Santa Monica Freeway

SMART

CORRIDOR

SMART CORRIDOR LESSONS LEARNED PROJECT

FINAL REPORT

EXECUTIVE SUMMARY

Prepared for:

LOS ANGELES COUNTY

METROPOLITAN TRANSPORTATION AUTHORITY

Prepared by:

TRANSCORE

An SAIC Company

35 South Raymond Avenue
Suite 200
Pasadena, CA 91105

March 31, 1999

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ACKNOWLEDGEMENTS

TransCore would like to recognize the contributions of the following agencies and firms in the development of this document.

Smart Corridor Agencies:

- Federal Highway Administration (FHWA)
- California Department of Transportation (Caltrans)
- California Highway Patrol (CHP)
- Los Angeles County Metropolitan Transportation Authority (MTA)
- City of Los Angeles Department of Transportation (LADOT)
- City of Beverly Hills
- City of Culver City
- City of Santa Monica

Firms:

- Gardner Transportation Systems
- Science Applications International Corporation (SAIC)

EXECUTIVE SUMMARY

E.1 LESSONS LEARNED PURPOSE

The I-10/Santa Monica Freeway Smart Corridor Demonstration Project is an innovative Intelligent Transportation Systems (ITS) project that uses advanced control, surveillance, and information technologies to maximize the efficiency and throughput of existing parallel freeway and arterial facilities throughout one of the most heavily traveled corridors in the nation. Because of its strategic importance to the advancement of ITS, the Smart Corridor (SC) project received funding from the Federal Highway Administration (FHWA) to prepare a report documenting the "lessons learned" by the participating Agencies as a result of planning, implementing, and operating the Smart Corridor system.

The "Lessons Learned" Report's ultimate goal is to identify factors that should be considered if components of the Smart Corridor are going to be transferred and replicated elsewhere. Because the core characteristics exhibited in the SC project – multi-agency interaction, freeway/arterial integration, and real-time traveler information – are new to many public agencies and private sector firms, such ITS stakeholders can benefit greatly from the Smart Corridor experience.

E.2 LESSONS LEARNED OBJECTIVES

The primary objective within this lessons learned project was to "...retrieve the Smart Corridor experience...". The objective of a lessons learned exercise is to record and analyze the opinions, views, and experiences of the people involved in the project and derive recommendations and pointers which can be adopted to aid the successful execution of future projects, activities and initiatives. As the previous section stated, this lessons learned document is more "institutional" in nature than "technical". Its focus is the complex decision-making processes, Agency interactions, and personal experiences that occurred in Smart Corridor. Accordingly, the project approach was a qualitative process where the primary method for assessing the lessons learned was through in-depth interview and workshop sessions.

E.3 SMART CORRIDOR PROJECT DESCRIPTION

Smart Corridor Agencies

The key Agency stakeholders involved in the design, development, and implementation of the Smart Corridor system are as follows:

- Federal/State Stakeholders
    - Federal Highway Administration (FHWA)
    - California Department of Transportation (Caltrans)
    - California Highway Patrol (CHP)
- Regional Stakeholders
    - Los Angeles County Metropolitan Transportation Authority (MTA)
    - Smart Corridor Technical Committee (SCTC)

- Local Stakeholders
  - City of Los Angeles Department of Transportation (LADOT)
  - City of Beverly Hills
  - City of Culver City
  - City of Santa Monica
- Agency Consultant
  - TransCore (formerly JHK & Associates)

Smart Corridor Overview

The key Agencies involved, Caltrans and LADOT, initiated a Smart Corridor Conceptual Design Study that identified a number of ITS project elements that could be deployed as part of a broad-based, multi-agency program to achieve the following program objectives:

- Operate the individual facilities in the Corridor at their maximum efficiency
- Balance traffic flow between the freeway and parallel surface streets
- Manage and disseminate motorist information

The vision emerged of the operating Agencies responding to congestion situations in a coordinated fashion, using a wide range of traffic management tools, techniques, and technologies at their disposal. At the heart of this coordinated approach is the Smart Corridor System; a network of computers supporting inter-Agency communications, real-time data management, and decision support processes, linked to the Agency-owned traffic management and traveler information systems.

