Program Plan

HUMAN FACTORS REQUIREMENTS FOR REAL-TIME MOTORIST INFORMATION DISPLAYS

RF-3112

Texas Transportation Institute
College Station, Texas 77843

Prepared for
Federal Highway Administration
Department of Transportation
Contract No. DOT-FH-11-8505

July 1974

Program Plan

TASK A - ANALYSIS OF HUMAN FACTORS REQUIREMENTS

The objective of Task A will be to conduct a functional analysis of the human factors requirements for route diversion and incident management signing and to determine candidate messages which will be investigated as test signs in Task B. The steps in accomplishment of Task A are described in Task A-1 through Task A-10. This effort will be summarized in a technical report to be submitted at the end of the eighth month, however, the functional analysis will continue at a reduced effort through the 24th month as new information is received.

Task A-1 - Review Total Work Plan and Task A Work Plan

This effort involved modification of the program as submitted in the TTI proposal of December 21, 1973, to incorporate the FHWA technical guidelines originally raised during the May 1974 Washington meeting and, as subsequently documented in the TTI Addendum of May 31, 1974.

Task A-2 - Submit Plan for Review and Approval

This program plan is hereby submitted to FHWA for review, modification, and approval as the fulfillment of Task A-2. It is based upon TTI's interpretation of the FHWA technical guidelines and is subject to revisions as directed.

Task A-3 - Summarize Technical Literature

TTI will review existing technical literature applicable to both fixed and variable message signing for the purpose of developing candidate messages and sign designs. The literature search will include both traffic engineering and human factors data sources.

The literature will be catalogued by both author and topic heading and will be filed in a technical library exclusively for this project. The literature

will be carefully reviewed for implications to candidate message signing and the evaluation of signing modes. The literature data store will be a primary input to the human factors systems analysis effort and to the development of the questionnaire.

TTI has published a comprehensive report entitled, "State of the Art Related to Real-Time Traffic Information for Urban Freeways" that covers the technology of systems prior to July 1970. Therefore, the literature search relative to studies concerned with real-time motorist information systems will primarily cover the time period subsequent to July 1970.

A preliminary annotated bibliography of references will be available by the end of the third month, but the effort will continue throughout the program. FHWA assistance in suggesting additional references will be sought.

Task A-4 - Review Existing Projects

TTI will review existing projects in this area by contacting operating agencies, researchers, and the FHWA. Upon recommendation and approval of the FHWA, an out-of-state field trip will be made to a designated site to observe the operation of a system and to discuss problems relative to signing in the areas of route diversion and incident management.

Task A-5 - Develop Catalogues of Corridor Situations

A human factors systems analysis will be conducted which will involve cataloguing in sequence the types of decisions that a driver traveling in a corridor must make in relation to various contingencies which might arise. The analysis will involve cataloguing in order the situations influencing route diversion or incident management from pre-trip planning to destination.

Task A-6 - Develop a Task Summary of Driver Activities

A driver task analysis will be prepared which will summarize the various activities to be accomplished by a driver in relation to route diversion and incident management situations.

Task A-7 - Develop Decision-Action Diagrams

Functional flow diagrams in the format of decisions and actions will be prepared to determine the types of information which must be known by the drivers. This effort, in combination in Tasks A-5 and A-6, will document the sum total of informational requirements as can be determined logically from an analysis of drivers decisions in a corridor.

Tasks A-5, A-6, and A-7 are part of an iterative task analysis effort which will be conducted in an integrated manner, and which derives inputs for the Task B effort.

Task A-8 - Conduct a Questionnaire Survey

TTI will determine the criteria used by drivers in selecting alternate routes by administering a questionnaire to familiar and unfamiliar drivers at several selected sites across the nation. The questionnaire will be prepared and administered to local and non-local motorists initially in the Dallas area and subsequently in the Los Angeles, Minneapolis, and Washington, D.C./Baltimore metropolitan areas. This effort will insure that possible regional differences in the way drivers interpret and ascribe meaning to messages on real-time information displays are taken into consideration in the development of informational requirements for candidate messages.

