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Development of Benchmark Data for the Iowa Department of Transportation Construction Offices

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report

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ABSTRACT

This report describes the development of performance measures for the Iowa DOT Construction Offices. These offices are responsible for administering all transportation construction projects for the Iowa DOT.

In conjunction with a steering team composed of representatives of the Construction Offices, the research team developed a list of eight key processes and a set of measures for each. The key processes include Inspection of Work, Resolution of Technical Issues, Documentation of Work Progress and Pay Quantities, Employee Training and Development, Continuous Feedback for Improved Contract Documents, Provide Safe Traffic Control, External/Public Communication, and Providing Pre-letting Information.

Two kinds of data were gathered: baseline data and benchmark data. Baseline data is used to characterize current performance. Similar data must be gathered in subsequent years to show improvement or lack of improvement. Baseline data was gathered by surveying Construction Offices personnel, DOT employees from other offices, contractors, law enforcement officers, and drivers of national motor carriers. Some data was also obtained from the DOT data base. In addition, selected county and city engineers were interviewed.

Benchmark data is gathered to find organizations that have excellent performance records for one or more of the key functions. After an organization with excellent performance is identified, discussions are initiated to pinpoint the reasons for success and to transfer this success to the organization collecting the data. Benchmark data was collected from other state Departments of Transportation, the U.S. Army Corps of Engineers, and Union Pacific Railroad.

This report discusses the methodology used and the results obtained. The data obtained represents the first set of data points. Subsequent years will establish trends for each of the measures, showing improvement or lack of it.

To insure that all Construction Offices employees are knowledgeable of the level of performance of their organization, the results of the data collected has been provided to them. In addition, two process improvement teams were initiated in areas showing a need for improvement.

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INTRODUCTION

Background

This is the final report to the Iowa Highway Research Board and the Iowa Department of Transportation for the research project HR 381 - Development of Benchmark Data for the Iowa DOT Construction Offices.

This project was initiated by the leadership of the Construction Offices of the Iowa DOT, which wanted to develop ways to measure the effectiveness of the organization's performance. Included are all of the construction offices, i.e., the central office in Ames, six transportation centers and twenty residencies.

To obtain assistance in developing a measurement system for the Construction Offices, the Iowa DOT asked the principal investigators from Iowa State University to become involved. They were approached because of their familiarity with DOT operations and their knowledge and experience with continuous improvement methodologies.

The project proposal was presented to the Highway Research Board on March 31, 1995, which provided its approval that same date. The contract between Iowa State University and the Iowa DOT was approved May 1, 1995. The original completion date of April 30, 1996 was extended to July 31, 1996.

Measurement of performance is one of the actions an organization must undertake if it is to improve its performance. How can an organization know how well it is doing if it does not have meaningful data? Such data should reflect current and past performance of the organization. Initial data provides a baseline. Then, with time, accumulated data shows trends, and these trends show improvement or lack of it.

There are several steps involved in establishing a measurement system for an organization. The first is to identify the key processes the organization performs. There were eight processes selected for this project. The second step is to determine a set of measures for each process which can be used to show how well the process is being performed. The third step is to gather baseline data. The fourth step is to look beyond

the organization to find others with similar functions and similar measures. The objective is to find out who is performing the function the best. This, then, serves as a *benchmark*. The organization searching for others to compare itself to may well find that it sets the benchmark for others in one or more of its functions.

When one speaks of measuring, the next logical question is what to measure. Based on past experience, the researchers suggested the following areas be included in establishing measures for any given process:

- the degree of external customer satisfaction, where external customer can be defined as any person or entity, external to the Construction Offices, affected by the process
- the satisfaction of the employees involved with the process
- the amount of waste in the process
- the amount of rework involved in the process
- the degree of safeness of the process.

To help guide an improvement effort such as this, an organization should appoint a *steering team*. This team oversees the improvement effort, evaluates measurement results, and seeks input from the field as well as customers of the organization. With this information, the steering team identifies processes which need to be improved and takes action to improve the processes. A steering team, representative of most grades and the geographically dispersed field elements of the Construction Offices, was formed at the beginning of this project.

Objectives

The objectives for this project were to assist the Iowa DOT Construction Offices as they:

1) identified key functions for continuous improvement
2) developed performance measures and benchmark data for use in the continuous improvement process

A subsequent objective, not stated in the project proposal, was to provide a roadmap for continuous improvement for other offices to follow.

Scope

The proposed scope of the project involved the following:

- identification of key functions
- identification of performance measures for those key functions
- identification of which customers should be asked for input
- collection of data to establish a baseline for measuring performance
- obtaining benchmark data on similar measures from other organizations
- comparing the performance of the Iowa DOT with that of others
- Start: May 1, 1995 Complete: April 30, 1996 (subsequently changed to July 31, 1996).

Tasks

The project was composed of seven tasks, as follows:

Task 1 - Initial activities - Construction Offices key processes, or functions, and internal and external customers were to be identified. These key processes were to be vital to the performance of the organization. They would be selected by the Construction Offices steering team after the interview results are reported. It was anticipated that between four and six key processes would be identified. As it turns out, eight functions were identified.

Task 2 - Identify performance measures for key processes - The researchers would help identify performance measures for key processes. This would involve working with a variety of sources to obtain input, including the Construction Offices, other offices and Divisions within the Iowa DOT, other DOTs, and other agencies with similar missions. It was expected that two performance measures would be identified for each key process. In actuality, that number varied from two to four.

Task 3 - Obtain baseline performance data for the Iowa DOT Construction Offices - The researchers were to assist the steering team in obtaining baseline performance data. Future improvements would be measured against this baseline data.

Task 4 - Identify organizations that could contribute benchmark data - Researchers would assist the steering team in identifying organizations that have achieved the best

performance in each of the previously identified key processes. It was expected that five candidate organizations would be identified for each process.

Task 5 - Obtain benchmark data and ideas for improvement from high-performance organizations. When necessary, researchers would travel to the organization to conduct interviews and collect information.

Task 6 - Evaluate benchmark data - Researchers would analyze the benchmark data and recommend performance goals for the Iowa DOT Construction Offices. The benchmark data would be included in a draft final report to be presented to the steering team.

Task 7 - Recommend improvements - Researchers would assist the steering team in developing recommendations for improving key processes.

INITIAL ACTIVITIES

Steering Team

One of the first actions taken was to establish a steering team. To help insure that the steering team was a representative slice of the Construction Offices, personnel from a variety of positions and geographical locations throughout Iowa were selected. The function of the steering team was to oversee and guide the research project. The team met with the researchers monthly from May 1995 through July 1996. The team members and the offices they represent are listed in the Appendix.

Development of a Mission Statement

Another initial action was to establish a mission statement for the Construction Offices. The mission, as developed and agreed to by the steering team, is as follows:

> "To manage construction projects in a manner that maximizes value to the public through a proactive, cooperative approach, with emphasis on safety, environmental preservation, and public convenience."

Identification of Key Processes and Performance Measures

Next, the steering team and ISU researchers identified the key functions, or processes, performed by the Iowa DOT Construction Offices. A brainstorming session produced a list of forty-five functions performed by field and office personnel. This list was clearly too long, and it was reduced through a voting process. Each steering team member was asked to vote for the five processes believed to be the most vital to the performance of the organization. This narrowed the list to seven key processes. Interviews were conducted throughout the summer with Construction Offices personnel to determine if there was general agreement with the list. Through these interviews, an eighth key process, Provide Pre-Letting Information, was added.

The steering team discussed how each key process could be measured. An initial list of measures for each process was generated, and a process of weighted voting was used to narrow the list. The measures for each function were also discussed with other employees through interview sessions. Their input is reflected in the final list of processes and measures. The final list of key processes (underlined) and their corresponding performance measures (bulleted) follows:

<u>Inspection of Work</u>

- Employee evaluation of non-productive activity, clarity and priority of duties, ability to influence quality of work, duplication of effort, overall inspection process
- Contractor evaluation of inspector competence, timeliness of inspection, overall inspection process
- Cost of inspection as a percentage of contract volume, statewide, on an annual basis

<u>Resolution of Technical Issues</u>

- Number of litigation cases per year
- Litigation payout
- Number of claims
- Number of repeat problems

- Contractor evaluation of inspector and Resident Construction Engineer (RCE) competence, availability, empowerment, influence on quality, overall process of resolving technical issues
- Employee evaluation of supervisor support, communication with Construction Offices and contractors, timeliness, non-productive activity, overall process of resolving technical issues

Documentation of Work Progress and Pay Quantities

- Employee evaluation of time spent, duplication of effort, non-productive activity, overall process
- Time from project acceptance to final payment

Employee Training and Development

- Internal customer evaluation of need, applicability, availability, scheduling, overall process
- External customer evaluation of employee competence, qualifications, thoroughness, understanding, knowledge, overall quality of employee training

Continuous Feedback for Improved Contract Documents

- Cost over-runs as a percentage of contract volume
- Contractor evaluation of contract documents and number of repeat problems
- Employee evaluation of number of repeat problems
- Evaluation of the Construction Offices performance by other offices within the DOT

Provide Safe Traffic Control

- Number of accidents in interstate and state highway construction zones
- External customer evaluation of signage, delays, visibility of workers, travel space, DOT personnel knowledge, concern, quality of plans, overall process of providing safe traffic control
- Field force evaluation of contractors' traffic control

External/Public Communication

- External Customer Evaluation of timeliness, level of detail, accuracy, responsiveness to questions, overall communication process

Providing Pre-letting Information

- Internal customer evaluation of explanation, clarity of instruction, time allotted, feedback, defined procedures, and overall process of providing pre-letting information
- External customer evaluation of timeliness and the overall process

PROCUREMENT OF BASELINE DATA

With key processes and performance measures identified, the next step in the study was to obtain baseline data. Baseline data must be collected to give an indication of where an organization currently stands, i.e., its current level of performance. When future data is collected, it will be compared to the baseline data to identify where changes have occurred. These changes can be positive or negative, representing, respectively, improvement or deterioration. So, the steering team's first step in process improvement was to identify the current performance level of the Construction Offices.

Baseline data for the processes in this study came, in general, from two sources: 1) numerical performance data already collected by the Construction Offices, and 2) customers of the Construction Offices. Numerical performance data was obtained from the Iowa DOT project database. Customers of the Construction Offices provided baseline data in the form of survey results.

Numerical performance data included 1995 statewide totals and averages in various areas. Previous years' figures are provided when 1995 figures were not yet available. This data was obtained primarily from the DOT's computer database of project records. This data provides an opportunity for benchmarking with other agencies because they typically monitor such measures.

The steering team decided to use several surveys to obtain customer evaluation data.

Customer Identification

Before surveying customers, it was necessary to identify them. When a person or an office provides a product or service to another, the 'receiver' is a customer of the

'provider.' The product or service provided should meet the needs of the next customer in the process or those of the ultimate consumer.

Customers can be grouped into two categories: internal and external. Internal and external customers work together to bring a project to completion. The steering team identified the internal customers as all Construction Offices employees both in Ames and in the field.

External customers are those persons outside the Construction Offices who have a hand in creating, are affected by, or use the final product. A brainstorming session was used to arrive at an initial list of external customers. This list was narrowed by the steering team to include:

- contractors,
- Iowa DOT employees in the following offices: Design, Bridges & Structures, Contracts, Specifications, and Right of Way,
- law enforcement agencies, and
- truck drivers for national motor carriers.

These external customers were those with whom the Construction Offices have the most interaction and could obtain the best information for measuring performance in the key processes.

