SCENARIO PLANNING FOR STRATEGIC REGIONAL TRANSPORTATION PLANNING

Christopher Zegras\textsuperscript{1}, Joseph Sussman\textsuperscript{2}, Christopher Conklin\textsuperscript{3}

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\textbf{ABSTRACT:} This paper proposes a framework for using business and organizational scenario planning techniques for regional strategic transportation planning purposes. The paper provides a brief history of scenario planning as it emerged from business strategic planning activities and gives an overview of its goals and limitations. The paper then reviews the context for scenario planning in regional transportation planning as well as precedents of its application in this field. The paper continues with a presentation of a scenario planning framework for transportation as refined and applied to the Houston, Texas metropolitan area. The major findings and lessons from this application are discussed, together with conclusions and observations regarding further potentials and refinements.

\textbf{Key Words:} metropolitan transportation planning, scenario planning, forecasting, Houston, Texas.

\textsuperscript{1} PhD Candidate, Department of Urban Studies and Planning, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Room 10-485, Cambridge, MA 02139, Tel: 617 784 1775, Fax: 617 258 8081, czegras@mit.edu.
\textsuperscript{2} JR East Professor, Civil and Environmental Engineering and Engineering Systems, Massachusetts Institute of Technology, 77 Massachusetts Avenue, 1-163, Cambridge, MA 02139, Tel: 617 253 4430, Fax: 617 258 5942, sussman@mit.edu.
\textsuperscript{3} Senior Project Engineer, VHB/Vanasse Hangen Brustlin, Inc., 38 Chauncy Street, Suite 200, Boston, MA 02111, Tel: 617 728 7777, cconklin@vhb.com.
INTRODUCTION
Scenarios are not new to planning. Indeed, the use of the term scenario is quite common across a range of planning disciplines, from business strategic planning to urban transportation planning. For example, in travel demand forecasting, it is common to develop “scenarios” of land uses that have a certain probability of developing in the future. Transportation projects can then be evaluated in the context of these different land use “scenarios.” Similarly, different “scenarios” of economic growth, or fuel efficiency improvements, or price changes are often used to develop ranges of future possibilities (i.e., the “high-growth” scenario, the “low-efficiency” scenario). In these cases, scenarios are simply alternative point estimates of potential futures.

In “scenario planning,” however, the term scenario adheres more closely to its literal definition of “an imagined sequence of future events.” Using what are sometimes called “decision scenarios” (see, for example, Wack, 1985a), scenario planning is a tool designed to help an organization judge how effective decisions made today will be in the uncertain future. Scenario planning is not a replacement for traditional planning techniques such as forecasting; instead it aims to help organizations better prepare for the unexpected. In short, scenario planning helps to make robust strategic choices.

It is in this broader meaning of the concept of scenarios that we propose here a framework for applying scenario planning to regional strategic transportation planning. Building on the recent rich history of scenario planning applications in a variety of contexts, this paper describes an application of the process by a group at MIT to a specific regional transportation setting (Houston, TX). The Houston application is intended to serve as a demonstration of how scenario planning can be applied in strategic regional transportation planning. The Houston case serves as one step in a broader effort towards exploring the potential value of scenario planning for practical transportation and urban planning needs.

This paper has three primary purposes. First, by situating scenario planning within the broader regional transportation planning process and its relevant tools, the paper attempts to show the reader where and how scenario planning might make a contribution. Second, by documenting the methodology as applied to the Houston case, the paper intends to offer a specific step-by-step framework which practitioners might use in combination with their traditional regional transportation planning process. The framework offers a structured, logical process – to enable consistency and deeper understanding – for depicting how the future for which we are planning for might evolve. Finally, by evaluating the approach used in the Houston case, the paper attempts to offer insights from the process, discussing links to other existing methodologies and suggesting extensions to the work. The ultimate goal of this work is to advance the development of an effective framework for improving strategic regional transportation planning in a world of uncertainty.

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4 The specific outputs of the nine-month Houston application are described in a separate document (see CMP-Res/SITE, 1999).
A PRIMER ON SCENARIO PLANNING

A Short History
Scenario planning as an approach to strategic planning is usually attributed to Royal Dutch Shell and its business planning group. According to Pierre Wack (1985a), a member of the team that pioneered the approach, Royal Dutch Shell first began applying what has become known as “scenario planning” in the late 1960s and early 1970s. At Shell, scenarios were a natural evolution in its strategic planning as its business environment underwent rapid change. In the early, post-World War II years, Shell concentrated on physical planning, its biggest challenge being coordinating the scheduling of new facilities. By the mid-1960s, financing became a central planning issue and Shell developed its “Unified Planning Machinery” (UPM), an over-arching six year planning process. UPM’s problem, however, rested in its dependence on forecasting. While forecasts seemed adequate for the relatively stable 1950s and 1960s, Shell was finding that the frequency and, occasionally, the magnitude of its forecasting errors had increased. UPM, it was felt, could not provide the right answers if the forecasts that it was based on were wrong. According to Wack: “sooner or later forecasts will fail when they are needed most: in anticipating major shifts in the business environment that make whole strategies obsolete.”

Recognizing these problems, the Shell team worked to develop a planning approach that could better deal with uncertainty, covering a “a wide span of possible futures” while being “internally consistent.” The key challenge, however, lay not only in developing alternative future visions, but ensuring that these visions could drive strategic thinking and – ultimately – strategic action. This suggests that scenario planning should occur across a broad-range of managers and decision-makers at varying levels of responsibility within an organization (sector). This “action-orientation” of scenario planning also suggests that the process should be ongoing and evolutionary: as certain scenarios become implausible/impossible, those are rejected and the range of the plausible is further refined. Shell’s application of scenario planning eventually enabled it to anticipate and prepare for the oil crisis of 1973, and its economic aftermath.

The Shell success spawned a veritable industry in scenario planning and today derivations of the approach are widely applied. Scenario planning can be used for a wide range of purposes: strategic planning, project planning, short-term tactical decision making, crisis management, consensus building, or (and) morale-building (van der Heijden, 1996). Specific examples of application include national consensus-building and future visioning in Colombia, South Africa and Japan; energy sector planning (see Kahane, 1992); and prospects for global “sustainability” (Hammond, 1998). Scenario planning embraces a systems thinking and strategic planning philosophy – helping to identify forces that affect us, but that we cannot influence, and helping us to plan for a range of potential futures that variations in those same forces imply (Dalton, 2001).

“Storytelling”
Scenario planning does not intend to predict the future, rather it aims to draw attention to the major forces underlying “potential” futures. In this way, it is believed, scenarios
prepare planners to be better able to recognize these forces, to make decisions today, and adapt to changes tomorrow (Wilkinson, 1995). Scenarios are not “a group of quasi-forecasts;” instead, they are “stories” which intend to “describe different worlds” not “different outcomes of the same world” (Wack, 1985a).

