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16. Abstract

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# FINAL REPORT

# A DEMONSTRATION OF EXPERT SYSTEMS APPLICATIONS IN TRANSPORTATION ENGINEERING VOLUME III EVALUATION OF THE PROTOTYPE EXPERT SYSTEM TRANZ

**Michael J. Demetsky**
**Faculty Research Scientist**

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia Department of Transportation and the University of Virginia)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

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## ABSTRACT

The validation and evaluation of an expert system for traffic control in highway work zones (TRANZ) is described. The stages in the evaluation process consisted of the following: revisit the experts, selectively distribute copies of TRANZ with documentation and an evaluation form, identify related problems that affect the problem domain of TRANZ, and conduct a formal evaluation workshop. It was very difficult to develop a system that would accurately handle all possible permutations of the problem. The validation process should establish a range of applicability, which can be continually updated as the system "grows" with experience. All expert systems require a mechanism for continual support beyond the prototype by a team familiar with the problem and the system-building technique.

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## INTRODUCTION

A critical stage in the development of an expert system is its verification and validation as an acceptable piece of applied software. It must be proved that the system is an accurate and useful representation of knowledge and associated decisions. At present, "bits and pieces of a verification and validation methodology currently exist, but have not been assembled and standardized due to the many applications, design paradigms, development approaches, and the stage of development and fragmentation of the industry" (*1*).

Verification has come to deal with the program text development, which is simplified when a shell such as EXSYS is used. In this report, *evaluation* refers to validation, which "is a determination that the completed program performs the functions in the requirements specification and is usable for the intended purposes" (*2*).

This report focuses on the validation of TRANZ (*3*). It describes the steps in the evaluation process and the relevant findings.

## BACKGROUND

In recent years, researchers have been investigating and developing knowledge-based expert systems for transportation engineering applications. At present, however, such computer programs are not ready for commercial use. The state-of-the-art consists of a range of prototypes that typically require extensive testing and refinement before they are acceptable for regular use.

These prototypes are a formulation of a problem through the application of selected system-building tools. The prototype is an applied statement of the system requirements and provides a focus for development of a complete knowledge base (*1*). The prototype provides a framework for a continuous process of working with experts in supplying the required knowledge.

The factors that limit the utility of these prototypes are (1) the scope of the problem domain addressed by the prototype in relation to the appropriate scope of issues influencing decisions, (2) the inability of the system to combine rules or other logic representations suitable for simple situations into more complex relationships suitable for more challenging situations, and (3) the accuracy of the representation of the decision process of the expert.

This report relates the steps taken after a prototype expert system was developed that are critical to the acceptance of the system as a decision aid to engineers.

## EVALUATION PROCEDURE

The overall evaluation plan for TRANZ actually began prior to the publication and release of the prototype. The prototype that was distributed for limited evaluation by the public is an improved version of the original prototype. The actual evaluation began with the assignment of a new software engineer to the project. The developer of the first prototype was a transportation engineer who employed an expert system shell (EXSYS) to code the knowledge base in a straightforward manner. The second software engineer was a computer scientist who took a more mechanical view of the system and improved its efficiency by an informal evaluation that included correcting logical errors, modifying rule specifications and structure, and enhancing the user interface.

The tasks that were specified for the evaluation were:

1. Revisit the experts who assisted in developing the system to receive comments concerning the current prototype and revise the prototype as warranted.

2. Selectively distribute copies of TRANZ with a documentation and an evaluation form. Users were requested to apply the system and report their observations on evaluation forms (see Appendix A). The intent was to compile an exhaustive list of case applications to enhance the knowledge base. If necessary, respondents would be contacted by telephone to clarify the data. The information sought included the appropriate input data to TRANZ and a description of the work zone traffic control plan as implemented. This approach was ineffective since it required considerable time from the user. This strategy was unrealistic, so a workshop was recommended as a substitute (see item 4).

3. Perform research on related problems that interface with and impact upon the work zone traffic control problem for the purpose of expanding the system so that it encompasses a broader and more complete decision problem than the prototype covers. Issues considered included queuing and delays to traffic, traffic diversion strategies (facility demand management), detour alternatives, timing of the work effort (including nighttime), delineation of traffic lanes through work zones, and worker safety (including applications of new technology).