Smart Corridor System Components

The Smart Corridor system is comprised of many technical components. These systems are operated and maintained by the various Smart Corridor Agencies as illustrated in Exhibit E.1. In addition, the following system elements were incorporated into Smart Corridor:

- Interfaces to Agency systems for the collection of data and issuing of commands
- A shared central depository for data
- An expert system for operator decision support
- Graphical user interfaces (GUIs) for input and display of real-time data
- High-speed local and wide area networks (LANs and WANs) for the distribution of data and the linking of system components

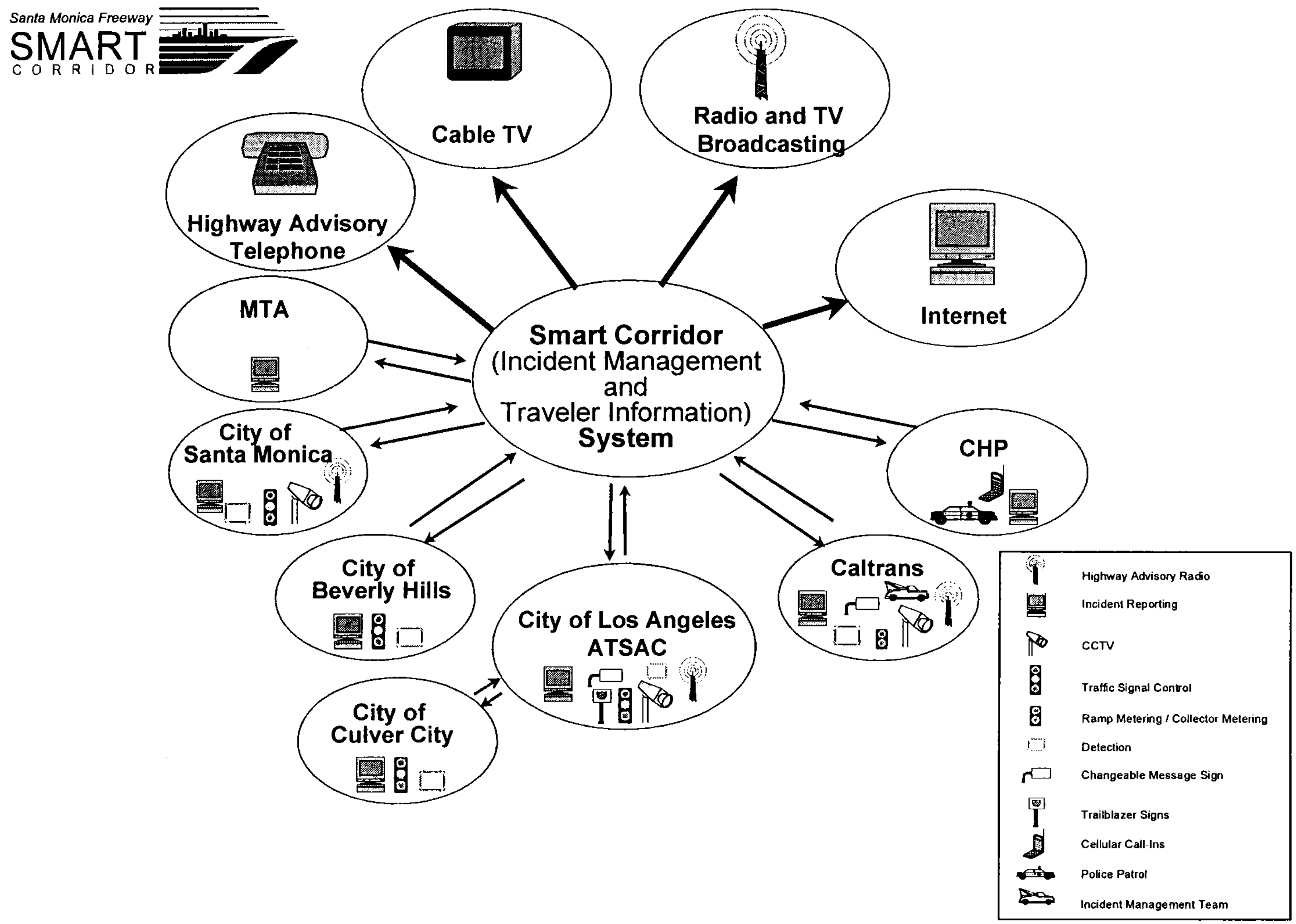

Exhibit E.1 - The Agencies and Their Elements

E.4 LESSONS LEARNED METHODOLOGY

In order to retrieve the Smart Corridor experience, the overall project approach used was a qualitative process where the primary method for assessing the lessons learned was through in-depth interviews and workshop sessions. The following sections highlight key steps in this process:

Develop a "List of Interview Questions"

- Questions addressed the complex decision-making processes that occurred during the development of the overall system configuration, hardware selection, software design, system integration, and the adoption of operating policies
- Questions also addressed participant observations concerning SC's technical components, development process, institutional relationships, and project administration
- Questions were structured along the lines of the FHWA's Professional Capacity Building (PCB) program's "ITS Integration Course" training modules (as described in Section 1.3)

Develop a "List of Interview Participants"

- Participants were identified from all of the Smart Corridor stakeholders (as listed in Section E.3)
- Participants comprised a representative set of key individuals (e.g., system operators, technical staff, upper management, etc.)
- Participants included both current and former employees

Conduct Interviews and Workshops

- In-depth interview process conducted at three (3) levels
    - "One-on-One" interviews with SC stakeholder participants
    - Individual Agency Workshops
    - SCTC Workshop
- Interview and workshop sessions were conducted/facilitated by unbiased representatives of the Project Team
- Participants were asked a set of prioritized questions during their "One-on-One" interview
- Agency workshops were held separately with as many interview participants in attendance as possible
- Workshop participants were led through a series of roundtable discussions on technical considerations and key areas identified within the interviews

E.5 SMART CORRIDOR CONCLUSIONS

The following conclusions were derived from the comments made by, and input received from the interview and workshop participants.

Strengths

