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Automation of Bridge Inspection Documentation

ANDREW P. L'AMOUREUX

SPECIAL REPORT 100

ENGINEERING RESEARCH AND DEVELOPMENT BUREAU
NEW YORK STATE DEPARTMENT OF TRANSPORTATION
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AUTOMATION OF BRIDGE INSPECTION DOCUMENTATION

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Final Report on Research Project 207-1
Conducted in Cooperation With
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16. Abstract
All state-owned bridges are thoroughly inspected at least biennially. Resulting inspection data are used in tracking deterioration and planning maintenance activities. The current General Bridge Inspection Program accomplishes these objectives, but requires considerable time to check and process the data. Reports generated by bridge inspectors are often six months out of date by the time they reach the Main Office database. The study reported here developed an automated system allowing inspectors to record data electronically at the bridge site. Validity of the data is verified immediately through computerized edit-checks, reducing time required for later corrective efforts. In addition, data can be transmitted electronically to the Main Office, eliminating need for later keypunching efforts. It is concluded that 1) time required for inspection reports to enter the data base may be reduced an average of 19.5 calendar days, 2) about $30,000 in annual keypunch costs will be saved, 3) data quality should be enhanced by eliminating edit-check responsibilities for engineering personnel, and 4) an additional average 18.5 calendar days processing time for each report can be eliminated by submitting them singly. It is recommended that the Management Systems Bureau review the reporting process for further benefits of automating bridge inspection documentation.

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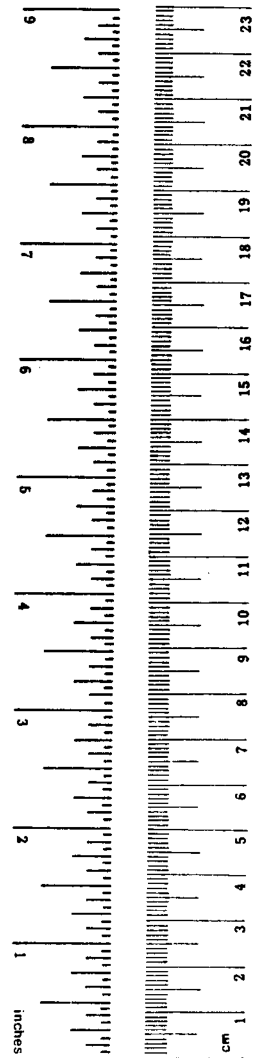
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

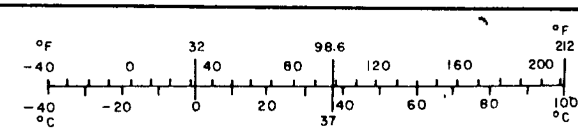
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

The General Bridge Inspection Program has undergone significant changes over the past several years. Once designed to schedule bridge maintenance activities, it now focuses on safety assurance issues. An accurate evaluation of structural safety is delivered through an intricate and sophisticated inspection program.

Inspection data are used to assess the vulnerability, serviceability, and condition of each bridge in the state. Management requires access to the Bridge Inventory and Inspection System (BIIS) data base for both short- and long-term planning decisions. Planning personnel and fiscal managers use inspection data to determine the levels of state and federal assistance necessary to formulate and carry out the Department's capital program. Lengthy delays in entering inspection reports into the data base make short-term planning difficult. The greatest pressure on the Inventory and Inspection Units comes from the requirement that information about state bridges be annually submitted to the federal government on a computer tape. In 1991, a federal program must be used to check the tape for errors before submission.

The importance of maintaining the current bridge inspection process tends to minimize efforts to identify and implement technological advances amenable to the collection and documentation of inspection data. The research project reported here, titled "Automation of Bridge Inspection Documentation," has been investigated into the use of portable computers to assist inspection personnel in collection, recording, and processing of inspection data. The project, approved for research by the Engineering Research Technical Advisory Panel and the Chief Engineer in October 1988, had its work plan approved by the Federal Highway Administration (FHWA) in May 1989.