4. Conduct a workshop with approximately eight experts on traffic management through highway work zones to finalize the evaluation of TRANZ for field applications.

The version of TRANZ critiqued is a version that reflects the results of the above tasks.

The remainder of this report focuses on this workshop because it was there that the status of the system as an aid to transportation practitioners was established. The results represent a group consensus, whereas the prior tasks encompassed only individual inputs obtained in isolated instances. However, summary statements regarding the other tasks are provided for completeness.

## EXPERT REVIEWS

After the preliminary evaluation, the first step in the formal evaluation of TRANZ required the participation of the knowledge engineer, the expert, and two selected users. The first user was a novice safety engineer who was interested in utilizing TRANZ in an office environment for consultation and learning. The second user was interested in seeing TRANZ used for teaching seminars and short courses in freeway work zone safety.

There were two tests. The first applied TRANZ to 11 problems that were used for a short course sponsored by the Virginia Transportation Research Council. The second applied TRANZ to 6 actual problems that were provided by the Staunton District Office of the Virginia Department of Transportation: (1) bridge deck maintenance, (2) pavement milling and plant mix operations on an interstate highway, (3) pipe replacement under a two–lane secondary road, (4) excavation near an interstate highway, (5) mowing along an interstate highway, and (6) pavement patching on the inside lane of an interstate.

To the 11 textbook problems, TRANZ gave correct solutions 100 percent of the time. This could be expected because the manuals were used in the development of the knowledge base, and no judgment was required beyond that given in the reference. For the actual problems, TRANZ and the expert disagreed in 4 of 6 cases. These observations directed the knowledge engineer to make specific changes in TRANZ's knowledge base.

## DISTRIBUTION OF PROTOTYPE

One of the reasons EXSYS (*4*) was selected to develop TRANZ was that the FHWA has a license for the Runtime version. This made it possible for a limited

number of copies of TRANZ to be selectively distributed to potential users including members of state DOT's outside of Virginia. Because TRANZ followed procedures used in Virginia and because procedures for directing traffic through or around highway reconstruction zones differ among states, the Virginia prototype was only directly useful for practice in Virginia. It would need to be modified for use in other states, notably, California and New York. A form for documenting the problems to which TRANZ was applied was included in the distribution. Very few cases, however, were recorded on the forms and returned. It was concluded that this approach was unrealistic, and the workshop strategy was recommended to meet the objectives of both tasks.

## PROBLEM INTERFACES WITH TRANZ

Figure 1 illustrates a comprehensive formulation of traffic management tasks for highway work zones. With given data on the job and roadway environment (condition descriptions), various options for traffic management are available. The ultimate choice will utilize information obtained from a series of appropriate analyses. TRANZ focuses on the traffic controls of the affected facility, but additional considerations are usually relevant. For example, the design of transit schemes for diverting traffic are not included in TRANZ. However, TRANZ does interface with detour considerations and construction work hour choices. These three strategies reduce overall traffic on the facility during reconstruction. Given the final demand estimate and the condition descriptions that have been prepared exogenous to TRANZ, the system then defines the appropriate traffic control plan, aids in the evaluation of the adequacy of any proposed detour, and calls the QUEWZ (*5*) program to compute delay on the facility. If any components of the traffic management plan prove to be inadequate, the analyst must go back and alter the demand plans to arrive at an acceptable plan. Once an acceptable strategy and/or the traffic management plan is formulated, the traffic flow through the work zone should be evaluated for safety considerations. The capability to assess safety does not exist in the current TRANZ, but a simulation model similar to the QUEWZ program could be coupled to it to perform this task.

## EVALUATION WORKSHOP

This task is the most formidable of the four, and in many ways, is inclusive of the three former tasks. Eight transportation engineers from different divisions of VDOT were invited to attend a workshop, the purpose of which was validation of TRANZ. Five representatives from the traffic engineering, location and design, and construction divisions, and three representatives from the district engineers offices participated. The Richmond Division Office of the FHWA was also represented at the workshop.

