PEER REVIEW
OF THE
METROPOLITAN TRANSIT AUTHORITY OF HARRIS COUNTY’S
REGIONAL COMPUTERIZED TRAFFIC SIGNAL SYSTEM

Conducted August 11 & 12, 1994
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OF THE
METROPOLITAN TRANSIT AUTHORITY OF HARRIS COUNTY'S
REGIONAL COMPUTERIZED TRAFFIC SIGNAL SYSTEM

Conducted August 11 & 12, 1994

by

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Texas Transportation Institute

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Texas Transportation Institute

Sponsored by the
Metropolitan Transit Authority of Harris County

Gloria Stoppenhagen
METRO Peer Review Manager

October 1994

TENAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135
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</tr>
</tbody>
</table>
1. SUMMARY

A Peer Review was conducted on August 11 and 12, 1994 in Houston for the Metropolitan Transit Authority of Harris County (METRO). The objective of this process was to perform an overall expert review of the design and concepts associated with the Regional Computerized Traffic Signal System (RCTSS) in Harris County. The following topics were the focus of the Panel’s review:

A: System Functionality
B: Communications
C: Phased Deployment
D: Staffing & Training
E: Traffic Signal Controller
F: Regional Integration

Five panel members were selected who collectively possess expertise related to computerized traffic control systems, communications, traffic signal local controller technology and operation of control facilities. The meeting was structured as a workshop involving presentations from METRO consultants and review sessions by the Panel members.

The Panel members were:

<table>
<thead>
<tr>
<th>Panel Member</th>
<th>Title</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craig Gardner, P.E.</td>
<td>Vice President</td>
<td>JHK &amp; Associates</td>
</tr>
<tr>
<td>Anson Nordby, P.E.</td>
<td>Senior Transportation Engineer</td>
<td>City of Los Angeles</td>
</tr>
<tr>
<td>Paul McGovern, Ph.D., P.E.</td>
<td>Principal Communications Engineer</td>
<td>Parson De Leuw</td>
</tr>
<tr>
<td>Bruce Bauer, P.E.</td>
<td>Manager, Transportation Systems</td>
<td>TRW DEL</td>
</tr>
<tr>
<td>Rick Denney, Jr., P.E.</td>
<td>Senior Associate</td>
<td>Barton-Aschman</td>
</tr>
</tbody>
</table>

The Peer Review Panel concluded that the METRO Consultant had done a significant amount of work and produced a conceptual design that if completely documented and designed and if properly implemented can produce a workable RCTSS.

During the course of the review, the Peer Panel identified the following issues related to the topics being considered. Further discussion of each is contained in Section 5.2.

1. Perform an additional communications trade-off analysis. The analysis should identify initial capital costs, operating and maintenance costs, functionality and future expansion capability associated with both:
   - partitioning the video signals to separate fibers (but in the same cable with the SONET fibers used to communicate voice and data) and transmitting this information in a non-compressed manner and
   - implementing the voice and data SONET fibers using a more commonly deployed level of SONET technology.
2. Investigate the operational and maintenance impacts of implementing a communications system that utilizes an OC-48 SONET network. From a national perspective OC-48 fiber networks are in the early stages of deployment. Therefore, it is important to investigate this technology choice with respect to:
   • operations and maintenance cost,
   • agency staffing and availability of skilled technicians,
   • contract maintenance opportunities, and
   • the impact on the Federal-Aid Policy Guide Implementation Plan connected to operation of the Transportation & Emergency Management Center.

3. Prepare a “System Architecture Recommendation” document to ensure that the RCTSS design satisfies METRO’s needs and can be appropriately incorporated into the Transportation & Emergency Management Center.

4. Perform a thorough review of the functionality of the RCTSS to ensure it satisfies METRO’s requirements regarding ITS user services including traffic control.

5. Define the impacts that the selection of an “Interim” traffic control system will have with regard to staff training and final system cost as well as philosophy of control and functionality.

6. Review the decision to use Computrans’ Protocol 90 communications protocol soon after the FHWA funded NEMA (National Electrical Manufacturers Association) NTCIP protocol (National Traffic Control / ITS Communications Protocol) is prototyped and tested. Establish a plan to transition the RCTSS to the NTCIP protocol that includes estimated costs, impacts on traffic control operations and a project schedule.

7. Monitor future METRO NEMA traffic signal local controller purchases and the pending release of new VMEbus traffic signal controller standards so that METRO best utilizes its infrastructure investments for current needs and future ITS user service delivery.

8. Empower technicians and other operations staff by providing enhanced training, purchase of appropriate tools and meters, and involvement in the design, construction and activation of the RCTSS. If necessary, create new employee classifications and define new reporting relationships.

9. Review the impact of the integration of the RCTSS into the Transportation & Emergency Management Center during the early stages of the TEMC integration process.

10. The following comments were made regarding installation, activation and operations.

   10.1. Create a manual specific to field implementation. This will be important for additions and revisions to the system throughout its life.
10.2. Provide training for all technicians and operational staff when equipment arrives, even for those who may only have occasional use for the information. This helps create a sense of community among those charged with maintaining the system.

10.3. Formulate an inspection team with training required as part of the procurement contract.

10.4. Consider leveraging federal funds for operations costs where possible. Some programs allow two years of funding for operations.

10.5. Include factory acceptance testing for software and other major components of the system.

10.6. Consider contract fusion splicing of single mode fiber.

11. The following comments were made regarding procurement specifications.

11.1. Establish a dollar figure in the contract for documentation and tie final system payment to delivery of the documentation.

11.2. Address intellectual property rights issues in the contract.

11.3. Involve an attorney that specializes in software procurement for writing the contract sections pertaining to software. Explore the various software “ownership” options. Review FHWA guidelines pertaining to public domain.
2. INTRODUCTION

2.1 BACKGROUND
The Metropolitan Transit Authority of Harris County (METRO) authorized a consultant contract with Kimley-Horn and Associates to develop specifications for a Regional Computerized Traffic Signal System (RCTSS). Several technical memorandums documenting the proposed system design were prepared by Kimley-Horn and presented to the RCTSS Steering Committee. Because of the high technology nature of the RCTSS system design, METRO felt it advisable to have the design reviewed by a panel of qualified experts, a Peer Review Panel.

In preparation for the Peer Review Panel workshop TTI, METRO and other Houston area agencies held a meeting on May 24, 1994. The purpose of the meeting was to identify topics for review by the Peer Review Panel and to formulate the agenda of the August 11 and 12 Peer Review meeting.

A subsequent meeting was held on August 5, 1994 with TTI, METRO, Houston area agencies (including TxDOT, the City of Houston, Harris County and the Greater Houston Traffic Management Center), and Kimley-Horn. The purpose of this meeting was to inform everyone of the agenda for the upcoming meeting and to identify needed adjustments to the Peer Review process scheduled for August 11 and 12.
2.2 OBJECTIVES

The following six topics were identified by METRO for Peer Panel review.

