D. IVHS SYSTEM INSTALLATION OPTIONS

BI-STATE ST. LOUIS AREA IVHS PLANNING STUDY

IVHS SYSTEM INSTALLATION OPTIONS

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Success during the system installation phase is, to a large degree, dependent on the quality of the work which preceded it. Thorough planning, coupled with complete and definitive plans and specifications, are essential to the installation of a successful traffic system. However, no set of contract documents will ever be perfect. Some facilities, such as underground utilities, may not be shown on the plans or marked out in the field (a consequence of erroneous or inadequate records), and their existence remains an unknown until the contractor literally runs into them. A time lag usually exists between the design phase and the actual start of construction during which conditions as reflected in the plans, or the technological state-of-the-art, may have changed. Finally, regardless of how definitive and certain the contract documents are, there will always be some conflicting interpretations as to their exact meaning.

Good contract management and thorough construction inspection are essential to a system's success. The biggest errors, longest delays, and the largest cost overruns have occurred during system installation. Unless this phase is properly managed, it can break a project, and turn the system into an operational failure and maintenance nightmare.

Intelligent Vehicle Highway System (IVHS) installation depends on effective construction contract administration and supervision, close cooperation among all involved parties, careful attention to plan details, and good workmanship. Good installation procedures and practices can make installation easier, avoid construction delays, minimize future operational problems and maintenance requirements, and reduce the risk of future liability.

This chapter describes recommended procedures and practices for successful traffic control and surveillance system installation. Areas covered include:

- Preconstruction administration, supervision, and coordination activities.
- Effective recordkeeping during construction.
- A construction inspection checklist to avoid common problems and facilitate good workmanship.
- Guidelines for final project inspection and acceptance.

PRECONSTRUCTION ACTIVITIES

Contract Supervision and Administration

Responsibilities and procedures for supervising the contractor and administering the construction contract can vary widely, depending on the contracting agency and the size of the project. Where federal and/or state aid funding is involved, additional requirements must be followed.

Most important, the respective roles and chain of command for decision making in the field and requirements for approvals by others must be clearly understood by all supervising engineers and inspectors and the contractor's representatives. Misunderstanding of such roles and requirements frequently leads to unnecessary errors, costs, and delays during construction and can lead to lawsuits.

As with any process, the construction management framework consists of both formal and informal elements. The formal requirements and channels-of-communication should be addressed and clearly defined in the specifications. It is emphasized that the formal elements apply equally to both parties of the construction contract--the contractor and the contracting agency. A frequent complaint by contractors is the delays incurred while the agency reviews submittal and processes change orders. Unreasonable delays will endanger good working relationships. If the review cycle is greater than the specified time, the contractor will likely be entitled to an extension of contract time, and possibly additional compensation. The agency and other involved parties must therefore respond promptly to all written correspondence from the contractor. Not only is this contractually required, but timely responses keep the ball in the contractor's court, thereby helping to ensure that the project moves along productively.

Obviously, it is in everyone's best interest if the formal channels-of-communication can be streamlined as much as possible. One possibility is to have the "official" submittal sent to the contracting agency with copies also delivered to all reviewing agencies. In this manner, the time spent solely for the transportation of the documents can be minimized. Those in the chain-of-command with review or approval authority should be kept in the loop as the project progresses. They will thus be more likely to review and sign-off in an expeditious manner.

The ultimate success of the system implementation phase depends on the informal elements of the process--specifically the experience, knowledge, cooperation, fairness, and commitment on the part of all participants. In fact, there is perhaps no other aspect of the system process where the relations between the individuals are so important. For example, there have been instances where the contract documents were less than ideal (e.g., split responsibilities, ambiguity, incomplete testing provisions, etc.), but because the individuals maintained good relations the traffic control system was successful. At the same time, there are other examples where the specifications and plans were quite good in terms of their accuracy and certainty, yet one or more individuals involved in the process automatically adopted an antagonistic and confrontational posture, with the result that major problems occurred.

Such exceptions are not meant to diminish the need for well-written specifications and accurate plans. Rather, they illustrate the critical importance of good human relations during system implementation. There will always be some interpretation of even the best contract documents--the contractor generally viewing them as the maximum requirements while the owner considers them to be the minimum requirements. The best way to resolve any differences in the interpretation is through cooperation and compromise.