RESEARCH OBJECTIVES

Goals were to develop a system that would allow the inspector to type inspection data into a computer at the bridge site, check the ratings for completeness and accuracy, store the ratings electronically for later use, and print out the inspection report for the inspector's signature. This concept of source data entry saves later keypunch effort, and building quality into the data up front saves repeated control efforts later.

CURRENT BRIDGE INSPECTION PROGRAM

To determine how automation could aid the bridge inspection process, it was necessary to study the policies and procedures of the Inspection and Inventory Units. The results of this study are described here.

The bridge inspection program involves the annual inspection and review of 11,000 bridges. Bridge inspections are performed by approximately 60 inspection teams, half of which are state forces. Team leaders, who must be licensed professional engineers, are supported by an assistant with a minimum of an associate degree. Some teams have a third member, usually a technician, to assist in data collection.

The process begins when the Main Office sends each regional office a list of bridges to be inspected in the upcoming year. Each regional office is then responsible for breaking down this list into a schedule for each inspector, subject to constraints such as equipment availability and the need to avoid the same inspector examining the same bridge in two consecutive inspections.

When an inspection is scheduled, the inspector proceeds to the site to make a thorough evaluation of the bridge's condition. The inspector examines the various components of the bridge, including abutments, deck, beams, etc. Each component is given a numerical rating in the range 1 (potentially hazardous) to 7 (new condition). Blanks or zeroes are not allowed. A rating of 9 is significant because it represents an "unknown" condition. Unknown ratings are not allowed on certain critical bridge elements such as primary members. The ratings are recorded on TP349 and TP350 forms supplied to the inspector by the Main Office. In addition to a numerical rating of each element, the inspector is also required to take photographs, verify plans, draw sketches, take scour measurements, and write comments describing the bridge's condition in more detail. A written comment is also required for each element rated 4 or less.

When site inspection has been completed, the inspector returns to the regional office to complete the inspection report. Photographs must be developed; plans, sketches, and scour tables must be attached to the forms; and often the comments will need to be recopied to assure legibility.

Each inspection report is then examined by a regional quality control engineer before submission to the Main Office. Numerical ratings are checked to make certain that they fall within the allowable ranges; presence of any required photographs, plans, sketches, or scour tables is verified; and it is determined whether the comments adequately explain and support the ratings. If not, the inspector and Q.C. modify the ratings and/or comments until a consensus is reached. Then the completed report is grouped with others into a submission of at least 25 to be sent to the Main Office.

When the submission reaches the Main Office, it is first examined by an auditor, who verifies that all numerical ratings fall within the allowable ranges and that any required photographs, plans, sketches, or scour tables have been included.

The submission is then forwarded to a liaison engineer (L.E.) for detailed review. The L.E. verifies that all numerical ratings fall within the allowable ranges and that any required photographs, plans, sketches, or scour tables have been included. In addition, the L.E. uses his engineering judgment and experience to decide whether the ratings are justified by the comments and photographs. The L.E. is also responsible for ensuring uniformity across the state -- for example, that a rating of 4 on a certain bridge deck represents nearly the same condition as a 4 on any other bridge deck.

Once the L.E. has approved the submission, it is grouped into a batch to be sent to Electronic Data Processing (EDP). The numerical ratings are keypunched onto the Department's Unisys A15 mainframe computer. These ratings are then examined by the pre-edit-check program (which looks for inappropriate 9 ratings) and the edit-check program (which looks for missing ratings).

When the quality of the inspection data has been assured, it enters onto the Bridge Inventory and Inspection System (BIIS) data base on the mainframe. The BIIS data base is used for long-term planning and bridge management issues, and to create a summary tape describing the condition of the state's bridges, which is annually sent to the federal government.

It should be noted here that this report describes the policies and procedures in place as of January 1990. Some modifications and improvements have been made since that time.

SYSTEM REQUIREMENTS

As a result of studying the current bridge inspection process, a number of system requirements were identified. The system must allow the inspector mobility to access all elements of a bridge. This precludes adding any bulky or heavy equipment to the inspector's load. Ideally, the system would be no larger than the clipboards they use now.