1. **Inter-Agency Coordination and Cooperation.** In working together, mutual trust and respect were achieved among Agencies with previously uncoordinated agendas for traffic management within the corridor. Agencies learned to regard the whole transportation system as a shared responsibility for a more effective product at a better price. Agencies also learned about how their individual actions may impact another Agency.
2. **Knowledge Gained through Technical Accomplishments.** Most interviewees believe that great technical accomplishments have been made on SC, and that much valuable knowledge has been gained through the program. Many believe that the technical accomplishments resulted in a system that is the most advanced of its type in the world.
3. **Individual Commitment and Dedication.** Many interviewees cited the strong personal commitment and dedication of many individuals as a strength of the SC program. Enthusiasm of the individuals involved in the program maintained momentum throughout the project's duration. Persons with a great deal of devotion and passion for the concepts supported the program tirelessly in order to make great strides.

Weaknesses

1. **Staff Turnover**. Turnover, both at TransCore, and at the Agencies, impacted the project as corporate/agency "memory" was lost whenever a project member left. When new people were brought in, each had to tackle a significant learning curve. Often, new staff did not have the detailed knowledge of prior decision-making, so they tended to want to "re-invent" the issues/decisions previously made.
2. **Demonstration System vs. Operational System.** Differing opinions exist, both within and across Agencies and TransCore, as to whether the SC system should be a demonstration system, an operational system, a demonstration of an operational system, or an operational system to demonstrate concepts. Many Agency "differences-of-opinions" stem from the fact that various perspectives exist as to what are acceptable performance requirements for the system.
3. **An Ambitious and Complex Undertaking.** In retrospect, the scope of the SC program was overly ambitious considering the technology available at the time, and the resulting system took too long to develop. Both TransCore as well as the Agencies underestimated the complexity and the schedule/time that it would actually take to complete.
4. **Requirements Issues Were Pervasive.** It is clear that many of SC's perceived weaknesses stem from requirement issues. Requirement expectations unfolded and were either not articulated, or not captured, or both. For example, performance requirements were not addressed in relation to a robust, reliable system. Requirements were not clearly documented, baselined, or managed for changes. This situation often caused a requirement to not be understood in the same manner by all involved stakeholders.