Successful construction management consists of being fair, but firm. The "hard nosed" approach in which the project engineer and inspectors exhibit an unyielding insistence on the "letter of the specifications," allowing no deviations no matter how justified, will seldom produce a successful system. At the other end of the spectrum, token ineffective management and inspection will also likely yield unsatisfactory results. Laxity and permissiveness in contract supervision will lead the contractor to believe that shortcuts or substandard workmanship will be tolerated, resulting in an unsuccessful system.

A major factor which is frequently overlooked or ignored in construction management is the need to establish a common goal. The most successful projects are those in which the agency gets the best job at the lowest cost, and the contractor realizes a profit.

Project Engineer

The key player during the construction management effort is the Project Engineer. The engineer has a many-sided responsibility. As the authorized representative of the owner, he/she is concerned with all of the owner's interests in the system construction and equipment procurement contracts. In this role, the engineer, with the help of a staff of inspectors, reviews contractor submittal, approves construction methods, watches the work to assure that the workmanship is satisfactory and that no defective materials are used, makes monthly measurements of the work completed and reports to the owner the amount of payment due the contractor, conducts component system acceptance tests, and generally enforces all requirements and provisions of the plans and specifications. The engineer should spend most of his/her time on-site and maintain close contact with the contractor's superintendent. However, the engineer should avoid exercising direct and complete control over the contractor's operations. Otherwise the contractor's independent-contractor relationship with the owner may become a master-servant relationship, which could relieve the contractor of some of his/her obligations and impose unanticipated liabilities on the owner.

One of the most valuable resources available to the project engineer is access to the design engineer. There is no quicker way to resolve questions concerning any aspect of the project than to ask the person who was responsible for the design. This situation is optimum when the design engineer is part of the installation process. This is possible under several different forms of contracting, but is most prevalent in the Systems Manager form of contracting. Another resource that is invaluable to the project manager is a skilled, educated, and motivated team of inspectors.

Another important function of the engineer is that of arbitrator of the contract documents. The engineer must interpret the requirements of the plans and specifications, and serve as an arbitrator of disputes between the contractor and the owner. As such, it is imperative that the project engineer be impartial, honest, and fair in such matters--even if it means deciding against the agency for whom he/she is an agent or even an employee.

Expertise and attitude are critical qualities in a successful project engineer. The engineer must obviously have an intimate knowledge of the contract documents, and his/her expertise should encompass both systems knowledge and construction experience. The systems knowledge is necessary for overseeing the technical requirements of the contract documents, while the construction experience is necessary for administering the general provisions. There are numerous examples of implementation problems and delays occurring simply because the engineer, as well as the inspectors, were totally unfamiliar with the electronic components and software complexities associated with traffic control systems. These construction managers, who were otherwise very competent, had no recourse but to base their decisions on the "letter of the specifications" when system knowledge and engineering judgement were needed. Similarly, problems have arisen when construction management responsibilities were assigned to system engineers who did not possess the necessary contract administration experience.

This combination of systems knowledge and construction management experience is seldom found in a single person. Thus, a team approach is usually necessary to assure that the project is successfully managed. For example, in one system, a contract administrator from the Construction Section of a State DOT was appointed the Project Engineer; and he alone could approve change orders and changes in work. The other members of the project team consisted of staff from the Traffic Control Systems Unit of the Department; they were given free rein for approval of matters within their particular areas of technical expertise and advised the engineer on other matters. Other system projects have used a similar arrangement for project management, except that, consultants were utilized to provide the necessary system's expertise and advice during construction.

Successful application of the team approach requires close liaison and good human relations between all members of the construction management team. The responsibilities and authority (e.g., approve catalog cuts, issue change orders, deviate from plans and specifications due to field conditions, final approvals, etc.) of each participant must be clearly spelled out, and the channels-of-communication identified. Furthermore, the contractor should also be made aware of the various authorizations and responsibilities to avoid any confusion during construction.

When consultants are being used for technical advice, they should play an ongoing role. If consultants are not brought in until a crisis has arisen, they will not have the project background needed to make an optimal contribution. It has also proven useful if the consultants are permitted to talk directly with the contractor. Finally, all team members must always be kept informed of the project status and any developing issues, and be involved in the decision making as appropriate.

Another important consideration is the attitude of the Project Engineer. The Project Engineer should be someone who is willing to take responsibility for making things happen, and will take great pride in a successful outcome. While this person must be assertive and firm, he/she must also fair. Successful construction management requires give and take and

unbiased thinking. The right attitude is always one of "win-win" between the agency and the contractor.