Inspectors need the freedom to examine bridge elements in any order, and to take as much time with each element and the entire inspection as is necessary. Multi-span bridges may take several days to complete, necessitating the ability to store partial inspection information in some form. After the inspection has been completed, the inspector needs to collate the information into the format that defines a bridge inspection report. Easing comment documentation was unanimously requested by the inspectors surveyed.

A literature search was conducted to determine whether existing data collection systems could be amended to fit the New York State bridge inspection program. There are currently no data collection systems that can automate all inspection report data requirements required by the Department.

The ability to perform an in-field edit-check requires a programmable computer. The most applicable of these are hand-held computers, electronic clipboards, voice activated devices, and laptop computers.

Hand-held computers are powerful enough to support programs but suffer from non-standard keyboards and small display screens. However, these problems may be overcome by skillful programming. Contact has been made with an experienced vendor who has developed other inspection systems. This option seems promising, though further investigation is required.

Electronic clipboards provide an advantage in their ability to read information in hand-printed form, and produce hardcopies in a typewritten format, thereby reducing illegibility. Also, the system stores and reprints sketches.

Disadvantages are the heavy computer and battery pack, and problems differentiating between connected characters, slowing data entry to an unacceptable pace.

Voice-activated devices are available in a wide array of capabilities and costs. The most elaborate systems provide two-way verbal communication between the user and a modified personal computer. Data is transmitted via a microphone headset over radio frequencies. The software, however, relies on an expansion board not available for laptop computers. In addition, such systems are expensive, approaching tens of thousands of dollars. On the other hand, much simpler systems are available for a few hundred dollars. These devices are unable to distinguish breaks between words in normal speech. Input must be done slowly and within a limited vocabulary. Since technology in this area is changing so rapidly, consideration of this option should be relegated to the future.

Laptop computers are compatible with existing desktop computers and are generally just as powerful. They include full-size keyboards and display screens to ease data entry, and operate at the same (or better) speeds as desktop models. In addition, they are a proven technology and are currently used in the Department for other purposes. For these reasons, laptop computers were chosen for the prototype system in this project.