Explanatory Note: The Smart Corridor program spans two (2) eras of transportation system design philosophy. It has its roots in the "traditional" engineering approach represented by carrying out a Conceptual Design Study, followed by a Preliminary Design Phase, and then a Detailed Design Phase. The outputs of these phases are characterized by wordy documents that are descriptive in nature. While providing a good narrative format that transportation engineering professionals are familiar, this approach is not suited to meet the need to precisely convey the desired system functionality to the system developer.

The deficiencies of this approach have been recognized, and there is consensus that more attention needs to be given to adopting a stricter "Systems Engineering" approach to system design and development. This approach lays great emphasis on the definition of Functions and Requirements; whereas a function describes "what" a system must do and requirement describes "how well" the function must be performed. The "Systems Engineering" approach uses a number of "shall" statements to succinctly describe it contents and is commonly broken down into concept-of-operations, user requirements, functional requirements, and detailed design phases.

In the latter stages of the SC project, specifically the GUI development in the Phase 2 implementation and the re-start of the SCEMIS contract, specific efforts were made to establish clear definitions and requirements for the remaining work. Interviews with participants have remarked on the benefits of these actions.

5. **Impacts of "New" Technology".** The SC program was not structured to keep up with rapidly changing technology. The project spanned more than a decade, during which unforeseeable technical evolutions came about. Overall, the project was not structured with the flexibility to respond to changes in technology, and only in specific cases were appropriate corrective actions taken when alternative solutions or approaches became available.
6. **System Reliability.** The current SC system is not reliable and crashes frequently. The lack of reliability is preventing further evaluation and extension of the SC concept in its current form.
7. **Risk Mitigation**. Risk mitigation activities were only performed in the latter stages of the project by TransCore. The participants as a group did not consistently consider what things might go wrong or determine what strategies could be used to mediate those risks.

E.6 QUESTIONNAIRE FINDINGS

Overview

Prior to conducting the interview and workshop sessions, an Interview Questionnaire package was sent to all identified Smart Corridor participants. A key component of this package was the "List of Interview Questions" (found in Appendix G). As stated previously, the interview/workshop questions were structured along the lines of the FHWA's PCB program's "ITS Integration Course" training modules. Although the questions were primarily qualitative in nature, a number of questions were presented in a multiple-choice, value-oriented format in order to obtain some quantitative insight on the Smart Corridor lessons learned.

Overall, 55 questionnaires were distributed and 16 responses received. Since this only represents a 30% return rate, the quantitative values presented below should be viewed accordingly. (Further statistical breakdown of the responses was not pursued in order to guarantee the anonymity of the participants). In addition, preliminary conclusions regarding the responses are forwarded as appropriate.

Short- and Long-Term Planning Needs

1. A majority believes that Smart Corridor planning was effectively coordinated, but with room for improvement.
2. A majority believes that project planning between the Agencies should be changed.
3. A majority believes that a process for furthering Smart Corridor type projects exists in Los Angeles County.

Stakeholders and Operational Objectives

1. A majority believes that the Operational Objectives were clearly articulated.
2. There was some understanding of Operational Objectives but some were not understood.
3. A majority believes that the Operational Objectives changed during the course of the project.
4. A majority believes that they would not change the Operational Objectives.
5. A majority believes that adequate staff was not available throughout the program.

Information Needs and Sharing

1. A majority believes that information sharing was effective.
2. A strong majority believes that Agency cooperation improved.
3. A majority believes that there was no reluctance to share information.

