into a common information flow. Through this information flow decisions must be anticipated, communication with decision makers effected, and, most important, illusions of certainty avoided. In times of uncertainty it is appropriate to acknowledge the limitations of the process.

On the receiving end, decision makers must understand the planning process. By direct participation in planning activities, decision makers can provide the strong leadership necessary to shape planning so as to make it more relevant to decision making while at the same time learning from planning and gaining a better sense of uncertainty.

The key is a hand-in-glove relationship between planning and decision making. It is suggested that such a relationship can be accomplished through an integrated planning/political/decision-making process and that this may well be the answer to increased planning efficiency in the 1980s.

REFERENCES


Revenue Versus Needs: An Analytic Approach

KAREN R. HOWE AND RICHARD E. ESCH

To examine the difficult choices created by growing transportation needs and decreasing revenue, the Michigan Department of Transportation developed a comprehensive State Transportation Plan. Within the plan, matching transportation needs in order of priority with available revenue was accomplished by using a planning process called the Transportation Revenue Investment Plan (TRIP). TRIP begins with the need that has the highest priority and continues retiring until all allocated revenue is spent or all needs are met. Accurate costs for the needs are determined by inflating the base-year cost to the year of revenue that is attempting to retire it. TRIP contains decision rules by transportation mode that regulate the way in which needs are retired and needs not met. TRIP output can be summarized in reports by transportation mode, year, and various other factors. Its highest utility can be seen when these summaries are displayed by means of bar charts, CALFORM maps, or network plotting. The ease with which the graphic display and summarized output of TRIP can be analyzed is beneficial in the State Transportation Plan and within the strategic planning process. In both cases, TRIP can help in evaluating the effects of alternative revenue levels and spending patterns.

Growing transportation needs in Michigan have been evident for some time. A 1977-1989 needs study reported Michigan's needs to be $10 billion. Decreasing transportation revenue in Michigan have become a reality the past few years. This combination of growing needs and decreasing revenues has made difficult choices for the people trying to provide the best transportation system possible in Michigan. To examine these choices, the Michigan Department of Transportation (DOT) developed a comprehensive State Transportation Plan (see Figure 1). Within the plan, available revenue is generated by using a fiscal forecasting model. The fiscal model uses current issues when generating revenue at the state, city, and county levels. An inventory of deficiencies is stored by transportation mode. Matching available revenue with needs was accomplished within the plan by using a planning process called the Transportation Revenue Investment Plan (TRIP). TRIP has a twofold purpose within the Michigan DOT. TRIP was first used in the State Transportation Plan to match available revenues with needs. The process is also useful as an early warning system within the strategic planning process. In daily strategic planning analysis, it can help decision makers to evaluate the effects of alternative revenue levels and spending patterns. Describing TRIP is the purpose of this paper.

SYSTEM OPERATION

The workings of TRIP are summarized in Figure 2. The major driving force of the program is the revenues available and the needs identified. Computer files for each were created, and both are categorized by mode and program element. The modes are aviation, highway, intercity bus, intercity rail passenger, local transit, marine, nonmotorized, and rail freight. The program elements are service continuation, service relocation, service improvement, new service, mobility disadvantaged, economic development, safety, and energy conservation.

Revenue is assigned to the year in which it will become available. In a similar manner, the needs are identified by the year in which they will become deficient. Deficiencies are also assigned a priority within each mode and program element based on highest need. These files are taken into TRIP and matched by mode and program element. Beginning with the highest priority for a given mode and program element, needs are retired or "bought" until either all the allocated revenue is spent or all the needs are met. If no state revenue remains for a given year, TRIP will not attempt to buy any more needs that year.
Transportation Research Record 931

Figure 1. Michigan State Transportation Plan.

Figure 2. TRIP.

Revenue for any given year can only be used to retire needs that are of the same year or are backlogged. To determine an accurate cost of the need, base-year costs are inflated to the year of the revenue that is attempting to retire the need. Each mode also has its own set of decision rules that regulate the method by which a need may be retired. These rules are based on the type of need and the federal-state-local revenue split unique to that mode. After the first match of revenue and needs is completed, a second matching may be attempted to adjust the distribution of remaining revenue among program elements. When all matching is finished, the needs are reviewed to determine which have been retired and which were not met. TRIP can also be run for the limit case, in which needs are retired from one program element until all available needs have been met. If any revenue remains, the procedure is repeated on the next program element. The order in which program elements are retired is based on a given ranking.

INPUT AND OUTPUT

The input and output files for TRIP are described in the next paragraph. Figures 3 and 4 and Tables 1 and 2 present a portion of the actual data for each file.