Contractors who perform Iowa DOT work

Contractors are external customers with whom the Construction Offices have significant direct contact. Contractors' input was sought in nearly every key process of the Construction Offices. Contractors performing work in the following areas were involved: (1) earthwork, (2) asphalt cement concrete (ACC) and Portland cement concrete (PCC) paving, (3) structures, and (4) miscellaneous construction. They were asked to evaluate the Construction Offices performance in the following key functions: "Inspection of Work", "Resolution of Technical Issues", "Provide Safe Traffic Control", "Employee Development and Training", "Communication", and "Provide Pre-Letting Information".

County and City Engineers

DOT construction projects often have an impact on Iowa cities and counties. Included are detours, haul roads, intersections, and projects where a joint responsibility is involved. At the request of the Highway Research Board, the researchers contacted a sampling of county and city engineers to determine their appraisal of the performance of the Iowa DOT Construction Offices. City engineers of Ames, Davenport, Des Moines and Dubuque, and county engineers of Polk, Scott, Story and Woodbury counties were interviewed. The engineers were requested to identify the strengths of the Construction Offices and to identify areas needing improvement. The results of these interviews are included under the key process External/Public Communication in the RESULTS section of this report.

Other offices within the Iowa DOT (outside the Construction Offices)

The Construction Offices work with the Office of Design, Office of Bridges & Structures, Office of Contracts, Office of Specifications, and Office of Right of Way on a daily basis, providing them with various types of project information. So, their evaluation of the performance of the Construction Offices was requested. The key functions evaluated by these other Offices include "Continuous Feedback for Improved Contract Documents" and "Providing Pre-letting Information".

Law enforcement agencies

State police and county sheriffs continually patrol construction work zones, making them valuable information sources for the evaluation of the key functions "Provide Safe Traffic Control" and "External/Public Communication." Six highway patrol districts and six counties, located in the areas having the most construction in 1995, were surveyed.

National motor carriers

The Iowa Department of Transportation considers the traveling public its primary external customer, especially for the key function "Provide Safe Traffic Control." However, it is difficult to develop, distribute, and collect surveys from the traveling public. This difficulty was addressed by surveying professional drivers of national motor carriers.

Since they regularly drive through several states, they can compare traffic control set-ups. Because their vehicles are longer and more difficult to control, they are likely to have a greater interest in the quality of traffic control set-ups. Surveys were distributed to a sample of drivers from Schneider National Carriers, Heartland Express, and Barr-Nunn Transportation, Inc. who were asked to evaluate the key function "Provide Safe Traffic Control." The motor carrier managers assisted the research team by collecting and distributing the surveys.

Customer Interviews for Survey Development

The researchers wanted to produce meaningful surveys; therefore, interviews were conducted with customers to obtain their input on the design of the surveys. A Construction Offices Employee Survey was developed with input from Construction Offices employees, including survey crews, inspectors, Resident Construction Engineers (RCEs), and Transportation Center Construction Engineers (TCCEs). Interviews were conducted in person, and information was sought regarding the relevancy and wording of the survey questions to ensure that the surveys would yield useful information.

Interviews were also conducted with contractors to assist in developing the External Customer Evaluation for Contractors. The interviews were conducted in person with contractors who work frequently with the DOT. Eight contractors were asked for their input on the key processes and relevancy of the performance measures. They also provided suggestions as to the survey format and pertinent questions that the DOT should ask contractors.

DOT employees in the offices of Contracts, Design, Bridges & Structures, and Specifications were interviewed to gather input for the evaluation they would make of the Construction Offices. These interviews resulted in information about the interface of each office with the Construction Offices and how the performance of the Construction Offices could best be evaluated.

Six law enforcement contacts were made via telephone and facsimile to obtain feedback on a sample External Customer Evaluation for Law Enforcement. Again, officials were asked to provide information on the relevance and wording of the survey

questions to obtain information which would most accurately address the issues important to law enforcement officials working with the Construction Offices.

Finally, a visit was made to Schneider National Carriers to discuss 1) the best method of obtaining feedback from drivers, and 2) appropriate survey questions.

Survey Distribution

Each survey for customer evaluation of the Construction Offices was reviewed by the Quality Coordinator for the Iowa DOT. A cover letter was attached to each survey explaining the importance of the recipient's feedback to the Construction Offices. To encourage responses, members of the customer organization were contacted before the distribution of the surveys. These contacts agreed to answer questions and encourage survey recipients to respond. For example, steering team members and Resident Construction Engineers encouraged employees in their respective offices to complete the Construction Offices Employee Survey honestly and return it promptly.

The Construction Offices Employee Survey was sent to all Construction Offices employees across the state. The surveys were distributed at the end of the construction season so the employees could accurately evaluate performance in each area for that year. The Construction Offices Employee Survey also included a page on which respondents could express an interest in participating further in the improvement process. Interested respondents were asked to give their name, address, and area(s) of interest. This information was used to create a list of potential members and leaders for future process improvement teams.

Contractor surveys were sent to members of the Associated General Contractors of Iowa (AGC), Iowa Concrete Paving Association (ICPA), and the Asphalt Paving Association of Iowa (APAI). The surveys were sent to the attention of the president of each company. The cover letter asked that the surveys be completed by persons who would be most familiar or work most closely with the Department of Transportation, for example, a project manager and/or foreman for each DOT job completed. Each contractor was asked to complete one survey for each of their 1995 Iowa DOT

construction projects. Several copies of the evaluation were included. Contractors were encouraged to make additional copies as necessary.

The Iowa DOT Construction Offices Evaluation for Law Enforcement Agencies was sent to twelve law enforcement agencies. The Iowa State Highway Patrol and County Sheriff Departments in the areas with the most construction in 1995 received surveys. Six of the 12 patrol districts were identified. The commander of the state patrol in each of these districts and the county sheriff received surveys.

Surveys were sent to three national motor carriers: Schneider National Carriers, Heartland Express, and Barr-Nun Transportation, Inc. Surveys were sent to local hubs, and drivers were asked to complete the surveys when they reported in at the hub.

Except for the national motor carrier and law enforcement surveys, the central Office of Construction assumed the responsibility and expense for addressing and mailing the surveys. These funds did not originate from the research funding paid to the ISU research team, but rather were in addition to the research funding. Completed surveys were returned to the ISU researchers for evaluation.

Tabulation of Results

Survey results were tabulated using SAS, a statistical software package. As results became available they were shared with the steering team. The steering team reviewed both the mean responses to survey questions and the written comments that accompanied the numerical responses. These results will serve as the baseline data for future evaluations.

Distribution of Results

A common concern among Construction Offices employees was that nothing would result from the surveys they were completing. To help demonstrate the steering team's commitment to the improvement process, the survey results and written comments were distributed to the Construction Offices employees. Results from contractors and law enforcement officials are also being returned.

BENCHMARKING

With the collection of baseline data underway, the team began to focus on collecting potential benchmark data. Potential benchmark data is performance data collected from organizations which perform similar functions. Although benchmark data is valuable to any DOT, it is difficult to obtain due to the time-consuming process of searching for the appropriate figures in large databases. Travel to each location for personal interviews is often required. Since the necessary information is likely to be scattered among several persons in the organization, an attempt should be made to identify which people are the most valuable sources of information. Potential benchmark data for this project was obtained through electronic inquiries, telephone conversations, and personal interview sessions.

Methods an organization may use to determine potential candidates for benchmarking include literature review, informal communication in quality committees of related associations, and personal knowledge. These methods will help identify organizations which are involved in the quality process. These candidates for benchmarking may then lead an organization to others.

ISU researchers identified several sources of potential benchmark data including the Departments of Transportation of other states, the U.S. Army Corps of Engineers, and the Union Pacific Railroad Corporation.

Other Departments of Transportation

In an effort to obtain benchmark data from other states, a survey was prepared and sent electronically to the DOT construction engineers of all other states. The following questions were asked for each key process:

Do you currently measure your performance in this area?

If so, what are your measures?

Do you have quantitative results you could share?

If so, would you please indicate what they are?

Replies were received from the states of California, Florida, Kansas, Missouri, Nebraska, New York, North Dakota, Ohio, Oklahoma, and Texas.

Some benchmark data was obtained directly from the Connecticut DOT Survey (Rolfe, 1995). In addition, a telephone survey was conducted of selected midwestern states. This included Wisconsin, Kansas, Missouri, and Minnesota. These states were selected because they are all rural midwestern states which are physically similar to Iowa, and likely to have similar transportation budgets. Arizona was selected for a visit based on conversations with other states. Utah was included in the telephone survey because it appeared they were following Arizona's lead in developing performance information.

Information from other states is included in the Results section of this report as benchmark data for each key process is discussed.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers was identified as a possible benchmark candidate as it is a government agency, it has several districts similar to residencies in function, and its construction mission involves both vertical and horizontal construction.

Union Pacific Railroad Corporation

The Union Pacific Railroad Corporation is able to provide a comparison with a transportation agency in the private sector; they are involved in horizontal construction (railways); they let their contracts on a unit-price basis; and, like each of the aforementioned agencies, have their personnel geographically dispersed.

PROCESS IMPROVEMENT TEAMS

It was vital to the success of this and further improvement efforts that the Construction Offices take the appropriate steps to implement the suggestions made by Construction Offices employees and contractors, and to continually keep all groups informed of project progress. Process improvement teams are intended to involve Construction Offices employees in the improvement process and to ensure that the efforts of this project are continued once outside research support is discontinued.

Process improvement teams are an effective method of making (or at least considering) changes within an organization. On each Construction Offices Employee

Survey, a sheet was attached which provided volunteers a further opportunity to participate in the improvement process. Team members were to be selected from those who volunteered and were to consist of a cross-section of employees, much like the steering team for this project, and would focus on problem areas identified from the surveys. Two such teams were started during this project. Each team received a team charter developed by the steering team and ISU researchers and two days of team training prior to the start of their project. A trained facilitator from the Iowa DOT was also provided for their team meetings.

RESULTS

This section will give a brief description of the survey instruments and will then present and discuss the baseline and potential benchmark data collected.

Surveys

Approximately 400 Construction Offices Employee Surveys were distributed. One hundred sixty-one were returned. The responses were categorized into four groups based on years of experience with the Iowa DOT. The groups were 1-10 years, 11-20 years, 21-30 years, and over 30 years of experience. This division was done to detect any significant differences in the views of various levels of experience and to check for normality of the responses. For each of the 36 questions on the survey, each experience category was evaluated for mean, variance, range, and statistical distribution. Questions with a low mean, a high variance, or an abnormal distribution (skewed, bi-modal, etc.) may warrant a closer look by an improvement team.

A total of 100 Contractor evaluations were received from 31 different contractors. The contractor surveys were analyzed for the mean response according to the type of work being performed: (1) earthwork, (2) roadwork (ACC and PCC paving, patching, etc.) (3) structures, and (4) other. The surveys were also analyzed for the overall mean, regardless of the type of work performed.

A total of 77 drivers were surveyed with the National Motor Carriers Survey. The surveys were analyzed for an overall mean only, to protect the anonymity of the carriers.

Of the 12 Law Enforcement Surveys delivered, there were 10 responses. The surveys were analyzed for the overall mean of each question and the statistical distribution.

The External Customer Evaluation for Iowa DOT Employees Outside the Construction Offices was distributed to the following offices: Contracts, Design, Bridges & Structures, Specifications, and Right of Way. A total of sixteen responses were received. The evaluations were sorted by office.