Operational Implications of Information Sharing

1. A majority believes that a coordinated concept-of-operations emerged.
2. A strong majority believes that operational responsibility was clearly partitioned.
3. A strong majority believes that the Agencies agreed to this partitioning.
4. A strong majority believes that Agency consensus was built/maintained.

Design and Implementation Considerations

1. A majority believes that system design methods were not effective.
2. A majority believes that to some extent, user requirements were translated into design considerations.
3. A majority believes that there was rejection of user requirements due to their technical difficulties relative to benefit.
4. A higher number of respondents felt that the design considerations were realistic.
5. Of those who felt that design considerations were unrealistic, the majority felt that concerns had been, to some extent, voiced.

6. A strong majority believes that technology advancements had an impact on Smart Corridor.

Procurement Strategies and Contracting Options

1. A strong majority believes that the Agencies had contract regulations to follow.
2. Broad range of opinion existed toward the contracting methods used to procure Smart Corridor; no conclusions could be drawn.
3. There could have been improvement in the contracting efforts by matching contract type to scope of work.
4. A majority believes that the contract Terms and Conditions managed Agency risk, but that there was room for improvement.
5. No conclusions could be drawn as to whether the contract Terms and Conditions placed an unreasonable burden on the Contractors/Consultants.
6. A majority believes that the budget estimates were not realistic.

Operations and Management

1. A majority was satisfied with the development of Smart Corridor Operational Planning Element.
2. A majority believes that Smart Corridor operations are satisfactory, but there is room for improvement.
3. A majority believes that their operational expectations have not been met.
4. The maintenance process has room for improvement.
5. Opinion on the satisfactory performance of maintenance efforts is broadly distributed.
6. A majority believes that their maintenance expectations have not been met.
7. A majority believes that O&M planning was adequately handled.
8. A strong majority believes that institutional barriers existed that impacted Smart Corridor O&M.

E.7 SMART CORRIDOR LESSONS LEARNED

Overview

In this section, some insights into what could make a Smart Corridor experience "better" are described. A series of recommendations have been derived by the Project Team (with concurrence from the SCTC) based upon the extensive comments received during the SC Agency and Consultant interviews and workshops. These represent the key findings as a whole and are not meant to replace or supercede the many individual recommendations made by the interview and workshop participants (as found in Appendices A-F).

The organization of these recommendations is structured along the lines of the FHWA's PCB program's "ITS Integration Course" training modules (as described in Section 1.3). This approach was chosen in order to help other Agencies to identify recommendations relevant to a specific project phase, and is particularly well-suited to multi-agency projects.

Selected recommendations are presented in this section (please refer to Section 6 for a complete listing of the derived recommendations).

Short- and Long-Term Planning Needs

1. Develop an agreed-upon understanding of the project's long-term vision within/between all participating stakeholders.
2. Ensure dedicated support/commitment from all levels of management.
3. Establish a "Lead Agency" based upon which Agency has (or can obtain) the necessary funding and/or has the desire and resources to accomplish the objectives.
4. Plan to execute the project or program in shorter, multiple phases rather than larger, more complex projects.
5. Plan for O&M at an early stage in the project planning.

Stakeholders and Operational Objectives

1. Establish and maintain inter-Agency coordination and cooperation throughout the project.
2. Decide "who's-in-charge" of each phase/component of the project up-front and in concurrence with all stakeholders (e.g., one particular stakeholder, a team of stakeholders, shared responsibility between all stakeholders, etc.).
3. Establish dedicated team(s) and individual project champions to develop, deploy, operate, and maintain the project/system.
4. Ensure that all project meetings (e.g., Steering Committees, Technical Sub-Committees, etc.) meet regularly, operate as an open forum, and are productive. In addition, meetings should adhere to developed agendas, maintain accurate minutes, and follow-up on Action item responsibilities.
5. Ensure that the project's "Operational Objectives" or "Concept-of-Operations" are articulated/documented clearly, understood in the same manner by all involved stakeholders, and adopted into each stakeholders "mission".