These “stories,” however, develop in a “structured” way, implying a “cause-effect” relationship for how the scenario might happen. It is not sufficient to suggest future directional movements in key factors (i.e., economic growth); instead, the idea is to “tell the story” – a logical depiction of a possible future. Far from trying to specify an exact future, however, scenario planning results in a range of possible futures, precisely because the future cannot be known.

Organizational Learning
Scenario planning is inherently a group process and should be developed as a group skill. The process (scenario planning) is certainly as important as the result (the scenarios), as scenario planning helps the organization better understand the outside world, expanding its view of potential futures, improving individual capabilities to communicate, and improving the organization’s ability to recognize and prepare for change (GBN, 1991; Wilkinson, 1995). According to Wack (1985a), after the Shell group realized that its first round of scenarios were not resulting in a changed mentality within management, they had to change the goal of their scenarios. By focusing on changing the “image of reality in the heads of critical decision makers,” the Shell team explicitly recognized the importance of scenario planning to improving the overall organization, not just its planning capacity.

If scenario planning is to fulfill its role of changing the decision-makers’ views about how the world works then organization-wide “buy-in” to the process is crucial. Shell was ultimately successful in using its scenarios for business planning and action because it involved individuals across various levels of the organization, with different responsibilities. Because of this, when change was necessary, the organization was better able to respond.

Ultimately, scenarios fulfill both a “protective” role – enabling the decision maker to anticipate and better understand risk – and an “entrepreneurial” role – enabling the decision-maker to discover new strategic options (Wack, 1985b). Once the scenarios are constructed, they can serve a variety of uses. Van der Heijden (1996) recommends that the organization use scenarios for evaluating internal capability and developing strategic direction, reviewing an existing plan/portfolio, and generating and evaluating new strategic/tactical options.

A Note on “Driving Forces”
Scenario planning focuses on opening the mind’s eye to the underlying macro-trends that normally escape the daily concern of the decision-maker and planner. Sometimes referred to as driving forces, these macro-trends form the foundation for the scenario “plots.” According to Wilkinson (1995), driving forces can be roughly categorized along four lines: social dynamics, such as major demographic trends; economics, such as
international trade flows; politics, including electoral, legislative, and regulatory possibilities; and, technology, such as the impact of wireless communication advances. In addition to these categories, Schwartz (1996) suggests a fifth, the environment.

Regardless of the driving forces eventually chosen to serve as the basis for the scenario plots in a given planning process, it is important that these driving forces meet two prerequisites. First, they must truly be important (“key” or “critical”) to the decision(s) to be made. Second, they must be uncertain; or in other words, the reactions to the driving force cannot be “predetermined.

Scenario Planning and Probabilities
Scenario planning typically does not utilize probabilistic methods to estimate the likelihood of one scenario (or aspects of a scenario) occurring. There is not, however, complete consensus on the use of probabilities in scenario applications (see for example, GBN, 1991). Some argue that probabilities can be useful in helping people understand the implications of overall scenarios while others suggest that “intuitive probabilities” have a role to play within a given scenario. Kahane (in GBN, 1991), from Royal Dutch Shell, says that they explicitly do not use probabilities in their scenario planning because: scenarios should be, more or less, equally plausible; the “probability” of any given scenario occurring is “infinitesimal;” and, quantification tends to lead to people focusing on the numbers and ignoring “the more important conceptual or structural messages” contained in the scenarios. Furthermore, suggest detractors of using probabilities, when probability is utilized in scenario planning, participants will often focus on the “most likely” scenario, which itself defeats the purpose of the process, which is “to make strategic choices that are fairly robust under all scenarios” (Heinzen in GBN, 1991).

Pearman (1988) outlines how probabilities might be utilized as inputs into different scenario construction techniques by, for example, using cross-impact methods to compute compound probability estimates for possible scenarios. The author, however, highlights fundamental questions regarding: cross-impact analysis in general, the ability to accurately estimate the probability of events (even by experts), and concerns about estimating conditional probabilities. Pearman echoes Kahane’s point that using probabilities to judge the likelihood of a given scenario contradicts the “scenario philosophy of planning,” which is “to look for wide coverage of types of future, not high likelihoods.”

SCENARIO PLANNING AND TRANSPORTATION PLANNING
Just as Shell in the late 1960s and early 1970s confronted a very different world with very different strategic planning requirements than in its past, transportation planning today faces a world that poses both new challenges and larger uncertainties. Shell in the late 1960s was driven from its historical focus on infrastructure and facility siting and financial planning towards looking much more closely at global oil supply and demand interactions and the forces underlying these. Transportation, particularly metropolitan transportation, has similarly moved from a supply-side focus – siting facilities to meet projected demands – towards a more integrated system- and demand-management perspective. At the same time, the sector confronts perhaps unprecedented uncertainties
over future technological developments, the role of telecommunications, large potential environmental threats, among others. Given the apparent value that other sectors have derived from scenario planning techniques, can strategic regional transportation planning benefit from scenario planning and, if so, how?

Scenario Planning in Context
The focus of any transportation or more general urban and regional planning activity is, naturally, the future. As a general rule, it is fair to say that as the planning timeframe grows (i.e., a more distant future), the planning gets more difficult. Planning for next year can generally be done with more confidence than planning for five years from now, which can generally be done with more confidence than planning for 25 years from now.

In cases of projects with long development times, typical of many large-scale metropolitan transportation projects, the planning timeframe is necessarily long. Data must be acquired and analyzed, the appropriate impact studies must be completed and approved, land for new facilities must be acquired, etc. before construction, which for some projects can often run a decade or more, can be undertaken. For transportation planning purposes, the methodologies typically used have over a 60-year history of development and refinement and in many countries their use has been formalized and codified through legislation and regulation and embedded in relevant institutions. For example, in the United States incremental federal legislation, beginning in the mid-1950s, worked to establish a uniform method for making transportation investment decisions, leading up to the landmark 1991 Intermodal Surface Transportation Efficiency Act (ISTEA). ISTEA and related regulations, together with the 1990 Clean Air Act Amendments, imposed new planning requirements on relevant state and local agencies. Among the many requirements, metropolitan planning organizations (MPOs) must develop long-range transportation plans, a 20-year outlook of an area’s transportation vision and goals. These plans are normally updated every three to five years.