RESEARCH PROCESS

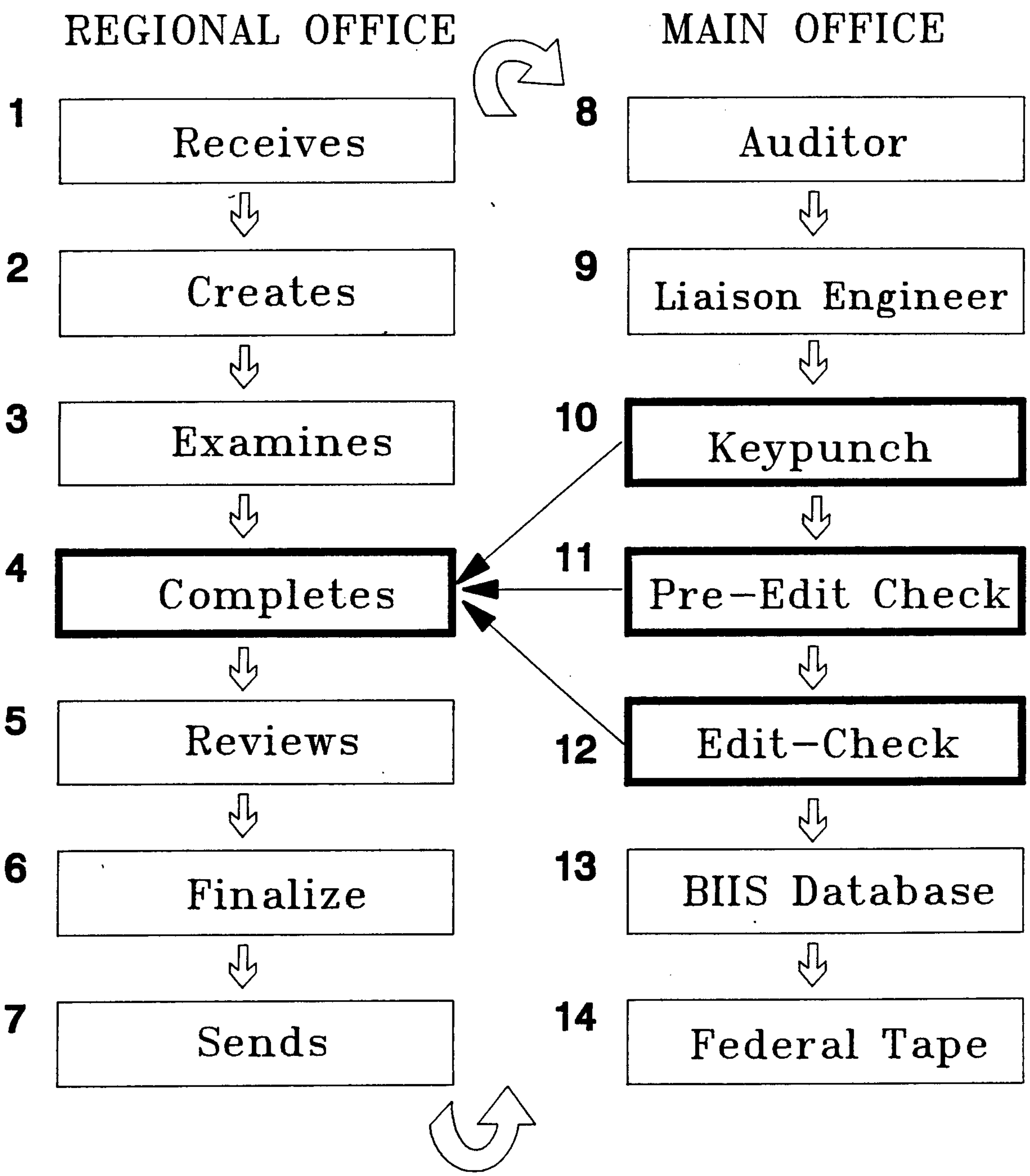
A users' group of bridge inspectors, quality control engineers, liaison engineers, and Inventory and Inspection Unit managers were assembled to provide researchers with guidance on the practices and procedures of the bridge inspection program. Bridge inspection personnel were queried regarding aspects of their responsibilities, work schedules, report preparation activities, and review procedures that could be automated.

The Computer Service Bureau (CSB) assisted with defining compatibility requirements with the mainframe BIIS program and the practices of uploading and downloading files. Specifications for the edit-check, pre-edit-check and weighted condition rating programs were used as the template to develop programs for use on a portable computer.

It is important to note that the edit checks are performed at the very end of the review process, and that errors found here may require tracing back along the process all the way to the inspector for correction. It is believed that if the edit checks were moved forward in the process, detectable errors could be corrected more quickly and efficiently.

The goals of this project are shown in Figure 1. The keypunch effort is to be performed by the inspector at the site, and the pre-edit-check and edit-check programs are to process the inspection data immediately instead of after many stages as in the current process. If these changes are implemented, it is anticipated that verified inspection data could enter the BIIS data base an average of 19.5 calendar days sooner than now. A full analysis of the processing times involved is in Appendix A.

Figure 1. Proposed reporting procedure.



SYSTEM DESCRIPTION

As a result of the investigation, minimal system requirements are defined as ability to store and recall data; be programmable to include the edit-check programs; facilitate inspection documentation, especially the input of comments; be expandable to include future enhancements; be portable; and be capable of withstanding the extreme environments encountered in the field.

Various portable computer systems were evaluated by the Engineering Research and Development Bureau (ER&DB). The hardware system selected was the Zenith Supersport 286 Model 40. This has a hard disk capable of storing 40 megabytes of information -- enough for considerable programs and data. The programming language used was Turbo Pascal Version 4.0. CSB specifications were used to assure compatibility with the BIIS and other mainframe data management systems. The program meets Department standards for software and hardware systems and is capable of producing data files that can be entered directly, either singly or batched, into the current BIIS data base.