Input Files

Needs

In the needs file, each need is entered as a separate record. The data on each record that are used by TRIP are mode, program element, subprogram element, cost in 1988 dollars, priority, year, and funding type. Other information about the need, such as identification and description, is also on the record. There is a separate file for each mode.

State Revenue

The state revenue file has a record for each year, program element, and funding source. The data on each record are mode, program element, year, funding source, and revenue available. There is a separate file for each mode.

Federal Revenue

The federal revenue file has a record for each year, program element, and funding source. The data on each record are program element, year, funding source, and revenue available. There is a separate file for each mode.

Inflation

The inflation file has a record for each mode-year combination. Each record contains mode, year, dif-
The retired needs file has a separate record for each need. The data on each record are mode, program element, priority, subprogram element, year in which the deficiency occurs, funding type, cost in 1980 dollars, cost inflated to the year the need was retired, dollars used to retire the need by the federal-state-local split, money funding source, and money year. There is a separate file for each mode.
Table 1. File formats.

<table>
<thead>
<tr>
<th>File</th>
<th>Data Name</th>
<th>Beginning Column</th>
<th>Size</th>
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</thead>
<tbody>
<tr>
<td>Needs</td>
<td>1 - Mode number</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2 - Subprogram element</td>
<td>37</td>
<td>2</td>
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<tr>
<td></td>
<td>3 - Program element</td>
<td>40</td>
<td>2</td>
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<tr>
<td></td>
<td>4 - 1980 cost</td>
<td>43</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>5 - Funding type</td>
<td>53</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>6 - Year (2-digit)</td>
<td>70</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>7 - Priority</td>
<td>73</td>
<td>6</td>
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<tr>
<td>State revenue</td>
<td>1 - Year (2-digit)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 - Funding source code</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3 - Revenue ($1,000)</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>4 - Mode</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>5 - Program element</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>6 - Subprogram element</td>
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<td>2</td>
</tr>
<tr>
<td>Federal revenue</td>
<td>1 - Federal source code</td>
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<tr>
<td></td>
<td>2 - Program element</td>
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<td>1</td>
</tr>
<tr>
<td></td>
<td>3 - Year (2-digit)</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4 - Revenue ($1,000)</td>
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<td>Rank</td>
<td>1 - Mode</td>
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</tr>
<tr>
<td></td>
<td>2 - Program element</td>
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<td></td>
<td>3 - Rank</td>
<td>6</td>
<td>3</td>
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<td>Inflation</td>
<td>1 - Year (2-digit)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 - Mode</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3 - Differential inflation (capital)</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4 - Differential inflation (operation and maintenance)</td>
<td>12</td>
<td>5</td>
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<td></td>
<td>5 - Base inflation</td>
<td>18</td>
<td>5</td>
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Retired needs
1 - Mode 1
2 - Program element 2
3 - Priority 3
4 - Subprogram element 7
5 - Year (2-digit) 9
6 - Funding type 11
7 - 1980 cost 14
8 - Inflation 23
9 - Dollars by federal-state-local split 135
10 - Funding source, revenue 167
11 - Year, revenue (2-digit) 170
12 - Deficient need record pointer 172

Unmet needs
1 - Mode 2
2 - Program element 4
3 - Priority 6
4 - Subprogram element 13
5 - Year (2-digit) 16
6 - Funding type 19
7 - 1980 cost 23
8 - Deficient need record pointer 35

Residual revenue
1 - Funding code 4
2 - Year (2-digit) 11
3 - Program element 14
4 - Appropriation 17
5 - Residual revenue 32

*99 indicates any subprogram.
*15 x 9.

Table 2. Subprogram element codes.