A. **System Functionality:**
   - **Objective:** Identify issues regarding system functionality.
   - **Comments:** Potential areas of review included: interim control and monitoring needs, regional traffic center requirements, MOEs relevant to system operation and future ITS user service delivery.

B. **Communications:**
   - **Objective:** Identify issues regarding communications.
   - **Comments:** Potential areas of review included: selection of media, cost, use of protocols, layout of communications network, capacity, reliability, maintainability and redundancy.

C. **Phased Deployment:**
   - **Objective:** Identify issues regarding the sequencing of construction activities.
   - **Comments:** The sequencing of critical tasks could be addressed, especially their interaction with construction of the TEMC.

D. **Staffing & Training:**
   - **Objective:** Identify issues regarding staffing and training for operations and maintenance.
   - **Comments:** Potential areas of review include: availability of trained staff, personnel costs and training requirements.

E. **Traffic Signal Local Controller:**
   - **Objective:** Identify issues regarding the existing controller specification.
   - **Comments:** Potential areas of review include: transition to other protocols, impacts on operations and maintenance (including cost) and impacts on ITS user services delivery.

F. **Regional Integration:**
   - **Objective:** Identify issues regarding integration of the METRO RCTSS in the TEMC.
3. PEER REVIEW PANEL

A panel of five experts was assembled who collectively possess expertise in the areas identified by METRO as appropriate to this review. Table 1 summarizes the expertise of the Panel members relative to the topics identified in Section 2.2. Section 6 contains the resumes of the Panel members.

Table 1 - Summary of Peer Panel Areas of Expertise

<table>
<thead>
<tr>
<th>Panel Members</th>
<th>Topics</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craig Gardner, P.E.</td>
<td>Vice President</td>
<td>P</td>
<td>S</td>
<td>P</td>
<td>S</td>
<td>S</td>
<td>P</td>
<td>Coordinates JHK's IVHS Program. Involved in numerous traffic management system projects including the following locations: Ottawa, Ontario, Anaheim, Tampa, Charlotte, Sioux City, Los Angeles, San Francisco.</td>
</tr>
<tr>
<td>Anson Nordby, P.E.</td>
<td>Senior Transportation Engineer</td>
<td>P</td>
<td>S</td>
<td>S</td>
<td>P</td>
<td>S</td>
<td>S</td>
<td>Works as a traffic control infrastructure manager in the multi-jurisdictional Los Angeles area. Has mixed communications media in LA system. Controllers are Type 170s. Working with Caltrans on Type 2070 controller specification.</td>
</tr>
<tr>
<td>Rick Denney, Jr., P.E.</td>
<td>Senior Associate</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>P</td>
<td>S</td>
<td>S</td>
<td>Major project with Barton-Aschman: multi-jurisdictional Las Vegas traffic system. Extensive controller expertise. Has worked as a traffic control engineer in San Antonio.</td>
</tr>
<tr>
<td>Paul McGovern, Ph.D., P.E.</td>
<td>Principal Communications Engineer</td>
<td>S</td>
<td>P</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>Designed fiber systems in New York, Toronto &amp; Chicago. Designed radio, CCTV and telephone systems. Worked as Director of Engineering for New York City Transit Authority and as Lead Design Engineer for the Port Authority of New York and New Jersey.</td>
</tr>
<tr>
<td>Bruce Bauer, P.E.</td>
<td>Manager, Transportation Systems Line-of-Business TRW DEL</td>
<td>S</td>
<td>P</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>Involved in communications systems design and deployment since 1977.</td>
</tr>
</tbody>
</table>

Topics where Peer Panel members with primary expertise have been identified  
P = Primary area of expertise  
S = Secondary area of expertise
4. PEER REVIEW PROCESS

4.1 PEER REVIEW AGENDA

Figure 1 identifies the schedule for the August 11 and 12 Peer Review in Houston.

```
<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 am - 12:00 Noon</td>
<td>Presentations by Houston METRO Consultants / Contractors.</td>
</tr>
<tr>
<td></td>
<td>Topics include:</td>
</tr>
<tr>
<td></td>
<td>• Topic A: System Functionality</td>
</tr>
<tr>
<td></td>
<td>• Topic B: Communications</td>
</tr>
<tr>
<td></td>
<td>• Topic C: Controller</td>
</tr>
<tr>
<td></td>
<td>• Topic D: Phased Deployment</td>
</tr>
<tr>
<td></td>
<td>• Topic E: Staffing &amp; Training</td>
</tr>
<tr>
<td></td>
<td>• Topic F: Regional Integration including freeways, arterials &amp; transit</td>
</tr>
<tr>
<td></td>
<td>• A question and answer period will follow each presentation.</td>
</tr>
<tr>
<td></td>
<td>• One break is scheduled for 10:00 am.</td>
</tr>
<tr>
<td>12:00 noon - 1:30 p.m.</td>
<td>Lunch.</td>
</tr>
<tr>
<td>1:30 p.m. - 5:00 p.m.</td>
<td>Peer Review Panel to identify issues relevant to Topics A through F.</td>
</tr>
<tr>
<td></td>
<td>Consultants / Contractors asked to be absent from the room during this portion of the meeting.</td>
</tr>
<tr>
<td>Friday August 12, 1994</td>
<td>8:30 am - 9:30 am</td>
</tr>
<tr>
<td></td>
<td>Consultants / Contractors available for follow-up questions by Peer Review Panel.</td>
</tr>
<tr>
<td>9:30 am - 9:45 am</td>
<td>Break</td>
</tr>
<tr>
<td>9:45 - 12:00 Noon</td>
<td>Peer Review Panel to refine and further identify issues.</td>
</tr>
<tr>
<td></td>
<td>Consultants / Contractors asked to be absent from the room during this portion of the meeting.</td>
</tr>
<tr>
<td>12:00 noon - 1:30 p.m.</td>
<td>Lunch</td>
</tr>
<tr>
<td>1:30 p.m. - 3:30 p.m.</td>
<td>Peer Review Panel to refine and further identify issues.</td>
</tr>
<tr>
<td></td>
<td>Wrap-up</td>
</tr>
<tr>
<td></td>
<td>Consultants / Contractors asked to be absent from the room during this portion of the meeting.</td>
</tr>
</tbody>
</table>
```

Figure 1 - Peer Review Agenda
4.2 CONSULTANT PRESENTATION AGENDA

Figure 2 identifies the Consultant presentation agenda applicable for August 11.

<table>
<thead>
<tr>
<th>Approximate Start Time</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 AM</td>
<td>Introduction and Program Overview</td>
</tr>
<tr>
<td>8:45 AM</td>
<td>System Architecture Overview</td>
</tr>
<tr>
<td>9:15 AM</td>
<td>Communication Structure</td>
</tr>
<tr>
<td>9:55 AM</td>
<td>Break</td>
</tr>
<tr>
<td>10:10 AM</td>
<td>System Functionality</td>
</tr>
<tr>
<td>10:50 AM</td>
<td>Field Hardware</td>
</tr>
<tr>
<td>11:10 AM</td>
<td>Phased Deployment</td>
</tr>
<tr>
<td>11:25 AM</td>
<td>Staffing and Training</td>
</tr>
<tr>
<td>11:40 AM</td>
<td>Regional Integration</td>
</tr>
</tbody>
</table>

Note: Questions and answers period allotted after each topic.