Underlying such long-term plans are projections and forecasts. Projections are generally developed through quantitative procedures, using hypothetical assumptions, such as an assumed relationship (i.e., elasticity) between per capita income levels and vehicle ownership. A projection ultimately produces a picture of the future, based on current trends, without questioning the validity of its underlying assumptions (Myers and Kitsuse, 2000). In contrast to projections, forecasts attempt to provide a “best guess” about the future, using judgment about the best techniques and the most likely underlying assumptions (Myers and Kitsuse, 2000). Forecasts can be based on detailed, complex quantitative models. They can also include relatively qualitative approaches, such as the “Trend-Delphi” method, which systematically draws from “expert” opinion, or technical and policy committees convened to develop or review assumptions or inputs, thereby enabling the transformation of projections into forecasts. Ultimately, forecasts are what feed into plans, which evaluate the forecasted future and produce an image of the “desired future” along with the steps needed to get there (Myers and Kitsuse, 2000).

The shortcomings in traditional approaches to urban transportation planning have been documented through the years. Some relate specifically to the theories underlying the
models, such as weaknesses in procedures typically used for estimating trip generation or for assigning trips to specific routes (see, for example, Deakin and Harvey, 1993). Others relate more closely to the application of the models, such as the use of modeling approaches designed for one context (i.e., an industrialized world city) in another (i.e., a developing world city) (see, for example, Dimitriou, 1992). Another more generalized level of criticisms, however, is aimed at the overall acceptability of the assumptions – and the processes used for choosing and presenting those assumptions – that in the end form the most critical inputs to making any forecast (Wachs, 2001). Wachs (2001) provides a brief review of the potential for “blatant abuse” of forecasting techniques, particularly for transportation planning, asserting that these underlying assumptions actually dominate forecasting outcomes. Furthermore, the core assumptions and judgments used by practitioners are often not made clear to the general public, or even decision makers, so that forecasts are accepted as inevitable futures for which we must plan (Myers and Kitsuse, 2000). The end result, then, is a single strategic plan – designed to address forecasted “problems” that may prove quite inaccurate – that fails to account for unforeseen events. In a recent survey of US transportation planning practitioners and decision-makers, Mehndiratta et al. (2000) conclude that, while some unforeseen events, or risks, might be effectively handled through the political and institutional aspects of the metropolitan transportation planning process, the process still fails to address many other risks – political, institutional, economic, and technological.

Scenario planning offers a potential platform for addressing these criticisms of traditional planning approaches. The potential value of scenario planning lies in its providing a coherent, systematic and collaborative framework for assessing the long-term effects of changes in key influencing factors. Following Dalton (2001), we believe that scenario planning could offer a means to avoid planning for a single forecasted future; instead enabling us to coherently develop several possible futures and plan for them. The use of scenario planning could satisfy what several authors have characterized as a need for better integrating “the future” into planning studies (i.e., Cole, 2001) and building more communicative approaches and processes for transportation planning (Willson, 2001). In his call for more collaborative planning, Wachs (2001) essentially makes the case for scenario planning: “Collaborative planning would benefit from the capacity to test alternative assumptions and different model parameters.” This would then turn the inherent subjectivity of forecasts into a benefit, by turning any given forecast into an “enumeration of the consequences of a particular set of assumptions that can be varied” (Wachs, 2001). The scenario planning approach potentially offers a logical structure for using forecasts in just this way.

Transportation Precedents
The application of the scenario planning approach to transportation planning is not new. In fact, Pearman (1988) reports that, as part of an attempt to “re-establish a role for long-term transport planning,” scenario planning applications in transportation first appeared in the early 1970s – one conducted for the Chicago metropolitan area and one conducted for the United States Department of Transportation. According to Pearman, these early examples were followed by “a steady trickle” of scenario planning examples in
transportation during the early 1980s, including for the European Community, for Sydney (Australia), for Metropolitan Manila (Philippines), and Baltimore, Maryland (USA).

In the Sydney case, Westerman (1981) endeavors to demonstrate an approach that can help transportation planning better formulate and implement “systems within a long time frame during which both ends and means can change in unpredictable ways.” Westerman proposes scenario planning (which he calls “systemwide forecasting” through “an exercise in lateral thinking” and “imagineering”) within a broader planning process. The purpose of scenario planning, in Westerman’s approach, is to discover “boundary conditions of the future” and to understand “the impact of possible fundamental rather than incremental changes of the system as a whole.” To demonstrate the applicability of the approach, Westerman applies it to the 1979 decision by the government to begin planning a major arterial through the city’s inner suburbs. Scenario planning techniques were apparently used to develop four different futures, by which four road configuration options were evaluated. No details are provided on the scenario planning techniques used to develop the “futures,” their links to other analytic techniques, nor the evaluation methods employed.

The Baltimore example, chronicled in Mordecai (1984), was conducted in 1981-82, in direct response to the energy crises of the 1970s and early 1980s. Carried out by the Baltimore Regional Planning Council, the “primary intent” of the Baltimore application “was to bring a new perspective to long-range transportation planning, particularly in relation to varying future conditions”. Recognizing that the “future is not necessarily an extension of the present and that existing programs and policies may not be appropriate for the future,” planning staff and invited panelists identified, through the use of scenario planning, a number of issues that “receive little or no attention in existing work programs.” While Mordecai suggests that the project did provide “a new perspective for long-term planning” and “a new context for the design of specific policies and programs,” it also revealed that scenario planning may conflict with established planning procedures and decision making processes and would likely require institutional changes. Based on this assessment, Mordecai concludes that the “long-term benefits [of scenario planning] remain uncertain at this time.”

The late 1980s brought another example in the United States of a scenario planning effort for long-term metropolitan transportation planning, this time as part of a process to develop a new long-range public transport plan for Seattle, Washington. According to Rutherford and Lattemann (1988), the planning agency chose scenario planning because a previous long-range public transport plan failed to account for potentially changing future conditions, particularly those over which the agency had little or no control. In mid-1986, agency staff, drawing on scenario planning applications from other sectors and from previous transportation precedents (including the Baltimore case), embarked on a scenario planning exercise to provide “a context for assessing future markets for public transportation” and “a framework for strategic thinking about both threats and opportunities for public transportation” in the region. The exercise was conducted by an interdivisional group of agency staff (the “Futures Team”), which developed the scenarios with feedback, review and validation coming from an independent panel of
outside experts from various disciplines. Through an iterative process between the agency staff and the expert panel, a total of five scenarios were developed, two of which were “contingency” scenarios to be used for planning if a “rather remote combination of events occurred simultaneously” (Rutherford and Lattemann, 1988). Variations in variables under three major categories (energy, economy, public policy) ultimately translated into scenarios for the metropolitan area that differed according to characteristics related to trends in national policy, demographics, economics, employment, housing, energy and institutions. Eventually, the effectiveness of a single public transport plan was evaluated according to the three principal scenarios’ impacts on public transport ridership (Rutherford and Lattemann, 1989). Although the benefits of the scenario approach were recognized – such as the increased understanding of influencing factors and an assessment of risks and tradeoffs (Rutherford and Lattemann, 1988; 1989) – scenario planning was discontinued at the agency, in part due to institutional changes (the merging of local governments) and statewide planning legislation that mandated a six year public transport planning horizon (Lattemann, 2002).