The questionnaire will be administered to selected companies and at rest areas. The questionnaire will inquire as to the drivers route planning through and around an urban area, and will require also write-in responses as to the reason or reasons for selecting a particular route. Frequencies of alternative responses will be analyzed statistically. High frequency responses would suggest informational needs, which would be considered in developing candidate messages. The results of the questionnaire will be documented in a research report.

Task A-9 - Define Candidate Messages and Allocate them to Visual/Audio Modes

From the analyses conducted in Tasks A-5 through A-7 and from the results of the questionnaire, Task A-8, TTI will determine the types of information which needs to be displayed and candidate formats for the messages. The messages will be allocated to the appropriate sense modality or modalities depending upon whether the message is better displayed visually; more amenable to being heard over the radio or telephone; or more suitable to a time-sharing of both visual and audio modes.

Task A-10 - Present Candidate Messages for Review

The candidate messages to be evaluated during Task B will be presented to the Contract Manager in the monthly progress reports and/or project review meetings as the messages are developed in Task A-9.

TASK B - DEVELOPMENT OF INFORMATIONAL DISPLAYS

The objective of Task B will be to conduct studies to screen and further develop candidate visual and auditory messages compiled under Task A. Message content, format, placement, quantity, and redundancy variables, among others, will be systematically investigated in order to develop more optimal information displays for route diversion and incident management.

At least thirteen proposed studies have been identified and will be further detailed prior to their conduct. These studies provide for systematic study of combinations of the above variables and, in addition, the investigation of the following:

(a) the study of color and size in dynamic display elements

(b) the study of auditory analogues of the message content variables

(c) the study of voice quality and language syntax, mixed-modal display combinations

Each of the thirteen proposed studies will be described in the research prospectus with regard to the following:

(a) the objective of the study

(b) the justification for the type of methodological approach selected and the expected validity or degree of generalization of the findings

(c) the methodological approach including subjects, independent and dependent variables, required equipment and facilities, procedure, experimental design and statistical analysis

(d) expected results in terms of traffic engineering design criteria or specifications

The proposed visual, auditory, and mixed modal studies will be conducted in the laboratory, on a TAMU proving ground using an instrumented vehicle and by "in situ" tests with a modified instrumented vehicle. As indicated in Table 1, which summarizes the proposed tests, five studies will be conducted in the Media-master laboratory; six studies will be conducted in an instrumented vehicle "in situ", and at least two studies will be conducted in an instrumented vehicle at the proving grounds.

The Media-master laboratory experiments will be conducted on a national sample of drivers, in addition to being conducted at TAMU. The Media-master laboratory experiments will be conducted in the Los Angeles, Minneapolis, and Washington, D.C./Baltimore metropolitan areas using non-local as well as local motorists.

The results of the studies will be documented in a preliminary report and will include recommendations for prime candidate information display systems for route diversion and incident management. The results will also be converted into design criteria to be incorporated into a handbook for traffic engineers and designers.

The studies conducted in the laboratory and/or in the instrumented car on the highway will be configured and combined in such a manner that a given experimental subject will participate in what amounts to a treatment by subjects experimental design with appropriate counter balancing of treatment orders. The studies herein identified are to be conceived as components of a total program to be administered to an individual driver and not necessarily as studies done in isolation.

Task B-1 - Review and Refine Task B Work Plan

TTI will meet with the Contract Manager to discuss the overall Task B work plan. The detailed work plan, submitted with the first monthly progress report, will be re-evaluated and refined if necessary.

Task B-2 - Review and Refine Experimental Designs

TTI will review, refine, and further detail each of the studies described herein and in the proposal. The design of each experiment will be to the level of a research prospectus including detailed procedures, proposed methods of data analysis, etc.