Consultant Representatives:
Kimley-Horn and Associates, Inc.
- Roy Wilshire
- John Benditz
- Bruce Abernethy
- Brent Christian
Computran Systems Corporation
- Nat Yagoda
- Harry Harstien
- Mark Madonna

Figure 2 - Consultant Presentation Agenda
### 4.3 ATTENDEES

Table 2 lists the individuals who attended the Peer Review meeting on August 11 and 12, 1994. Local, public agency attendance is shown in the first seven rows of the table.

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Phone</th>
<th>Fax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karimi, Sholeh</td>
<td>METRO</td>
<td>713-613-0315</td>
<td>713-739-4081</td>
</tr>
<tr>
<td>Lupher, Mark</td>
<td>METRO</td>
<td>713-739-4996</td>
<td>713-652-8998</td>
</tr>
<tr>
<td>Stoppenhagen, Gloria</td>
<td>METRO</td>
<td>713-739-6953</td>
<td>713-652-8998</td>
</tr>
<tr>
<td>Hemme, John</td>
<td>TxDOT</td>
<td>713-802-5836</td>
<td>713-802-5900</td>
</tr>
<tr>
<td>Ha, Chi Ping Stephin</td>
<td>City of Houston</td>
<td>713-658-4328</td>
<td>713-658-4382</td>
</tr>
<tr>
<td>Mao, Andy</td>
<td>Harris County</td>
<td>713-755-5141</td>
<td>713-755-5295</td>
</tr>
<tr>
<td>Wiersig, Douglas</td>
<td>TEMC</td>
<td>713-658-4314</td>
<td>713-658-4559</td>
</tr>
<tr>
<td>Denney, Rick</td>
<td>Barton-Aschman (P)</td>
<td>214-991-1900</td>
<td>214-490-9261</td>
</tr>
<tr>
<td>Harstien, Harry</td>
<td>Computran Systems *</td>
<td>201-489-7500</td>
<td>201-489-7500</td>
</tr>
<tr>
<td>Madonna, Mark</td>
<td>Computran Systems *</td>
<td>201-489-7500</td>
<td>201-487-5977</td>
</tr>
<tr>
<td>Yagoda, Nat</td>
<td>Computran Systems *</td>
<td>201-489-7500</td>
<td>201-487-5977</td>
</tr>
<tr>
<td>Gardner, Craig</td>
<td>JHK &amp; Associates (P)</td>
<td>510-428-2550</td>
<td>510-655-5730</td>
</tr>
<tr>
<td>Abernethy, Bruce</td>
<td>Kimley-Horn</td>
<td>214-770-1327</td>
<td>214-239-3820</td>
</tr>
<tr>
<td>Benditz, John</td>
<td>Kimley-Horn</td>
<td>713-954-4680</td>
<td>713-954-4681</td>
</tr>
<tr>
<td>Christian, Brent</td>
<td>Kimley-Horn</td>
<td>713-954-4680</td>
<td>713-954-4681</td>
</tr>
<tr>
<td>Wilshire, Roy</td>
<td>Kimley-Horn</td>
<td>214-770-1300</td>
<td>214-299-3820</td>
</tr>
<tr>
<td>Nordby, Anson</td>
<td>LA DOT (P)</td>
<td>213-485-4271</td>
<td>213-616-2409</td>
</tr>
<tr>
<td>Schreckenghost, Andy</td>
<td>Loral</td>
<td>713-335-6973</td>
<td>713-335-6220</td>
</tr>
<tr>
<td>Beyer, Henry</td>
<td>Naztec</td>
<td>713-240-7233</td>
<td>713-240-7238</td>
</tr>
<tr>
<td>McGovern, Paul</td>
<td>Parsons De Leuw (P)</td>
<td>714-453-0220</td>
<td>714-453-0321</td>
</tr>
<tr>
<td>Bauer, Bruce</td>
<td>TRW (P)</td>
<td>513-429-7830</td>
<td>513-429-7924</td>
</tr>
<tr>
<td>Goolsby, Gene</td>
<td>TTI</td>
<td>713-686-2971</td>
<td>713-686-5396</td>
</tr>
<tr>
<td>McCasland, Dick</td>
<td>TTI</td>
<td>713-686-2971</td>
<td>713-686-5396</td>
</tr>
<tr>
<td>Seymour, Ed</td>
<td>TTI</td>
<td>214-691-8124</td>
<td>214-691-8172</td>
</tr>
</tbody>
</table>

**Note:**  
* - Subconsultant to Kimley-Horn  
(P) - Peer Review Panel
4.4 ADVANCE MATERIALS LIST

The following documentation was submitted to the Peer Review Panel prior to the August 1994 meeting. They were asked to examine the material while considering the Peer Review objectives stated in Section 2.2.

- **RCTSS Projected Annual Operating and Maintenance Incremental Expenses**
  Memo dated May 26, 1993 from John F. Benditz, Jr. Project Director, Kimley-Horn to Gloria Stoppenhagen, RCTSS Project Manager, METRO

- **RCTSS System Logic Definitions**
  Draft May 1994 by Kimley-Horn

- **Technical Memorandum on Field Hardware Evaluation**
  May 1993 prepared by Kimley-Horn

- **Technical Memorandum on RCTSS Communications Technology**
  March 1993 prepared by Kimley-Horn

- **Technical Memorandum on RCTSS Communications Trade-Off Analyses and Recommendations**
  May 1993 prepared by Kimley-Horn

- **Technical Memorandum on System Architecture**
  May 1993 prepared by Kimley-Horn

- **Technical Memorandum on Traffic Control Needs Assessment**
  May 1993 prepared by Kimley-Horn

- **Various pages from Computerized Transportation Management System Central Control System Integration Purchase Requisition Specifications**

During the Consultant presentation on August 11 the following document was distributed to the Peer Panel by Kimley-Horn:

- **Regional Computerized Traffic Signal System for Houston, Texas: Executive Summary**
  May 1994 prepared by Kimley-Horn
5. CONCLUSIONS

5.1 ITEMS OF CONCURRENCE
The Peer Review Panel concluded that the METRO Consultant had done a significant amount of work and produced a conceptual design that if completely documented and designed and if properly implemented can produce a workable RCTSS.

5.2 RECOMMENDATIONS
The following recommendations reflect the opinions expressed by the Peer Review Panel. These suggestions reflect the majority opinion of the Panel and are not necessarily indicative of complete concurrence regarding the recommendation. No attempt was made by the Panel to rank the recommendations or to establish criteria for the ranking of recommendations. The order of recommendations in the Final Report corresponds to the amount of time and discussion applied to these suggestions during the two day Peer Review Workshop. Recommendations are ordered from greater to lesser Workshop emphasis.