Prior to the workshop, copies of a notebook and a TRANZ disk were sent to the attendees. The purpose was for them to familiarize themselves with TRANZ and the

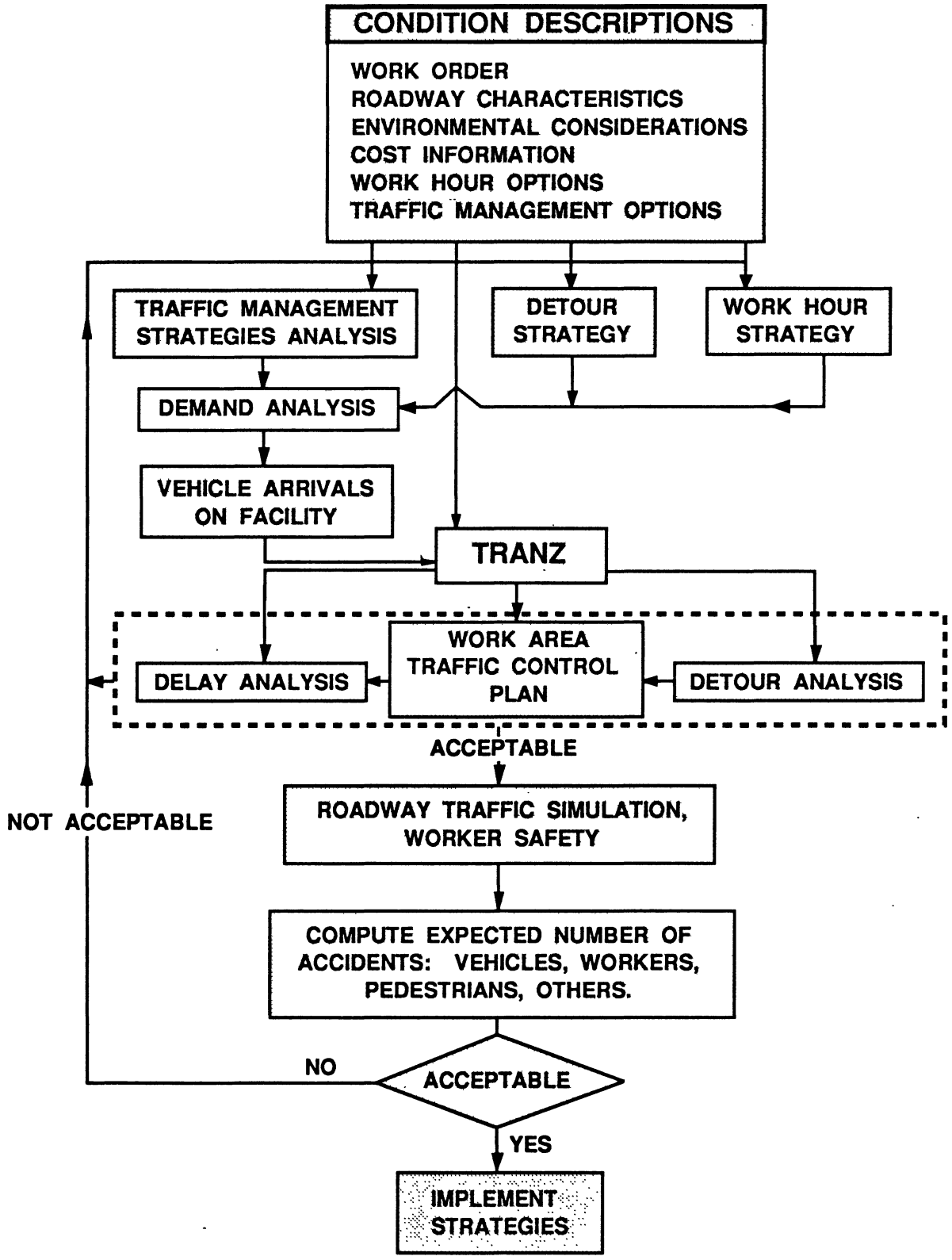


Figure 1. Traffic Management tasks for highway work zones.

issues to be addressed. The attendees were requested to document applications (as in Task 2) for discussion at the meeting.