Despite these early precedents, since the late 1980s few scenario planning efforts for metropolitan transportation planning or for more general regional planning appear in the literature. The Third New York City Regional Plan (Yaro and Hiss, 1996) contains two scenarios in its Appendix, though these appear essentially as “visioning exercises” depicting possible futures with or without Plan implementation. The American Planning Association introduces its model statutes for growth management (APA, 1996) with two scenarios of “contrasting environments in contemporary American life,” essentially visions representing some of the choices that leaders and citizens must make. Myers and Kitsuse (2000) characterize both of these efforts as “largely gratuitous.” In the mid-1990s, the American Public Transit Association utilized scenario planning to identify trends relevant to public transportation usage in the United States. These were, however, aimed at developing a vision of a “preferred future” and were not, in any case, specific to a particular regional planning application (APTA and Olson, 1996). In 1997, the Research and Technology Coordinating Committee (RTCC) of the U.S. Federal Highway Administration utilized scenario planning to help develop research recommendations (RTCC, 1997).

None of these more recent examples advance the potential application to specific regional circumstances. The apparent lack of recent applications to metropolitan transportation planning, in the face of earlier precedents, may signal that the method is untenable within current planning contexts. However, as noted in the previous section, the need has not disappeared for more comprehensive, coherent and transparent long-term approaches for developing transportation plans that can ultimately withstand the vagaries inherent to the future.

The authors are aware of only one recent example of strategic regional transportation planning incorporating the scenario planning approach, conducted in 1997 as part of project at MIT to look at the potential for developing a tunnel across the Andes from the Province of Mendoza (Argentina) to Chile. As part of the analysis, Muñoz conducted a scenario planning exercise for the Mendoza Macro-region (see Muñoz, 1998; Muñoz and
Sussman, 1999). As a purely research exercise, the Mendoza example does not enable us to view the potential organizational inputs and implications of scenario planning; nonetheless it does offer a useful illustration, upon which we ultimately based the Houston case, discussed in the following section. The steps followed by Muñoz (see Table 1) in the Mendoza application, roughly follow those proposed by Schwartz (1996). These steps ultimately formed the foundation for the Houston case.

THE HOUSTON CASE

A Preface
Building on Muñoz’s Mendoza application and the more recent literature on scenario planning approaches in other sectors, an MIT team (comprised of three professors in transportation, urban planning and public policy, together with five graduate students in transportation and urban planning) undertook a case study application to refine scenario planning as it might be applied to strategic regional transportation planning. For the case study, the team focused on the Houston, Texas (USA) metropolitan area. This section outlines the steps undertaken by the team and the following section attempts to evaluate the application.

Among three different potential approaches to structuring scenarios, van der Heijden (1996) outlines two – inductive and deductive – that we ultimately used in our Houston application. According to van der Heijden, the inductive approach “builds step by step on the data available and allows the structure of the scenarios to emerge by itself.” By contrast, in the deductive method, the overall framework is started with, “after which pieces of data are fitted into” it. In our initial approach to scenario planning for Houston, we took essentially a deductive approach, developing general frameworks for stories which we thought would provide useful and interesting foundations for evaluating mobility futures in the metropolitan region. The initial scenario themes were: the United States of North America (USNA) – which intended to represent a world of accelerated globalization, trade integration, and increased prosperity; Balkanization of the World – which signified global fragmentation, regional strife, and an extended period of economic stagnation; and, Mother Nature Bites Back (MNBB) – which intended to depict a world where environmental constraints and environmental disasters became the principle influencing factors affecting the future.

While interesting as themes, our initial scenario frameworks proved difficult to make compatible and consistent and, most importantly, proved difficult to actually use. In particular, we were challenged in our attempts to derive “mobility” implications of the different scenario frameworks. Eventually, we revisited our initial scenario construction method, adopting essentially the inductive method. This is the approach that we outline in the rest of this section (and shown in Figure 1). Ultimately, our inductive scenarios were somewhat similar to the initial themes we constructed deductively; our inductive

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5 The third, the incremental approach, is not immediately relevant to this presentation.
6 It might effectively be argued that our scenarios actually resulted from a combination of the two (inductive and deductive) approaches; van der Heijden (1996) provides a chronicle of a similar experience in a Canadian government scenario exercise.
scenarios however, shared a logical uniformity and, more importantly, they gave us a more solid base from which mobility implications could be reasonably assessed.

**Step I: Define the Scope/Identify the Strategic Options**

Our group began the process by defining the scope of the work that we were undertaking. Was our scope to evaluate the future mobility conditions in the Houston Metropolitan Region? Was it to search for ways to provide for a “sustainable” level of mobility in the Houston area? Or, was it to prioritize a strategy from a suite of potential future mobility options in Metropolitan Houston over approximately the next 20-25 years? Eventually, the latter became our defined scope, our major strategic decision.

Building on this broad purpose, we further delineated a series of potential strategic transportation options that might be appropriate within that scope:

1. Construction of Light Rail through CBD
2. Expanded HOV system
3. Congestion/Value Pricing
4. Construction of Grand Parkway Ring Highway
5. Construction of Interstate 69 through Houston
6. Expansion and Remodeling of the Two Major Airports
7. Expansion of the Port of Houston
8. Growth Management and Land Use Controls
9. Implementation of an Automated Highway System
10. Construction of Heavy Rail Transit
11. Development of Intercity High Speed Rail
12. System Maintenance and Incremental Development

Many of the options were traditional, drawn in large part from existing transportation plans for the city, primarily the MPO’s (the Houston-Galveston Area Council, or H-GAC) year 2020 transportation plan. We also included options, such as airport and port expansion, which, while obvious transportation options, might not typically be considered integrated within an urban transportation planning process. We also attempted to “push the envelope” somewhat, looking at – for example – automated highway systems and inter-city high speed rail (which in the U.S. can fairly be characterized as “pushing the envelope”). In some cases, we grappled with whether an item was actually an option or a “driving force” (see Step III).

For example, specific automotive technological developments would fall within a broader category of technological driving force; these were not likely to be options that Houston would have much liberty to implement on its own. A similar challenge was presented by growth controls and land management – while these are certainly mobility options themselves, they might also be considered as “external driving forces,” particularly due to their close links to the broader environmental movement and potential national trends towards “Smart Growth.” We ultimately considered growth management as a local strategic option, although it was also a component of the environmental “driving force,” as discussed in Step 3 below. It is worthwhile pointing out that we (seemingly unintentionally) did not really focus on issues that perhaps did not “fit” into our
perception of Houston: for example, bicycle planning and other non-motorized transportation options.