Key Process: Inspection of Work

Baseline Data

The performance measures for the key process "Inspection of Work" are

1) Internal customer evaluation of the clarity of their duties, their understanding of the priority of their duties, the ability of the inspection process to influence the final quality of Iowa DOT construction projects, the amount of duplication of effort in the paperwork they complete, the amount of non-productive activity that occurs during the inspection process, and the overall quality of the inspection process
2) Contractor evaluation of competence and availability of inspectors, competence and availability of the RCE (Resident Construction Engineer), empowerment of the inspector to make field decisions, the ability of the inspection process to influence the final quality of Iowa DOT construction projects, and the overall quality of the inspection process
3) Cost of inspection as a percentage of contract volume, statewide, on an annual basis (direct inspection costs, not including supervisory or overhead costs).

Internal Customer Evaluation

The results of the Construction Offices Employee Survey are provided in Table 1. The Construction Offices employees have given the lowest ratings to "the amount of duplication of effort in the paperwork you complete"(2.59) and "the amount of non-productive activity that occurs during the inspection process"(2.94). At the time of publication of this report, there is a study (Iowa DOT Project HR-377) being performed

by a similar DOT steering committee and team of ISU researchers which focuses on eliminating duplication in certain forms completed by both Construction Offices employees and Office of Materials personnel. The results of that study will hopefully eliminate much of this duplication, and thus improve the ratings in this area.

Table 1. Construction Offices Employee Survey: Inspection of work

Mean response based on years of experience with Iowa DOT

Questions	Years of experience 1-10 n=35	11-20 n=47	21-30 n=33	31+ n=46	Overall mean
(1) the clarity of your duties	3.67	3.52	3.79	4.05	3.77
(2) your understanding of the priority of your duties	3.52	3.75	3.71	4.27	3.81
(3) the ability of the inspection process to influence the final quality of Iowa DOT construction projects	3.20	3.23	3.50	3.69	3.43
(4) the amount of duplication of effort in the paperwork you complete	2.67	2.64	2.47	2.57	2.59
(5) the amount of non-productive activity that occurs during the inspection process	2.76	3.00	3.02	2.90	2.94
(6) the overall quality of the inspection process as it is now	3.28	3.44	3.23	3.49	3.37

Significant comments and recommendations:

- Provide more full-time inspectors and less summer help. Downsizing has created a lack of experienced personnel in the field (27 responses)
- Reduce the amount of duplication in paperwork (21 responses)
- Provide continued training for inspectors and do not rush the training to be completed in one day (16 responses)

N = 161 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

There was little difference in the ratings of the four experience categories. None of the mean ratings differed by more than 0.49. The exceptions came in the areas of "the clarity of your duties" and "your understanding of the priority of your duties," where the experience category of "30+ years experience" rated both areas noticeably higher than did the other experience categories. From the nature of the question though, this can be expected. Overall, there were no differences which warrant special consideration.

Contractor Evaluation

The results of the Contractor Survey are provided in Table 2.

Table 2. Contractor evaluation: Inspection of work

Mean response based on type of work

Questions	Type of work: Earthwork n=16	Roadwork n=60	Structures n=16	Other n=8	Overall mean
(1) inspector competence	4.07	3.88	3.69	4.29	3.91
(2) RCE competence	3.87	4.15	4.27	3.86	4.11
(3) availability of inspector	4.07	4.02	4.31	4.43	4.10
(4) availability of RCE	3.73	3.98	4.13	3.71	3.95
(5) empowerment of inspector to make field decisions	3.80	3.17	3.25	4.43	3.37
(6) ability of inspection process to influence the final quality of project	3.80	3.60	3.50	4.14	3.65
(7) overall quality of inspection process	3.87	3.78	3.75	4.00	3.80

What is particularly good about the inspection process?
- inspectors are experienced and knowledgeable (16 responses)
- inspectors worked well with us and were open to suggestions (8 responses)
- experienced inspectors used "common sense" (6 responses)

Which types of work are "over-inspected"?
- plant inspection (5 responses)
- traffic control signage (4 responses)
- certification and inspection of materials (3 responses)

Which types of work are "under-inspected"?
- items of greater importance compared to minor items (2 responses)
- pipe laying (2 responses)

How could the inspection process be improved?
- more empowerment to field inspectors (12 responses)
- encourage the use of common sense when applicable (3 responses)
- provide better trained summer help (3 responses)

N = 100 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

The area rated lowest by the contractors was "empowerment of inspectors to make field decisions"(3.37). This question also had high variances and a bi-modal distribution. These factors indicate that this area of inspection may warrant further detailed consideration by a process improvement team. Other areas of inspection were rated fairly high by the contractors, all 3.65 or above.

Cost of Inspection

Cost of inspection as a percentage of contract volume, statewide, on an annual basis (direct inspection costs, not including supervisory or overhead costs) was 3.3% for 1995. This has been a steadily decreasing figure over the past four years. Figure 1 presents Iowa's inspection costs over the past five years.

Data from Potential Benchmark Organizations

The Connecticut DOT Office of Construction undertook a benchmarking study to set standards for its Department's work processes and programs (Rolfe 1995). A survey was distributed to all 50 state highway agencies; thirty-five of fifty states responded. The following benchmark figures are taken from the results of this survey. Inspection Costs (defined as those costs necessary to inspect and administer construction projects, expressed as a percentage of the contract value, and generally including all costs incurred at the District / Regional level) for those states replying to the survey are: **IA(3)**, ND(5), KY(6), TX(6), SD(6), MS(7), MT(8), PA(8), CO(10), MD(10), OR(10), AK(11), AL(12), DE(12), FL(12), KS(12), NY(12), MI(13), MO(13), ME(14), UT(14), MA(15), WA(15), WI(15), AZ(16), CT(16). The average of those states replying was 10.8%. These results are presented in Figure 2.

In 1994, Iowa's "cost of inspection as a percentage of contract volume" was 3.3%. This does not include benefits, social security, supervisory, and support costs. In data provided by the Connecticut DOT survey (Rolfe, 1995), Iowa has one of the lowest percentages. However, the figures provided by some of the other states may include some supervisory and overhead expense. A reasonable upper bound to Iowa's cost of inspection as a percent of contract volume can be calculated by including all RCE office costs, 50% of Transportation Center costs, 50% of Field Materials costs, 25% of Central

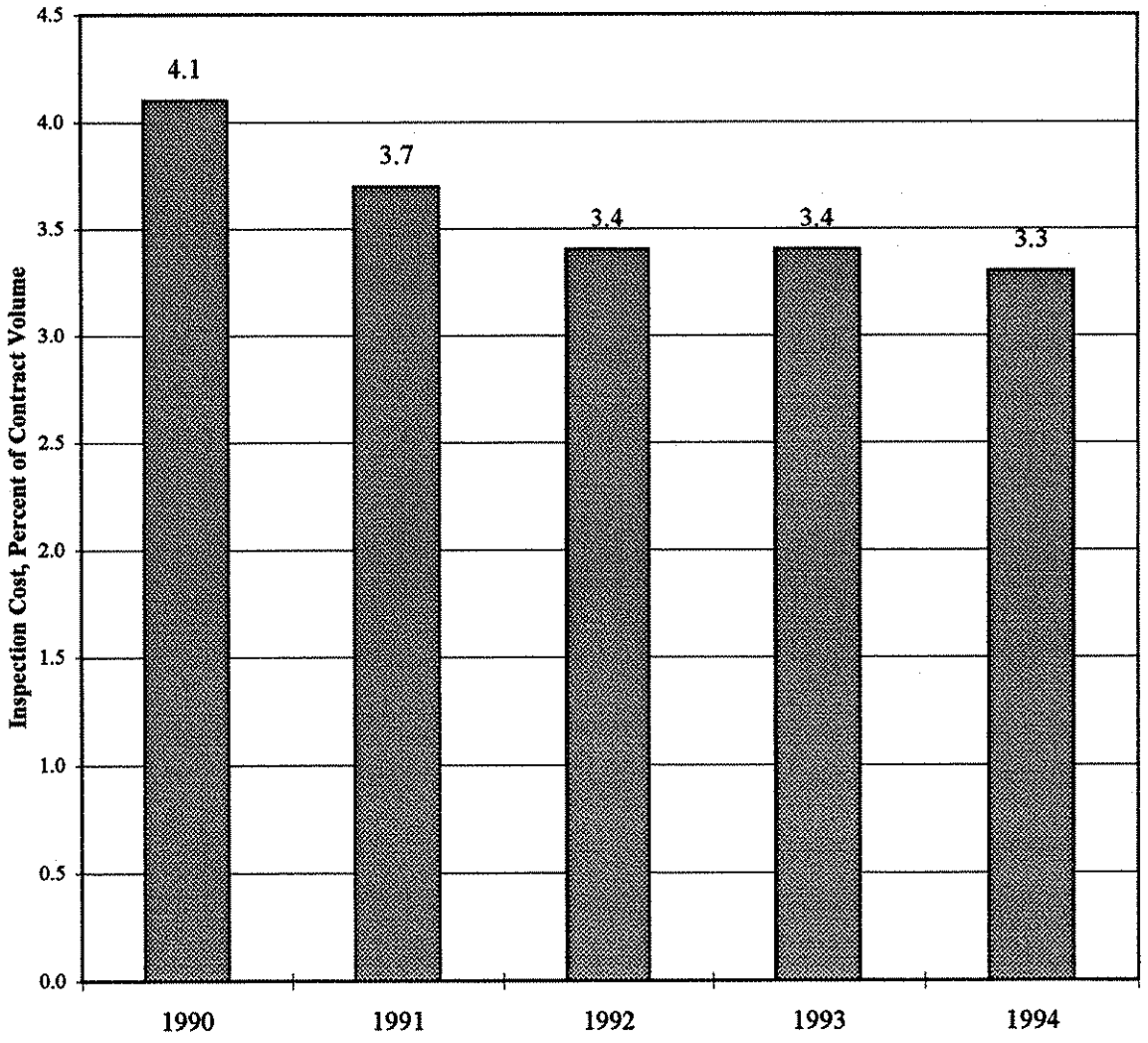

Figure 1. Iowa DOT Inspection Costs

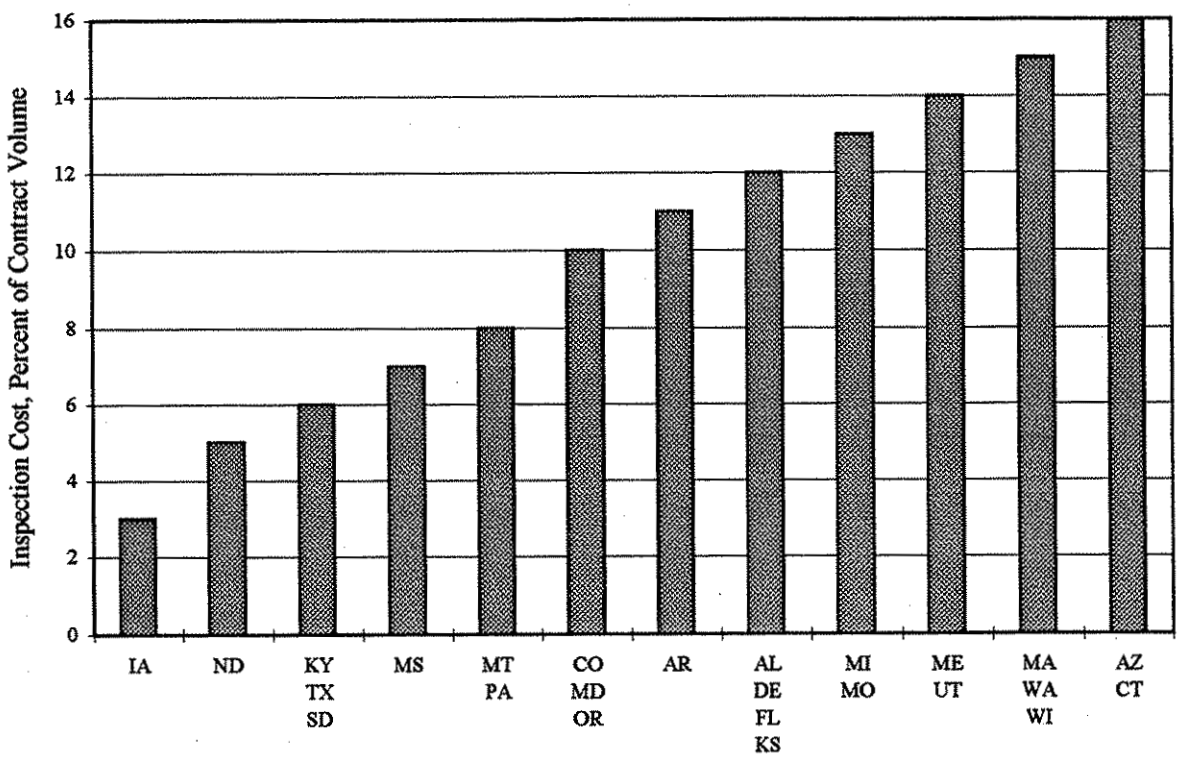

Figure 2. Inspection Costs for DOTs responding to CTDOT survey

Materials Lab costs, and 100% of Central Construction Office costs. With these additions, the upper bound is 9.3%. This would give Iowa the eighth lowest percentage of the 26 responding states.