Generally, a project engineer is assigned by the contracting agency to be responsible for direct supervision of the project work. The project engineer usually has contracting authority on all matters pertaining to contract execution, and is subject only to administrative direction from agency superiors. Various agencies use other titles for this position such as "resident engineer" or "supervising engineer." On large projects separate project and resident engineers may be assigned, the latter having responsibility for direct, day-to-day on-site supervision. Assistants and inspectors are usually assigned for direct supervision and inspection of the various phases of the work.

System Integrator

Any traffic control system can be thought of as having four distinct components, a computer system, a communications network, local control and detection hardware, and applications software. A cursory examination of the background of each of these four components reveals four distinctly different lineages. The computer system will trace its heritage back to the mainframe computer industry. The lineage of the communications network is founded in the telecommunications industry.

The local controller and detector hardware brings yet another culture to the forefront. Whether the control equipment follows the Type 170 or the NEMA standards, the supplier is basically a custom electronic manufacturer who has targeted his resources to a very specialized market, supplying traffic control equipment. The fourth component is the applications software. The suppliers in this last category, are the most highly specialized and have evolved from either the traffic consulting community, or the defense contracting industry.

The role of the System Integrator is to employ the contributions of each of these four diverse trades to achieve an efficient operating traffic control system that meets the user's requirements. To gain a perspective on how a System Integrator performs his function, it is useful to consider the organizations that are typically involved in the installation of a traffic control system: the User Agency, the System Designer, the Contracting Agency, the Prime Contractor, the System Suppliers, and the Subcontractors.

The User Agency is the owner of the system. In the United States, this is typically a City, State, or Toll Authority. This agency typically knows well the operational requirements or the system, but frequently does not have anyone on staff who understands the intricacies of the technology of the system. In spite of this, it is imperative that the operating agency has at least one person who is dedicated to the project and who will function as an advocate of the project within the organization.

The System Designer will range in skills from one with strong knowledge of the computer and communications technology; to a designer who understands little of the operational needs of the agency but has considerable strengths in the system technologies. Ideally, the designer should have strengths in both areas and would bring a combination of understanding both the functional requirements and the technical solutions to the project. The System Designer is typically a consulting firm although some agencies undertake the design function in-house. The products generated by the designer are plans, specifications, and cost estimates that are required to advertise and award the contract. During the construction phase, the design firm is generally involved as a reviewer of the work and available to interpret plans and specifications.

The Contracting Agency frequently is the state agency that is responsible for highways. The responsibilities of this agency begin with overseeing the selection of the system designer and continue through the administration of the construction contract. A primary responsibility of the contracting agency is to make sure that all contracting requirements are met and that each participating organization meets its contractual requirements. This is the agency that supplies the project inspectors who are accountable for authorizing payments to the contractor. A primary focus of the contracting agency is to make sure that all rules and regulations concerning the administration of the contract are followed. Few contracting agencies have the luxury of being able to employ engineers who are specialized in the complex technologies of today's traffic control and surveillance systems. In fact, it is not uncommon for the contracting agency to rely heavily on the system designer for technical expertise.

The Prime Contractor is the agency that has the responsibility of producing the operating system. This is the organization that has the responsibility of system integration. For most traffic control and surveillance system contracts, the most costly elements of work are associated with the field construction. The cost of installing conduit, footings, installing local control hardware, and pulling wire cables are cal of field construction. Since these elements represent most (i.e., 90% +) of the work, it is common to see electrical contractors who are efficient in performing these tasks as the prime contractor. The prime contractor, therefore has a role in the project to construct the specified filed components. The prime contractor, however, has a second role--that of integrating all of the elements in the operating system.

System integration has many dimensions; equipment selection and acquisition, hardware interfacing, and monitoring software development are several of the more important dimensions. Most specifications allow the prime contractor latitude in selecting hardware items. This responsibility, therefore, implies a need to select hardware that meets specifications, and hardware that will be delivered in a timely manner when it is needed. A primary criterion when procuring hardware, is not only the quality of the hardware itself, but also the quality of the installation support which is frequently provided by another organization, the distributor. A closely related issue is the need to make sure that the hardware from one manufacturer will interface and operate correctly with the hardware from a second manufacturer. Interfacing issues are particularly critical with communications and computer hardware.

The history of traffic control and surveillance systems has demonstrated time and again that the most trouble-prone element of the system is the software. It is important to recognize that real-time, control software is among the most difficult and complex assignments in the field of Traffic Engineering. Virtually all electrical contractors subcontract this work element to firms that specialize in traffic control software.

The role of the System Integrator is two-fold: 1) to monitor the progress of the software supplier to be sure that a software package is ready to be installed when the field construction is complete, and; 2) to test, retest, and test the software again before installing it on the streets.

