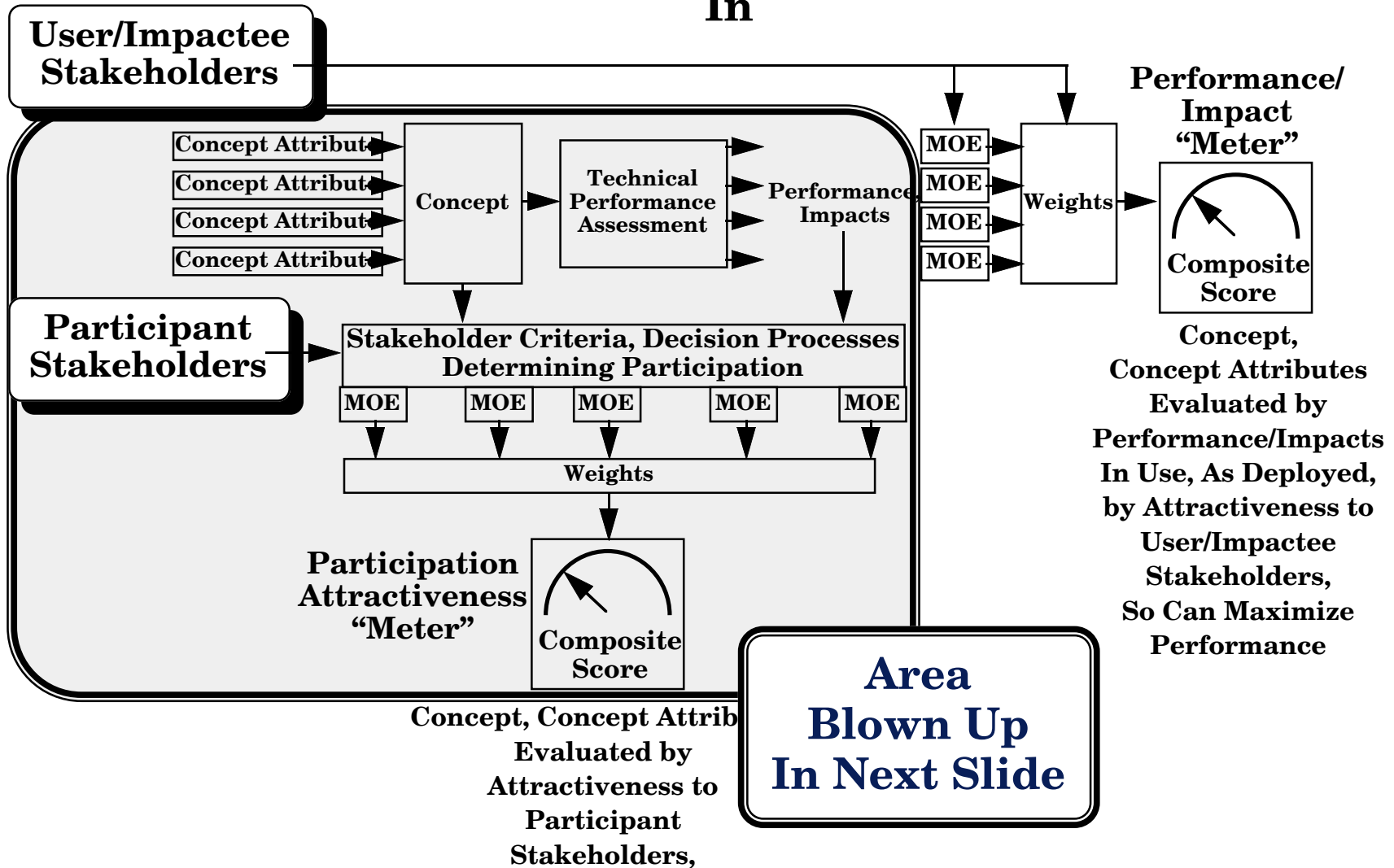


## Issues Spreadsheet, 3 of 3

<b>DVR/ENV</b>	1	Willingness to pay (wtp)	p-uncertainty in wtp
<b>/INS</b>	2	VMT & urban sprawl	m.p-stakeholder MOEs & uncertainty
(Driver/User/	3	Value to non-users	n.m-MOEs for non-users
Environment/	4	Synergy with ITS America?	<i>procedural</i>
Insurance	5	Value of demo	p-affecting subjective probabilities
	6	Reporters as a focus group?	p-impact on subjective probabilities
	7	AHS driver certification	p-affecting probability of safety
	8	Downselect involving driver response?	SDA to help reconcepting, incl. driver
	9	Risk in job loss	p-uncertainties in stakeholder MOEs
	10	Risk associated with liability	p-uncertainties in stakeholder MOEs
	11	Risks in return to investment (ROI)	p-uncertainties in stakeholder MOEs
	12	Risks associated with human factors, etc.	p-affecting probability of safety
	13	Risks of incremental vs. radical paths	t.p-uncertainties in multiple stages