Task B-3 - Obtain Approval of Task B Activities

The revised experimental designs and work plan will be submitted to the Contract Manager for review and approval prior to initiating any major experimental effort.

Task B-4 - Prepare Visual Studies

Prior to the conduct of the eight visual studies, several preparatory activities must be completed. These include subject selection, laboratory preparation and equipment checkout, training of test administrators, preparation of specifications for modification of proving grounds and development of test signs and support structures; development and mounting of test signs and checkout of the facility and equipment; rental of a trailer for off-site testing and planning the equipment interface; test vehicle preparation; development of on-board display system and instrumentation, preparation of art work for slide and film presentations in Media-master laboratory.

Task B-5 - Prepare Audio Studies

Preparation activities for the audio studies will be conducted concurrently with the visual studies. This effort will include acquisition and checkout of equipment to be installed in the instrumented vehicle for the audio-interface; selection of speakers for development of the tapes, preparation of tapes upon completion of the Task A definition of message content variables, etc.

Task B-6 - Conduct of Visual Tests

The eight visual studies are summarized in Table 1 and are described in greater detail in the Technical Approach section of the TTI proposal.

The five Media-master laboratory studies including one auditory study will be administered at TAMU and will be replicated using local and non-local motorists in the Los Angeles, Minneapolis, and Washington, D.C./Baltimore metropolitan areas.

The two proving grounds studies and two "in-situ" studies will be conducted as outlined in Table 1.

Task B-7 - Conduct of Audio Tests

The three auditory studies are summarized in Table 2 and are described in greater detail in the Technical Approach section of the TTI proposal.

One of the auditory studies involving the Media-master laboratory will be administered at TAMU and off-site in accordance with the schedule indicated for the visual studies in the Media-master laboratory. Two auditory studies will be conducted in instrumented vehicles "in-situ".

Task B-8 - Reduce and Analyze Visual and Audio Data

This task involves reduction and analysis of data collected during Task B-6 and Task B-7.

Task B-9 - Document Visual Studies

A preliminary report documenting the visual studies and design recommendations will be prepared.

Task B-10 - Document Audio Studies

A preliminary report will be prepared documenting the audio studies with design recommendations.

Task B-11 - Conduct Mixed-Modal Studies

The two mixed-modal studies are summarized in Table 2 and described in greater detail in the Technical Approach section of the TTI proposal.

TABLE 1 - SYNOPSIS OF VISUAL DISPLAY STUDIES

TASK CODE AND TITLE	OBJECTIVE	INDEPENDENT VARIABLES	DEPENDENT VARIABLES	MODE OF SIMULATION	EXPERIMENTAL DESIGN	APPROX. NUMBER OF SUBJECTS	STATISTIC USED
1-1 Message Content and Format	To determine from both preference and performance data, the optimal signing elements and the arrangement of these elements in messages	•Traffic Descriptors •Word Legends •Symbolic vs. Verbal •Ordering of elements	•Response Time •Choice-Point Error •Preferences	Media-Master Lab at TAMU and in Portable Facility	Treatment by Subject	200	Non-parametric (Friedman)
-2 Message Placement and Redundancy	To determine the distances which real-time displays should be placed upstream of decision points and distances between signs. Criteria based upon driver processing time and maneuvering time in traffic	•Distances between signs and distances to exits •No. of elements in sign •Repetition of message •Traffic loads (2)	•Lane changing & vehicle tracking response •Response time •Lane changing to exit time •Verbal responses	Instrumented Vehicle "In Situ" with On-Board Display System	Factorial (4x2x2)	64	Analysis of Variance (exc. verbal R- These will be used to interpret results)
-3 Placement and Format	To determine design recommendations for overhead and roadside signs (vertical and lateral displacement from line of sight)	•Horizontal and vertical displacement of signs	•Reaction time to sign •Vehicle control while reading it (lane line crossings)	Instrumented Vehicle at Proving Grounds	Treatment by Subject	24	Analysis of Variance
-4 Quantity and Format in Variable Matrix Signing	To determine design recommendations for information loading in signs and modes of presenting long messages on variable matrix signs	•Signing elements per row •No. of rows with fixed elements per row •Discrete presentation (flashed messages) •Continuous movement of message (self-paced)	•Alternative measures •Reading time •Accuracy of recall after fixed exposure times •Number of bits read in a fixed time with subject pacing	Media-Master Lab at TAMU and in Portable Facility	Treatment by Subject replicated for each variable	100	Analysis of Variance