1. \textit{Recommendation}: Perform an additional communications trade-off analysis. The analysis should identify initial capital costs, operating and maintenance costs, functionality and future expansion capability associated with both:
   - partitioning the video signals to separate fibers (but in the same cable with the SONET fibers used to communicate voice and data) and transmitting this information in a non-compressed manner and
   - implementing the voice and data SONET fibers using a more commonly deployed level of SONET technology.

\textit{Discussion}: The existing communications design seems tailored around minimizing the number of fibers used. If it is feasible (from a service delivery perspective) to partition the video onto a separate, single fiber network, it may be possible to create an alternative design that could reduce capital and operating costs associated with the communications system and enhance future video expansion capacity.

The recommendation to partition video separate from voice/data and to implement SONET at a more commonly deployed level of technology could allow the following.
   - The SONET, data focused primary ring to be operated at a SONET standard less than OC-48 in the near to intermediate time frame. This design could reduce capital and maintenance costs associated with the SONET network.
   - Eliminate the need for environmental housing in field locations that is typically associated with video data compression equipment.
   - Improve the maintainability of the communications system because of the increased availability of maintenance personnel associated with SONET applications less than OC-48. This assumption should be verified in the case of Houston.
In a written response to questions asked by the Peer Review Panel dated August 19, 1994, Kimley-Horn estimated that (a) partitioning the video to separate fibers and using uncompressed multiplexed communications technology could reduce costs by approximately $2.6 million and (b) implementing the SONET network at a more commonly deployed level of technology could reduce costs by approximately $2.4 million. The Panel’s rough estimate of cost reductions for elimination of compressed video technology achieved by separating the video to separate fibers was approximately $2 million. The consultant’s estimate of capital costs associated with uncompressed video was a broad range interval estimate that requires more analysis to refine.

Unfortunately, documentation was not available for the Peer Review Panel that would allow a more thorough review of RCTSS/transit data loading and routing requirements. The documents listed in Section 4.4 were concerned primarily with RCTSS requirements. Because of this absence of documentation, the Panel could not estimate (a) cost savings associated with implementing the SONET network at a more commonly deployed level of technology and (b) capital cost details associated with uncompressed video.

2. **Recommendation:** Investigate the operational and maintenance impacts of implementing a communications system that utilizes an OC-48 SONET network. From a national perspective OC-48 fiber networks are in the early stages of deployment. Therefore, it is important to investigate this technology choice with respect to:
   - operations and maintenance cost,
   - agency staffing and availability of skilled technicians,
   - contract maintenance opportunities, and
   - the impact on the Federal-Aid Policy Guide Implementation Plan connected to operation of the Transportation & Emergency Management Center.

**Discussion:** The communications design is structured around an OC-48 SONET architecture. From a national perspective OC-48 fiber networks are in the early stages of deployment. The phone companies are currently installing OC-48 and OC-12 systems to interconnect their central offices and installing OC-3 systems for major service drops.

Because of the lack of an existing, pervasive SONET OC-48 infrastructure with its associated support capabilities, maintaining the RCTSS fiber communications systems may be expensive compared to other SONET standards. In addition, there was no data in the documentation regarding the availability or cost of maintenance for an OC-48 SONET network in the Houston area.

Therefore, it is important to investigate:
   - Staffing impacts for METRO and other public agencies associated with communications (e.g., employee classifications, organizational structure, training, & maintenance equipment/supplies).
• Availability of trained OC-48 SONET maintenance technicians in the Houston area.
• Responsiveness of maintenance service if an external, contract organization is used (this should be evaluated both for routine and emergency maintenance situations).
• Cost of maintenance for the OC-48 SONET network (including the cost of public agency staff and any contract maintenance service).
• Maintenance impacts associated with the video CODEX equipment required for the SONET digital communications system (especially the equipment's environmental requirements).

3. **Recommendation:** Prepare a “System Architecture Recommendation” document to ensure that the RCTSS design satisfies METRO’s needs and can be appropriately incorporated into the Transportation & Emergency Management Center.

   **Discussion:** The Panel observed that the documents listed in Section 4.4 did not contain a recommendation regarding the system architecture. The Consultant communicated to the Panel during discussions on August 11 and 12 that the analysis supporting the selection of the communications architecture had not been completely documented and that the communications design was based on combined RCTSS/transit needs. These assumptions and the analysis supporting the proposed architecture should be documented.

   The System Architecture Recommendation should also define the type of traffic signal control that will be implemented, e.g., centralized second by second, distributed time-based.

4. **Recommendation:** Perform a thorough review of the functionality of the RCTSS to ensure it satisfies METRO’s requirements regarding ITS user services including traffic control.

   **Discussion:** The document *RCTSS System Logic Definitions* contained a general description of the functionality of the system. In general the logic descriptions appeared to include the typical functions associated with an advanced transportation management system of this type. However, a more detailed review is advocated after the System Architecture Recommendation document referenced in Recommendation #3 above is completed. This functionality review should also consider the impacts of the TEMC integration and evolving ITS applications.

5. **Recommendation:** Define the impacts that the selection of an “Interim” traffic control system will have with regard to staff training and final system cost as well as philosophy of control and functionality.
Discussion: The Panel recommends a formal delineation of the impacts of interim control. The interim control philosophy (e.g., distributed, once per second central control) and the interim communications protocol will tend to develop a style of maintenance and operations linked with these decisions. Staffing, training, and support equipment associated with interim control will tend to perpetuate into the final system. The more closely the interim system corresponds to the final system, the more productive are the investments in human resources and capital.

6. Recommendation: Review the decision to use Computrans’ Protocol 90 communications protocol soon after the FHWA funded NEMA (National Electrical Manufacturers Association) NTCIP protocol (National Traffic Control / ITS Communications Protocol) is prototyped and tested. Establish a plan to transition the RCTSS to the NTCIP protocol that includes estimated costs, impacts on traffic control operations and a project schedule.

Discussion: The NTCIP protocol offers the potential to incorporate emerging ITS applications as well as increase the functionality of distributed traffic signal operations using NEMA traffic signal controllers. Both the NEMA market segment and the Type 170 / VMEbus market segment are likely to incorporate this federally funded protocol. If the NTCIP prototype due in the first half of calendar year 1995 is successful and meets expectations, METRO should transition to this protocol as quickly as possible. Protocol 90 could, if desired, be operated within this protocol as a series of NTCIP user defined message types.

Further, it should be noted that protocol and user interfaces are not independent. Therefore, continued use of Protocol 90 could exacerbate use of interfaces not compatible with the complete functionality of the system.

7. Recommendation: Monitor future METRO NEMA traffic signal local controller purchases and the pending release of new VMEbus traffic signal controller standards so that METRO best utilizes its infrastructure investments for current needs and future ITS user service delivery.