In summary, the System Integrator, has a role like the conductor of a symphony orchestra with the plans and specifications providing an analogy to the musical score. Through the skillful efforts of the system integrator, various suppliers and subcontractors will make this contribution at the right time in the project.

Inspectors are employed to ensure that construction is performed in accordance with the plans, specifications, and related contract provisions. Inspectors are generally on-site throughout the construction operations and act as the project engineer's representative on routine field decisions and interpretations. However, all directions to the contractor on major actions such as field plan revisions and change orders, defective work, unacceptable materials, or work suspensions are normally handled through the project engineer. Inspectors should also keep the project engineer informed of work progress and of any disputes or misunderstandings with the contractor regarding work performance, materials acceptance, or interpretation of the plans and specifications. Similarly, even though the project engineer does have a qualified inspector(s) to directly observe and inspect the work, on occasion the project engineer should personally visit the job sites and review the inspection operations and reports.

On large, multifaceted projects, a team of inspectors may be necessary. In such cases a chief or head inspector is usually designated.

Where installation is a relatively minor portion of a larger highway or street construction project, separate electrical and/or "traffic signal" inspectors may be assigned to inspect the traffic system installations. Specialty division of inspection work has become increasingly common, particularly for traffic system work, due to the increasing sophistication and complexity of electronic equipment. Most roadway construction inspectors have little familiarity with traffic control and surveillance equipment.

By contrast, on small jobs such as single signal installation with little or no roadway work, the project engineer may also serve as inspector. Alternatively, a signal or electrical inspector may be assigned full field supervision and inspection responsibilities. In either case, the field engineer or inspector would likely be responsible to the public works director or engineer of the contractor agency. Electrical inspectors so assigned must also understand installation and inspection requirements for the non-electrical signal installation components. The inspection

checklist provided later in this section is intended to assist in an inspector(s) in conducting a thorough inspection of all traffic signal installation components.

One of the problem areas of traffic control system projects is project inspection. Inspectors assigned to such projects often lack the electronic systems experience and qualifications. Past experience indicates that a multitude of things can go wrong on a relatively straightforward signal installation job when inexperienced inspectors are used. The potential for mistakes on a complex traffic control system project is significantly greater. Regardless of whether such errors are the result of an honest mistake, carelessness, incompetence, or even premeditated; if errors are not discovered until final inspection or later during maintenance, costly rework or repair may be required, resulting in a less-than-successful system.

Successful inspection consists of providing an adequate number of inspectors to observe all of the contractor's activities. Furthermore, some or all of these inspectors must be qualified in the electrical and systems area. Given the great advances that have occurred in electronic and systems technology, coupled with an emphasis on roadway and bridge projects, some agencies do not possess this systems inspection capability. There are ways for overcoming this problem:

- Establish a small group of inspectors who are trained and assigned to handle systems work. This is feasible only for those agencies which plan to fund and manage several system projects over a number of years. Another consideration is the ability to assign members of the system inspection group to other duties within the agency when there is limited or no system construction underway.

- The best technical inspectors are often those individuals who will be operating and maintaining the system once it is completed. Using such a group to supplement the construction inspection force has proven very successful. A potential drawback of this approach is that during a major system expansion these personnel will be unable to perform their normal duties while administering and inspecting the expansion contract. The owner may be planning to staff up the system maintenance unit to operate the new system and to use this expanded staff for inspection. It will be necessary in such cases to plan ahead and initiate the position descriptions, classification, and recruitment process sufficiently in advance to train the new people and have them available at the time they are needed.

- Contract inspection services have also been very successful. One form of contract inspection is to hire a systems consultant to supplement the agency's inspection force and provide systems expertise during construction. The responsibilities of the system consultant can be extended to include all contract administration--construction inspection as well as the role of "project engineer".

- A team approach may be desirable. Inspection includes record keeping, testing and observation of the work. Maintenance technicians will have much of the experience

required for good electrical inspection but will probably not be familiar with record keeping and other procedural aspects of the job. Thus a mix of experienced project inspectors and maintenance technicians may be the best approach to traffic control inspection.

When contract inspection and/or engineering services are used, the system consultant becomes an agent of the owner. It is good practice to state the terms and conditions of the relationship in a written agreement. The agreement should address, as a minimum, the following:

- Who is the official contracting agency, the engineer, etc.
- Final approval regarding contractor submissions, extra work, test results, etc.
- Authority to deviate from the plans and specifications, to change quantities, to issue written change orders, resolve disputes, etc.
- Any restrictions/requirements as to inter-organization communications (consultant-contractor).