TABLE 1 - SYNOPSIS OF VISUAL DISPLAY STUDIES (Cont.)

TASK CODE AND TITLE	OBJECTIVE	INDEPENDENT VARIABLES	DEPENDENT VARIABLES	MODE OF SIMULATION	EXPERIMENTAL DESIGN	APPROX. NUMBER OF SUBJECTS	STATISTIC USED
1-5 Quantity and Format in Static Signs	To determine design recommendations for arrangement of static signing elements - left-to-right on one line or on two rows	•Horizontal and vertical orientation of messages	•Reading time-from exposure to report of message (voice key) •Errors in message recall after brief durations •Speed reduction & lane-line crossings	Instrumented Vehicle at Proving Grounds. Signs automatically exposed at fixed distances within legibility range	Treatment by Levels- 3 Categories	100	Analysis of Variance
6 Target Value, Color, and Size	To determine design requirements for colored lights as a mode for augmenting a route diversion decision	•Alternative route time delays •Yellow/green lights •Blue/white lights	•Decision-making time in route selection with & without light reinforcement	Media-Master Lab at TAMU and in Portable Facility	Treatment by Subject	100	Analysis of Variance;Chi-square for enumerative data
7 Color and Letter Coding	To determine design requirements for a traffic condition display in terms of coding modes. Coding criteria will include modes of communicating currency and operating system	•Traffic Condition Display Modes: •Letter coding •Color coding •Letter/color coding •Word message	•Distance at which messages are first readable •Appropriate vehicular response	Instrumented Vehicle "In Situ"	Treatment by Subject	20	Analysis of Variance
8 Target Value, Color, and Shape Coding	To explore feasibility of color and shape coding of route shields as techniques for reducing search time in banners of shields. Present methods have redundant cues	•Shapes & colors of route shields •Location of the target shield in the banner	•Response time •Route-selection errors. Task is to quickly press a key corresponding to the position of target shield in the banner	Media-Master Lab at TAMU and in Portable Facility	Treatment by Subject	20	Analysis of Variance

NOTE: All treatment by subject designs involve counterbalanced orders of treatment

TABLE 2 - SYNOPSIS OF AUDITORY AND MIXED-MODAL STUDIES

TASK CODE AND TITLE	OBJECTIVE	INDEPENDENT VARIABLES	DEPENDENT VARIABLES	MODE OF SIMULATION	EXPERIMENTAL DESIGN	APPROX. NUMBER OF SUBJECTS	STATISTIC USED
2-1 Message Content Format, Length & Language Factors	To determine design recommendations for auditory signing modes	•Message content •Ordering of elements •Message lengths •Narrative vs. sign-language format •Male/female voice •Trained/amateur speaker •Repetitions (1,2)	•Preferences •Accuracy of recall •Response time to recall	Media-Master Lab at TAMU and in Portable Facility	Treatment by Subject - Series of Studies	100	Chi-Square Non-Parametric Tests (Friedman)
2-2 Alerting Modes for Traffic Advisories (format)	To determine optimal modes of alerting drivers to listen to traffic advisories under ambient noises	•Tones A & B •Voice message •Traffic noise levels (2) •No alert mode	•Response time •Recall accuracy for message •Preferences	Instrumented Vehicle "In Situ" with Taped Messages Patched into AM Radio	Treatment by Subject	24	Analysis of Variance Non-Parametric Tests (Friedman)
2-3 Placement & Redundancy	To determine distances which audio messages should be received up-stream of decision points and repetition requirements	•Distances between message & decision point •Number of repetitions •Message format	•Recall accuracy •Response time •Vehicle movement time and tracking response pattern	Instrumented Vehicle "In Situ" with taped Messages	Mixed- Treatments Between Subjects by Treatments Within Subjects	24	Analysis of Variance
3-1 Mixed-Modal Message Compatibility and Redundancy	To determine mixed-modal message requirements in terms of degree of similarity of messages presented	•Sign & radio give: same message, unrelated messages, radio amplifies sign message	Same as 2-3	Instrumented Vehicle "In Situ" with On-board Display and Tapes	Mixed- Treatments Between Subjects by Treatments Within Subjects	48	Analysis of Variance
3-2 Sign Vs. Radio Alerting Modes for Traffic Advisories	To determine relative advantages of signs and auditory alerting modes in directing attention to radio bulletins	•Sign alert •Audio alert (broad-band)	•Response times from message onset •Correctness of reported response	Instrumented Vehicle "In Situ" with On-Board Displays and Tapes	Treatment by Levels (Driver Classes)	40	Analysis of Variance