The results of the workshop are first stated in terms of comments received and then as specific tasks which, when completed, will render a validated version of TRANZ. Shortcomings that could not be removed at this time will be noted as "qualifications" to users of TRANZ.

## General Comments

The following comments represent the attendees general perceptions of TRANZ.

1. "The TRANZ expert system should be a very beneficial tool for engineers dealing with the development of traffic control plans . . . it should not replace the important aspect of engineering judgment and the knowledge and experience gained from the individuals who are responsible for the traffic control devices in the field. In other words, you should generally know what the answer will be before applying TRANZ." (This indicates a lack of confidence in TRANZ in that it should only be used by experts themselves as a check on plans. This concern should be lessened as experience with TRANZ is gained.)

2. "One . . . use [of TRANZ] could be to allow students in a classroom situation to solve some problems using the manual and some using TRANZ, or a combination of the two. Feedback from the instructor could then be an asset in considering further upgrades of TRANZ." (This is a necessary stage if TRANZ is to become a reliable tool.)

3. "Once the existing logic is refined, field tested, and the "bugs" worked out, one desirable feature for consideration. . . would be the inclusion of graphics in both the screen as well as printed output." (This could be accomplished with the integration of a laser disk with TRANZ.)

4. "When the program is revised, it is recommended that the new software be provided to the districts for an evaluation. This should be a good test for the system."

5. "Traffic engineering and location and design strongly support the program and we will be glad to assist in any way to implement the project."

These comments indicate that the attendees would not completely rely on TRANZ for work zone traffic control solutions. However, they also indicate a willingness and desire to work with TRANZ in the field and during instructional programs, and thus, to bring it along slowly, while carefully evaluating it. This approach is probably representative of the evaluation of all expert systems before they become practical tools.

TRANZ deals with a very complex and open-ended problem that will require a long period of testing and revision before it becomes a complete knowledge system.

This clearly requires a continuing effort toward maintaining the expert system, which is not normal for software developed and used only at the state level. It is the norm for many federally supported software packages such as HCM and NETSIM, which are distributed and supported through McTRANS. The maintenance of an open-ended software package such as TRANZ is much more critical and resource consuming than that for a conventional algorithmic program. Accordingly, this issue must be addressed when a state DOT pursues the development of an expert system.

## Programming Modifications

Specific recommendations for improvements in the overall program derived from applications of TRANZ to real problems by experts include the following.

1. While running the program there was some uncertainty in selecting whether or not the work crew was exposed to traffic. This option should be given further explanation to ensure consistent application, preferably on the screen where the question is displayed. For example, does this mean before traffic control devices are installed? Or does this mean the crew will be working in the lane(s) of travel?

2. Selecting "Resurfacing and Shoulder Buildup" as the type of operation on an interstate resurfacing job does not give the desired level of work zone protection, but selecting "stationary operation" gave the desired result. The "Resurfacing" option should be further explained so that the user will know up front when to select this option and precisely what it means.

3. In certain situations, it is not clear if the recommended devices are alternatives to one another or are to be used in conjunction with one another. For example, on an interstate lane closure, Barrier A, Temporary Concrete Parapet, Temporary Concrete Traffic Barrier Drums, and Temporary Asphalt Median all had a value of 9 on the output screen. Discussions at the workshop revealed that drums would be used in conjunction with the physical lane closure device but that a Type A device would not be used in conjunction with a Temporary Asphalt Median. Devices that are alternatives to one another should be clearly shown on the output.

4. Several recommended signs were indicated only by the code in the manual such as W20-7A or W4-2. It would be desirable to have a short verbal description with each recommendation.

5. The inclusion of QUEWZ is a favorable option. Perhaps the TRANZ manual could include the title page and summary pages ii and iii from QUEWZ as information for the operator who is unfamiliar with its use.

6. TRANZ should include quantities for the recommended traffic control devices.

7. New accident data for different classes of roads are used by the Department to replace the single bar graph listed in the Work Zone Safety Shortcourse

Notebook for Runoff Roadway Accidents. Also, new values for different road systems by ADT levels are recommended to be used in the formula p = f x t x 1. These changes should be made in TRANZ

8. In the question and answer process of TRANZ, the following adjustments should be made.

   a. define *barrier A* in the answers as concrete

   b. define *barrier B* in the answers as guardrail

   c. define terms *on travelway* and *off travelway*

   d. "travelway" perhaps should read "edge of pavement."