Judgments concerning such comparisons can be made only after a detailed analysis of the differences in the results. Besides Iowa, those states which initially appear to be leaders in the area are North Dakota, Kentucky, Texas, and South Dakota. The Construction Offices steering team may wish to contact the construction engineer of these states to discuss the results for possible further benchmarking activities.

Key Process: Resolution of Technical Issues

Baseline Data

The performance measures associated with the key process "Resolution of Technical Issues" are

1) Internal customer evaluation of their confidence that their superiors will support their decisions, communication within the Construction Offices, communications with contractors, timeliness of resolution, the amount of non-productive activity that occurs during the process, and the overall quality of the process of resolving technical issues
2) Contractor evaluation of communication with the inspector and RCE, use of fair judgment by the Construction Offices, and overall quality of the process of resolving technical issues
3) Number of litigation cases per year
4) Litigation payout per year
5) Number of claims per year
6) Number of repeat problems with plans and specifications.

Internal Customer Evaluation

The results of the Construction Offices Employee Survey are provided in Table 3. This process received ratings of less than 3.0 from the Construction Offices employees in three areas: "the timeliness of resolution of technical issues"(2.74), "the amount of non-

Table 3. Construction Offices Employee Survey: Resolution of technical issues

Mean response based on years of experience with Iowa DOT

Questions	Years of experience 1-10 n=35	11-20 n=47	21-30 n=33	31+ n=46	Overall mean
(1) your confidence that your supervisors will support your decisions which you feel you are qualified to make	3.50	3.59	3.49	3.89	3.59
(2) communications within the Iowa DOT Construction Offices during the resolution of technical issues	3.04	3.00	2.96	3.53	3.13
(3) communications with contractors during the resolution of technical issues	3.13	3.28	3.08	3.56	3.25
(4) timeliness of resolution of technical issues	2.76	2.78	2.55	2.83	2.74
(5) the amount of non-productive activity that occurs during the resolution of technical issues	2.74	2.88	2.61	2.79	2.74
(6) the overall quality of the process of resolving technical issues	2.82	2.81	2.80	3.19	2.89

Significant comments and recommendations:

- Answers need to be provided to the field more quickly (18 responses)
- Give inspectors more power to make field decisions (16 responses)
- Improve overall communication within the Construction Offices and with contractors (9 responses)

N = 161 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2= Marginal 1 = Poor

productive activity that occurs during the resolution of technical issues"(2.74), and "the overall quality of resolving technical issues as it is now"(2.89). Because of the less-than-satisfactory ratings in these three areas, a process improvement team was established to address this process.

Contractor Evaluation

The results of the Contractor evaluation are provided in Table 4. The contractors rated this process quite high (3.69 overall). Traditionally, there has been a perceived adversarial attitude between contractors and the DOT. It would follow that this process involving so much interaction between the two groups might receive a low rating, as the preliminary interviews with contractors predicted, however this is not the case. It appears

Table 4. Contractor evaluation: Resolution of technical issues

Mean response based on type of work

Questions	Type of work: Earthwork n=16	Roadwork n=60	Structures n=16	Other n=8	Overall mean
(1) communication with inspector	3.86	3.85	3.88	4.25	3.89
(2) communication with RCE	3.79	3.82	4.07	3.75	3.85
(3) timeliness of resolution	3.50	3.51	3.56	4.25	3.57
(4) use of fair judgment by the Iowa DOT Construction Offices	3.57	3.54	4.06	4.25	3.68
(5) overall quality of the process of resolving technical issues	3.64	3.59	3.88	4.25	3.69

What is particularly good about the process of resolving technical issues?

- it keeps work moving (8 responses)
- it doesn't take long (6 responses)

How could the process of resolving technical issues be improved?

- empower local personnel, such as inspectors and the RCE, to make decisions (12 responses)
- improve the time required to receive an answer (7 responses)

N = 100 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

that contractors believe the Construction Offices are doing satisfactory to good in this process.

Litigation

This measures incidences of contract-related court action initiated by a contractor against the Iowa DOT. The number of cases initiated during the past three years are as follows:

1993: 0 1994: 0 1995: 1.

Litigation Payout

The amount of litigation payout by year, for the past three years, regardless of year initiated, is as follows:

1993: $ 0 1994: $ 0 1995: $ 0.

Number of Claims per Year

For the purposes of this study, a claim is considered to be a contractor's request for additional compensation. Only those that cannot be handled at the local or transportation center level, which are referred to the central Construction Office in Ames for resolution, are considered in measuring the effectiveness of the key process, *resolution of technical issues*. There were no such claims in 1995.

Number of Repeat Problems

An indicator of the effectiveness of the key process *resolution of technical issues* is the frequency of repeat problems. The Construction Offices have not been keeping track of such data. In late 1995, Transportation Center engineers were requested to advise the Central Office of repeat problems. Quantitative data may be available in the future, but it is not currently available.

Key Process: Documentation of Work Progress and Pay Quantities

Baseline Data

The performance measures for the key process "Documentation of Work Progress and Pay Quantities" are

1) Internal customer evaluation of the amount of time spent documenting work progress and pay quantities, the amount of duplication of effort in the paperwork they complete, the amount of non-productive activity that occurs during the process, and the overall quality of the process of documenting work progress and pay quantities
2) Project closeout (time from project acceptance to final payment).

Internal Customer Evaluation

The results of the Construction Offices Employee Survey are provided in Table 5. The Construction Offices employees have given the lowest rating to the question "the amount of duplication of effort in the paperwork you complete"(2.77). This is likely the biggest opportunity for improvement for the Construction Offices and is being addressed in a separate study, previously mentioned (Iowa DOT Project HR-377). Reducing duplication

Table 5. Construction Offices Employee Survey: Documentation of work progress and pay quantities

Mean response based on years of experience with Iowa DOT

Questions	Years of experience 1-10 n=35	11-20 n=47	21-30 n=33	31+ n=46	Overall mean
(1) the amount of time you spend documenting work progress and pay quantities	3.24	3.20	3.13	3.41	3.25
(2) the amount of duplication of effort in the paperwork you complete	2.93	2.90	2.54	2.78	2.77
(3) the amount of non-productive activity that occurs during the process of documenting work progress and pay quantities	2.84	3.11	3.00	2.97	3.02
(4) the overall quality of the process of documenting work progress and pay quantities as it is now	3.22	3.14	3.04	3.59	3.23

Significant comments and recommendations:

- Reduce the amount of duplication in paperwork (29 responses)
- Provide notebook computers to field personnel in all residencies (27 responses)

N = 161 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

in paperwork and the addition of electronic fieldbook computers may increase the ratings of this process. There was little difference between the experience categories, with the mean responses differing by no more than 0.55.

Project Closeout

Iowa DOT Construction Offices project closeout time (time from project acceptance to final payment) for 1995 was 67.4 days (average for 276 projects).

Data from Potential Benchmark Organizations

The following benchmark figures are also taken from the survey conducted by the state of Connecticut Department of Transportation (Rolfe, 1995). Project Closeout (defined as the duration from completion of construction work until project records are complete and accepted) for those states replying to the survey are: AR(60), CO(62), UT(68), MO(88), DE(90), AZ(90), IN(90), MD(90), MA(90), MT(90), RI(90), TX(98),

ND(120), KS(120), ID(120), OK(180), CT(200), MN(360). The average for those states replying was 130 days. These results are presented in Figure 3.

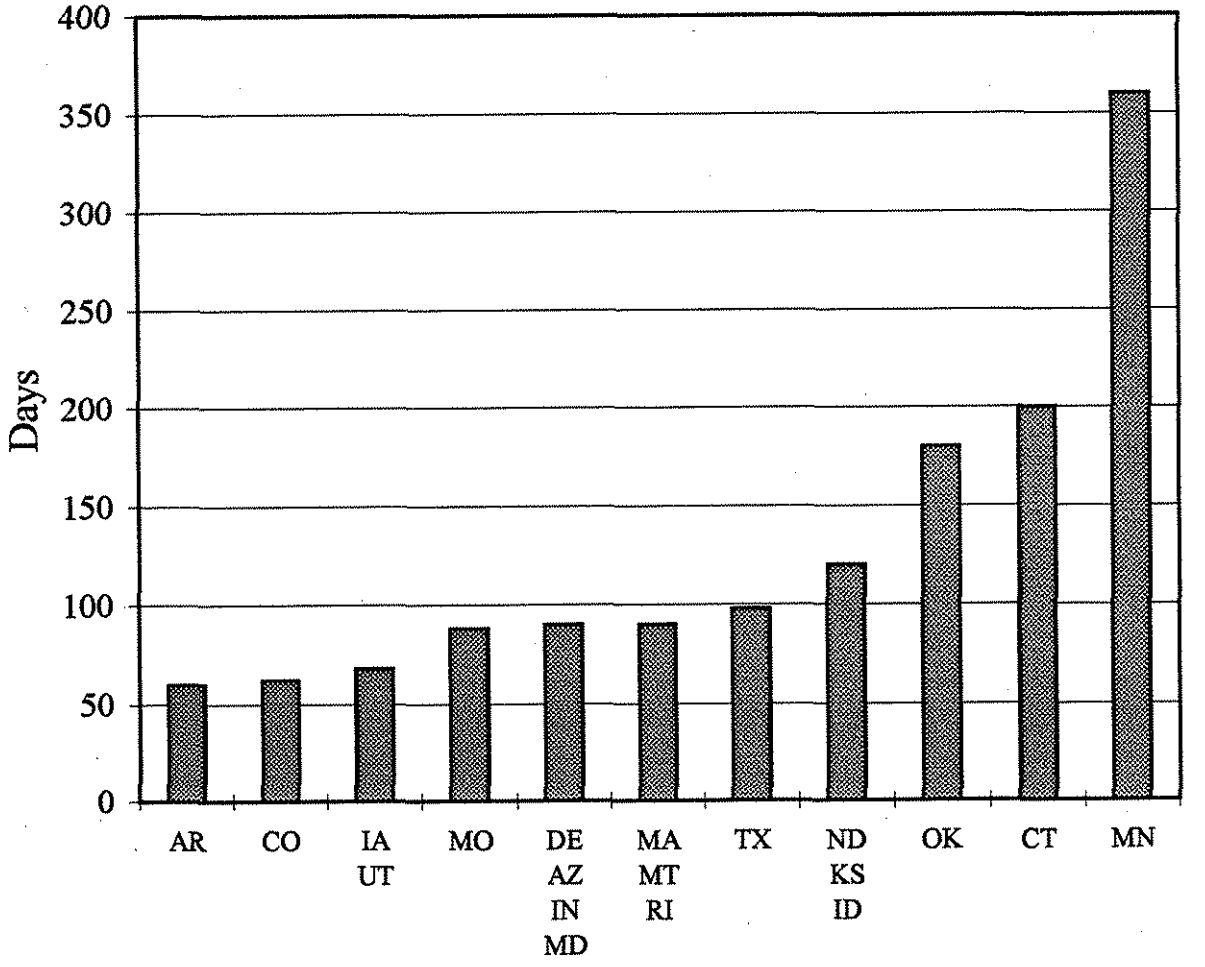

Figure 3. Time for project closeout for DOTs responding to CTDOT survey

Iowa's project closeout duration of 67.4 days appears to be among the leaders in this category. Comparing this figure to those of the Connecticut survey (Rolfe, 1995), Iowa is behind only Arkansas (60 days) and Colorado (62 days). Utah (68 days) also appears to be comparable. Caution must be observed in using these results because it has not been verified that each state uses the same terminology and nomenclature.