Discussion: The decision to use NEMA controllers is prudent at this point in time. However, the absence of secured long term capital funding, the infrastructure requirements of emerging ITS user services, the impact of the NEMA NTCIP protocol, the operational and maintenance issues associated with a combination of different NEMA products, all necessitate a close examination of controller alternatives to best position METRO for the future.

8. Recommendation: Empower technicians and other operations staff by providing enhanced training, purchase of appropriate tools and meters, and involvement in the design, construction and activation of the RCTSS. If necessary, create new employee classifications and define new reporting relationships.

Discussion: Complex systems of this nature require a paradigm shift in human resource management to achieve successful operation. Every effort should be
Page 17 is missing from original.
11.3. Involve an attorney that specializes in software procurement for writing the contract sections pertaining to software. Explore the various software "ownership" options. Review FHWA guidelines pertaining to public domain.
Table 3 cross-references the recommendations to the review topics identified by METRO.

### Table 3 - Summary of Recommendations & Topic Areas

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Topics</th>
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<tbody>
<tr>
<td>A. Perform an additional communications trade-off analysis which partitions the</td>
<td>A: X</td>
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<tr>
<td>video on fibers separate from the SONET fibers used to communicate data.</td>
<td>B: X</td>
</tr>
<tr>
<td>B. Investigate the operational and maintenance impacts of implementing a</td>
<td>C: X</td>
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<tr>
<td>communications system that utilizes an OC-48 SONET network.</td>
<td>D: X</td>
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<tr>
<td>D. Perform a thorough review of the functionality of the RCTSS.</td>
<td>F: X</td>
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<tr>
<td>E. Define the impacts that the selection of an &quot;Interim&quot; traffic control</td>
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<td>system will have with regard to staff training and final system cost as well</td>
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<td>as philosophy of control and functionality.</td>
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<tr>
<td>F. Review the decision to use Computrans' Protocol 90 communications protocol</td>
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<tr>
<td>soon after the FHWA funded NEMA NTCIP protocol is prototyped and tested.</td>
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<tr>
<td>G. Monitor future METRO NEMA traffic signal local controller purchases and the</td>
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<td>pending release of new VMEbus traffic signal controller standards.</td>
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<tr>
<td>H. Empower technicians and other operations staff by providing enhanced</td>
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<tr>
<td>training, purchase of appropriate tools and meters, and involvement in the</td>
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<tr>
<td>design, construction and activation of the RCTSS.</td>
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<tr>
<td>I. Review the impact of the integration of the RCTSS into the</td>
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<tr>
<td>Transportation &amp; Emergency Management Center during the early stages of the</td>
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<tr>
<td>TEMC integration process.</td>
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<tr>
<td>J. Various comments regarding installation, activation and operations.</td>
<td></td>
</tr>
<tr>
<td>K. Various comments regarding the procurement specifications.</td>
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</tbody>
</table>

Where:  
A: System Functionality  
B: Communications  
C: Phased Deployment  
D: Staffing & Training  
E: Traffic Signal Controller  
F: Regional Integration
6. RESUMES OF PEER REVIEWERS

B. K. Bauer

Title: Manager, Transportation Systems Line-of-Business
Years Experience: 20 years
TRW Location: Dayton OH

Education:
B.S., Electrical Engineering, Ohio Northern University, 1974
M.S., Systems Engineering, Wright State University, 1983
Registered Professional Engineer, State of Ohio, 1978 and State of Kentucky, 1993

Current Assignment(s):

**Line-of-Business Manager, TRW** - Manage all aspects of the Transportation Systems Line-of-Business at DEL. Responsible for review of potential programs and determination of matching capabilities within TRW. Member of DEL New Business Council which evaluates and approves targets that should be pursued. Develop technical approaches for proposals in the application of technology to Intelligent Vehicle Highway Systems (IVHS). Systems engineer for development of the Ohio Kentucky Indiana Regional Traffic Management System proposal. Manager and technical lead for TRW's IVHS National Architecture proposal. Work closely with other companies to determine joint efforts in this arena. Provide program leadership in the pursuit and performance of programs related to Transportation Systems. Develop strategic planning in Transportation Systems for DEL and communicate this planning to other TRW organizations. Responsible for staffing proposal and program efforts. Chairman of the Transportation and Support Systems Directorate Working Group on Transportation. Responsible for coordinating transportation activities between geographically locate sites within the organization. Involved in transportation strategic planning for the directorate.

Previous Assignment(s):

1992: **Technical Director, TRW** - Provide technical and programmatic support to Dayton Engineering Laboratory programs in addition to the CNI Laboratory contract at Patuxent River, Maryland. Responsible for review of technical, cost, and schedule performance of each program at least monthly. Review includes identification of potential problems areas and assignment of actions for resolution of these problems. Led major efforts to define solutions to program problems. Participated in the technical and programmatic definition of new business. Develop briefings and white papers for delivery to customer. Participate in the decision to bid specific programs within the Laboratory. Support the Laboratory Manager in all areas of operations. Act as Laboratory Manager during periods of his absence.

1991: **Project Manager, TRW** - Responsible for start up of CNI Laboratory Support project ($16M, 5 year program) at Patuxent River, MD. Defined personnel, facility and ADPE required to conduct project. Responsible for staffing project with personnel from TRW and 5 subcontractors. Activities included advertising, reviewing personnel qualifications, interviewing personnel, negotiating relocations, and participating in subcontract negotiations. Coordinated team technical activities to insure a cohesive approach to project tasks. Established as single point of contact with customer for all project activities. Prepared Delivery Order responses as required to support activity on the project. Reported project status to upper TRW management. Facility Security Officer for this new facility.

1987 to 1991: **Department Manager, TRW** - Manager of the Systems Engineering Department, Dayton Engineering Laboratory. Responsible for leadership and overall functional management of department's thirty-five employees working 3 to 4 small ($100K) to large ($15M) avionics and avionics support facility related projects. Focal point for manpower assignments and related decisions within matrix organization. Responsible for technical guidance of department personnel and review of department programs to insure accomplished work was within scope, on schedule, and within budget. Reported results of these reviews to upper management. Identified new business targets for the organization including preparation of white

1986 to 1987: Project Manager, TRW - Project Manager for the Integrated Electromagnetic System Simulator (IESS). Responsible for leadership and overall management of the IESS project (personnel, financial, and schedules) to insure project success and compliance with contract requirements. Insured that the project complied with internal TRW hardware, software, product assurance, and configuration management policies. Provided focal point for IESS in addition to new business related to IESS and other CNI projects. Responsible for the preparation and presentation of briefings and reports to the IESS customer and various levels of TRW management identifying IESS financial and schedule status, project activities, problems, and corrective actions. In addition, provide management of IESS related subcontracts.

1985 to 1986: Section Head, TRW - Manager for the Digital Communication Section of the Dayton Engineering Laboratory. Subproject manager responsible for management and conduct of the system engineering efforts on the Integrated Electromagnetic System Simulator (IESS). Focal point for the development of system interface control documents (ICDs), evaluation of system designs versus technical performance measures, and review of hardware and software approaches for conformance to overall system requirements.