	14	Risks wrt privacy, security, etc.	p-uncertainties in evaluatory design
	15	Risks in platooning with competitors	p-uncertainties in evaluatory design
	16	Risks in regulators' acceptance	p-uncertainties in regulator part'on
	17	Risk in mixed classes of vehicles	p-uncertainties in performance
	18	Risks of mixed classes in platoon	p-uncertainties in performance (NO)
	19	Risks in load securing	p-uncertainty in safety
p.54	20	AHS can't be less safe than present system	m-nonlinear utility
<b>VEI</b>	1	Merits of dedicated lane vs. mixed traffic	p.n.t.s.m-SDA comprehensive eval.
(Vehicle Ind)			

# Where Participant Stakeholder Considerations Fit

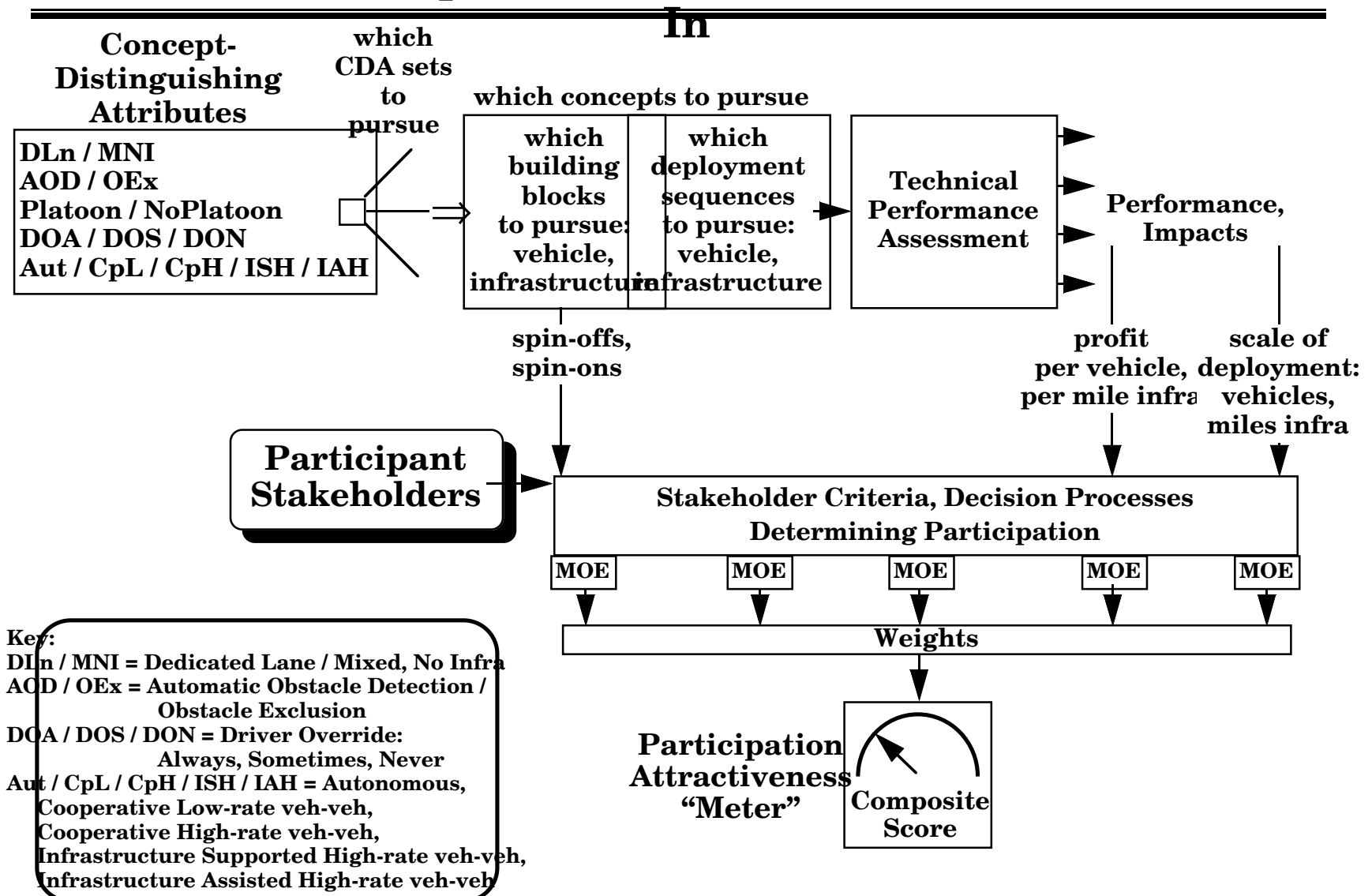
In



Performance/Impact "Meter"  
 Concept, Concept Attributes Evaluated by Performance/Impacts In Use, As Deployed, by Attractiveness to User/Impactee Stakeholders, So Can Maximize Performance