The contractor should also be made aware of the terms of the agreement to avoid any confusion during construction. Regardless of the manner in which construction inspection is provided, it is imperative that the inspection force have the appropriate knowledge and expertise, that they be on hand before the start of construction, and that a sufficient number of inspectors are available so all work is thoroughly inspected and the contractor's progress is not delayed.

Regardless of the particular assignments and procedures applicable to a given project, the project engineer should take all necessary steps to ensure that all supervisors, inspectors, and contractor's representatives understand in advance their respective responsibilities and procedures to be followed when questions arise. One good method is for the project engineer to hold an informal preconstruction meeting with all project assistants and inspectors to explain and answer questions regarding work expectation. Recommended items to be covered include:

1. Delegation of work and chain of command.
2. Responsibilities of the assistants and their role in the overall engineering supervision and inspection.
3. Employee work hours, overtime arrangements, holidays, and performance standards.
4. Employee legal relations and responsibilities to the public, the contractor, and visiting officials.
5. Applicable regulations regarding misstatements, false reporting, or similar fraudulent representations.

6. Frequency of tests and inspections, and procedures to follow when unacceptable work or improper methods or equipment are encountered on the job.
7. Quality and quantity control and documentation procedures.

On large or lengthy projects, supplementary meetings at appropriate intervals throughout the construction process may be helpful as a reminder or refresher and to acquaint any new personnel with the required policies and procedures.

Construction Sequence

A typical construction sequence for an IVHS installation may involve one or more contracts. In either case the sequence is similar and includes:

- installation of communication infrastructure
- installation of foundations
- construction of control center
- installation of electric service
- installation of field assets (i.e., CCTV, signs, detectors, HAR and weather stations)
- activation of complete communications system
- activation of field assets
- system integration

Traffic Control Plan

Safe and efficient routing of traffic through and/or around the work zone during construction is an important component of system installation. Basic plans and/or specifications informing the contractor of minimum traffic control requirements are normally included in the contract documents by the contracting agency. Detailed traffic control plans are generally prepared by the contracting agency only for complex projects involving staged construction, detours and/or bypass roads.

Prior to construction, the contractor should submit a detailed traffic control plan to the project engineer for review and approval. All warning devices, traffic control hardware, and related provisions of the control plan must conform to the federal Manual of Uniform Traffic Control Devices (Ref. 1). Similar state or local agencies' manuals that incorporate the federal standards may also apply. In addition to the plan details for regulating traffic, the control plan should specify the names and duties of agency and contractor representatives responsible for implementing the plan and provisions for informing law enforcement and emergency service agencies of all lane closures, detours, or other changes in traffic control that will occur during the construction process.

Preconstruction Conference

A preconstruction conference with the contractor and other interested parties is normally conducted on all construction projects, including traffic signal installation. Many agencies have formal, written policies for the conduct and content of the preconstruction meeting. Whether formally or informally conducted, however, the primary goal of such a conference is to establish a sound working relationship and a clear understanding of the work to be accomplished, procedures to be followed, and respective obligations and expectations among all parties affected.

Prior to the conference, the project engineer and any key inspectors or supervisory assistants should thoroughly review the plans and specifications and visit the project site, making special note of any potential conflicts or items that might require clarification or field modification. A project supervisory staff that displays a thorough knowledge and understanding of the plans will help gain the confidence and cooperation of the contractor and the other parties involved.

Every construction contract is a joint venture of the contracting agency and the contractor.

The project engineer should clearly establish this “common objective” at the opening of the preconstruction conference. Other items covered under a typical agenda include:

1. Project Engineer/Inspector/Contractor relationships and responsibilities.
2. Labor and Equal Employment Opportunity requirements.
3. Project Scheduling.
4. Coordination with utilities.
5. Traffic control plan.
6. Required permits and other legal responsibilities.
7. Construction safety regulations, including required inspections and documentation.
8. Special construction features, site access, field office, and laboratory requirements.
9. Subcontractors’ responsibilities including requirement that all direction be handled through the prime contractor.
10. Contractor’s material list, including suppliers and anticipated delivery dates.
11. Emergency provisions, including names and phone numbers of all who might need to be called in the event of an emergency.

Meeting attendance, agenda, and any major comments or concerns expressed with regard to any of the agenda items should be properly documented. Most agencies have standard forms and/or formats for documenting the preconstruction conference.