The software developed maintains existing bridge inspection data collection formats; performs an automatic field check for completeness of inspection record; assures an elementary level of data quality through an automatic field check for validity of inspection date, agency code, inspection type, inspection rates, and general recommendation; and performs an automatic field check to ensure that the 9 ("unknown") rating is properly used. (Elements with restricted use of "unknown" ratings include bridge abutment components, wingwalls, stream channel, approaches, deck elements, piers, superstructure, and utilities.)

Existing TP349 and TP350d inspection forms were used as the input format. Sections of the forms are displayed so that data entry format is similar to the current system. The input process leads, but does not restrict, the user to the next input category. Random access within and between screens for data entry and editing is allowed.

The system assists in report preparation by automatically replicating bridge inspection date, bridge identification number and region and county codes onto the TP350 form(s); features a self-generated coded comment dictionary with recall; allows inspectors to perform a partial inspection and recall an incomplete inspection at a later date; prompts users for mandatory comments pertaining to time on and off the site, inspection team members, and equipment used; automatically displays region and county names with the input of R/C code; calculates the weighted condition rating; signals inspectors to provide comments for elements rated 4 or less; automatically combines comments, element, and rating for report hardcopy; displays edit-check errors; and produces a printed copy of the inspection report.

The system can store final reports in a read-only form, preventing data alteration. The system also protects against data loss (in the event of system failure) by writing each entry to the hard disk every time the ENTER key is pressed.

RESULTS

Inspection teams in Regions 2, 3 and 8 used the system for approximately two months. Inspectors and quality control engineers involved in the testing were asked to evaluate the performance of each element of the system. Their suggestions and comments are continually being solicited so the system may better meet their needs.

Little training was required to use the system. Inspectors were introduced to the laptop, given three pages of documentation, and shown a demonstration of the program. The entire process consumed only a half-day.

With the present system there is considerable redundant data entry. Laptops are too large to be carried during the course of the inspection, which forces inspectors to record all of the inspection data on the clipboards they currently use, and then at a later time, enter this data into the laptop. This redundancy is undesirable.

Still, bridge inspectors were receptive to using the laptops for the documentation of their reports, even though limited use and inexperience with computers slowed data entry time to approximately 45 minutes per report. As inspectors become more familiar with the keyboard, data entry time should be reduced.

Although portable printers were not evaluated, hardcopies of the report can be generated in regional offices. Those surveyed agreed that printed output greatly improves report legibility.

FUTURE ENHANCEMENTS

Inspectors who evaluated the system asked for several enhancements: automatic entry of header information, ability to merge comments stored in personal dictionaries, and more space for written comments.

"Header information" refers to bridge data currently supplied on the preprinted TP349 and TP350 forms, such as Bridge Identification Number, location, etc. This rarely (if ever) changes, which is why it is preprinted by the Main Office. However, the current program does not have access to this information, which forces inspectors to spend time entering it in the report. Automatic transcription of this information onto the simulated TP349 and TP350 forms on the laptop would have the most immediate positive impact on the system, significantly reducing input time.

An expert system for steel bridge superstructure inspection and evaluation is being developed at the University of Buffalo through the University Transportation Research Consortium. The system is being designed for personal computers and if successful could be installed on the laptop. This will extend the inspection effort by providing ability to interpret inspection data and diagnose structural faults.

Other suggestions and modifications to the system include using comments as captions for photographs, installing a program to facilitate workload scheduling and equipment and personnel needs, providing the ability to comment on significant discrepancies between the condition rating and the general recommendation, including the load rating and inventory rating forms on the laptop, and creating an inventory of non-redundant fracture-critical (100-percent hands-on) checklist for each bridge.

A personalized tracking program that assists inspectors and/or quality control engineers to file reports within the allotted time could be installed on the system. Inspectors would be reminded of days passed since the date of inspection, and alerted when their number nears a deadline. Main office-supplied inspection schedules driven by Technical Advisory 85-03 may limit the time inspectors can devote to completing inspection reports. Inspectors should be able to deviate from the proposed inspection schedule if it interferes with completing reports in a timely manner.