Key Process: Employee Training and Development

Baseline Data

The two performance measures for the employee training and development function were:

1) internal customer evaluation of need, applicability, availability, scheduling, and the overall process, and

2) external customer evaluation of employee competence, qualifications, thoroughness, understanding, knowledge, and overall quality of employee training.

Internal Customer Evaluation

The results of the Construction Offices Employee Survey are displayed in Table 6. On the average, the responses indicated that training and development for Construction Offices employees is satisfactory to good (3.24). Only the scheduling of training sessions received an overall response that was less than satisfactory (2.81). All experience levels rated this area as less than satisfactory. Similarly, question number eight, in reference to employees' ability to obtain a specific training session, received a response just above the satisfactory level (3.03 overall). These responses, in addition to the written comments received on the surveys, indicate that employees are not able to attend training sessions at times and locations most preferable to them, and that some specific training sessions are either not available to them or are not offered at times/locations which they can conveniently attend. Written comments indicated that many training sessions are scheduled during the construction season and that employees must be absent from their jobs to attend training sessions. Comments also indicated that most training is offered either in Ames or Des Moines, requiring significant travel for many employees in field offices around the state.

Table 6. Construction Offices Employee Survey: Employee training & development

Mean response based on years of experience with Iowa DOT

Questions	Years of experience 1-10 n=35	11-20 n=47	21-30 n=33	31+ n=46	Overall mean
(1) my ability to do my job with the training I have	3.72	3.72	3.82	4.03	3.80
(2) the extent to which structured classroom training & development sessions have been beneficial	3.50	3.28	3.39	3.46	3.40
(3) the extent to which on-the-job training (from co-workers or supervisor) has been beneficial	3.65	3.87	3.59	3.68	3.69
(4) Have you had training sessions in which employees from other divisions of the DOT were present in the same training group?	143 - yes		18 - no		
(5) If yes, rate your experience when in training with employees from other divisions	3.66	3.35	3.36	3.41	3.44
(6) the extent to which the training you receive is applicable to your job	3.55	3.66	3.41	3.44	3.51
(7) your ability to request a specific training session	3.32	3.31	3.00	3.39	3.23
(8) your ability to obtain a specific training session	3.11	3.09	2.79	3.17	3.03
(9) scheduling of training sessions	2.96	2.81	2.73	2.70	2.81
(10) the overall quality of training as it is now	3.34	3.20	3.02	3.24	3.24

List any additional training you would like to receive:

- computer training (46 responses)

List any training you suggest be discontinued:

- repetitive AA/EEO (11 responses)

What training has been particularly good?

- computer courses (26 responses)
- PCC & ACC school (17 responses)
- survey schools taught by DOT staff (14 responses)
- work zone traffic control (11 responses)

How may training be improved?

- offer training in residencies, not just in Ames & Des Moines; keep it at the office level (15 responses)
- do not require training during the construction season (13 responses)
- allow employees to attend seminars on subjects important to them (12 responses)

N = 161 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

External Customer Evaluation

The results of the External Customer Evaluation Form for Contractors are located in Table 7. Overall, contractors rated the training and development of Construction Offices employees as satisfactory to good (3.53). There was little variation among the responses. Written comments indicated that new employees should be given more field experience alongside experienced personnel, interpersonal/communication skills could be improved, and summer help needs more training. Contractors written responses indicate that training is good.

Table 7. Contractor evaluation: Employee training & development

Mean response based on type of work

Questions	Type of work: Earthwork n=16	Roadwork n=60	Structures n=16	Other n=8	Overall Mean
(1) overall competence of employees	3.62	3.51	3.44	3.50	3.51
(2) qualifications	3.77	3.53	3.62	3.75	3.60
(3) thoroughness	3.92	3.51	3.56	3.25	3.58
(4) understanding of procedures	3.69	3.39	3.38	3.50	3.44
(5) knowledge about the projects	3.85	3.39	3.50	3.50	3.50
(6) overall quality of employee training	3.73	3.52	3.50	3.25	3.53

What is particularly good about DOT employee training?

- Most inspectors well-trained; Field training good (10 responses)

How could DOT employee training be improved?

- Give summer help more training so they know what's going on (4 responses)
- Put new employees out with more experienced personnel (4 responses)

N = 100 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

Data from Potential Benchmark Organizations

Two organizations provided information about employee training and development: the Arizona DOT (ADOT) and Union Pacific Railroad (UP).

Arizona Department of Transportation

Results of the 1995 Annual Employee Assessment of ADOT, a survey of all ADOT employees, included employee satisfaction with training. A five-point scale was used, similar to the scale used for the Construction Offices Employee Survey, ranging from "1 = not satisfied" to "5 = very satisfied." One question common to both the ADOT survey and this Iowa DOT survey was that of overall employee satisfaction with training. The ADOT employees gave a 2.68 mean response, corresponding to slightly less than satisfied. This is less than Iowa DOT Construction Offices employees' response of 3.24, which represents satisfactory to good. The ADOT survey was distributed to all employees, not just those in the Highway Division.

Union Pacific

All UP employee training is done in-house using Instructional Development Methodology (IDM). Additionally, much training is done on CD-ROM, which allows employees to view it in their motel rooms while away on projects. The performance measure used by UP for employee development is annual training hours per employee ("1995 Engineering . . . " 1995). UP employees receive an average of 33 hours of training per year. This compares with 83 training hours per employee in the RCE offices of the Iowa DOT in 1995, according to the Construction Offices. This 83 hours per employee does include travel time of an unknown amount.

While annual hours of training indicates the level of activity of employees in training, perhaps a more relevant performance measure would be the improvement in employee performance because of training, i.e., the results of the training. This has not been measured.

Key Process: Continuous Feedback for Improved Contract Documents

Baseline Data

The steering team identified four performance measures for this process:

1) Cost overruns as a percentage of contract volume,
2) Contractor evaluation of contract documents and number of repeat problems,

3) Employee evaluation of number of repeat problems, and
4) Evaluation of Construction Offices performance by other offices within the DOT.

Cost Overruns

Poor quality contract documents are often the cause of cost overruns. By providing good feedback, an organization could hope to improve the quality of its contract documents. Therefore, one would expect that a low cost overrun rate would be associated with effective feedback to improve contract documents. Cost overruns include the following items:

- Change orders - changes to existing contract items which require management authorization,
- Extra work orders - newly created contract items which require authorization, and
- Overruns/underruns - changes in contract quantities which result in higher or lower contract costs.

Non-work items such as incentives, penalties, and price adjustments are not factored into cost overruns.

The percent net cost change to bid value (over- or underruns) for completed construction contracts in fiscal years 1993 through 1995 provided by the Iowa DOT Office of Audits (Iowa Department of Transportation 1995) are as follows:

1993: + 4.68 % 1994: + 3.77 % 1995: + 4.93 %.

The Office of Audits indicated that the percent overrun in 1995 was acceptable, and this number therefore suggests that extra work orders are being properly used to adjust quantities. However, it was also reported that over 40 percent of the cost of extra work orders can be attributed to just 20 items and that these 20 items account for over 600 occurrences of extra work orders. A few of the most frequent and most costly items for which extra work orders are used include excavation, clearing & grubbing, and pavement scarification.

While the Office of Audits believes these numbers are acceptable and that extra work orders are being used properly, this baseline data indicates that room for improvement does exist in the project development process.

Contractor Evaluation

Contractors were not directly surveyed for their evaluation of this process. In the future, however, they should be included. Their feedback will be a useful measure of performance in this area.

Employee Evaluation

The employee evaluation of the number of repeat problems is a measure that will be included in future Construction Offices employee evaluations. It was not done as a part of this study because the steering team added it as a measure after the survey had been distributed.

Evaluation of Construction Offices Performance by Other Offices within the DOT

The results of the External Customer Evaluation for Iowa DOT Employees Outside the Construction Offices are shown in Table 8.

Table 8. Other DOT offices: Continuous feedback for improved contract documents

	Mean response based on DOT office			
Questions	Design n = 7	Contracts n = 4	Specific-ations n = 1	Overall Mean
(1) my level of satisfaction with the *amount* of feedback I receive from Construction about my work on the contract documents (5=too much 3=about right 1=too little)	2.67	1.50	3.00	2.27
(2) my level of satisfaction with the *specificity* of the feedback I receive from Construction about my work on the contract documents	3.17	2.00	3.00	2.73
(3) my level of satisfaction with the *timeliness* of the feedback I receive from Construction about my work on the contract documents	3.17	1.75	3.00	2.64
(4) my level of satisfaction with the *method* of providing/receiving feedback	3.33	1.50	3.00	2.64
(5) the overall process of feedback for improved contract documents	2.67	1.50	3.00	2.27

N = 12 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

These results indicate that, overall, the process is considered less than satisfactory (2.27) by the offices involved. The lowest ratings were with the amount of feedback received from the Construction Offices and with the overall process of providing/receiving feedback for improved contract documents. The Office of Contracts consistently gave responses of poor to marginal. The Offices of Design and Specifications were, in general, satisfied with the process, but on the average, none of the offices said the process was "good." The data indicates that there is much room for improvement in this process.

Data from Potential Benchmark Organizations

Continuous feedback for the improvement of contract documents was not a process identified by the potential benchmark organizations. However, several sources provided cost overrun information similar to the first measure for this key process.

State Highway Agencies

One of the nine processes measured by the Connecticut DOT study was project cost increase (decrease). The cost increase was defined as the average percentage increase of construction projects. Thirty states responded to this item. See Figure 4. The average percent increase was 7.1%, with individual state increases ranging from 0% to 18%.

Iowa DOT's percent net cost change to bid value (over- or under-runs) for completed construction contracts over the past three fiscal years ranged between 3.77 and 4.93%. These values place Iowa DOT in good standing in comparison to the thirty five states responding to CTDOT's survey. However, five states (Missouri, Montana, Kansas, Oklahoma, and Oregon) reported lower increases than Iowa DOT, indicating that there is room for improvement in this area.

Other Organizations

From the interviews conducted by researchers and steering team members, the cost overrun data in Table 9 was collected.