Due to the specialized nature of electronic systems, an additional special preconstruction meeting may be advisable immediately prior to starting electrical work on complex projects or where a separate electrical subcontractor is involved. the project engineer, electrical inspector, contractor’s supervisor, and electrical contractor’s representatives should

thoroughly review the plans, specifications and details and discuss any installation problems and concerns that are anticipated based on prior experience.

Notification to Proceed

Construction work cannot proceed until a written "work order" or "notice to proceed" is provided to the contractor. Normally this notice is provided by the project engineer.

Prior to issuing the work order, the project engineer usually must be notified by his or her agency that the necessary funds have been authorized. On federal and/or state aid projects, additional approvals must be obtained by the engineer, usually in writing, before the notice can be given for the contractor to proceed.

Shop Drawing Reviews

Following notification to proceed, but prior to actual construction, the contractor must normally submit working or "shop" drawings detailing the fabrication and erection of all nonstandard equipment required on the project.

For all industry-standardized items, the contractor should submit the manufacturer's or supplier's catalog cuts, certification of compliance, and/or similar documentation that the item as furnished to the contractor will comply with the pertinent plans and specifications. Certified test reports and/or samples for testing may also be requested by the contracting agency.

The project engineer and inspector(s) should review the shop drawings and product certifications thoroughly for compliance with the plans and specifications and acceptability for use on the project. Each shop drawing must be stamped and the applicable following designation checked:

- Acceptable (approved)
- Unacceptable (disapproved)
- Approved as noted (deficiencies identified)

Sampling and Testing of Materials

Material sampling and testing, depending on the nature of the material being tested, may be conducted either on- or off-site. Materials produced or prefabricated at remote locations are often inspected at the manufacturing site by representatives of the contracting agency. Inspection during manufacture is ordinarily made on the basis of random sampling and testing. All furnished materials shall be new.

Field testing is normally conducted by the inspector and assistants on the basis of pre--specified minimum sampling rates. Acceptability is determined by the test results and/or the inspector's visual observations as to the compliance with specifications and shop drawings.

On-site materials should be checked for such items as:

1. Size, diameter, length, color, thickness, and similar physical properties.
2. Manufacturer' s name, production location, production date, any required certification (e.g., Underwriters Laboratory listing).
3. Serial and model number of all electrical components.

Materials that are found to be defective, damaged, or otherwise unacceptable should be rejected and removed from the site. Appropriate documentation should be prepared as discussed in the "Construction Records" section that follows.

Electric Service Confirmation

Provisions for electric service to the signal installation as defined in the plans and specifications should be confirmed with the utility responsible for such service. Final electric service connectors to energize the signal installation are normally not installed by the electric utility until the signal installation is nearly complete. In practice, failure to confirm the details of such connections immediately prior to actual signal installation often has resulted in costly construction revisions and delays.

Important items include:

1. Source of power (location.
2. Size of service (e.g., 100 amp, single phase).
3. Feed:
   - underground (manhole)
   - above ground (pole)
4. Whether a meter will be required.
5. Location of meter, if required.
   - poles
   - meter cabinet
   - controller cabinet
6. Special requirements of utility company:
   - wire type, size, gauge (AWG)
   - number of conductors
   - conduit type (rigid metal or PVC)

Communications Carrier

Many IVHS type projects make use of leased communications services. The communications carrier may be the local telephone company, and the technology may be as simple as twisted-wire pairs of copper wire. With the more complex systems, however, the technology is likely to be based on coaxial or fiber-optic cable, or even data radio (i.e. spread spectrum/micro lane).

Prior to installing any equipment which uses the facilities of a communications network, it is highly desirable to meet with representatives of that utility to determine the details and logistics of how the system is to be interfaced to the network. Of particular concern, is the licensing agreements, rate tariffs, payment of the monthly bill and switchover procedures. Who should performs the final hookup, what trade unions are allowed to perform what work, and who are the responsible supervisors for each agency are typical issues that must be resolved.

CONSTRUCT/ON RECORDS

Adequate documentation during construction is essential to the successful administration of all construction projects. Records required for system installation projects are similar to those for any roadway construction project. Each contracting agency normally has its own specific recordkeeping procedures, responsibilities, and record formats, including, where applicable, provisions for complying with federal and/or state aid requirements.

Generally, these records consist of:

1. Daily project diaries
2. Weekly status reports
3. Monthly estimates
4. Inspection and test reports
5. Plan revisions and change orders

Typical recordkeeping requirements for each of these categories are summarized below. All supervisory engineers and inspectors should be thoroughly familiar with the specific recordkeeping requirements of the contracting and funding agencies.