So Can Maximize Likelihood/Level of Participation

# Where Participant Stakeholder Considerations Fit



## **Now On to the Next Step On Our Agenda:**

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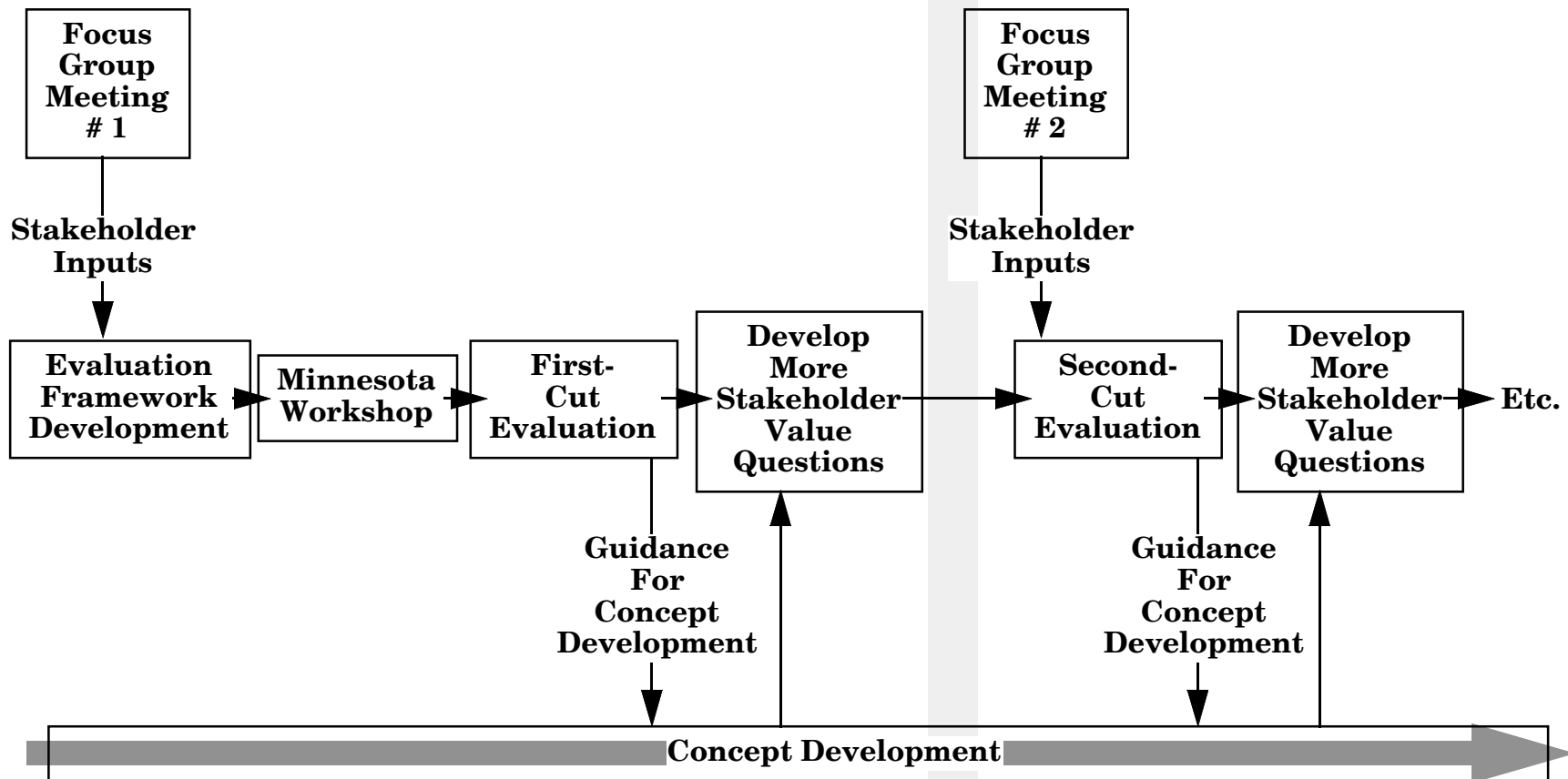
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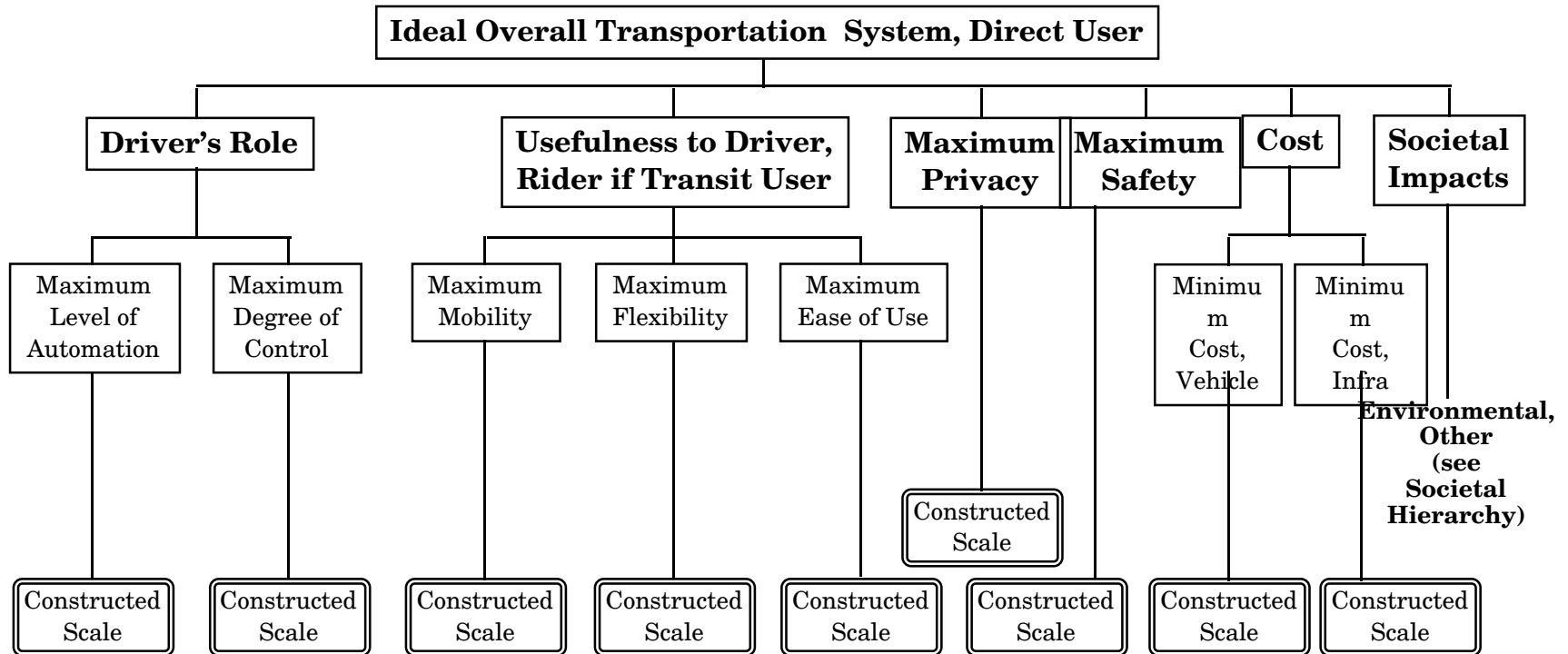
# Can We Really Do All This Today?