The above are the key statements made by the panel concerning changes that should be made to clarify the TRANZ question-and-answer process. Appropriate corrections will be made in the validated version of TRANZ.

**Errors in TRANZ's Recommendations**

TRANZ gave incorrect solutions to the following problems according to the experts; appropriate changes are warranted.

1. Problem: Interstate facility, ADT = 20,300 VPD, operating speed = 68 mph; replacing existing concrete pavement, two mile segments, four lanes, close one lane while work is underway in the adjacent lane.

   Solution: TRANZ provides different traffic control devices for the inside lane and outside lane. Typical drawing WAPM 6–79 is used for the inside lane and WAPM 6–83 for the outside lane.

   In this problem, WAPM 6–83 should have been used for both inside and outside lanes. The only difference should be the messages on the signs. The Work Area Protection Manual does not provide a typical drawing for both the inside and outside for the same type of construction. In other words, if the typical drawing indicates the inside lane then the same drawing would apply to the outside with word changes on the signs.

2. Problem: Four-lane divided primary route, ADT = 40,000 VPD, operating speed = 35 mph; excavation of a 10-ft vertical drop trench 3 ft from the edge of pavement in the median, 15 ft wide by 30 ft long.

   Solution: TRANZ indicates channelizing devices (Group 2 drums) as the solution.

It appears that signing should also be included in this solution and in solutions to similar problems.

3. Problem: Limited access roadway, on travelway, resurface and shoulder build-up operation.

   Solution: The sign layout provided is wrong. It should be the same as for a mowing operation.

4. Problem: Drop inlet existing in the median of a four lane limited access roadway, 30-day work operation is stationary and off the travelway, work crew is not exposed to traffic; operating speed = 55 mph; ADT = 37,500 VPD; hazard length = 0.3 mi.

   Solution: A minimum sign layout should be given that includes roadwork ahead and end roadwork.

5. Problem: Stationary work off the travelway is being conducted for 120 days on a four-lane limited access highway; the work crew is exposed to traffic; operating speed = 65 mph; ADT = 37,500 VPD.

   Solution: A barrier is specified by TRANZ.

   A sign layout should also be displayed. Also the distance from the traveled roadway should be considered. On some interstates, this work could be within 25 ft of the traveled roadway.

6. Problem: Stationary work off the travelway is being conducted for 120 days on a four-lane primary highway; the work crew is exposed to traffic; variable operating speed = 55 mph; ADT = 30,000 VPD.

   Solution: Same as no. 5 except on a primary highway. This work could be behind the ditch line but within 10 to 15 ft of the traveled roadway.

7. Problem: A stationary operation between the travelway and ditch line is being conducted on a four-lane primary highway for 120 days; the work crew is exposed to traffic; operating speed = 55 mph; ADT = 30,000 VPD; median width = 50 ft.

   Solution: Distance from the roadway should be a factor. This work could be anywhere from 1 to 20 ft from the edge of the pavement. If it were 1 ft, lights would be needed.

8. Problem: A stationary operation between the travelway and ditch line is being conducted on a four-lane limited-access highway for 120 days; the work crew is exposed to traffic; operating speed = 65 mph; ADT = 37,500 VPD.

Solution: When work is on an Interstate or divided primary, the left shoulder also needs to be considered. The program now assumes everything is on the right.

9. Problem: A stationary operation is being conducted off of the travelway, on a four-lane interstate highway for 120 days; a nonremovable fixed object near the travelway exists for 2.5 miles, the work crew is not exposed to traffic; operating speed = 65 mph; ADT = 43,130 VPD.

   Solution: If a barrier is specified, there should be a minimum sign layout of "road work ahead" and "end of roadwork."

10. Problem: The work is a deck replacement on the inside lane of a four-lane limited-access highway; the work is to be done between 8:00 a.m. and 4:30 p.m. for a period of four months; the length of the work zone is 300 ft; the work crew is exposed to traffic; operating speed = 65 mph; ADT = 35,000 VPD.