Daily Diaries

Daily diaries are commonly kept by each supervising engineer and inspector. On large projects, separate inspection diaries may be kept for each major construction item. On small projects, all entries may be recorded in a single “project diary” kept by the project engineer or authorized representative.

The diaries provide a written, day-to-day record of all important events, activities, decisions, and discussions. These include such items as weather conditions, location and quantities of materials installed, inspections and tests performed (including summary results), unusual conditions or problems encountered, major decisions and actions taken, and official conversations, telephone calls, or discussions related to the project. Any accident should be described in detail.

All entries should be neat, concise, and complete. When entries are made by more than one person, each entry should be signed individually. These diaries are an essential part of the project records should the project be subjected to audit, investigation, or litigation. They are also useful for determining construction progress and for judging claims for extra work.

To facilitate monitoring of installation progress, the project manager can use the design plan sheet as a supplement to the diary. Completed installation of each major item is recorded on the plan sheet, and the actual to-date quantity of each item is listed in the summary of quantities. This provides the project engineer a simple, quick, and effective means for estimating overall work progress.

Weekly Status Reports

Most contracting agencies require submission of weekly reports by the project engineer or authorized representative. These reports generally summarize the weekly accomplishments, overall construction progress, weather conditions, working day changes and delays, work suspensions/resumptions, contractors and subcontractors performing work, and any major problem encountered.

Monthly Estimates

Partial payments to the contractor for completed work are ordinarily based on monthly estimates prepared by the project engineer. Most contracting agencies have standard procedures and forms for recording materials, labor, and equipment used on the job and measured or estimated quantities of installed pay items required to determine the amount of partial payment due the contractor.

Some agencies require a daily or weekly tabulation of contract quantities placed for each pay item. This tabulation, and the contractor's breakdown of item cost, can be useful to the project engineer in preparing the monthly estimate. Lists of materials on hand but not yet placed may also be required.

On large projects, monthly estimates for such items as traffic signal installation may be difficult to determine, particularly where traffic signals are paid for on a lump sum or per signal basis. If a progress payment agreement for such items is not provided directly by agency policy, the project engineer should be sure to negotiate a partial payment plan with *the* contractor during the preconstruction conference.

Inspection and Test Reports

Each contracting agency normally has many different forms for reporting the results of inspections and tests on equipment, materials, and workmanship. Included are such records as plant inspection, materials, test reports, materials inspection reports, job control tests, storage of materials certificates, defective materials reports, equipment tests, and equipment weight certifications. All inspectors and project supervisory personnel should be thoroughly familiar with the forms and any manuals or other instructions for performing the tests and inspections. The project engineer and/or inspectors should review the project records frequently to ensure that all required reports are complete, accurate, and promptly submitted. Wherever practicable, the forms should be completed in the field by inspection personnel to minimize time expenditures and avoid subsequent transaction errors.

PIan Revisions and Change Orders

The construction plans and specifications are intended to provide for a completed installation. However, prevailing conditions at the time and location of installation may require changes in the contract documents. Such changes must be approved before the contractor can proceed with the work affected.

A paradox of the low-bid process is that the contractor who wins the project also has the greatest risk of losing money. Contractors base their bids on their interpretation of the conditions identified on the plans and the requirements in the specifications. Should these conditions and specified requirements change or prove erroneous, or should the contractor's interpretation be different than the engineers, then the project may start to cost the contractor more than originally anticipated as reflected in the bid. Given the low bidder's minimal tolerance for being subjected to additional costs, the contractor can easily end up in an unprofitable situation. Since profit is a precondition to a contractor's continued existence, the construction manager can expect to see change order requests and claims for additional compensation.

Most requests for extra compensation result from the contractor's contention that he/she was required to provide extra work and materials by reason of errors in the contract documents, changes, additions, delays and the like during the course of construction. It is the engineer's responsibility to determine if claims are legitimate and, if so, to determine an equitable value of the additional compensation. In general, a contractor is entitled to additional compensation under the conditions described below:

- Actual Quantities Exceed Initial Estimate -- Since it is the very nature of most unit-price contracts for the owner to agree to pay the contractor for each unit of work accomplished and/or material installed, this is usually not a problem. It is noted, however, that severe budgeting problems can occur if it becomes necessary to significantly increase certain quantities during system construction.

- Reduction in Quantities/Elimination of Work -- The contractor is usually not entitled to loss-of-profits resulting from the actual quantities being less than originally estimated, or elimination of entire items of work. This assumes, of course, that the specifications give the engineer the right to reduce quantities and to omit portions of the work. There are exceptions to this general rule. The elimination of work cannot alter the main purpose of the contract (i.e., to install a traffic control system). Furthermore, the contractor may be entitled to an adjustment in the unit price of an item if the reduction in quantities increases his/her unit cost of procuring or installing the item.