<table>
<thead>
<tr>
<th>No.</th>
<th>Subprogram Element Code</th>
<th>No.</th>
<th>Subprogram Element Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Facility replacement in kind</td>
<td>28</td>
<td>New interchanges</td>
</tr>
<tr>
<td>2</td>
<td>Service subsidy a,b</td>
<td>29</td>
<td>New rest areas/information</td>
</tr>
<tr>
<td>3</td>
<td>Facility acquisition</td>
<td>30</td>
<td>Facility construction</td>
</tr>
<tr>
<td>4</td>
<td>Precision instrumentation</td>
<td>31</td>
<td>Equestrian access</td>
</tr>
<tr>
<td>5</td>
<td>Roadside amenities</td>
<td>32</td>
<td>New dredging</td>
</tr>
<tr>
<td>6</td>
<td>Transportation systems management</td>
<td>33</td>
<td>New port authorities a</td>
</tr>
<tr>
<td>7</td>
<td>Turnbacks</td>
<td>34</td>
<td>Site access</td>
</tr>
<tr>
<td>8</td>
<td>Off-system improvement</td>
<td>35</td>
<td>Federal forest highways</td>
</tr>
<tr>
<td>9</td>
<td>Vehicle acquisition</td>
<td>36</td>
<td>Economic growth center highway</td>
</tr>
<tr>
<td>10</td>
<td>Rural small bus</td>
<td>37</td>
<td>Rail/land banking</td>
</tr>
<tr>
<td>11</td>
<td>Facility maintenance a</td>
<td>38</td>
<td>Basic ground aids</td>
</tr>
<tr>
<td>12</td>
<td>Maintenance dredging</td>
<td>39</td>
<td>Upgrade to standards</td>
</tr>
<tr>
<td>13</td>
<td>Vessel acquisition</td>
<td>40</td>
<td>High hazard locations</td>
</tr>
<tr>
<td>14</td>
<td>Port authorities a</td>
<td>41</td>
<td>Critical Bridges</td>
</tr>
<tr>
<td>15</td>
<td>Relocation service subsidy a,b</td>
<td>42</td>
<td>Railroad crossings</td>
</tr>
<tr>
<td>16</td>
<td>Facility relocation in kind</td>
<td>43</td>
<td>Pedestrian access</td>
</tr>
<tr>
<td>17</td>
<td>Freight transfer facility</td>
<td>44</td>
<td>Railroad signalization</td>
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<tr>
<td>18</td>
<td>Facility expansion</td>
<td>45</td>
<td>Security measures</td>
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<td>19</td>
<td>Increased service subsidy a,b</td>
<td>46</td>
<td>User information/controls</td>
</tr>
<tr>
<td>20</td>
<td>Increased facility maintenance a</td>
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<td>Hazard elimination</td>
</tr>
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<td>21</td>
<td>Improvement dredging</td>
<td>48</td>
<td>Minimal track safety</td>
</tr>
<tr>
<td>22</td>
<td>Improved port access</td>
<td>49</td>
<td>Carpool lots</td>
</tr>
<tr>
<td>23</td>
<td>Increased load capability</td>
<td>50</td>
<td>Ride-sharing</td>
</tr>
<tr>
<td>24</td>
<td>Increased speed capability</td>
<td>51</td>
<td>Park side lots</td>
</tr>
<tr>
<td>25</td>
<td>New airport</td>
<td>52</td>
<td>Vaanpool</td>
</tr>
<tr>
<td>26</td>
<td>New service subsidy a,b</td>
<td>53</td>
<td>Commuter facilities</td>
</tr>
</tbody>
</table>

*Operation and maintenance.
*a Subsidy.

Unmet Needs
The unmet needs file has a separate record for each need. The data on each record are mode, program element, subprogram element, year in which the deficiency occurs, funding type, and cost in 1980 dollars. There is a separate file for each mode.

Residual Revenue
The residual revenue file has a separate record for each funding combination of source, year, and program element. The data on each record are funding source, money year, program element, money appropriated, and residual money. There are records for both state revenue and federal revenue. Each mode has a separate file.

Program Details
The TRIP program was written in FORTRAN programming language and run on a Burroughs B7700 computer. The details of the computer program decision rules are described by mode.
Within TRIP, each mode has its own set of decision rules that determine whether a need may be re-
there is no funding for these types of projects. The revenue input is all assigned to program element 1, service continuation, for the first match of revenue and needs. This reflects the reallocation of funds. These revenues are also separated into two groups: the share that funds air carrier needs and the share that goes to general aviation needs.

Highways

Decision rules for the highway mode are shown in Figure 6. Highway mode has the most complex set of decision rules within TRIP. The different funding types within this mode have separate state and federal revenue allotments. The various funding types are linked with their revenue allotment through the funding source code. To simplify the discussion of highway decision rules, they are described here by funding type.

For projects with funding type 1, Interstate, the first check is on program element. When the program element is service continuation, Interstate projects are retired in the same way as funding types 2, 3, 8, and 9. The next check is on federal funds. The federal share is set at 90 percent of the cost. If 90 percent is not available from the appropriate federal fund, the project cannot be retired that year. If the federal share is available, the next check is on the state share. The state share is set at 10 percent. When 10 percent of the cost is not available from state revenue, the project cannot be retired that year. If the state share is available, the project is retired.

For projects with funding type 4, nonfederal aid, there is only one check and that is on state revenue. If 100 percent of the cost is available from the appropriate state fund, the project is retired. When there is not enough state revenue to cover the state share, the project cannot be retired that year.