Of course not.  
Today is only the beginning:

C2 C3



# Example, Thought-Starter: Private Alone, or Direct User: Private and/or Trucking and/or Transit --- --- **User**



## Key Features of an Objectives Hierarchy

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**Top Box** = “Mission Statement” level.

**Bottom Boxes** = MOEs: each measurable on some scale.

**Each box defined by its daughters.**

### Principles:

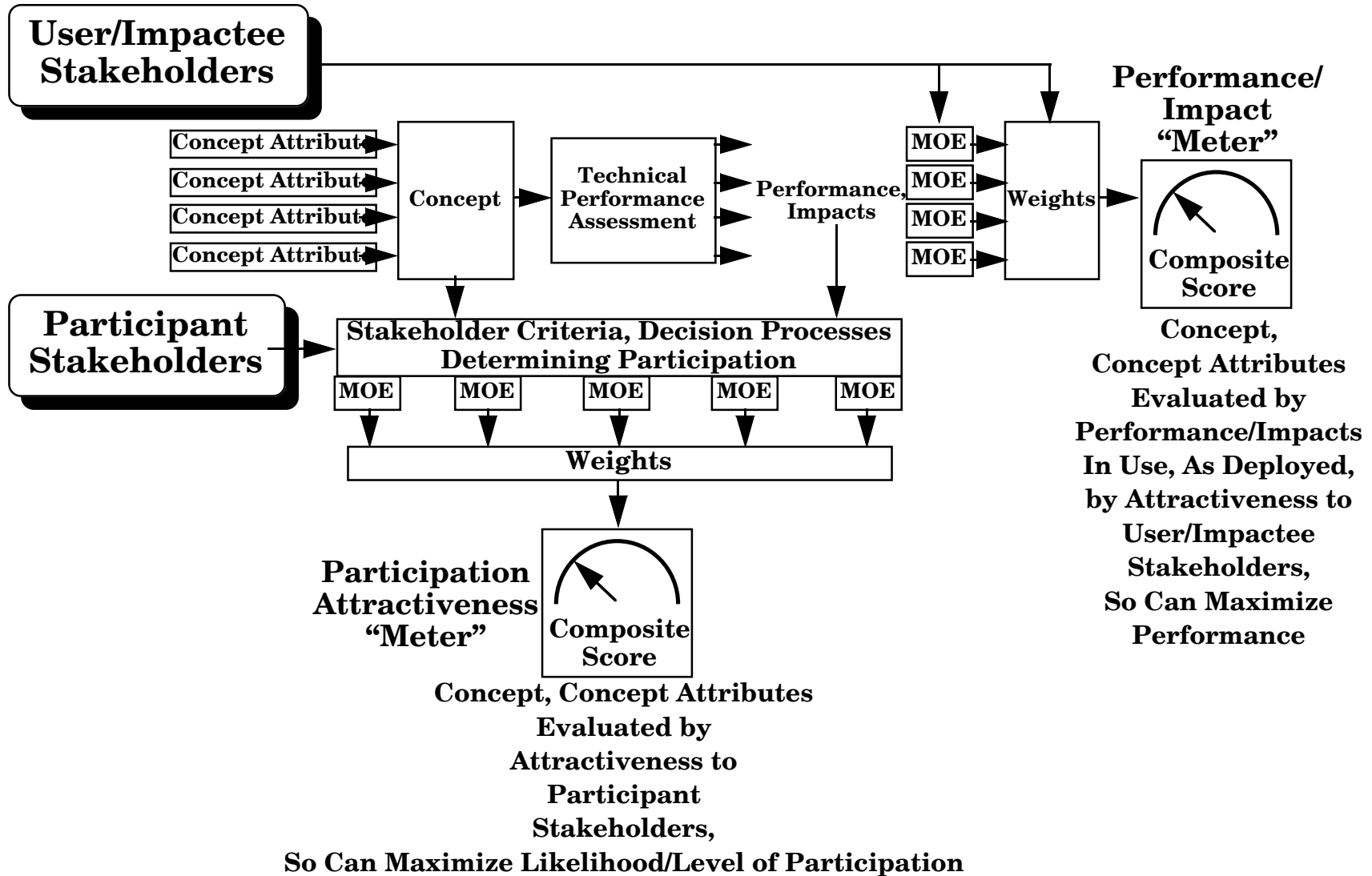
What’s up there are thought-starters only  
(e.g., miss on deployability concerns, spinoffs.)

### Strive for:

- Complete
- Non-overlapping (“orthogonal”)
- Represent underlying values

ex: Not “I like automatic obstacle detection  
But why do you like it?”