1984 to 1985: Staff Engineer, TRW - Subproject manager responsible for communication system engineering support efforts for the Worldwide Airborne Command Post (WWABNCP) System Program Office. Responsibilities included management of technical personnel, project funding, and schedules. Evaluated new communication systems for installation on the WWABNCP aircraft, investigated/researched new communication system/equipment to support the aircraft mission, and designed/developed "proof-of-concept" communication hardware.

1983 to 1984: Member of Technical Staff, TRW - Responsible for conducting analysis, evaluation, and research in anti-jam clear/encrypted voice communication and intercommunication/voice switching networks. Participated in hardware design and development of the RF Signal Synthesis and RF Test Equipment subsystems of the Integrated Electromagnetic System Simulator.

1981 to 1983: Senior Project Engineer, ASD, WPAFB - Managed feasibility study for development of a standard aircraft intercommunication system for the Air Force. Responsible for defining technical approach, schedule, and organization of the study program. Initiated Tri-Service program (Digital Audio Distribution System) to develop a standard intercommunication system for use by the Air Force, Army, and Navy. Identified requirements and developed the functional specifications. Provided technical guidance and support to other programs in the areas of UHF anti-jam communication systems, VHF communication systems, laser communication systems, intercommunication systems, and integration of these systems into Air Force aircraft.

1977 to 1981: Project Engineer, ASD, WPAFB - Responsible for Combat Identification System (CIS) Direct Question and Answer Subsystem. Provided technical guidance to contractors and reviewed contract efforts to insure that the resultant designs would meet Tri-Service requirements and interoperate with NATO developed equipment. Managed engineering team on the Air Force Standard VHF AM/FM Radio (AN/ARC-186(V)) Program. Identified system requirements, conceived and developed the contractual Mean-Time Between Failure Verification Test requirements, and participated as both the source selection co-chairman and principal evaluator of technical proposals/engineering prototype hardware submitted by each contractor. Planned and conducted Development Test & Evaluation portion of the operational test and evaluation. Air Force Advisor to the principal U.S. Member of Subgroup 2 NATO Tri-Service Group on Communications Electronics Equipment.
1974 to 1977: Project Engineer, ASD, WPAFB - Project engineer for the Air Force Standard UHF Radio (AN/ARC-164(V)) Program. Developed and installed UHF modification package to update the communication system on F-4 aircraft. Conducted study program to determine AN/ARC-164(V) modifications required to provide 25 KHz, baseband compatibility with KY-58 secure speech equipment. Technical advisor to DoD study investigating approaches to providing tactical jam resistant secure voice communications. Participated in the definition and testing of interim anti-jam system which evolved into the HAVE QUICK program.

Papers and Publications:

Richard W. Denney, Jr.

EDUCATION
Bachelor of Science in Civil Engineering
Texas A & M University
Master of Science in Engineering
University of Texas at Austin

REGISTRATION
Professional Engineer in Texas, No. 63068

PROFESSIONAL EXPERIENCE
Barton-Aschman Associates, Inc.,
Dallas, Texas, 1993-present

• Technical Project Manager for the Design and Implementation of the Upgrade to the Las Vegas Area Computer Traffic System.
• Technical Project Manager for the Traffic Management Center and Traffic Signal System Upgrade for the City of El Paso, Texas.

City of San Antonio, Public Works Department,
San Antonio, Texas, 1987-1993

• Traffic Management Engineer in Traffic Division. Responsible for design, installation and operation of traffic signal systems. Responsible for all operational aspects of traffic signals including specifications, warrant analysis and signal timing development.
• Designed and installed 150-Intersection Downtown Traffic Signal System. Advanced distributed system using Type 170 controllers and microcomputers. System design included four levels of process distribution, resulting in the most communications-efficient large-scale signal system to date. Final cost of $9,000 per intersection, including $5,000 controller.
• Designed and installed many suburban systems converting about 250 intersections.
• Managed Oil Overcharge grants for signal operations improvements. Nineteen projects covering 530 intersections that funded 175 new signal controllers and 300,000 feet of cable.

Houston METRO Regional Computerized Traffic Signal System (RCTSS) Peer Review
Final Report, 10/94
PROFESSIONAL EXPERIENCE
(cont’d)

City of Austin, Urban Transportation Department, Austin, Texas 1986-1987

- Traffic Signal Engineer in Urban Transportation Department. Responsible for all aspects of traffic signals including warrant analysis, design, construction, maintenance, and operation.
- Managed installation of UTCS signal system covering 362 intersections. Most of the field work was performed during my tenure. Project under budget and on-schedule at my departure.
- Designed approximately 25 signals.
- Established policy for left turn signing which reduced the number of different signs from five to two and applied consistent signal indications.

Texas Department of Highways and Public Transportation, Division of Safety and Maintenance Operations, Austin, Texas 1982-1986

- Supervised numerous research projects. Assisted field engineers in implementing research. Developed the Left Turn Analysis Package based on research conducted by UT Austin (now being distributed nationally by McTrans). Co-developed the first microcomputer implementation of PASSER II, which received national distribution.
- Member, TxDOT Specification Review Team.
- Supervised numerous traffic operations training courses, including FRE06, TRANSYT-7F, PASSER II, PASSER III, TEXAS Model for Intersection Traffic, and NETSIM. Taught courses on PASSER.

OUTSIDE WORK

- Developed PC-Warrants™, a PC-based signal warranting program, and PC-Travel™, a travel data acquisition and analysis system, now being distributed nationally by Jamar Technologies.
PROFESSIONAL ACTIVITIES

• Institute of Transportation Engineers, Member

• International: Policy Committee; Co-Winner, 1986
  Section Technical Award; Co-Winner, 1990
  Section Technical Award

• District Nine: Student Chapter Coordinator

• Texas Section: Editor: TexITE News; Co-Chairman, Technical Committee; Authored chapters
  on traffic signals in TexITE Correspondence Course;
  Numerous other committee posts

• Transportation Research Board: Committee on
  Traffic Flow Theory and Characteristics: Paper
  Review Subcommittee; Committee on Traffic Signal
  Systems: Advanced Transportation Controller Task
  Force, Advanced Technology Subcommittee, Paper
  Review Subcommittee

• Reviewed papers for Transportation Science

PUBLICATIONS

• "Developing a Scheduling Tool for Work Zones on
  Houston Freeways," with Steven Z. Levine.
  Transportation Research Record 979.
  Transportation Research Board, Washington, DC,
  1984.

• "Traffic Platoon Dispersion Modeling," Journal of
  Transportation Engineering, American Society

• "True Distributed Processing in Modular Traffic
  Signal Systems-San Antonio Downtown System,"
  Transportation Research Record 1324.
  Transportation Research Board, Washington, DC,

• "Beyond the 170 and NEMA: The VME Bus,"

• "Beyond the 170 and NEMA: The NEMA TS2,"

• "Improved Protected-Permitted Left Turn Signal
  Displays-The Texas Approach," with Gerard B.
  deCamp, ITE Journal, Institute of Transportation

• "Calibrating NETSIM for a CBD Using the Two Fluid
  Model," with James C. Williams, Sudarshano C.S.
  Bhat and Siamak A-Ardekani. Large Urban
Craig C. Gardner, P.E.