**Step II: Outline Key Local Factors Affecting the Outcome of the Options**

Early in the process, the team worked to identify those *key local factors* that influence the success or failure of the decision to be made (strategies chosen). These should be both important to the decision to be made *and* uncertain. Ultimately, we determined that these are the local factors that will be affected by the drivers; the scenario plot-lines will be “fleshed” out with consideration of how these key local factors are affected (“Implications”) and ultimately how the strategies are ranked. With this definition in hand, we went through a variety of potential key local factors, such as: social issues, “vision” for the region, relation to the state, relation to the nation, relation to international economies. By concentrating on the key focal point – mobility – we eventually narrowed our list of key local factors down to five categories:

- Health of the Local Economy,
- Shifts in Environmental Attitudes/Policies,
- Demographics,
- Federal/State Investments/Control,
- Local Politics.

**Step III: Identify the Driving Forces Which Impact the Key Local Factors**

The driving forces are the key elements behind the scenario “stories.” These are social, economic, political, environmental and technological *macro*-issues, which are most likely external to the area being considered. Similar to the key local factors identified in the previous step, these must be both uncertain and important to our decision. Our scenario team went through various iterations of potential driving forces. At one point, we had two critical, unpredictable drivers: environmental constraints and economic growth. To these, we later added transportation and technological innovation, geo-political forces, finance, and demographic trends. From these six general categories of forces, we determined that four would be most manageable and worked to narrow the six down. Although we discussed the use of an “influence diagram” (as used by Muñoz, 1998 and recommended by van der Heijden, 1996), we eventually took an ad-hoc approach, based in part on research and in part on experience, to arrive at our final driving forces for the Houston case. We arrived at four categories of driving forces – the economy, finance, technologies, and environment (as detailed in Table 2).

**Step IV: Develop Potential Combinations of Driver “States” & Select Scenario Plots**

In this step, the scenario team developed a matrix of the “states” of the driving forces. For simplicity, we decided that each of our driving forces had two potential states; essentially “good”/“bad” binary possibilities (i.e., for economy either “rapid growth” or “stagnant”). This left us with sixteen potential driver combinations. From these potential combinations of states, we selected three - based on Wack’s recommendation - to form the basic plots for our scenario “stories.”

In selecting our driver combinations, we aimed to effectively represent interesting and broadly different potential futures. We also were somewhat wed to our initial
“deductive” scenario themes (USNA, Balkanization, and MNBB – see the preface to this Section). The final challenge was to ensure that each scenario would be different enough to represent a range of futures with diverging mobility implications, but with plot-lines that were logical and plausible. Eventually our three scenarios became: United States of North America, Balkanization, and Earth Day 2020 (see Table 3). These final scenario “logics” presented above actually resulted from a somewhat iterative process between this step and the following step, “Fleshing out the Scenarios,” to which we now turn.

**Step V: Flesh Out the Scenario Stories**

At this stage, narrative creativity became key, with the aim being to give “full reality” to the scenarios, so that the stakeholder could easily recognize and connect the various scenario components. Each scenario is intended to leave a clear impression, while remaining faithful to the scenario logics and building plausible cause-effect relationships within the stories. As an example, the base logic of the scenario that the team had initially, deductively, called “Mother Nature Bites Back” metamorphosed into a different combination of drivers. The team had wanted this “environmental” scenario to represent a world where economic growth was high, but environmental concern was also high. Convincingly and plausibly developing this story required that Mother Nature Bites Back, which had originally been cast as an environmental crisis scenario, evolve into what would eventually be called Earth Day 2020, representing a world where the environment is embraced as an opportunity for prosperity. The cause-effect relationship which enabled this to occur in the scenario story-line basically required that technological innovation form a building-block to the scenario. In this case, we then decided to return to the USNA plot-base (combination of drivers; see Table 3), which originally contained technology innovation, and make USNA a scenario where technology is relatively stagnant. We felt able to support this story-line as both logical and plausible.

With the basic macro story-lines (drivers) fleshed out in each scenario, the second stage of this step was to estimate the driver effects on the key local decision factors (from Step II). By developing estimates of the effect of these drivers – on local politics, the local economy, environmental attitudes, federal/state investments, and demographics – we were then better situated to examine mobility implications, Step VI in our process (see Figure 2).

**Step VI: Mobility Implications of the Scenarios**

With our basic scenario stories in hand, we then returned to our focal issue: to examine the state of mobility in Houston under each scenario. Again, it is important to emphasize that our exercise is intended to serve as an example, rather than an “official” application to the Houston region. The initial framework for assessing the mobility implications was established in the previous step – by estimating the drivers’ effects on the key local decision factors (see, also, Figure 2). The scenarios can affect the transportation system in three primary ways: a) changing the magnitude of activity in the region; b) changing the spatial distribution of activity in the region; and, c) changing the types of activity in the region. The process we used to estimate rough mobility effects involved a qualitative manipulation of primary data projections, which we translated into macro-zonal level
population, employment, and trip end attributions – different for each scenario – across Houston. 7

From these attributions, the team roughly judged the mobility requirements under each scenario. These estimates – which we call “Mobility with the ‘Status Quo’” – are initial portraits of mobility needs in the future against which the various options (from Step 1) would be evaluated for performance. At this stage, we confronted the challenge of trying to “separate” the actual scenarios from the various options. For example, the USNA scenario was, in part, characterized by ongoing and accelerated urban outgrowth and heightened levels of regional and international trade. Almost implicit in these trends were major peripheral highway investments and trade corridors; USNA’s trends could not really occur without them. In this sense, we were confronted with the question: were the scenario stories separate from the options being considered? Or, in other words, how could some of the scenarios evolve, without the options in place?

We ultimately chose to map out the initial mobility portraits “option free.” Although imperfect, this approach does provide a reasonable fit within the overall scenario planning philosophy which aims to help address the question: “given these potential futures, what are the best strategic decisions we can make today?”

Step VII: Options Evaluation

At this stage, the team evaluated the various options across the mobility portraits drawn in the previous step. The team ultimately settled on a basic form of multi-criteria analysis for options evaluation. Multicriteria analysis methods seem well-suited for the task since they, by their nature, are designed to incorporate a range of social, economic and environmental factors into the evaluation framework (for examples of different techniques, see Won, 1990). Scenario planning takes a multi-dimensional, holistic and organizational perspective to strategic decision-making; multicriteria analysis integrates quantitative and qualitative factors into evaluations, through a process that can also “lead to better communication between the analysts and the decision-makers” (Won, 1990). The two techniques are strongly complimentary.