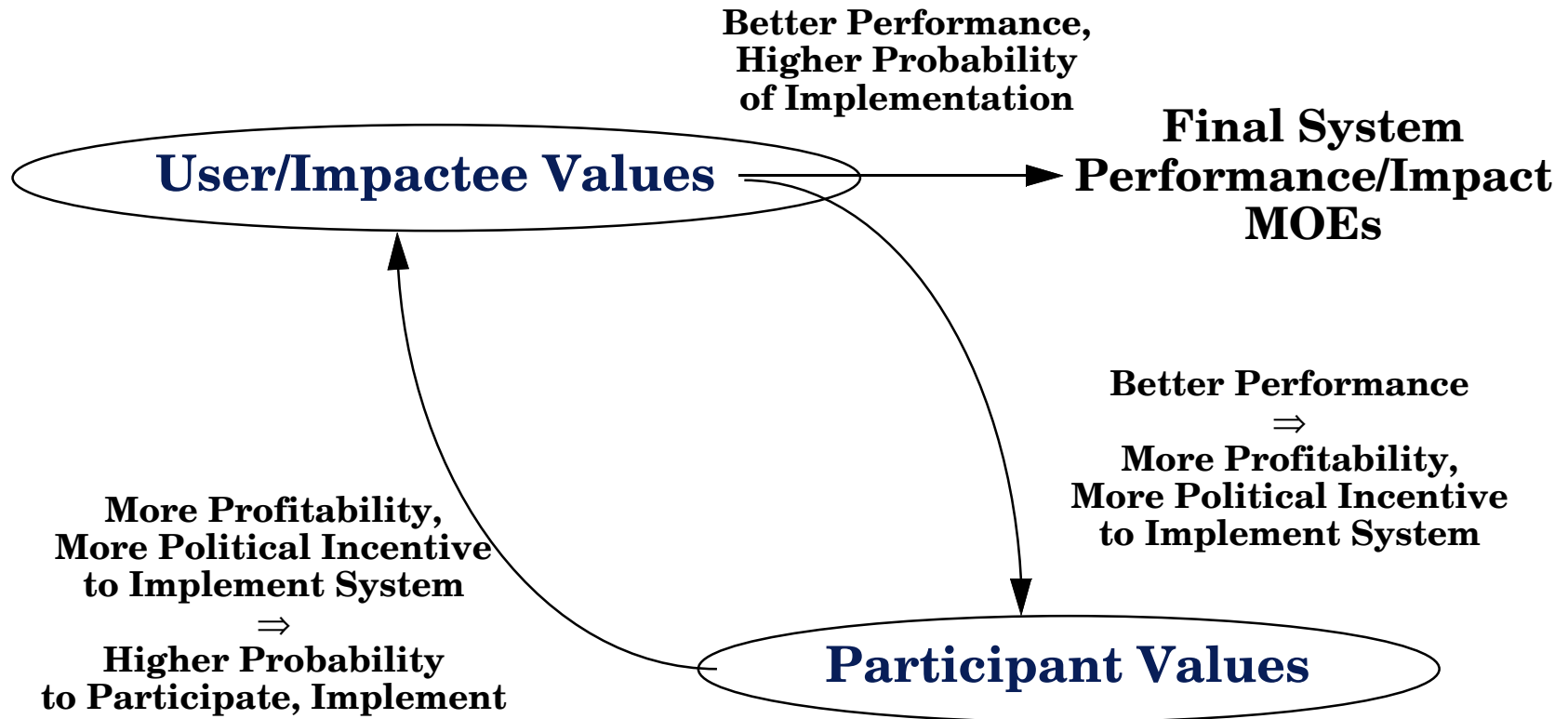
## There Are Two Types of Stakeholders in This Process:





# The Evaluation is Driven by User/Impactee Values

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## **You Have Many Choices**

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**One hierarchy for all users?**

**One hierarchy for all users + nonuser  
impactees?**

**One hierarchy for each user,  
also considering nonuse impacts?**

**If multiple stakeholders on one hierarchy:  
if any stakeholder wants a box on the  
hierarchy,  
it's on there,  
but we let each stakeholder assign own  
weight.**

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## **Just naming the MOEs is not enough.**

---

**An MOE name is just a title on a bottom box,  
a name of a concern / impact / performance.**

**In order to really use an MOE, we need a measurable scale.**

### **Scales for MOEs Have Four Requirements**

- A scale must:**
- 1. ... represent a value/concern of at least one stakeholder.**
  - 2. ... be assessable at reasonable effort.**
  - 3. ... be in units understandable to a nonspecialist.**
  - 4. ... discriminate among alternatives.**