Kansas DOT appears to be the organization to benchmark for cost overruns. They calculate percentage increase in project cost as final annual costs divided by initial annual

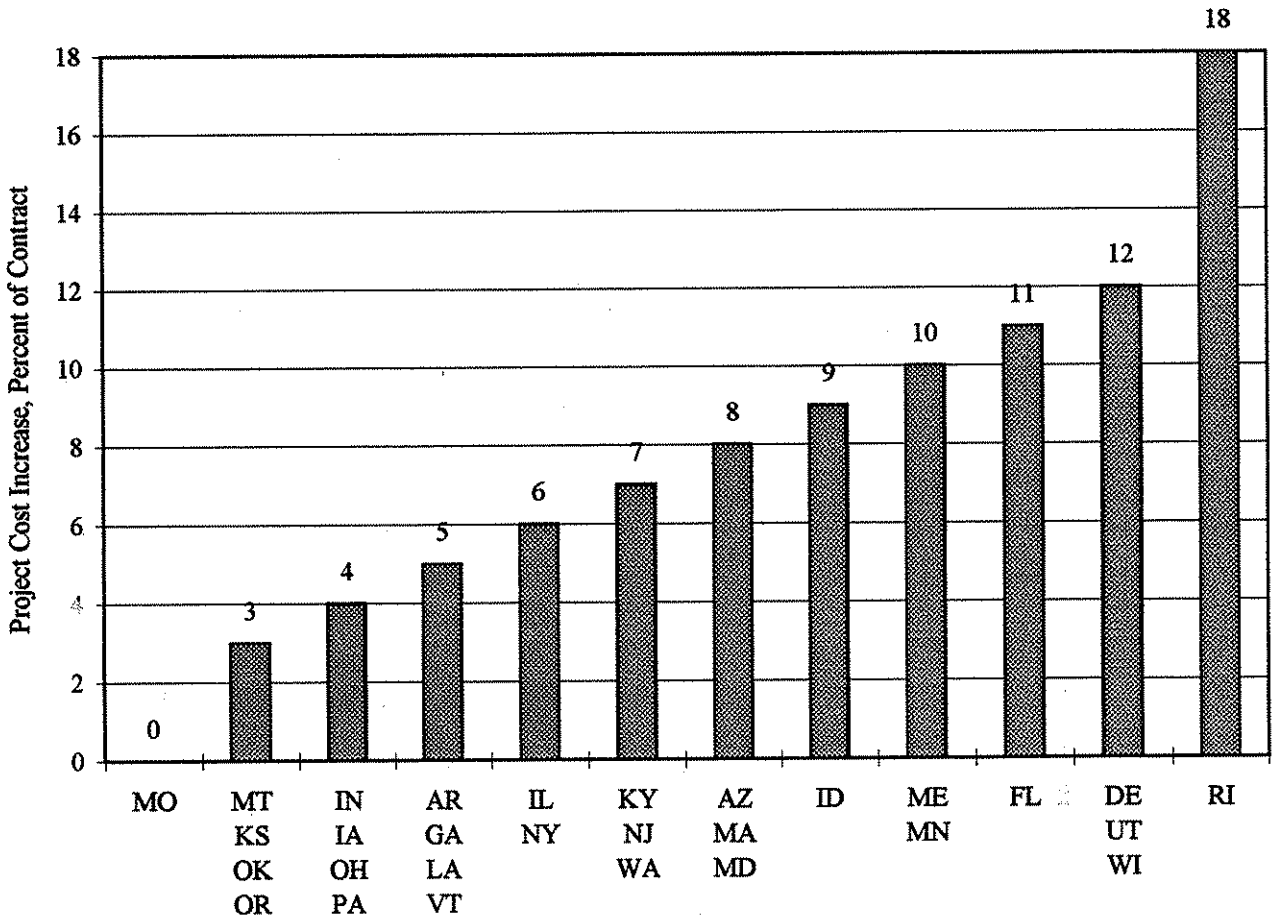

Figure 4. Project cost increase for DOTs responding to CTDOT survey

Table 9. Cost overrun (as a % of contracts)

Kansas DOT	Iowa DOT	Arizona DOT	Union Pacific	U.S. Army Corps	Minnesota DOT	Wisconsin DOT
3.0%	4.9%	6.6%	7.7%	7.8%	10.0%	11.3%

letting costs. In the past 13 years, the average percentage increase has risen from 2.5% to 3%.

The Iowa DOT and Arizona DOT both report cost overruns as the percent of actual costs versus contract bid amount. ADOT's annual percent overrun for 1995 was 6.6%, compared to Iowa DOT's 4.9%.

Union Pacific (UP) uses property investment project costs as a measure similar to cost overruns. Property investment project costs measures how accurately UP estimates project expenses and manages the financial resources to complete the project within Work Order Authority, i.e., the difference of the final cost and the engineer's estimate divided by the engineer's estimate. As of November 16, 1995, the 1995 over-run was 7.7% ("1995 Engineering . . ." 1995).

The U.S. Army Corps of Engineers reported 7.8% cost growth (or cost overruns) for its military construction projects.

The Minnesota DOT calculates cost overruns as final cost minus bid. They reported that this calculation is all inclusive and includes cost reductions.

Finally, the Wisconsin DOT reported a Construction on Budget Index (COBI). This number indicates the percent of construction which is on budget as opposed to cost overrun. The COBI for 1995 was reported as 88.2%. This is equivalent to an 11.3% cost overrun rate.

By comparison with these organizations, the Iowa DOT Construction Offices fares well in terms of project cost overruns.

Key Process: Provide Safe Traffic Control

Baseline Data

The performance measures for the key process "Provide Safe Traffic Control" are

1) Internal customer evaluation of contractor knowledge of traffic control regulations, contractor concern for traffic control, the quality of the plans and specifications provided by the DOT for traffic control, and the overall quality of the process
2) Contractor evaluation of DOT personnel knowledge of traffic control regulations, DOT personnel concern for traffic control, the quality of the plans and specifications provided by the DOT for traffic control, and the overall quality of the process of providing safe traffic control
3) External customer (national carriers and law enforcement) evaluation of the intent of signage and markings displayed on Iowa highway construction projects, the reasonableness of delays experienced, visibility of construction workers, the travel space allotted, your feeling of safety when traveling through Iowa highway construction projects, and the overall quality of the process of providing safe traffic control
4) Number of accidents in interstate and highway construction zones
5) Field force evaluation of contractors' traffic control (on a scale of one to ten).

Internal Customer Evaluation

The results of the Construction Offices Employee Survey are provided in Table 10. The Construction Offices employees rated the Iowa DOT fairly high in "the quality of plans and specifications provided for traffic control"(3.51) and "the overall quality of the process of providing safe traffic control"(3.33), however, "contractor concern for traffic control"(2.73) received a less than satisfactory rating.

Contractor Evaluation

The results of the Contractor Survey are provided in Table 11. The contractors rated the Construction Offices extremely high (as compared to other areas) in their performance in "Provide Safe Traffic Control". This process was rated the highest of all

Table 10. Construction Offices Employee Survey: Provide safe traffic control

Mean response based on years of experience with Iowa DOT

Questions	Years of experience 1-10 n=35	11-20 n=47	21-30 n=33	31+ n=46	Overall mean
(1) contractor knowledge of traffic control regulations and specifications	3.07	3.00	3.02	3.11	3.05
(2) contractor concern for traffic control	2.64	2.72	2.68	2.83	2.73
(3) the quality of the plans and specifications provided by the Iowa DOT for traffic control	3.45	3.72	3.40	3.61	3.51
(4) the overall quality of the process of providing safe traffic control as it is now	3.30	3.32	3.28	3.42	3.33

Significant comments and recommendations:

- Require contractors to attend annual traffic control seminars and to be certified (13 responses)
- Put a harsher penalty on non-compliances and do not overturn them when submitted by inspectors (12 responses)
- Provide more site-specific traffic control plans. Standards do not cover every situation (7 responses)

N = 161 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

Table 11. Contractor survey: Provide safe traffic control

Mean response based on type of work

Questions	Type of work: Earthwork n=16	Roadwork n=60	Structures n=16	Other n=8	Overall Mean
(1) DOT personnel knowledge of traffic control regulations	4.14	4.27	4.00	4.00	4.19
(2) DOT concern for traffic control	4.29	4.59	4.43	4.00	4.48
(3) quality of plans and specs provided by DOT for traffic control	4.00	3.60	3.50	4.00	3.67
(4) overall quality of process of providing safe traffic control	4.00	3.88	3.79	4.00	3.89

What is particularly good about the process of providing safe traffic control?

- concern of both DOT and contractors is high (9 responses)
- provides a safe area for us to work (5 responses)
- allows for continued safe traffic flow (4 responses)

How could the process of providing safe traffic control be improved?

- provide greater presence of state and local law enforcement to enforce speed limits (9 responses)
- each job needs its own traffic control layout and plans, not standards, included in the bid documents (3 responses)
- provide more media coverage of construction zones, or "status updates" (3 responses)

N = 100 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

key functions on the survey (3.89 overall). The contractors also wish to see an increased presence of law enforcement on the projects, as is reflected by the short-answer question summary.

External Customer Evaluation

Law Enforcement Evaluation

The results of the Law Enforcement Evaluation are provided in Table 12. The Iowa State Patrol and County Sheriffs rated the Construction Offices performance in this

Table 12. Law enforcement evaluation: Provide safe traffic control

Questions	Mean response
(1) the intent of signage and markings displayed on Iowa highway construction work zones	4.40
(2) the reasonableness of delays experienced, considering the size of the project, when traveling through Iowa highway construction work zones	3.60
(3) visibility of construction workers on Iowa highway construction work zones	3.80
(4) the travel space allotted for traffic to pass through Iowa highway construction work zones	3.50
(5) your feeling of safety when traveling through Iowa highway construction work zones	3.90
(6) the overall quality of traffic control through Iowa highway construction work zones	4.00

What is particularly good about the traffic control through Iowa highway construction work zones?

- they are clearly marked (3 responses)
- the advance warning provided (2 responses)

What recommendations for improvement do you have?

- provide wider travel lanes (4 responses)

N = 10 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

area as good (4.00 overall). Their only recommendation for improvement is to provide a wider travel space through work zones.

National Carriers Evaluation

The results of the National Carriers Evaluation are provided in Table 13. The national motor carriers also rated the Construction Offices fairly high in this area (3.27 overall). From the ratings of the law enforcement officials and national motor carrier drivers, the steering team may wish to consider ways in which to increase the travel space allotted through their highway construction work zones.

Table 13. National motor carrier evaluation: Provide safe traffic control

Question	Mean Response
(1) the intent of signage and markings displayed on Iowa highway construction work zones	3.70
(2) the reasonableness of delays experienced, considering the size of the project, when traveling through Iowa highway construction work zones	3.06
(3) visibility of construction workers on Iowa highway construction work zones	3.29
(4) the travel space allotted for traffic to pass through Iowa highway construction work zones	3.04
(5) your feeling of safety when traveling through Iowa highway construction work zones	3.31
(6) the overall quality of traffic control through Iowa highway construction work zones	3.27

What is particularly good about the traffic control through Iowa highway construction zones?

- advance warning of construction sites (19 responses)
- nothing (8 responses)
- they are clearly marked (5 responses)

Does any other state(s) do a better job of providing safe traffic control through its highway construction zones? If so, which state(s) and why?

- no state does a better job (17 responses)
- it's about the same everywhere (6 responses)
- Kansas routes around on large projects (2 responses)
- Illinois provides a state trooper to monitor speeds at construction zones (2 responses)
- Ohio provides a state trooper to monitor speeds at construction zones (2 responses)
- Massachusetts and Connecticut provide a state trooper to monitor speeds at construction zones (2 responses)

N = 77 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

Number of Accidents

The number of accidents in interstate and highway construction zones in 1993 was 234 (Note: at the time of publication, the results of this measure for 1994 and 1995 were not yet available). Figure 5 presents this measure for the years 1989-1993.