    Solution: The solution provides devices that are alternatives to one another, but it does not indicate that they are. The temporary asphalt median recommended is not likely to be used on an Interstate highway.

11. Problem: Resurfacing job on the travelway of the outside shoulder on a four-lane limited-access highway; the length of the work zone is 10,000 ft; the stationary work crew is exposed to traffic; the duration is 90 days; work is conducted between 8:00 a.m. and 4:30 p.m.; operating speed = 65 mph; ADT = 29,569 VPD; if barriers are used, access openings to the construction site will be used by work vehicles entering the main traffic flow.

    Solution: TRANZ provided an incorrect solution according to the experts. The solution should include advanced construction signs, taper lane closure, drums or cones, 72-in concrete barriers and a flashing arrow. Selecting "stationary operation in the outside lane" gave the correct solution.

12. Problem: A one-way deck operation on Rt. 60, two lane undivided primary highway, between 8:00 a.m. and 4:30 p.m. for 120 days duration; the length is 400 ft for a stationary operation where the work crew is exposed to traffic; no access through the barrier is required; gore areas are not present; operating speed = 55 mph; ADT = 3,255 VPD.

    Solution: TRANZ specified a flagger, but in the actual case reviewed, a temporary traffic signal was used; the solution gave barrier b as an option, but these are not used on a bridge deck.

These applications and comments are indicative of the kind of feedback from users that expert system developers need in order to validate their systems. In the

case of the version of TRANZ used here, recommendations arose from interactions among 128 rules. This provides for quite a complex set of possible outcomes based on the firing of relevant rules and incorrect recommendations can be expected in prototype systems. In fact, no system can ever be expected to be 100% consistent with the experts since even experts disagree.

## QUALIFICATIONS

At the present time, TRANZ can be recommended as either a check on a plan for work zone traffic control in Virginia or as a first formulation of such a plan. In the latter case, experienced engineers should verify the plan before implementation. In either case, TRANZ should replace at least one expert in the process and provide savings in time and costs. TRANZ can be used in short courses or as a pseudo–tutor for individuals who wish to become familiar with the Virginia Work Area Protection Manual.

Since the purpose of the project from which TRANZ was developed was to demonstrate expert system applications in transportation engineering, the completion of TRANZ as a validated professional tool is beyond the scope of this effort. The present version of TRANZ meets the study objective by providing a case study that demonstrates:

1. the development of an expert system, which incorporates standard engineering procedures with expert judgments and interpretations
2. the programming complexities of combining rules, calculations, and external programs in a complete decision support system
3. the need to identify the role of the expert system in a broad system decision framework (i.e., its interaction with other decisions and the assumptions governing the scope of the system)
4. the identification of inappropriate (voluntary) and appropriate (controlled) validation and evaluation procedures
5. the identification of the continuing maintenance and support requirements necessary for an expert system to remain relevant.

## CONCLUSIONS AND RECOMMENDATIONS

The results of the two phases of this study indicate a strong potential for the application of expert systems as decision support systems in transportation engineering. By way of a case study demonstrating the initial refinement and validation of a prototype expert system for traffic control through highway work zones, the study demonstrated the present and potential utility of the system and support requirements. Expert systems are potentially valuable as knowledge sources and decision aids in transportation system planning, design, operations, maintenance, and management. The resource requirements are extensive, however, because of the complexity and dynamic nature of the knowledge base. Regarding complexity, it is very difficult to develop a system that will accurately handle all possible permutations of a problem. The validation process should therefore establish a range of applicability, which can be continually updated as the system "grows" with experience. Applications need to be fed back to the support agency when incorrect solutions are given.

Specific recommendations regarding expert systems applications in transportation engineering and management are:

1. The expert system development team should include, at a minimum, an expert on the problem addressed and a knowledge engineer/programmer. This implies that the development team should be very knowledgeable about the problem and expert system building technologies and tools. This team must first structure the decision problem to be addressed, the appropriate knowledge representation method, and select an expert system building tool (i.e., shell).