## **Key Challenge: An MOE scale is a**

**... compromise ...  
... between what matters and what is assessable**

**An ideal stakeholder MOE scale:**

**Represents the underlying value directly,  
in understandable units.**

**Examples:**

**Mobility: How far I can get through the city in 20  
minutes.**

**Safety: Fatalities per million vehicle miles.**

**An ideal technical MOE scale:**

**An aspect of performance that can be assessed  
by solidly defensible measurement.**

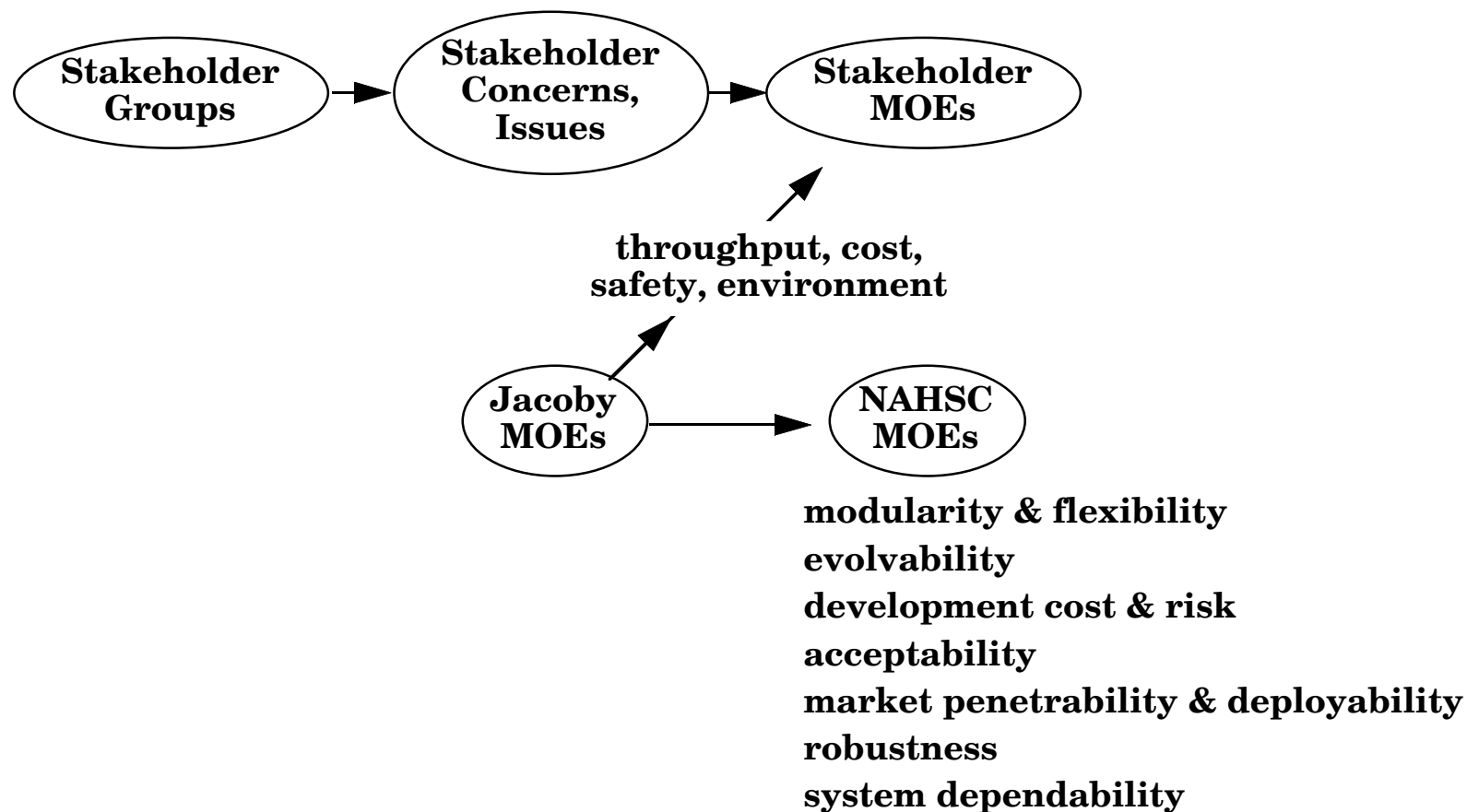
**Examples:**

**Mobility: Ideal, undegraded throughput.**

**Safety: Expected value of  $v^2$ ,  $v$  = initial**

## Relationships Among MOEs

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## So What Is A Constructed Scale?

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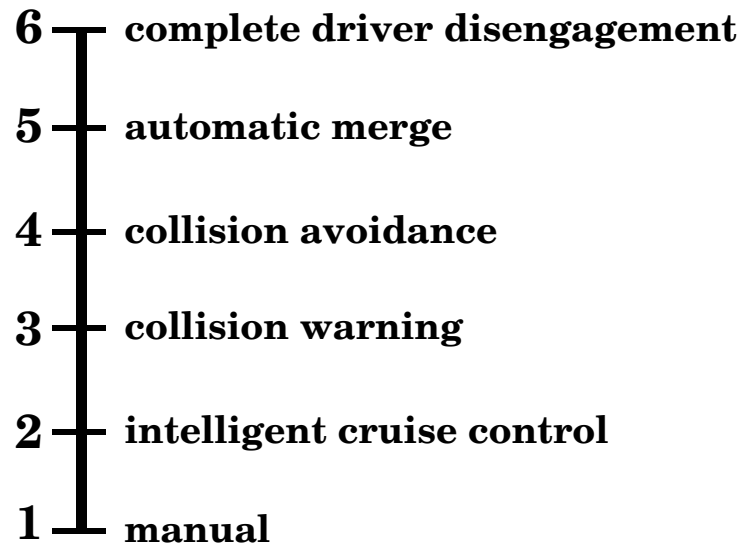
### Constructed Scale:

A scale with from 2 to 10 points.