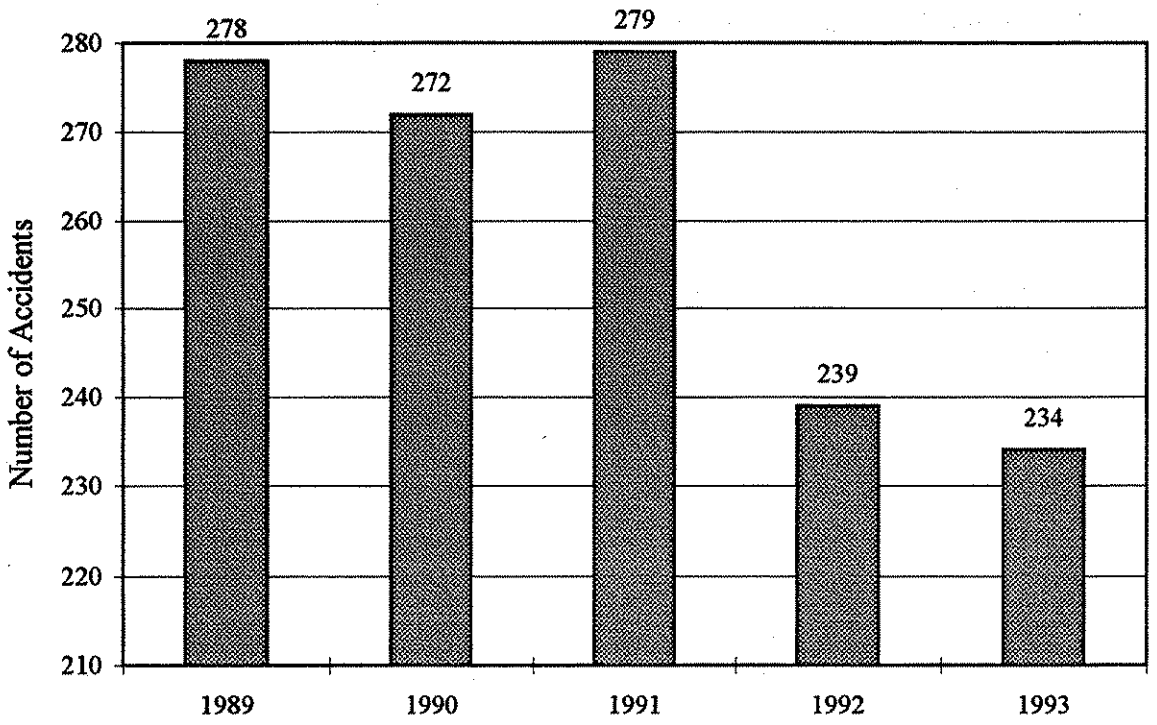

Figure 5. Number of Iowa DOT work zone traffic accidents

Field Force Evaluation

The field force evaluation of contractors' traffic control for 1995 (on a scale of one to ten) was 8.06. This data was obtained from the Contractor Evaluation Report (Form 830430) that is completed at the end of each construction project by the RCEs. These evaluations rate contractors on eleven items in the general areas of organization/management, work performance, safety practices, and equipment. The survey results are stored in a data base and are used to make decisions regarding the size of projects that contractors can bid. "Signing and Traffic Control" is one of two items in the category of safety practices.

Key Process: External/Public Communication

Baseline Data

The key process of External/Public Communication had one performance measure: external customer evaluation of timeliness, level of detail, accuracy, responsiveness to questions, and overall communication process. The steering team identified two external customers to whom this process would be most applicable, law enforcement agencies and contractors. A third external customer group, city and county engineers, was added later during the research project.

External Customer Evaluation

Law Enforcement Evaluation

The results of the Evaluation for Law Enforcement Agencies are located in Table 14. All the law enforcement officials gave very positive responses about communication with the Construction Offices. The means were all at least 4.00, in the good-to-excellent range. The written comments supported the numerical data, indicating that communication is clear, concise, and timely.

Contractor Evaluation

The results of the External Customer Evaluation Form for Contractors are located in Table 15. Contractors, overall, gave communication ratings of satisfactory to good (3.71). Communication with law enforcement agencies received the highest overall rating

Table 14. Law enforcement evaluation: Communication

Questions	Mean response
(1) the timeliness of advance notification about highway construction projects	4.40
(2) the level of detail of the information provided	4.10
(3) accuracy of the information	4.20
(4) responsiveness to questions	4.00
(5) the overall quality of communication	4.00

What is particularly good about the communication regarding Iowa highway construction work zones?

- Message is clear, concise, and timely (5 responses)
- They are excellent in responding to safety concerns (2 responses)

What recommendations for improvement do you have?

- Continue to give plenty of advance warning to traffic when approaching construction sites
- Suggest alternative routes

N = 10 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

Table 15. Contractor evaluation: Communication

Mean response based on type of work

Questions	Type of work: Earthwork n=16	Roadwork n=60	Structures n=16	Other n=8	Overall mean
(1) media	3.78	3.69	3.67	4.00	3.72
(2) utilities	3.20	3.61	3.62	4.00	3.58
(3) fire and rescue	4.00	4.10	3.62	4.00	3.99
(4) law enforcement	4.00	4.07	3.77	4.00	4.00
(5) general public	3.67	3.67	3.62	4.00	3.68
(6) land owners	3.44	3.56	3.62	4.00	3.58
(7) overall quality of public communication	3.73	3.68	3.69	4.00	3.71

How could public communication be improved?

- Need to notify utility companies more in advance (5 responses)
- Radio addresses (5 responses)

N = 100 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

of 4.00 or "good." Communication with land owners and with utilities received the "lowest" overall ratings of 3.58. This is still in the satisfactory-to-good range, but it shows that there is room for improvement.

Communication with utilities received a rating of 3.20 by earthwork contractors, the lowest of the mean responses. This is significant because the problems caused by lack of communication with utility companies will most often affect the earthwork contractors more than other contractors. Usually, utilities need to be relocated before earthwork can begin.

County and City Engineers

Favorable areas of performance mentioned in interviews with city and county engineers included the following:

- Working relationship, responsiveness to requests
- Help in training county staff
- Setting the example for and providing advice on contract administration
- Help in resolving issues between counties and contractors on county projects
- Invitation to attend pre-construction conference
- Promptness on all safety-related concerns
- Help in interpreting requirements on federally funded projects
- Timely news releases on closures and impending construction

The following were mentioned as areas in need of improvement:

- Invitation to attend regularly scheduled project meetings during construction of major DOT projects
- A joint coordination and informational meeting early in the planning phase
- A more satisfactory means of determining damage to haul roads and detours and corresponding compensation
- Work out a ton-mile agreement on haul roads
- Timeliness of responding to issues
- Provide the city/county engineers with copies of the project contract documents; i.e., treat like a contractor for purposes of providing project information

- Have the Transportation Center Engineers introduce new Resident Engineers. Perhaps an informal coffee. Provide an opportunity to discuss issues, working relationships, etc.
- Streamline procedures and shorten lead-time for approval of materials, mixes, etc., and collection of compliance information on federally funded projects administered by the city/county
- Provide as-built drawings in a more timely manner
- Pavement breaking in cities can adversely affect nearby structures, therefore, when breaking up pavement in urban areas, consider changing the specifications to require equipment and procedures which deliver energy in such a manner that nearby structures are not damaged.
- The "highway" approach to finishing concrete sometimes results in finishes and details that are not of the quality desirable for urban areas. City engineers should be consulted in the preparation of specifications for curbs, gutters, drainage structures, and finishing of concrete.

Data from Potential Benchmark Organizations

None of the potential sources of benchmark data provided performance measures for this process.

Other Studies by the Iowa DOT

The Iowa DOT has conducted at least two other studies to determine the effectiveness of its communication with the media and with the general public. A 1995 "General Public Construction Awareness Study" (Kragie/Newell 1995) surveyed drivers regarding whether they collect travel information before trips and which resources they use to obtain travel information. Fifty percent of the motorists indicated they do collect information about road and weather conditions; the other fifty percent do not. Of the respondents who do collect travel information, 49% use television and 23% use radio. In regard to obtaining work zone information, 51% indicated that a hot line (local or 800 number) would be useful. Thirty-five percent said that newscasts would be the best place to advertise this information.

The "Know Your Way Around" public information campaign (Iowa Department of Transportation 1995) distributed press kits, posters, newsletters, brochures, check stuffers and Hayden Fry public service announcements in an attempt to reach motorists. Of those surveyed, 46% reported the newsletter was the most helpful tool for disseminating information about road construction. The second most-popular item was the press kit which allowed the media to provide current information in a timely manner. Ninety-four percent of those surveyed were in favor of participating again in 1996.

Key Process: Providing Pre-letting Information

Baseline Data

The steering team identified two performance measures for the process of providing pre-letting information (information gathered by the Construction Offices for use by others within the Iowa DOT). Such information includes surveys and quantity estimates. The two measures are:

1) Internal customer evaluation of explanation, clarity of instruction, time allotted, feedback, defined procedures, and overall process of providing pre-letting information, and
2) External customer evaluation of timeliness and the overall process.

Internal Customer Evaluation

Internal customer evaluation was measured with the Construction Offices Employee Survey by employees of the Construction Offices both in Ames and in the field. The results of this survey are in Table 16.

According to the employees of the Construction Offices, the process of providing pre-letting information ranges from marginal to satisfactory. The question receiving the highest mean response was in regard to explanations of why the pre-letting information is needed. This question received an overall mean response of 3.34, or between satisfactory and good. The question receiving consistently lower ratings was number four, regarding feedback about performance. This question received the lowest overall mean of 2.42, between marginal and satisfactory. The lowest mean in each years-of-experience category

Table 16. Construction Offices Employee Survey: Providing pre-letting information

Mean response based on years of experience with Iowa DOT

Questions	Years of experience 1-10 n=35	11-20 n=47	21-30 n=33	31+ n=46	Overall mean
(1) level of satisfaction with explanations regarding why information is needed	3.32	3.04	3.37	3.58	3.34
(2) clarity of instruction I receive on what information is needed and how to obtain it	3.23	2.86	3.16	3.42	3.20
(3) level of satisfaction with the amount of time allotted to gather the information	2.70	2.75	2.42	2.92	2.69
(4) level of satisfaction with the amount of feedback I receive regarding my performance	2.60	2.35	2.26	2.44	2.42
(5) level of satisfaction with the defined procedures for handling requests for information	2.78	2.56	2.74	2.94	2.80
(6) the overall quality of the process of providing pre-letting information	2.84	2.65	2.78	2.97	2.85

How may the process of providing pre-letting information be improved?

- more lead time; get plans or proposals out to the field personnel well in advance of letting so we may find errors that will reduce work orders later (38 responses)

N = 161 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

was located in this area of feedback, which indicates that, although the process overall is less than satisfactory and has room for improvement, the area needing the most improvement is feedback.

As a result of these low ratings, a process improvement team was established to address this issue.

External Customer Evaluation

Two external customers provided an evaluation of the process of providing pre-letting information. These were contractors and DOT offices outside the Construction Offices.

Contractor Evaluation

The results of the External Customer Evaluation Form for Contractors are located in Table 17.