Information Needs and Sharing

1. Determine what data/information is necessary to your Agency in order to fulfill your "mission".
2. Determine what Agency operations you need to provide in order to fulfill your "mission".
3. Establish/maintain an effective information sharing process and/or mechanism within/between all stakeholders.
4. Clearly identify what information is to be shared and how frequently.
5. Identify and respect data/information "ownership". However, do not let this become an obstacle to sharing.

Operational Implications of Information Sharing

1. Investigate the identified information sharing "gaps" (i.e., desired information sharing capabilities vs. current level).
2. Investigate the identified Agency operational "gaps" (i.e., desired operations vs. current level).
3. Clearly partition the areas of operational responsibility within/between all stakeholders.
4. Establish/define stakeholder agreements/MOUs/commitments to all identified operational and maintenance roles/responsibilities.

Design and Implementation Considerations

1. Incorporate a pre-planned, disciplined, end-to-end "Systems Engineering Process" throughout the project's life-cycle.
    - Agencies and Consultants alike should be trained to employ this process including configuration management, peer reviews, and risk management, etc.
2. Develop/define clear, concise, and agreed-upon system requirements.
    - Determine requirements at every level, (e.g., functional, performance, reliability, physical, environmental, etc.)
    - Ensure that requirement inputs/expectations are obtained from every stakeholder
    - Ensure that requirements are properly elicited, documented, baselined, and managed for change
    - Ensure that requirements are traceable, verifiable, and testable
3. Develop a phased/incremental approach within the project's design, development, and implementation process, with frequent "builds" to establish progress.
4. Ensure that the design and development processes are "visible" to all parties (Agencies and Consultant). This implies that there are adequate opportunities/time for reviews, regular review meetings are scheduled, and materials are reviewed by staff members that possess the appropriate skills.
5. Carefully weigh all requirements against available technology; thereby ensuring that the ensuing design is realistic, cost-effective, and capable of being supported.

Procurement Strategies and Contracting Options

1. State clear, concise Terms and Conditions that effectively manage contract risk.
2. Consider a "best value" approach rather than "low bid".
3. Consider issuing a beginning phase contract to scope out the effort, document requirements, and sort out institutional policy differences, then follow-up with a second phase to implement the effort.

4. Enact appropriate contracting methods suitable to the task at-hand [e.g. do not use a Firm Fixed Price (FFP) contract for undefined software development, etc.]
5. For a program with multiple projects/contracts, distribute contract responsibilities (as far as possible) to ensure that every Agency has a "stake" in the final outcome.

Operations and Management

1. Plan for O&M at an early stage in the project planning.
2. Ensure appropriate staff is available/trained to "de-bug" and "troubleshoot" software and hardware problems.
3. Ensure support/commitment by senior management.
4. Tailor the project's/system's operations to the City's need and Agencies' capabilities.

Technical Elements

Technical considerations within the Smart Corridor project were discussed at all of the Agency Workshops conducted for this project. Data/information on the SC's chosen systems, technologies, and processes was only gathered in this manner as there was not enough time available within the "one-on-one" interviews to cover this topic. SC technical considerations covered the following topics mentioned in Section E.3, illustrated in Exhibit E.1, and described in detail in Section 2 and Section 7 of the report.

Overall, workshop participants generally believe that the key issues considered in reaching technical decisions within Smart Corridor centered around the following themes:

- Operability
- Maintenance
- Cost
- Year 2000 Compliance

Thus, each technical decision made was based upon consideration as to whether the element would fulfill operational requirements, in a maintainable fashion, with relative cost effectiveness. Oftentimes the Agencies were able to capitalize upon existing technical capabilities to enhance SC's technical effectiveness.

Over 120 recommendations have been drawn from the comments made by the workshop participants. The nature of the technical recommendations do not lend themselves to summarizing and so the reader is referred to Section 7.3 of the report.