Each point defined by between 3 words and 3 sentences.

Test of scale: Two people with equal knowledge  
should typically agree on how a system is rated.

### Example Scale: Level of Automation



## **Developing a Constructed Scale: Reverse Engineering**

**A Good Way to Develop a Constructed Scale:**

**Try to sort / group / rank concepts by the MOE.**

**If you can at least sort the concepts into 2 “bins” by the MOE, e.g., “high” and “low,” you’ve got a scale.**

**If you can fully rank all concepts, you’ve got more of a scale.**

**Each separately-ranked concept or bin is a point on the scale.**

**Now assign from 3 words to 3 sentences to describe each point on the scale.**

**Now see if there are intermediate points on the scale, between points occupied by existing concepts, that you can assign the same pattern of 3 words to 3 sentences.**

**The test: Two people of equal knowledge should typically agree on how a concept is rated.**

**If not, you have too many points.**

**Don’t worry about nonlinearities in the scale, we can elicit that.**



## **Now We Can Take The Next Steps:**

### **I. Introduce Evaluation Framework**

**Map Current Stakeholder Issues Into Framework**

### **II. Elicit Stakeholder Concerns, Anticipated Benefits and Impacts, Including Spinoffs and Deployability/Transition Concerns**

### **III. Identify How to Capture Those With Measures of Effectiveness (MOEs)**

**Identify an Assessable Unit Scale for Each MOE  
Estimate Endpoints for Each MOE Scale  
Elicit Relative Importance of MOE Scales**

### **IV. Identify Stakeholder Criteria for Participation in Development, Including Strategies to Maximize Participation**

**Identify Concept Features Important for Decisions to Participate,  
and Affecting Relative Attractiveness of Concepts, Including Spinoffs**

### **V. Evaluate and Suggest Improvements In**

- Evaluation Framework**
- Focus Group Meeting Process, Including Invitees**

**Scales + Endpoints Give Us Placards. Now Rank Them**

**Ranking Placards Requires “THE LITANY:”**

**If you have a concept  
that performs at the worst level  
on both of these MOE scales,**

**And you have only enough money to upgrade one of them  
from the worst to the best level,**

**Which MOE would you choose to upgrade?**

## **5 Good Things Happen When You Rank Placards:**

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- 1. Discussion clarifies why care about each one.**
- 2. Teaches discipline of: "endpoints matter."**
- 3. Miniplacards allow quick multiple elicitations,  
even "homework."**
- 4. Identifies attributes of most concern, to focus on  
for numerical weight elicitation,  
development.**
- 5. Can use to estimate numerical weights,  
using "Barron Approximation."**

## **But in FGM-1, We Received 2 Messages From SHs:**

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**I. AHS performance should be measured in terms of SH MOEs, though often the MOEs SHs care about are hard to measure  
Example: Controlled, Predictable Environment**

**II. AHS performance should be measured on dimensions that are directly useful by local decision-making agencies for comparing AHS options with non-AHS options.  
Example: NO<sub>x</sub>, SO<sub>x</sub>.**

# **And Those 2 Messages Give Us 2**

## **Insights:**

### **I. We need two kinds of MOEs:**

- 1. Ones that capture SH concerns and preferences  
(and are often subjective and hard to measure).**
- 2. Ones that match what the local decision-making agencies  
use to compare options  
(and are often highly precise and hard to predict).**

### **II. Some SH concerns are procedural, and not easily captured by MOEs.**

**Example: Case Studies should involve  
local decision-making agencies, so that can  
specify how AHS options have to be characterized  
to support the decision-making process of those agencies**

# **Note: The MOE Work Lays Out an Analysis Plan**

**Currently Realistic Scale:** Measurements that can be made in  
**Ultimate Achievable Scale:** Measurements that can be made later  
but soon enough  
to be useful for development.  
**Nearest Numbers:** Starting points for system requirements

**So for the two kinds of MOEs:**

- I. MOEs to capture SH concerns/preferences:**  
may be “pretty fuzzy” as we specify them today,  
but they can be later firmed up, as data becomes available.
- II. MOEs to match the MOEs used by local decision-making agencies:**  
may have to be stated with probabilities for FY97,  
to be firmed up later.  
**Example: “Probability NO<sub>x</sub> < xx = 50%”**

## **So Here's What We Have To Do To Start**

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- We need to specify MOE scales well enough to start the process of firming them up into firmer numbers.
- We need to gauge the relative importance of each MOE, so we can focus on the more important ones.
- To do that, we need to know the “swing range” of each MOE, i.e., the range from least-preferred to most-preferred.
- So we need to know the scale and endpoints for each MOE.