Title
Vice President
Director of Technology

Education
University of Arizona, MS in Civil Engineering, 1976
California State Polytechnic University, BS in Transportation Engineering, 1973

Years of Experience
Twenty Years

Professional Registrations
Professional Engineer (Civil) in California

Professional Affiliations
Member of the "Mobility 2000" select working group on Advanced Traffic Management Systems (ATMS), Institute of Transportation Engineers
Transportation Research Board, Communications Committee
IVHS - America, ATMS Committee, System Architecture, Steering Committee
Institute of Electrical and Electronic Engineers Association

Summary
Mr. Gardner specializes in providing technical consulting in the area of traffic management and control systems. He coordinates JHK's Intelligent Vehicle Highway Systems (IVHS) program nationwide. His experience in traffic control systems ranges from system feasibility studies and design to implementation and construction management. During his career, he has participated in over 50 traffic signal control systems projects and over 20 freeway management systems projects throughout the United States and Canada. Currently, Mr. Gardner is leading the consulting team efforts in the California Department of Transportation's development of a new Model 2070 Traffic Controller.

Traffic Systems Engineering
Mr. Gardner is currently Program Manager for the "Cornerstone" project for the California Department of Transportation. This project, now in the implementation phase, involves the design and implementation of a freeway traffic surveillance and control system which will ultimately serve the entire San Francisco Bay Area and will interface with local agency traffic management systems.

Previously, Mr. Gardner directed the preliminary design phase of the Smart Corridor Demonstration Project in Los Angeles. This project involves the installation of a multi-agency traffic management system along the Santa Monica Freeway Corridor. The purpose of the project is to demonstrate the application of advanced traffic management concepts including expert system-based traffic operations management and in-vehicle information systems technology.

Manager of System Design of Phases I and II of the City of Los Angeles' ATSAC program. Phase I (148 intersections) was completed for the 1984 Summer Olympics and included the first application of fiber optics communications in traffic control. The ATSAC program is an ongoing series of projects which will ultimately bring more than 3,500 City intersections with Model 170 controllers under centralized control.

Project Manager for the Sioux City, Iowa, traffic signal system modernization feasibility study.

Project Manager for Phase I (Concept and Feasibility Study) for the City of Charlotte, North Carolina, central business district traffic control system upgrade project.
Project Manager for the City of Tampa, Florida, traffic signal system project. Mr. Gardner was responsible for performing the system installation and integration. Other duties included design, inspection, and testing of computer and communications equipment.

Project Manager responsible for system design and construction management of the Howard Frankland Bridge freeway surveillance and control system. This project involved the design, integration, and testing of a computer-based system to detect and manage traffic incidents on a heavily traveled bridge linking the cities of Tampa and St. Petersburg, Florida.

Program Manager for the City of Anaheim, California, traffic signal management system installation project.

Engineering Manager for the Municipal of Ottawa/Clareton, Ontario, traffic signal control system upgrade project.

Engineering Manager on the I-25/I-225 surveillance and control system in Denver, Colorado. Managed the integration of all elements for the ramp metering control systems installed.

System Engineering Manager for Burlington Skyway (Ontario, Canada) freeway surveillance and control system software development and implementation.

Mr. Gardner served as Principal Investigator for a national research study sponsored by the FHWA, entitled "Traffic Control System Hardware Reliability". This research compiled national reliability statistics for field located traffic master, traffic controller, and detection equipment. The project also resulted in the development of a PC-based software package used by agencies to inventory and track equipment maintenance histories and loop reliability statistics.

He was Project Engineer for the FHWA research project entitled "Measurement of Delay at Intersections". Mr. Gardner co-authored the final report which was later the preparation material for Chapter 9, "Signalized Intersections", of the 1985 Highway Capacity Manual.

Mr. Gardner is currently the Principal in Charge of JHK's activities on another FHWA research project titled "Detection Technology for IVHS". This ongoing project is testing the application of advanced vehicle detector technologies to traffic control systems.
PAUL A. McGOVERN

EDUCATION
New Jersey Institute of Technology, Doctor of Engineering Science, 1981
Michigan State University, M.S.E.E. (National Science Foundation Traineeship), 1966
Newark College of Engineering, B.S., Electrical Engineering, 1965

LICENSES
Professional Engineer:
New Jersey No. 20475
New York No. 064147

SOCIETIES
National Engineering Honor Society (Tau Beta Pi)
Institute of Electrical and Electronics Engineers

EXPERIENCE PROFILE
Systems Engineer with more than 25 years of experience in the management and engineering of major communication systems and transit capital projects. More than 20 years were with major transit authorities. Fully qualified to perform feasibility studies; planning; design; contract document preparation; review of consultant-prepared RFP's; negotiations with contractors; and the installation and placing in service of state-of-the-art systems.

EXPERIENCE

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>RESPONSIBILITIES:</th>
</tr>
</thead>
</table>
| 1992  | date   | PARSONS DE LEUW, INC. - Principal Communications Engineer

Lead communications engineer for the New York office. Primary technical resource for supporting communication system designs throughout the company.

Fiber Optic Communications Network - Designed the Toronto Transit Commission's Let's Move backbone network. The network will support all voice/data and video transmission for the Toronto Rapid Transit System.

Designed the Chicago Rapid Transit System's backbone network. The network will support all voice/data, and video transmissions, all telephone communications and an MIS department broadband data service.

Radio - Designed the Izmir, Turkey highway tunnel Radio System, which will provide two-way service for operations, maintenance and emergency response services and rebroadcast of FM radio with advisory voice-over.

Designer for the Boston Transit System's radio system upgrade, which will provide for the transition from the present 20 year old system design to a high capacity trunked system with the latest narrowband technology.

IVHS - Design Engineer for the New York City Department of Transportation's IVHS program for the Williamsburg Bridge. A video vehicle and incident detection system provides input to the Traffic Management Center for diversion of approaching traffic through the activation of ten variable message signs.
Performing quality assurance review of the IVHS design for Caltrans' Los Angeles Area Highway surveillance and control systems.

Design Engineer for New Jersey Highway Authority IVHS Program for the Garden State Parkway intersection with Route 17.

Designed the 100 percent coverage CCTV traffic monitoring system for the San Joaquin Hills Transportation Corridor, south of Los Angeles.

New Rail Transit Start-Up - Performed a failure avoidance assessment for opening day operation of the Los Angeles Red Line rapid transit system. Systems assessed included radio, public address telephone, CCTV, and fire detection and emergency response station operation.