For funding type 7 (federal aid primary), 3 (federal aid secondary), 8 (federal aid urban), 9 (structure replacement), 10 (structure widen), 11 (railroad crossing upgrade to structure), 12 (railroad crossing at grade), and 13 (special projects), the federal share is 77 to 90 percent depending on the program element. If the federal share is available from federal revenue, the next check is for the state share. If the federal share is not available, the state share is calculated based on remaining federal revenue. Then a state share is calculated based on the federal share. When the federal share is available and the funding type is not federal aid urban, the state share is set at 10 to 23 percent depending on the program element. If the state share is not available, the project is not retired that year. When the state revenue is available, the project is retired.

If the funding type is federal aid urban, a remainder cost, which is the inflated cost minus the federal share, is calculated. The local share for funding type 8 is 10 percent of the remainder cost. If the local share is not available from local revenue, a new local share is calculated based on remaining revenue. A state share is then calculated based on the local share. When 10 percent of the cost is available from the local fund, the state share is 90 percent of the remainder cost. If the state share is not available from state revenue, the project cannot be retired that year. If the state share is available, the project is retired.

InterCity Bus

Decision rules for the intercity bus mode are shown in Figure 7. The only check in retiring an inter-
city bus need (project) is on state funds. If the entire cost of the project is available from the state fund, the project is retired. When only part of the cost is available, a partial buy is done by using the remaining state funds for that year. Intercity bus projects cannot be backlogged.

Intercity Rail Passenger

There are two sets of decision rules for the intercity rail passenger mode: one for capital needs (projects) and another for operation and maintenance needs (projects). These two sets of decision rules are shown in Figures 6 and 9.

Capital Projects

The first check for capital projects is on funding type. If the funding type is 100 through 135 or 220 (Detroit to Chicago and Detroit to Toledo projects), TRIP attempts to buy the project with 100 percent federal funds. When 100 percent of the cost is not available from federal revenue for these types of projects, they are handled in the same way as other capital projects.

When the capital project is not funding type 100 through 135 or 220 or 100 percent of the cost is not available in federal funds, TRIP checks to see whether 50 percent of the cost is available from federal revenue. If 50 percent of the cost is not available, a new federal share is calculated based on the remaining funds. Then a state share is calculated based on the federal share. If the federal share is 50 percent of the cost, the state share is set at 50 percent.

The next check within TRIP, which is on state revenue available, is then performed. If the state share is available from the state fund, the project is retired. When the state does not have enough funds to meet the state share, the remaining state revenue is used to retire as much of the project as possible.

Operation and Maintenance Projects

Funding type is the first check for operation and maintenance projects. When funding type is 1 through 9 (Detroit to Chicago and Detroit to Toledo projects), TRIP attempts to buy the project with 100 percent federal funds. If 100 percent of the cost is not available from federal revenue for these types of projects, they are handled in the same way as other operation and maintenance projects. Other projects have a federal share set at 35 to 50 percent depending on the revenue year and program element. If the federal share is not available from federal funds, a new federal share is calculated based on remaining revenue. A state share is calculated based on the federal share. The next check on available state revenue is then performed. If the state share is available from the state revenue, the project is retired. When the state does not have enough revenue to meet its share, the project is not
retired and no more operation and maintenance projects are retired that year.

Local Transit

There are two sets of decision rules for the local transit mode: one for capital needs (projects) and another for operation and maintenance needs (projects). These two sets of decision rules are shown in Figures 10 and 11.

Operation and Maintenance Projects

The first check for operation and maintenance projects is on federal revenue. If the federal share, 50 percent, is not available from the federal fund, a new share is calculated based on the remaining funds. Then a state share is calculated based on the federal share. If the 50 percent federal share is available from the federal fund, the state share is set at 30 percent of the cost. The local share is set at 20 percent of the cost. The second check is on available state revenue. If the state share is available from the state fund, the project is retired. When the state does not have enough revenue to meet its share of the cost, the remaining state revenue is used to retire as much of that project as possible.

Capital Projects

Funding type is the first check with capital projects. If the funding type is 3 or 4 (county incentive programs) and 100 percent of the cost is not available from state funds, the project cannot be retired. The federal share is set at 80 percent when the funding type is 1 or 2 (urban programs). If the federal share is not available from federal funds, a new share is calculated based on the remaining federal revenue. Then a state share is calculated based on the federal share. If there is enough federal funding to cover 80 percent of the

*PE - Program Element*
cost, the state share is set at 20 percent of the cost.
The check on state revenue is then performed. If the state share is available from state revenue, the project is retired. When the state fund cannot cover the state share of the cost, the remaining state revenue is used to buy as much of the project as possible. All local transit projects can be retired only with revenue of the year in which they become deficient.