We developed a straightforward multicriteria framework. We established two different categories of criteria by which each strategic mobility option would be evaluated: feasibility of implementation and effectiveness if implemented. Within the feasibility category, the specific evaluation criteria we identified were financial, environmental, and institutional; for the category of effectiveness, the criteria were individual accessibility, goods movement, and equity (see Table 4). Then, under each of the three scenarios, the individual options 8 were evaluated according to their performance by each criterion

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7 A description of the rudimentary data analysis procedures used in the Houston example are contained in the Appendix of the CMP-ReS/SITE (1999) report.

8 The team also attempted to package the options into strategic “bundles” for evaluation, with the understanding that certain options would certainly perform better when implemented in conjunction with others. We eventually abandoned this technique for a variety of reasons: 1) in strategic bundles, poorly performing options brought down the performance of the overall bundle (i.e., the evaluation lost resolution); 2) our rudimentary analysis technique did not allow us to capture potential synergies between
within the assumed reality of the scenario. We used simple cardinal numbers to relatively subjectively judge the performance of each option; these were summed for each option, which provided a ranking of the option’s performance in the scenario. The end-result, for each of the three scenarios, was a separate ranking/prioritization of options for implementation.

The results were quite different for each of the three scenarios. Strategies for the USNA, for example, focused heavily on infrastructure expansion, including the Grand Parkway outer ring road, expanded HOV facilities, and airport and port expansion. The Balkanization scenario represented a stark contrast to USNA. Except for port expansion, expanded HOV facilities and light rail investment, few additional major investments appear feasible. Finally, under Earth Day 2020, policy measures come to the fore, including congestion pricing and growth management, while HOV and light and heavy rail also come out favorably. In all scenarios, system maintenance is the best-performing strategic option. It is important to remember that we present these results only to illustrate the outcomes of our proposed framework, not as strongly substantiated options for the Houston metro area (although they may well be).

**Step VIII: Composite Analysis of Strategic Options**

The final step in our scenario planning application to Houston consisted of aggregating the individual multicriteria analysis outputs into a composite matrix. We took two different approaches to the composite analysis. One was to simply sum each option’s performance (across the six criteria) in each scenario. These aggregate “scores,” then, represented the option’s robustness across the range of potential futures that our scenarios presented. These aggregate scores also represented a possible ranking or prioritization of the mobility options identified for the Houston Metropolitan Region. The other approach to composite analysis aimed to prioritize options via risk minimization. This process ranked the options according to the highest minimum score of each option. In other words, each option’s lowest score across the scenarios became its overall ranking.

The two approaches produced similar but not identical option prioritizations. The “robustness” approach identifies five options that appear robust across all scenarios: a) system maintenance; b) HOV network expansion; c) congestion pricing; d) port expansion; e) light rail. These represent a set of investments that makes sense if one is deciding today what the region will need in 20 years. Interestingly, the risk-minimization approach to composite analysis yields the same top five strategic options, although the order varies between the two approaches. For more details of the process and outcome see CMP-ReS/SITE (1999).

**EVALUATION OF THE HOUSTON CASE**

By outlining, step-by-step, the Houston case we aim to offer the framework for an approach that can be adopted and adapted, in whole or in part, for other long-range metropolitan transportation planning exercises. In reality, Steps 1 through 5 above constitute the actual scenario planning approach, while steps 6 through 8 more accurately
represent “sketch planning” techniques that might be substituted, to some degree, by more traditional planning tools such as travel forecasting and cost-benefit analysis. Time constraints prevented us from exploring links between the proposed scenario planning approach and such tools, although this could be an area for additional research (as discussed further below). With the aim of further exploring the potential value of scenario planning applications in transportation planning, this section evaluates specific relevant aspects of our approach.

**Key Local Factors and Driving Forces**

It might be argued that our categories for driving forces (i.e., “state of the economy”) and key local factors (i.e., “demographics”) are generic, applying to any planning exercise. In effect, they may well be. However irrespective of whether or not the general categories are universal, the details of each, particularly the key local factors and how they ultimately might impact mobility in a given area, will certainly vary from one metro area to another. Part of the importance of the scenario process rests in the actual exercise of identifying the key local factors and driving forces—making planners and stakeholders explicitly recognize them. Furthermore, and particularly at the local level, variation among the key local factors category will almost certainly arise, as geographical constraints might be particularly important for planning in one context, while environmental, political or cultural factors might have important explanatory influence in another (such as a given locality’s motorization rate, or the propensity for motorized two-wheeler use in certain regions).

**Number of Scenarios**

Wack (1985a) recommends three as the ideal number of scenarios: “The ideal number is one plus two; that is, first the surprise-free view (or “official future”) and then two other worlds or different ways of seeing the world that focus on the critical uncertainties.” Based on that recommendation and the Muñoz example, we settled on three scenarios for the Houston case, although we might actually consider the Houston-Galveston Area Council 2020 Transport Plan as our fourth, “surprise-free” scenario. Additional scenarios could also be developed. For example, the Seattle example developed five scenarios, two of which were “low probability” scenarios for contingency planning and three of which were actually used for comparing fixed route transit ridership (Rutherford & Lattemann, 1989). The Baltimore example utilized four scenarios—basically a trend, high and low, as well as a combined scenario, where one scenario “transitioned” into another scenario in order to help identify potential responses to a major, sudden change (in this case, a prolonged interruption of fuel supply) (Mordecai, 1984). While the use of more scenarios or the concept of utilizing “sub-scenarios” (i.e., having certain relationships within each scenario also be subject to varying states), is possible, one must keep in mind the increased complexity implied. This is particularly true when efforts are made to link the scenario planning framework with more formal modeling techniques, when each model run may require hours of computing time and significant additional staff work. The question of an “ideal” number of scenarios remains open for research.
Subjectivity and Ultimate Quality of the Scenario Planning Exercise
As discussed previously, planning is inherently subjective (see Wachs, 2001). We believe that the use of scenario planning can actually help reduce subjectivity in planning, because the ranges contained in the various scenarios makes it more difficult (though certainly not impossible) for biases to unduly influence future possibilities. Again, this lends itself to Wachs’ call for collaborative planning and the subsequent need to vary preferences based on participants’ understanding and assumptions.

On a related point, in our scenario planning demonstration we did not undertake a process to establish whether our scenarios were actually “good.” Due to time and data constraints, we could not effectively test our scenarios through the detailed analysis of hard and soft data which Wack (1985a) calls crucial to expanding the number of predetermined elements and getting at the “core of what remained uncertain.” Furthermore, we could only briefly assess our scenarios to see whether they contained, as Wack (1985a) suggests, “many outcomes” that are “simply not possible.” In addition, we should have conducted a thorough comparison of pre-determined elements across scenarios, to ensure that these remain consistent throughout each (van der Heijden, 1996).