NOTE: All treatment by subject designs involve counterbalanced orders of treatment

These studies both involve the instrumented vehicle "in situ" and will be conducted concurrently with the auditory studies.

Task B-12 - Reduce and Analyze Mixed-Modal Data

This task involves reduction and analysis of data collected during Task B-11.

Task B-13 - Document Mixed-Modal Studies

This task allows for the preparation of a preliminary report documenting these studies with design recommendations.

Task B-14 - Prepare Design Recommendations

Design recommendations for candidate information display systems for route diversion and incident management will be prepared and incorporated into Task C activities as they become available. It is envisioned that some preliminary design recommendations will be developed early in the conduct of Task B studies so as to expedite the initiation of Task C as early as possible.

Design criteria will also be prepared and coordinated with the developers of the handbook.

Task B-15 - Obtain Approval of Task B Results

The preliminary report(s) documenting the results of the visual, auditory, and mixed mode signing studies will be submitted to the Contract Manager for approval. The results of Task B will also be presented to the Contract Manager at a research review meeting. Recommendations will be incorporated into the preliminary report.

TASK C - EVALUATION OF INFORMATION DISPLAYS

Dallas and Houston have been selected as study locations for Task C because of the existing corridor surveillance, control, and communications facilities available to TTI as part of an ongoing research effort.

The evaluation study designs will be influenced by the type of information displayed, mode and location of information display, and the nature of freeway operating conditions. They will also be influenced by individual driver and traffic performance characteristics that are required to serve as inputs to the preparation of the handbook in Task D.

The primary measures of individual driver and traffic performance will largely be dictated by the type of information displayed, mode of communications, study design, and information display function. As an example, warning messages may dictate different measures of effectiveness than re-routing information. TTI will make optimum use of the entire electronic instrumentation and other facilities within the corridors including detection, communications, and computer hardware and software. Also, full utilization will be made of TTI's instrumented vehicle. In addition, stationary and portable video tape recording capabilities will be used for many of the studies proposed.

All data collected from detectors in the corridor and that from the instrumented vehicle will be processed using computer facilities in Dallas and Houston.

Individual driver and traffic performance characteristics proposed will include, but not be limited to:

- Volumes
  - Freeway
  - Entrance Ramps
  - Exit Ramps

  - Frontage Roads
  - Alternate Routes
  - Link Routes
- Turning Movements at Critical Intersections
- Occupancy at Queue Detectors at Entrance Ramps
- Speeds
  - Freeway
  - Frontage Road
  - Alternate Routes
- Lane Distribution on Freeway Sections
- Erratic Driver Maneuvers
- Lane Changing Patterns
- Brake Lights Observed
- Acceleration Noise (Instrumented Vehicle)
- Brake Applications (Instrumented Vehicle)
- Number of Stops/Unit Distance (Instrumented Vehicle)
- Verbal Response of Test Driver (Instrumented Vehicle)
- Visual Observation of Controlled Group of Motorists
- Motorist Opinions (Questionnaire)