2. A mechanism for continued support past the prototype demonstration by a team familiar with the problem and system building techniques should be provided. At present, this appears to be the biggest obstacle to developing operational systems(*6*). In the past, for example, the majority of the prototypes in the literature that were developed by university researchers and published as theses never became useful because of discontinuity in the effort when the student received his/her degree. Full scale agency support is required to develop and maintain expert systems.

3. As a follow-up to this and other recent studies by the states, it is recommended that a national study research the development of appropriate support systems strategies at the national and state levels (i.e., FHWA, NCHRP, etc). This would be a natural continuation of the 1988 FHWA aid to developing expert systems. Cost effectiveness should be included.

4. Standards for expert systems should be established to aid in their development, utilization, and maintenance.

Recommendations regarding TRANZ include:

1. That VDOT incorporate TRANZ into ongoing short courses using the WAPM.

2. That an operating division work with the Research Council to establish a support base for TRANZ.

3. That a TRANZ Advisory Committee be formed similar to the attendees of the evaluation workshop to guide the future improvements and support for TRANZ.

4. That utilization and feedback of TRANZ be encouraged whenever possible.

5. That graphic interpretations of the recommended configurations be investigated and developed using laser disks.

6. That the legal implications of using TRANZ as an advisory tool be investigated.

7. That, if warranted by departmental review, TRANZ be expanded to interact with supporting analytical models to include a complete evaluation of the traffic management problem for highway work zones including:

   - a complete demand analysis to replace transit and other traffic diversion strategies
   - a detailed feasibility and cost–effectiveness evaluation of alternative work zone strategies
   - an evaluation of specific detour routes
   - a safety analysis of alternative strategies
   - an interacting spreadsheet for estimating required quantities of traffic control items.

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# APPENDIX A

## Applications Documentation Form

## CASE STUDY DATA

The following form is available for you to describe the examples that you are requested to bring to the workshop. It represents all the data that TRANZ uses. In no one case does it all apply, so just enter that which applies for each case.

It is not necessary that you document each case with this form if you feel it is convenient to do otherwise. It is important, however, that you bring your experiences with you in some form of documentation.

A. Case Scenario

1. Average daily traffic in both directions is _____.
2. 85th percentile operating speed is _____ mph.
3. The posted speed is _____ mph.
4. The number of lanes in two directions is _____.
5. The median width in feet is _____.
6. The roadway on which the work is being conducted is:
   divided _____
   undivided _____
7. The time of day in which work was in progress was from
   to _____.
8. The roadway on which the construction/maintenance is being conducted is:
   limited access roadway (including interstate) ____
   primary (nonlimited access) ____
   secondary ____
9. Describe the type of work effort: _____
   _____
   _____
10. The construction/maintenance operation is being conducted:
    on the travelway _____
    between the travelway and ditchline (including shoulder) _____

off travelway _____

other (please specify)_____

11. The duration of the construction/maintenance effort is_____years/days.

12. The total width of the closed lane is _____ft.

13. The length of the work zone is _____ft.

14. The type of operation and/or lane on which the construction/maintenance is being conducted is:

    stationary operation - inside lane _____

    stationary operation - center lane _____

    stationary operation - outside lane _____

    mobile operation (not more than two hours in the immediate area) _____

    resurfacing and shoulder buildup _____

    information not available _____

15. The stationary work crew is:

    exposed to traffic _____

    not exposed to traffic at any time _____

16. The type of mobile construction/maintenance can be described as:

    mowing operation

    ditching operation _____

    pavement marking operation _____

    none of the above _____

17. The object/slope/excavation is:

    a nonremovable fixed object _____

    not a nonremovable fixed object _____

18. The nonremovable fixed object existing near the travelway is (choose all that apply):

    any object considered to be damaging to a moving vehicle such as:

| | | | |
|---|---|---|---|
| headwall | box culvert | manhole | guardrail end |
| drop inlet | barrier ends | pipe | stored material |

bridge pier equipment parapet sign poles/bases

an excavation at least 6" deep _____

a slope _____

none of the above _____

19. The nonremovable fixed object is considered as:

hazardous _____

not hazardous _____

information not available or not applicable _____

20. The slope of the ground that leads to any ditches, drop offs, etc. near the road is approximately:

more shallow than 3 to 1 _____

3 to 1 _____

2 to 1 _____

1.5 to 2 _____

1 to 1 _____

information not available or not applicable

21. The depth of the ditch, drop-off, etc. in feet is _____.

22. The distance from the travelway to the potential hazard is _____ft.

23. The length of the potential hazard is _____miles.

24. f barriers are used, access openings to the construction site will be used by:

entering and exiting work vehicles _____

work vehicles entering the main traffic flow _____

no access openings to the construction zone are required _____

25. Gore areas within the construction/maintenance zone are:

present _____

not present _____

26. Was a delay analysis conducted for this project?

yes _____

no _____

If yes, what were the results and conclusions?

_____

_____

_____

_____

27. The type of rerouting strategy under consideration is:

    2-lane, 2-way (close one direction of a 4-lane highway) _____

    4-lane, 2-way (close one direction of a 6-lane or 8-lane highway) _____

    use an existing route _____

    a rerouting strategy other than those above _____

    no rerouting needed _____

28. The average daily traffic on the proposed detour is_____

29. Was a detour route used?

    yes _____

    no _____

30. Are nighttime operations being considered?

    yes _____

    no _____

    If yes, what strategy was developed?_____

    _____

    _____

B. Traffic Plan

1. What was the source of the guidelines for the procedures used for this traffic plan (circle those that apply)?

   MUTCD State Procedure Manual Other (specify) _____

2. Describe in detail the traffic control plan that was used in this situation. Include sketches and any available printed information.

# APPENDIX B

Workshop Agenda

# AGENDA

## EXPERT SYSTEM EVALUATION WORKSHOP

**for**

## TRANZ

An Expert System for Traffic Control in Highway Work Zones

Virginia Department of Transportation

and

Federal Highway Administration

November 2-3, 1989

Charlottesville, VA 22901

### Day One

| | |
|---|---|
| 9:00 - 9:15 | Welcome (Gary R. Allen, Director, Virginia Transportation Research Council) |
| 9:15 - 9:30 | Introduction to Workshop Agenda (Michael J. Demetsky) |
| 9:30 - 10:30 | Overview of expert systems as expert advisors (James A. Wentworth) |
| 10:30 - 10:45 | Break |
| 10:45 - 11:30 | Presentation of TRANZ (Ardeshir Faghri)<br>Scope of application<br>Knowledge base<br>Related problems |
| 11:30 - 12:15 | Applications of TRANZ (Demetsky)<br>Examples from manual<br>Others<br>Problems from attendees |
| 12:15 - 1:30 | Lunch |
| 1:30 - 2:30 | Logic of TRANZ (Demetsky, Faghri)<br>Decisions addressed<br>Rules<br>Critique |
| 2:30 - 2:45 | Break |
| 2:45 - 4:45 | Workshops on TRANZ |

| | |
|---|---|
| 5:30 - 8:00 | Cocktails, Dinner |

**Day Two**

| | |
|---|---|
| 8:30 - 9:30 | Discussion of workshop experiences (Wentworth) |
| 9:30 - 10:30 | Critique of TRANZ (Faghri) |
| 10:30 - 10:45 | Break |
| 10:45 - 12:00 | Critique; Recommendations; Closure (Demetsky) |

## STAFF

Michael J. Demetsky, Professor of Civil Engineering, Department of Civil Engineering, University of Virginia, Charlottesville, Virginia.

Ardeshir Faghri, Senior Transportation Systems Analyst, KLD Associates Inc., Huntington Station, New York.

James A. Wentworth, Federal Highway Administration, Turner Fairbank Highway Research Center, McLean, Virginia.

Holly J. Mattox, Graduate Research Assistant, Virginia Transportation Research Council, Charlottesville, Virginia.

## LIST OF ATTENDEES

| | |
|---|---|
| R. E. Blankenship, | Traffic Engineering |
| L. W. Epton, | Northern Virginia District |
| C. D. Hall, | Traffic Engineering |
| C. B. Harris, | Staunton District |
| R. A. Mannell, | Location and Design |
| Ken Myers, | FHWA, Richmond |
| Robert Napier | Construction |
| L. S. Sheets, | Staunton District |
| G. F. Williams, | Location and Design |