Van der Heijden (1996) suggests scenarios can be validated through a process of “actor testing,” which he considers key to determining internal scenario consistency. To carry out this step, the scenario team must identify the stakeholders (Schoemaker, 1995): those with a major interest in the issue, those who are affected by the issue, those that might influence it, their current roles and interests (and power) and how these have changed over time. Again, this is closely linked to the idea of “collaborative planning” (Wachs, 2001; Willson, 2001).

Links to Quantitative Tools
As discussed in steps six and seven above, we undertook a preliminary “sketch planning” analysis of the ultimate mobility consequences of our scenarios and options performance since a more detailed analysis was hampered by time and data constraints. Despite the simple approach the team utilized in estimating mobility effects, we believe that the scenario planning methodology proposed could be integrated with a more sophisticated modeling analysis. In this sense, principal constraints would be time, data, and modeling tools available to the scenario planning team. These constraints, while not trivial, are likely surmountable, although ongoing theoretical and practical limitations in the available economic development-land use-transport demand modeling package might prove restrictive (see, for example, Wilson, 1998).

Furthermore, one cannot ignore the computational requirements of running a long-term travel forecasting exercise for several different potential futures. In the Seattle scenario planning application, for example, the scenario planning team translated the scenario “descriptions” into variables (economic, household income, traffic congestion, private automobile costs, and parking costs) used for modeling public transport patronage (Rutherford & Lattemann 1989). Although different combinations of variables under each scenario were analyzed using the EMME/2 (see, for example, INRO, 2000) transportation planning software (Rutherford & Lattemann, 1988), traffic congestion was
not varied across the different scenarios because of the impracticalities of developing several different congestion forecasts in each case (Rutherford & Lattemann, 1989). Advances in computing since the Seattle application may help to reduce such impracticalities. Clearly, this is an area that would benefit from additional research work and practical experiments.

Even if scenario planning as practiced at the metropolitan transportation decision-making level could be integrated with formal quantitative tools, care would need to be taken to ensure that the restrictions of these tools did not then become restrictions to the futures considered under each scenario. In addition, there are certain contexts for which scenario planning and related “sketch planning” techniques might be a more appropriate and more viable approach. For example, Vasconcellos (2001) summarizes the criticisms of traditional transportation planning approaches in the developing country context, including: the reliability of forecasts (of, for example, socioeconomic characteristics and land development patterns), the availability of data, the lack of strategic long-term perspectives, a politically insular and non-transparent process, and ideological biases towards certain solutions. Scenario planning in such a context might bring considerable value. In fact, the first two authors of this paper are currently participating on a multi-disciplinary team in a multi-year project analyzing air pollution control strategies for Mexico City. Looking at the long-term potential for improving air quality (through the year 2025), the team is utilizing the scenario planning approach as the general framework for developing the “solution space.” In this case, the scenario plots (driving forces) are being linked to bottom-up, activity models (i.e., of vehicle technologies and traveler behavior); the scenarios are also being informed by macro-economic, quantitative analysis. Currently a work in progress, the Mexico City effort will hopefully shed additional light on the potential use of this approach.

**Evaluation Techniques**

Closely linked to the issue of quantitative techniques is that of options evaluation. For example, our “sketch planning” assessment of each scenario’s mobility impacts did not allow us to effectively capture the mobility interactions among options (i.e., network effects). This hampered a more thorough evaluation of options and “bundles” of options. In addition, in our options evaluation we utilized a basic form of multicriteria analysis (again limited by time and data constraints). We did not apply a more traditional appraisal technique, such as cost-benefit analysis although, again, such a technique could be incorporated into the methodology. It is important to keep in mind, however, that the evaluation methodology chosen depends on the scope of analysis. In the Seattle scenario planning case, for example, the purpose was to assess the viability of a single transit assumption, the performance of which was assessed for each of the scenarios (Rutherford & Lattemann, 1989). For a broader, system-wide strategic planning effort, multi-criteria analysis can fit the need of scenario planning, especially because it allows for an evaluation to combine necessarily subjective criteria (i.e., institutional feasibility), with more objective (such as freight movement). With better modeling tools and consensus on appropriate metrics (i.e., ton-kilometers traveled or vehicle hours of travel), the multi-criteria analysis also provides an additional contribution to organizational learning – a key benefit of scenario planning (as discussed earlier).
Multi-criteria analysis is receiving increasing attention for transportation planning evaluation purposes (see, for example, UK DTLR, 2001), as it can assist in incorporating criteria that are not easily monetized. Connors (1996) offers an example of a “bottoms-up” approach applied to the electric utility sector that seems well-suited as a complement to the transportation scenario planning application proposed here. Indeed, Connors’ multi-attribute trade-off analysis approach is being used in the above-mentioned Mexico City scenario planning effort currently underway.

**Limitations to the Demonstration**

The Houston exercise, though conducted in a group setting, suffers from the same weakness as the Muñoz application, in that we did not include decision-makers and planners in the process. As discussed, one of the main purposes of scenario planning is to better prepare the organization for the changes that its world will face. Organizational learning and broadening the perspectives of decision makers can make scenario planning worthwhile even if no explicit decision results.

There is, however, a possibility that scenario planning will meet with resistance if attempted at the metropolitan transportation planning level. Most institutions are naturally resistant to change; this might be even more the case in a field for which planning processes have become so institutionalized and codified. As Mehndiratta et al. (2000) point out, “local planners find their jobs complex enough and are not enthusiastic about adding another layer of complexity to it.” Furthermore, use of the process may actually present legal barriers. Myers (2001), for example, notes that in California state law requires that the state’s Department of Finance projections be used as the basis for all local planning. Finally, in a field accustomed to heavy dependence on quantitative planning methods, skepticism might be strong for the seemingly qualitative approach embodied in scenarios. In this sense, it is important to keep in mind that scenario planning is not intended to replace quantitative planning; instead it is intended to augment traditional planning techniques.

**Potential Variations and Extensions of the Work**

Despite some of the limitations of the case presented here, we do feel that scenario planning offers promise as an enhancement to more traditional long-term transportation planning techniques. Further exploration of its usefulness, however, is required. Perhaps the most valuable extension, in this sense, would be to bring the approach – as a pilot application – into the formal transportation planning process of a specific metropolitan area. This would enable a better understanding of its performance in strict organizational settings with formal decision-making processes, utilizing accepted quantitative methodologies. Such an effort would help to answer some of the questions raised in our Houston case, including the degree of organizational learning and public participation that the process might facilitate. In addition, it might be useful to utilize the approach in tandem with traditional approaches to see whether they yield significantly different results (i.e., in terms of projects/policies ultimately selected). In further applications it would also be useful to explore the potential use of variations in primary trends over time (i.e., having each scenario contain different “packets” of economic growth rates) and
whether or not probabilities could be effectively integrated into scenario analysis, by for example, giving each scenario a “probable weight” by which the options being tested would ultimately be evaluated (see, Pearman, 1988).