In addition to individual driver and traffic performance, TTI will perform studies to evaluate the effectiveness of real-time motorist displays to total corridor performance. This information will be useful in assessing probable effectiveness of alternative sign and mixed modes in other corridors. Since the sign design engineer will in most cases be forced to make trade-offs between cost and system design, this type of information will be useful in the preparation of the sign design manual discussed in Task D. Measures of effectiveness to assess corridor effects of real-time information subsystems will include:

- Gasoline Consumption
- Travel Time
- Speed
- Volumes
- Vehicle Miles of Travel
- Delay
- Kinetic Energy
- Acceleration Noise (Instrumented Vehicle)
- Brake Applications (Instrumented Vehicle and Observed)
- Stopped Time (Instrumented Vehicle)
- Number of Stops/Unit Distance (Instrumented Vehicle)
- Mean Velocity Gradient (Instrumented Vehicle)
- Greenshields Index (Instrumented Vehicle)

In view of all studies conducted, basic data such as time of day, day of week, season, environmental and pavement conditions, energy crisis status, type and extent of incidents, operating conditions on all the facilities affected, etc., must be documented for effective analysis of sign messages. Documentation of messages displayed on visual and audio displays will be made either manually, by use of a tape recorder in the control center, or by the computer.

Task C-1 - Review and Refine Task C Work Plan

TTI will meet with the Contract Manager to discuss the overall Task C work plan. The detailed work plan, submitted with the first monthly progress report, will be re-evaluated and refined based on results of Tasks A and B.

Task C-2 - Obtain Approval of Task C Activities

The revised work plan for Task C will be submitted to the Contract Manager for review and approval.

Task C-3 - Identify Candidate Sites

Candidate field sites will be identified for visual, audio, and mixed-mode hardware installations. TTI will meet with the Contract Manager and the Project Technical Committee to identify and discuss candidate sites. Because of experience gained from on-going research on the Dallas Freeway Corridor Project, the Bus Demonstration Project in Dallas, and Gulf Freeway Project in Houston, TTI has suggested possible sites. These candidate sites are summarized in Table 3.

Task C-4 - Identify Preliminary Hardware Requirements

Preliminary requirements will be identified for visual, audio and mixed-mode displays that will be installed in the field for test and evaluation of prime candidate information messages. Hardware requirements will be dictated by results of laboratory experiments conducted under Task B. Although visual and audio laboratory experimentation will occur simultaneously in Task B, it is possible that the experimental results of individual modes will be finalized at different time periods. Therefore, the time dependency of hardware identification will be made in concert with the availability of results from the laboratory experimentation.

Task C-5 - Select Prime Field Sites

Prime field sites will be selected as a result of Task C-3 and will be submitted to the Contract Manager for approval.

Task C-6 - Select Prime Display Candidates

Prime display candidates will be selected as a result of Tasks C-2, C-3, and C-4 and will be submitted to the Contract Manager for approval.

Task C-7 - Work Out Cooperative Agreements with City and State Agencies

Installation of roadside visual and audio information displays will require cooperative agreements between TTI and the agencies involved. Although this activity is placed under Task C, a considerable amount of lead time will be