- Failure of Plans and Specifications -- As previously noted, the owner impliedly warrants the sufficiency of the plans and specifications supplied to the contractor. A corollary of this rule is that the contractor is entitled to additional compensation for any extra work resulting from defective plans and specifications. Defective in this sense means that the contract documents are technically incapable of producing the desired result, or they make misrepresentations of essential facts and conditions. A frequent example of this are underground utilities which have been hit and damaged by the contractor, but which were not shown on the plans nor marked in the field. Generally, the contractor cannot be held responsible to pay for the repairs. Another example is the use of existing conduit for communications cable. If the contractor is unable to install the cable in the conduit as specified due to blockages, collapses, severe bends, bends between handholes, existing cables that are tangled, or insufficient space, he/she is entitled to additional compensation for the time and materials initially spent attempting to install the cable, for locating and identifying the conduit problems, and for any resulting delays.

- Work Beyond the Contract Scope -- In general, a contractor who performs additional work not shown on the plans nor defined in the specifications is entitled to additional compensation if the work was requested by the agency. Following on with the conduit example, the contractor would also receive additional compensation for any repairs or other adjustments made to the existing conduit, if directed by the Project Engineer, and if such work was not included in the contract documents. Extra work of this nature is often relatively minor, involving incidental items which were inadvertently left out of the contract documents--for example, resetting a brick walk, or replacing an entire sidewalk slab (as required by local codes) when the specifications only require replacement of the trench width. However, there have been instances where the specifications were vague or incomplete concerning a major system item, resulting in substantial extra costs.

- Delays Caused by Owner -- A contractor is entitled to additional contract time for any delay caused by the owner, the owner's agent, or another contractor engaged by the owner on the same project. If the delay results in increased costs to the contractor, the contractor may also be entitled to additional compensation.

The contract documents also apply to the agency, and the agency must be prepared to satisfy these requirements so as to not interfere with the contractor's work. Examples of delays which have been attributable to the owner or the owner's agents include failure to review contractor submittal within the specified time, failure to provide all government-furnished equipment and installations in accordance with the contractor's schedule,

failure to complete make-ready work for utility poles on time, failure to complete testing for acceptance, and incomplete or substandard work provided by other contractors hired by the owner in conjunction with system implementation. The latter situation might include a leased-line communication network that is not functioning properly when contractor is ready to commence system integration, system detectors installed by another contractor which are inoperable, and a computer room contract that is still in progress when the central hardware is ready for shipment and installation.

- Change in Manner of Performance -- When the contract documents do not specifically describe the method of performance, the customary economical method is proper. If the contractor is directed by the engineer to perform in a more expensive manner than is customary, (i.e., night work limited work hours on an Interstate Road 9:00 Am to 3:00 PM contraflow lanes, etc.) the contractor is entitled to additional compensation. As such, when advanced techniques are contemplated, they should be specifically provided for in the contract documents.

Change Orders provide the formal means by which the contract documents may be modified with minimal impact on the system process. Some change orders should be expected during the construction process--after all, the estimated quantities can only be a close approximation; no design is ever all-inclusive and unknown conditions and additional work are bound to be encountered; and the participants in the system process, being human, are prone to change their minds sometime during the process. At the same time, “significant” change orders can be avoided by thorough planning, accurate and comprehensive design, and firm construction management.

Change order report forms generally must be completed by the project engineer or authorized representative. Change orders can cover such items as increased or decreased quantities, design alterations, materials substitutions or alterations, revisions to contract payment or completion time provisions, and other modifications to the specifications or special provisions. To avoid confusion, each change order should cover only one subject. Most change orders must also be signed by the contractor and approved by other responsible officials of the contracting agency. When FHWA funds are involved, change orders for increases or decreases of 20 percent or more on major contract items require approval by the FHWA area engineer. Similar approval by state officials may also be necessary for change orders on local state aid projects. Supplemental agreements generally require additional approvals. It is extremely important that the project engineer and his representatives be aware of all such requirements to avoid construction delays and potential future liability problems.

All design changes during construction should also be neatly and accurately recorded on applicable design plan sheets, which will become the record “as-built” plans. Included are such typical field modifications as signal pole or controller relocations, detector or conduit placement, and wiring or electrical modifications ordered as a consequence of field conditions and inspection.