Marine

Ports have two sets of decision rules: one set is for dredging-type needs (projects) and the other is for all other types of needs (projects). These two sets of decision rules for the marine mode are shown in Figures 12 and 13.

Dredging Projects

The first check in ports is on federal revenue. If 100 percent of the cost is available from federal funds, the project is retired entirely with federal revenue. If 100 percent is not available in federal money, a new federal share is calculated based on the remaining funds. A state share is then computed that picks up the remaining cost of the project. If the state fund does not have enough revenue for the state share, the project is not retired that year.

Other Projects

There is only one check for other projects. If 100 percent of the cost is available from the state fund, the project is retired. If there is not enough revenue, the project is not retired that year.

Nonmotorized

Decision rules for the nonmotorized mode are shown in Figure 14. There is only one check in retiring a nonmotorized need (project). If 100 percent of the

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Figure 12. Marine dredging decision rules.
Figure 13. Marine operation and maintenance, terminal construction, and vessel acquisition decision rules.

Figure 14. Nonmotorized decision rules.

Figure 15. Rail freight capital decision rules.

Figure 16. Rail freight operation and maintenance decision rules.

cost is available from the state fund, the project is retired. If there is not enough revenue, the project is not retired that year.

Rail Freight

The rail freight mode has two sets of decision rules: one for capital needs (projects) and the other for operation and maintenance needs (projects). These two sets of decision rules are shown in Figures 15 and 16.

Capital Projects

The first check for capital projects is on federal revenue. If the federal share, 70 percent, is not available from the federal fund, a new share is calculated based on the remaining funds. Then a state share is calculated based on the federal share. If the 70 percent is available from the federal fund, the state share is set at 30 percent of the cost.

The second check, which is on available state revenue, is then performed. If the state share is available from the state fund, the project is retired. If the state does not have enough revenue in the fund to meet the state share, the project is not retired that year.

Operation and Maintenance Projects

Operation and maintenance projects are retired solely with state funds. If 100 percent of the cost is not available from the state fund, the project
cannot be retired that year. If the cost is available, the project is retired.

Service continuation projects (program element 1) of either the capital or operation and maintenance type cannot be backlogged.

APPLICATION

The primary output of TRIP is computer files of needs: one containing retired needs and the other unmet needs. Computer listings of these files can be large and difficult to use. It is not easy to use these files in the daily decision-making process. In order to make more use of TRIP, application reports were developed.

The first application report examined is TRIPSUM. This is a computer program that inputs TRIP output files and produces reports. The report shows dollars of retired deficiencies accumulated by mode and program element (see Figure 17). It also has the ability to report deficiencies by deficiency type and region. It can compare retired needs with total needs and produce results reports. TRIPSUM is a valuable tool in the initial assessment of TRIP output.

To analyze the location and distribution of TRIP
output, CALFORM maps and network plotting are used. By using a code on the need record, the total dollars of retired deficiencies by county can be accumulated. These county totals are then displayed with shading in CALFORM maps (see Figures 18 and 19). The number of projects or selected subsets could also be displayed in a CALFORM map. Network plots are created in a similar manner. By using control section number, highway projects can be associated with their corresponding links in the highway network. Retired projects can be accumulated by number of projects or dollars. The magnitude can be displayed on the links by using bandwidth plotting (see Figure 20). Selected program elements or years can also be displayed. CALFORM maps and network plots visually explain TRIP output easily and quickly.

Another way to look at TRIP output is with bar charts (see Figures 21 and 22). These bar charts show the total (1980) dollars of needs versus the retired needs by year for a given mode. These graphs could be used to look at particular program elements also.

All of the applications shown could easily be run for different revenue package TRIP outputs. The CALFORM maps (Figures 18 and 19) show an example of this. Figure 18 shows TRIP output from the 1982 tax revenue and Figure 19 shows TRIP output for Brown tax revenue, which was a tax revenue package proposed during 1982. The two maps point out quickly the implications in terms of needs retired for two different policy decisions. This is where TRIP can become a valuable tool in daily strategic planning analysis.

CONCLUSIONS

As transportation systems grow older and the number of transportation needs grows larger, deciding where to spend the limited revenue available becomes an ever more difficult question. TRIP helps decision makers to address this question. Various revenue projections and different distributions of revenue among transportation modes can be input into the TRIP planning process. The output can be summarized and graphically displayed to enable analysis to be done quickly and easily. TRIP can assist decision makers in making more knowledgeable and informed choices.

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