TABLE 3 - POSSIBLE FIELD SITES

LOCATION	FACILITY	DIRECTION	MODE	POSSIBLE HARDWARE	FUNCTION
Dallas	North Central Expressway Mainlanes between Lovers Lane and Henderson	Outbound Inbound	Audio	Linear Radio	Incident Management/ Route Diversion
Dallas	Skillman	Inbound	Visual	Changeable Message Signs	Incident Management/ Route Diversion
Dallas	Frontage Road North Central Expressway between Lovers Lane and Henderson	Outbound Inbound	Audio	Linear Radio	Incident Management/ Route Diversion
Dallas	Entrance Ramps North Central Expressway between Lovers Lane and Henderson	Outbound Inbound	Audio	Linear Radio/Low-Power Radio	Incident Management/ Route Diversion
Dallas	North Central Expressway Corridor	Outbound Inbound	Audio	Telephone	Incident Management/ Route Diversion
Dallas	Major Generators, Intersections, Entrance Ramps	Outbound Inbound	Audio	Low-Power Radio	Incident Management/ Route Diversion
Dallas	Park & Ride Facilities in North Central Expressway Corridor	Outbound Inbound	Not Defined	Not Defined	Route Diversion
Dallas Area Houston Area	Not Defined	Not Defined	Visual/Audio	Fabric Changeable Message Signs/ Low-Power Radio	Maintenance and Construction Incident Management/Route Diversion
Houston	Gulf Freeway Mainlanes	Inbound	Visual	Changeable Message Signs/ Warning Signs with Beacons	Incident Management
Houston	I-10 at I-610 (Mainlanes)	Outbound	Visual	Signals/Changeable Message Signs	Incident Management

TABLE 3 - POSSIBLE FIELD SITES (Cont.)

LOCATION	FACILITY	DIRECTION	MODE	POSSIBLE HARDWARE	FUNCTION
Dallas	Not Defined (Mainlanes)	Not Defined	Visual	Signals	Incident Management
Dallas	Frontage Road North Central Expressway, Lovers Lane, Skillman, Loop 12	Outbound	Visual	Changeable Message Signs/Static Signs	Incident Management/ Route Diversion
Dallas	US 75 North of I 635	Inbound	Visual/Audio	Changeable Message Signs/ Radio	Route Diversion
Dallas	North Central Expressway Corridor	Not Defined	Visual/Audio	Changeable Message Signs/ Static Signs/Radio	Incident Management/ Route Diversion

necessary to work out cooperative agreements. Therefore, this activity will begin early in the contract period and will occur simultaneously with Task B.

Task C-8 - Select Final Displays and Sites

This task will be to meet with the Contract Manager to select the displays and installation sites for visual, audio, and mixed-mode evaluation studies.

Task C-9 - Procure Equipment

This task involves the entire process of procuring visual, audio, and mixed-mode hardware and, therefore, requires considerable lead time to meet Project schedules. The hardware includes signs, sign structures, communications links, and equipment necessary to interface with existing or new hardware and for operating the sings. This process includes:

- Specification Preparations
- Agency Approvals
- Bid Advertising
- Bid Evaluation
- Contract Award

Task C-10 - Install and Test Equipment

The equipment procured will be installed at the selected sites and then tested to insure that all hardware components are functioning as a system.

Task C-11 - Define Measures of Effectiveness

This task involves selection of measures of effectiveness that will be used to evaluate individual driver and traffic performance as well as corridor system performance.

Task C-12 - Design Studies

Preliminary study designs will be formulated as soon as agreements have been reached for field sites and sign mode. Since the study designs are influenced by the type of information displayed to the motorists, it is anticipated that studies for specific aspects of incident management and route diversion will be finalized at different times as results become available from Task B.

Task C-13 - Collect Data Base

A data base will be required for each study outlined in Task C-12. Because of TTI's involvement in the Dallas Freeway Corridor Project, the Bus Demonstration Project in Dallas, and the Gulf Freeway Project, extensive data files are already available for evaluating signs that may be placed in Dallas or Houston. However, it is anticipated that current data would need to be increased with additional field studies. Also, the energy situation may result in changes in driver patterns and vehicular mode choices that could reduce the value of existing data.

Task C-14 - Develop Sign Operational Control Strategies

Before real-time motorist information can be effectively implemented in the real world, operational control strategies need to be developed and formalized. The control room operator needs to know what messages are to be displayed in relation to the current and predicted conditions on the freeway and alternate or diversion routes. This task would provide for the development of operational control strategies and the learning process involving using simulated tests. This task is important to insure credibility of information displays.