Table 17. Contractor evaluation: Providing pre-letting information

Mean response based on type of work

Questions	Type of work: Earthwork n=16	Roadwork n=60	Structures n=16	Other n=8	Overall Mean
(1) adequacy of contract documents	4.14	3.53	3.46	3.50	3.59
(2) amount of repetitive problems with pre-letting information	4.00	3.22	3.00	3.50	3.32
(3) quantity of information provided	3.71	3.53	3.38	3.50	3.52
(4) accuracy of the information provided	3.71	3.45	3.31	3.50	3.45
(5) timeliness of the information provided	4.00	3.39	4.00	3.50	3.60
(6) the overall quality of the pre-letting information	3.71	3.32	3.61	3.50	3.43

How can we provide better information for the preparation of your bid?

- Improve plan/photocopy quality (4 responses)
- Check plans more thoroughly for errors (3 responses)
- a pre-bid meeting with contractor would anticipate problems and changes (3 responses)
- address questions to someone involved in the project, not Contracts Office (3 responses)

N = 100 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

Overall, the responses regarding the process of providing pre-letting information were positive; all categories of contractors gave mean responses in the satisfactory-to-good range. Earthwork contractors gave the highest ratings for this process, with a few questions receiving means of 4.00 or higher. The area which received the lowest overall mean response was in regard to repetitive problems, with a 3.32 overall mean. This is not significantly lower than the other questions, however, it does indicate that, in comparison, this area is the weakest.

Written responses included in the evaluations indicated that the pre-letting information is accurate and is provided in a timely manner. Suggestions included checking plans more thoroughly to avoid problems. In general, the responses were positive, but room for improvement still exists.

Other DOT Offices

The results of the External Customer Evaluation for Iowa DOT Employees Outside the Construction Offices are shown in Table 18.

Table 18. Other DOT offices: Providing pre-letting information

	Mean response based on DOT office				
Questions	Design n = 7	Bridges & Structures n = 4	Contracts n = 4	Specific-ations n = 1	Overall Mean
(1) my level of satisfaction with the *accuracy* of the pre-letting information provided by the Construction Offices	4.40	4.00	3.25	1.00	3.79
(2) my level of satisfaction with the *completeness* of the pre-letting information provided by the Construction Offices	4.40	3.50	3.00	2.00	3.57
(3) my level of satisfaction with the *timeliness* of pre-letting information provided by the Construction Offices	3.00	3.25	1.50	3.00	2.67
(4) my level of satisfaction with the *amount of lead time* given for special notes, contract periods, etc.	3.57	2.00	1.25	3.00	2.64
(5) my level of satisfaction with the *reasonableness of requests* made by Construction	3.85	3.25	2.75	3.00	3.38
(6) the overall quality of the process of providing pre-letting information	3.71	3.25	2.50	2.00	3.19

How could the process of providing pre-letting information be improved?

- Provide information in a timely fashion (5 responses)

N = 16 Scale: 5 = Excellent 4 = Good 3 = Satisfactory 2 = Marginal 1 = Poor

The mean responses had a wide range among the different offices for different questions. The Office of Design gave the highest responses with means ranging from 3.00 to 4.40. The timeliness of the pre-letting information received the lowest rating from Design, while accuracy and completeness were given the highest ratings from that office. Bridges & Structures gave responses with a larger range and slightly lower means, from 2.00 to 4.00, or marginal to good. Question four, regarding the amount of lead time, was given significantly lower scores than the other questions for this process. Lead time was also given the lowest rating (1.25) of the six questions by the Office of Contracts, followed closely by timeliness which received a mean rating of 1.50. The Office of Specifications was least satisfied with the accuracy and completeness of the pre-letting information, averaging 1.00 and 2.00, respectively.

Overall, the areas receiving the lowest means were timeliness and the amount of lead time, with means of marginal-to-good, 2.67 and 2.64, respectively. These results indicate that, overall, information needs to be provided in a more timely manner. However, the accuracy and completeness of the information provided to the Office of Specifications is rated poor to marginal and also needs improvement.

Data from Potential Benchmark Organizations

None of the sources of potential benchmark data provided information indicating performance measures or other information for the process of providing pre-letting information.

Conclusions on Baseline Data

The previously described baseline data will guide the Iowa DOT construction offices as they develop a strategy for continuous improvement. The baseline data also provides a point of measurement that can be used to detect progress during improvement efforts.

The employees rated the Construction Offices between good and satisfactory in most cases and between marginal and satisfactory in a few. The questions that drew the highest rating involved the clarity of priorities in inspection duties, confidence that supervisors will back up decisions, and benefits of training. The questions that drew the

lowest ratings involved cumbersome reporting procedures, difficulties in resolving technical issues, lack of feedback when providing pre-letting information, lack of contractor knowledge in providing safe traffic control, and convenience in scheduling training.

The contractors rated the Construction Offices between satisfactory and good in most categories and between satisfactory and excellent in a few. In general, contractors rated the construction offices higher than the employees. Grading contractors noticed difficulties regarding pre-letting information on utilities. Contractors gave the construction offices the highest ratings with regard to their concern on providing safe traffic control. During preliminary interviews contractors expressed concern about differences in policies and procedures between residencies.

Surveys from motor carrier drivers rated the Construction Offices between marginal and good. Drivers expressed the most concern regarding the width of traffic lanes. They indicated that it was desirable to provide as much warning as possible in advance of a workzone. They recommended more law enforcement presence in work zones. Law enforcement officials rated the Construction Offices between good and excellent in their effort to provide safe traffic control.

City and county engineers reported good working relationships with the Iowa DOT Construction Offices. They indicated that they obtain prompt and helpful answers to their questions and are kept well informed regarding state construction projects. Improvements could be made by simplifying procedures (especially mix design approval), developing better ways to resolve issues on detours and haul roads, and providing more opportunities for input during the design phase.

Conclusions on Benchmark Data

The benchmark data have helped the Construction Offices identify other organizations that have a leadership position with regard to the key functional areas. The Construction Offices may then investigate these organizations to investigate how they have accomplished their achievements and to determine if those methods can be applied to the Iowa DOT.

This project identified several organizations as possible benchmarking partners. Connecticut DOT, Arizona DOT, Wisconsin DOT, Union Pacific Railroad, and the U.S. Army Corps of Engineers were selected because they have been developing improvement measuring systems. Minnesota DOT, Missouri DOT and Kansas DOT were also selected because of geographic proximity and similarities in road systems. Utah DOT was selected because it has recently embarked on the continuous improvement process.

It is desirable to maintain measures that can be compared with other organizations that administer construction projects. Such measures include cost of construction administration and inspection as a percent of construction volume, cost growth, schedule growth, as well as time required to process change orders and close out jobs. In comparison to other states that reported to the Connecticut DOT survey, Iowa appears to have among the lowest cost growth rates and inspection costs as a percentage of contract costs.

SUMMARY

This research project has provided the foundation for the Iowa DOT Offices of Construction to embrace continuous improvement. A quality steering team has been appointed which includes representatives from most levels and geographic regions of Iowa. Key functions, measures, internal customers, external customers, and potential benchmark partners have been identified. The first year's baseline data and benchmarks have been established, and two quality improvement teams have been started. The establishment of benchmarks for construction management organizations is groundbreaking research. Few construction organizations are involved in continuous improvement, and, despite extensive literature searches and personal telephone interviews, only one other state transportation Office of Construction (Connecticut DOT) was found to have attempted to establish benchmarks.

The research has identified the strengths of the Construction Offices and focused attention on areas for improvement. In comparison to others, the Offices appear to be leaders in cost effectiveness as measured by inspection and administrative cost as a percentage of construction cost and the cost overrun rate. Iowa is also relatively prompt

in finaling-out contracts. Contractors and law enforcement officials are satisfied with their interactions with the Construction Offices. Employees appear to have a clear understanding regarding the priorities of their inspection tasks, and they are satisfied with the training opportunities available from the DOT.

Employees want procedures to be streamlined, improved feedback when they provide pre-letting information, better scheduling for training, and quicker resolution of technical issues. Truck drivers would like to see several improvements in traffic control, including fewer delays and wider lanes. Earthmoving contractors would like better communication with utilities.

What remains to be done?

This research project has provided one year of baseline data and several initial benchmarks. A baseline for measuring improvement or lack of it cannot be established until three or four years of baseline data is processed and trends are established. It is necessary to look at several years' worth of data to eliminate statistical variations. The effect of the quality improvement teams must also be monitored. The teams were established to make noticeable improvements in the performance measures. Any improvements should be reflected in future data. The Construction Offices need to make periodic review of the key functions, performance measures, internal customers, and external customers. As data collection and reporting are automated and communications improve at the Iowa DOT, opportunities to develop new measures may present themselves. Also, as the steering team gains experience, it may be possible to focus on fewer, more relevant measures.

Now that some benchmarks have been established, the Construction Offices should determine how the organizations that were benchmarked have achieved their performance. Quality improvement teams may be formed to work with benchmark partners to improve specific processes.

Aside from the process improvement teams which have already been established, the following areas should receive first priority for further investigation by process improvement teams:

- empowerment of inspectors to make field decisions
- contractor knowledge of traffic control regulations and specifications and concern for traffic control in general
- width of travel lanes through highway work zones
- scheduling of training sessions, both the location and the time of year
- feedback for improvement of contract documents with the Offices of Design, Contracts, and Specifications
- communication between the Construction Offices and utility companies

Many opportunities for improvement will require cooperation with other Iowa DOT offices. The Construction Offices will be asking the Iowa DOT Quality Council to appoint an interoffice quality improvement team to develop recommendations for problems shared among offices.

What does this research mean to other construction management organizations?

Other construction management organizations can use this research project to start a continuous improvement process. The key functions, performance measures, customers, and questionnaires could serve as a point of departure for their efforts. For smaller organizations, the questionnaires may be replaced by interviews or group discussions on the topics covered by the questionnaires. It is recommended that such organizations appoint a steering team and follow the same general process that is documented in this report.

What does this research mean to other Iowa DOT offices?

Other Iowa DOT offices can use a similar procedure to start the continuous improvement process. The following is a list of lessons learned that will assist organizations in laying foundations for continuous improvement efforts:

- Identify potential steering team and quality improvement team members by asking for volunteers in employee surveys.

- When sending questionnaires, consider using motor carrier drivers to represent the driving public. These drivers are able to compare states and have substantial experience in navigating work zones.
- Find out what benchmark data will be available when performance measures are being developed. Otherwise, measures may be specified that cannot be benchmarked.
- After the steering team selects key functions and measures, interview other employees to find out if there is general agreement with the selection.
- Work closely with benchmark partners to insure measurements are made the same way and are comparable.
- Develop questionnaires to fax to benchmark partners. This will improve the uniformity of communication with the benchmark partners.

RECOMMENDATIONS

The following recommendations are made to the Iowa DOT Construction Offices:

- Continue to measure performance
- Expand benchmarking activities by seeking new data and benchmarking partners
- Plot data to show trends over a number of years
- Make additions or changes to performance measures as necessary
- Obtain external customer evaluations from city and county engineers by developing a written survey similar to others discussed in this report
- Obtain evaluations from contractors for the key process Continuous Feedback for Improved Contract Documents
- Develop a means to measure the number of repeat problems experienced.

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REFERENCES

Iowa Department of Transportation. "1995 'Know Your Way Around' Campaign Materials Survey Results." Ames, IA: 1995.

Kragie/Newell. "General Public Construction Awareness Study." Des Moines, IA: Iowa Department of Transportation, 1995.

"1995 Engineering Services Business Objectives." *Union Pacific Business Quarterly Newsletter*, 2nd quarter 1995.

Rolfe, Mark D. "State of Connecticut Department of Transportation Office of Construction Benchmarking Project." New Haven, CT: Connecticut Department of Transportation, 1995.

APPENDIX

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