CONCLUSIONS
Scenario planning is a strategic planning approach well-known for its ability to get decision-makers to think “outside of the box,” to enable organizations to make decisions in a world of increasing uncertainty and unpredictability, and to produce robust strategies. The goal of scenario planning is not to produce a more precise portrait of tomorrow, rather more sound and robust decisions today.

Scenario planning continues to be used across a range of disciplines and sectors. In metropolitan transportation planning, although several examples exist from the 1970s and 1980s, more recent scenario planning applications are scant in the literature. The challenges for incorporating long-term strategic vision into metropolitan transportation planning have not, however, gone away. With the goal of advancing the possibilities for scenario planning to contribute to the study and long-term planning of regional transportation systems, this paper has presented the framework used in an academic application to the Houston Metropolitan Region.

Drawing from examples from other sectors, the scenario literature, and some precedents from the field of transportation, the Houston case adapted an eight-step scenario planning approach (see Figure 1). Though the analysis is admittedly rough and preliminary in scope, we believe it contributes a step forward in using scenario planning for strategic regional strategic transportation planning. Not only do the steps outlined provide a logical planning framework, but the case itself offers several lessons and suggests areas for further research and refinement.

Among the points raised in our evaluation of the Houston application, perhaps the most important one relates to the fact that our exercise was conducted in the confines of academia. This inevitably limits the case’s ability to shed light on how the proposed process might fit into the institutional, procedural and political confines of a “real life” strategic transportation planning process. In addition, further work needs to be done in relation to determining an “ideal” number of scenarios for transportation planning, testing the scenarios for consistency, and linking scenario planning to quantitative transportation planning and evaluation tools. The use of scenario planning in the context of a Mexico City air quality management project currently underway, in which the first two authors of this paper are involved, will hopefully help to answer some of these questions. We hope, however, that others might undertake field applications to help see how planning agencies can adapt the proposed approach and how the approach might compare in use and ultimate results with other approaches. The ultimate goal is to help regional planning authorities, the private sector, and citizens in the development of robust transportation strategies in a time of uncertainty.

REFERENCES


Lattemann, J. (2002). Senior Transit Planner, King County Metro, Seattle, WA. Personal communication.


<table>
<thead>
<tr>
<th>Step</th>
<th>Product of Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify the <em>key decision or focal issue</em> of the scenario planning exercise</td>
<td>Prioritization of seven regional transportation strategies</td>
</tr>
<tr>
<td>2. Identify <em>key factors in local environment</em> which will most impact success of key decision</td>
<td>Three key factors identified</td>
</tr>
<tr>
<td>3. Identify the <em>driving forces</em> that influence the key local factors</td>
<td>Twelve driving forces identified</td>
</tr>
<tr>
<td>4. Rank driving forces according to <em>importance and uncertainty</em></td>
<td>Driving forces ranked and three selected as scenario “plots”</td>
</tr>
<tr>
<td>5. Select the <em>scenario logics</em></td>
<td>The combination of driving force “states” upon which scenario plots will be developed</td>
</tr>
<tr>
<td>6. Flush out the <em>scenarios</em></td>
<td>Scenario narrative, the “story” behind the driving forces</td>
</tr>
<tr>
<td>7. Estimate <em>implications</em></td>
<td>Impacts of the scenarios on the key decision or focal issue</td>
</tr>
<tr>
<td>8. Identify <em>leading indicators</em></td>
<td>Those indicators which will enable decision-makers to recognize a scenario’s actual emergence</td>
</tr>
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Table 2: “Driving Forces” in the Houston Scenario Planning Application

<table>
<thead>
<tr>
<th>Driving Force</th>
<th>Example Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>State of the Economy</td>
<td>global and regional economic integration, trade, capital flows, competition, wages</td>
</tr>
<tr>
<td>Finance</td>
<td>availability of infrastructure funding, user fees and charging mechanisms, private sector participation in infrastructure</td>
</tr>
<tr>
<td>Technology</td>
<td>intelligent transportation systems, telecommunications, vehicle technologies, fuel supply technologies, advances in other modes (rail, shipping)</td>
</tr>
<tr>
<td>Environment</td>
<td>local air pollutants, climate change, endangered species, water pollution, “sprawl”</td>
</tr>
<tr>
<td>Scenario</td>
<td>Drivers</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>United States of North America</td>
<td>Rapid Growth</td>
</tr>
<tr>
<td>Balkanization</td>
<td>Stagnant</td>
</tr>
<tr>
<td>Earth Day 2020</td>
<td>Rapid Growth</td>
</tr>
<tr>
<td>CRITERIA CATEGORY</td>
<td>CRITERIA</td>
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<td>------------------------</td>
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<td></td>
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<tr>
<td>Feasibility</td>
<td>Financial</td>
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<td>Institutional</td>
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<td></td>
<td>Individual Accessibility</td>
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<tr>
<td>Effectiveness</td>
<td>Freight Mobility</td>
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<tr>
<td></td>
<td>Equity</td>
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FIGURE 1
THE SCENARIO TRANSPORTATION PLANNING FRAMEWORK AS APPLIED TO HOUSTON

I. DEFINE THE SCOPE/IDENTIFY THE STRATEGIC OPTIONS

II. IDENTIFY KEY LOCAL FACTORS AFFECTING THE STRATEGIC OPTIONS

III. IDENTIFY THE DRIVING FORCES WHICH IMPACT THE KEY LOCAL FACTORS

IV. DEVELOP POTENTIAL COMBINATIONS OF DRIVER “STATES” & SELECT SCENARIO PLOTS

V. “FLESH OUT” SCENARIO STORY
   |   |   
   V. “FLESH OUT” SCENARIO STORY
   |   |   
  VI. MOBILITY IMPLICATIONS
   |   |   
  VII. OPTIONS EVALUATION

V. “FLESH OUT” SCENARIO STORY
   |   |   
  VI. MOBILITY IMPLICATIONS
   |   |   
  VII. OPTIONS EVALUATION

V. “FLESH OUT” SCENARIO STORY
   |   |   
  VI. MOBILITY IMPLICATIONS
   |   |   
  VII. OPTIONS EVALUATION

VIII. COMPOSITE ANALYSIS OF STRATEGIC OPTIONS
FIGURE 2
TRANSPORTATION SCENARIO PLANNING LOGIC

SCENARIO DRIVERS

ECONOMY    ENVIRONMENT    TECHNOLOGY    FINANCE

KEY LOCAL FACTORS

LOCAL ENVIRONMENT
LOCAL ECONOMY
FEDERAL/STATE
LOCAL TRANSPORTATION EFFECTS
LOCAL POLITICS

DEMOGRAPHICS