1987 1992

NEW YORK CITY TRANSIT AUTHORITY - Director, Planning and Engineering Communications
New York, New York

RESPONSIBILITIES:
Directed the activities and staff for the planning, design, and contract document preparation of all Transit Authority capital projects for radio, telephone systems, public address, intercom systems, CCTV and electronic security systems. This included review of Contractor submissions, engineering of field modifications during system installation, and review of Consultant-prepared RFP's. A typical year's communications capital project work (1991) was six design contracts worth $26 million, 24 contracts in construction worth $250 million and supporting 91 design projects and 102 construction projects administered by other departments.

Telephone Projects - Chief Designer for an eight PBX network, (seven SL100's, and one NEAX 2400), with a total line capacity of 25,000, as a replacement for obsolete telephone company service to the principal administration buildings and all wayside facilities along 400 miles of right-of-way, including 2,400 emergency telephones.

Radio Projects - Chief Designer for a 20-channel, 800-MHz trunked radio system installed in 4,000 bus and maintenance vehicles and 80 police vehicles for all mobile operating and emergency communications between the vehicles and their respective command centers. The system provides coverage throughout the five boroughs of New York City using four "simulcast" base stations, interconnected by microwave links. The entire central system is redundant to first contingency level. Conducted a feasibility study for adding UHF and 800 MHz bands to the existing VHF band radiating cable antenna system in the subways to accommodate up to 100 additional channels, including some cellular telephones.

Security CCTV - Chief Designer for closed circuit television coverage of high risk areas at 65 subway stations in a test program with the station token booth clerks observing the monitors. The system includes talk-back speakers at each camera location, the activation of which initiates an audible alarm and a separate display of that camera's coverage at the token booth.

Security Alarms - Chief Designer for a replacement token booth "emergency booth communications system" between command center (CC) and 739 token...
booths, including a mass-call feature between CC and any group of booths and a speed dial feature between CC and any single booth. System is silent alarm, booth microphone recorded, with two-way voice override initiated from the booth. The system incorporates redundant dial-up lines, redundant electronics, and many enhancements over the original system.

Public Address - Chief Designer for new public address systems for 12 test passenger stations that provide 85 db plus or minus 1.5 db uniform coverage throughout the station platforms and mezzanine area. Outdoor station systems provide for reduction of active speakers during night hours to prevent noise pollution.

Transit Emergency Alarms - Chief Designer for the manufacture and testing of electronic 'gamewell' type emergency alarm circuits for manual wayside tripping of third-rail power. Electronic units are "throw-away" devices, due to their cost, eliminating the prior yearly maintenance requirements.

PORT AUTHORITY OF NEW YORK & NEW JERSEY
New York, New York

RESPONSIBILITIES:
Functional Senior Engineer
Directed the activities of a staff of 22 professionals in the development and implementation of all analog and digital electronic projects undertaken by the Port Authority's Engineering Department. Responsibilities included conducting in-depth feasibility studies, determination of costs, preparation of contract specifications, negotiations with contractors, the administration of contracts, and the installation and placing in service of new systems.

Traction Power SCADA - Designed the replacement SCADA system for PATH Rapid Transit. Features included three levels of control, remote automatic, local automatic, and local manual, all electronics/computers redundant, software-based emergency trip "gamewell" logic, and software downloading. Directed consultant's staff for preparation of contract documents.

Fiber Optics - Designed a fiber optic backbone communications network for PATH rapid transit system. Features included a redundant fiber pair installed in separate tunnel with redundant DS-3 level electronics and bidirectional loop addressing of each node, separate fibers for multiplex analog transmission of CCTV signals, and provisions on the DS-3 transmission system for the SCADA system, telephone, fan control, and pump and intrusion alarms.

Telephone - Designed and supervised the installation of a 3,000-line ITT redundant processor PBX for the Authority's offices in the World Trade Center and a 500-line Oki PBX for service to all of the restaurants in the World Trade Center towers and mezzanine, and designed a 100-line switch for the Essex County, New Jersey, resource recovery plant.

Automated Control Systems - Designed the remote monitoring and control systems for the incinerators and boilers of the Essex County Resource Recovery Plant; for the HVAC facilities, the smoke purge, and escalator shutdown systems at the Port Authority Bus Terminal; for the 5-kV ac power distribution system at
J. F. Kennedy Airport; and for a 130-vehicle automated key dispatching system at the World Trade Center.

Intrusion and Access Control - Designed the intrusion detection and access control systems for the George Washington Bridge complex; for the machine room lobbies of the World Trade Center; and for the Essex County resource recovery plant.

Passenger Information - Designed and implemented the automated arrivals and departure information system for the central terminal and gate positions at the IAB Building at J. F. Kennedy Airport.

IVHS - Designed and implemented a computerized traffic surveillance and control system for the roadways and parking lots at Newark Airport, complete with variable message signs.

Parking Lot Control - Designed and implemented the employee parking lot automated access control systems for J. F. Kennedy, La Guardia, and Newark Airports and the World Trade Center, with a total capacity of more than 50,000 users.
Mr. Anson Nordby is the Senior Transportation Engineer in charge of the Automated Traffic Surveillance And Control (ATSAC) Operations Division of the City of Los Angeles Department of Transportation. He is a California licensed Civil Engineer and a member of the American Society of Civil Engineers, the Institute of Transportation Engineers, and active with the Transportation Research Board of the National Academy of Sciences.

He was the Project Engineer during the design and installation of the ATSAC computerized traffic control system successfully used during the 1984 Olympic games in Los Angeles. That system has continued to expand throughout the city and in 1992 the project received the Ford Foundation Award For Innovation In Government by the Kennedy School of Management at Harvard University. Mr. Nordby currently has responsibility for the implementation of Intelligent Vehicle Highway Systems (IVHS) for the City of Los Angeles.

Mr. Nordby's experience has included work in the following areas:

- The planning and design of the Los Angeles traffic management system. The system when completed will control over 4,000 intersections. Responsibilities have included:
  - Project definition
  - Procurement of Federal, State, and Local funding.
  - Management of in-house design of the system construction plans.
  - Negotiation and management of consultant and construction contracts.
  - System integration and operation.
  - Staffing and training.
- The Los Angeles SMART Corridor project, one of the first applications in the United States of IVHS technology to transportation corridor traffic management.

- Work with the Los Angeles Department of Telecommunications toward the development of an integrated multi-agency fiber optic telecommunication network.

- Various projects with LADOT staff, traffic signal hardware manufacturers, and defense/aerospace firms to develop concepts and devices for new IVHS related products and systems.

- The FHWA IVHS operational test to implement Spread Spectrum radio traffic signal interconnect on the Los Angeles ATSAC system.

- Participation with national and local committees on transportation systems related topics. These have included:
  - Transportation Research Board Signal Systems Committee.
  - TRB Advanced Transportation Controller (ATC) subcommittee.
  - IVHS America Advanced Transportation Management Committee.
  - FHWA Expert Panel on the operations and maintenance of traffic management systems.
  - FHWA steering committee on the development of a National Traffic Control IVHS Communications Protocol (NTCIP).
  - The Southern California IVHS Priority Corridor planning committee.