Task C-15 - Conduct Field Studies

Field studies will be conducted in accordance with the study designs developed in Task C-12.

Task C-16 - Operate Equipment

During the course of the field studies, it will be necessary to operate the visual, audio and mixed-mode signs in real-time. TTI envisions that remote control operation of the information displays will be from the surveillance center for most signs that will be tested.

Task C-17 - Reduce and Analyze Data

This task involves reduction and analysis of data collected during Tasks C-13 and C-15.

Task C-18 - Document Results

TTI will prepare a detailed research report documenting the results of field studies conducted in Task C. Recommendations will be included in the report.

Task C-19 - Submit for Review and Approval

The research report prepared in Task C-18 will be submitted to the Contract Manager for review and approval.

TASK D - PREPARATION OF HANDBOOK

TTI will prepare a handbook for use by sign design engineers which incorporates specifications and guidelines based on the analysis, development and evaluation work conducted under Tasks A through C. The handbook will be developed to satisfy the design needs of the sign design engineer within the context of a highly integrated freeway corridor surveillance and control system. It will contain illustrations and engineering drawings to enhance reader comprehension. The handbook will be bound separately from the detailed revised research reports.

Task D-1 - Develop Format and Outline

This task allows for the development of the handbook format and outline

Task D-2 - Submit Format and Outline for Review and Approval

The basic format and outline of the handbook developed in Task D-1 will be submitted to the Contract Manager for review. This task will also provide for making necessary revisions and securing approval of a basic handbook format and outline.

Task D-3 - Assign Narrative Responsibilities

The task of preparing the initial handbook narrative will be given to several members of the project team. The assignment of specific narrative responsibilities to an individual will be based upon his special area of training and experience such as human factors, freeway corridor management and control, communications, sign design, etc. The assignments will also consider the basic sections of the handbook as defined by Task D-2.

Task D-4 - Prepare Initial Sections

Based on the assignments made in Task D-3, work will be initiated to develop the narrative for the various sections of the handbook. A team approach will be utilized with approximately six individuals working on various sections of the handbook. This will facilitate accomplishment of the writing task within the desired time frame.

Task D-5 - Review and Assemble Drafts

After initial drafts of the various secitons of the handbook have been completed, they will be carefully reviewed, revised as necessary, and assembled into a first draft of the handbook.

Task D-6 - Prepare Illustrations

This task includes the definition of the illustration theme, identification of illustration needs, and preparation of draft illustrations for use in the handbook. It is desired that preliminary illustration development begin as soon as possible to insure that subsequent drafting, art work, photographic processing, and layout work will be completed on schedule.

Task D-7 - Prepare Draft Handbook

When the first draft and illustrations of the handbook have been completed in Tasks D-5 and D-6, the handbook will then be prepared and subjected to a thorough editing and evaluation to assure grammatical correctness, clarity of presentation, and ease of reader comprehension. Editorial work will be accomplished by the project team member skilled in technical writing. Selected highway department and municipal sign engineers will be asked to evaluate the manual with respect to acceptability and ease of reader comprehension.

Task D-8 - Submit Draft Handbook to Selected Highway Engineers for Review

TTI will submit the handbook draft to selected highway engineers for review and comments.

Task D-9 - Submit Draft Handbook for Review by FHWA

The draft handbook will be submitted to the Contract Manager for review, comments, and any changes as may be deemed necessary.

Task D-10 - Receive, Review and Revise Handbook

Upon receipt of the FHWA review of the draft handbook as conducted in Task D-9, necessary and other desired revisions to the handbook will be made. After all comments and suggested revisions have been responded to in a satisfactory manner, the final version of the handbook will be developed.

Task D-11 - Submit Completed Handbook to FHWA for Approval

The final version of the handbook will be submitted to the Contract Manager for final review and approval.