Personnel using inspection data have expressed the need to transfer data within and between offices. Specifically, bridge maintenance personnel regard bridge condition rating information as important in developing a maintenance schedule. (Bridge condition ratings are generated by the mainframe system when data have been entered onto the system.) Modems were installed on the laptops, but data transfer has not yet been evaluated.

Hand-held computer systems offer another possibility -- automation of comments. Contractors have developed software for other inspection tasks that allow the inspector to choose words from a limited technical dictionary. A few keystrokes can be used to generate a brief sentence. This could greatly speed up writing of comments and, perhaps even more significant, could allow for computer processing of comments, including sorting on key words.

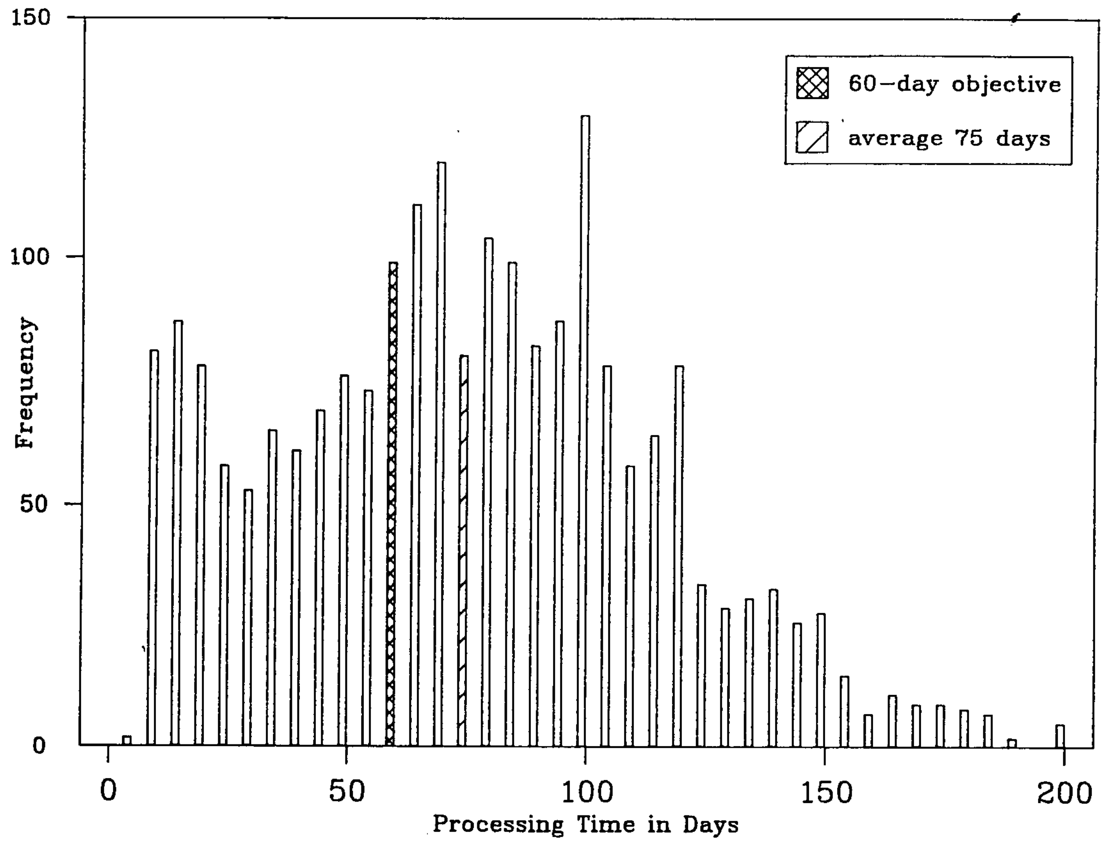
CONCLUSIONS

It is difficult to measure whether the system facilitates report preparation, because no reports using it have yet been submitted. Timely arrival of system-generated reports in the Main Office within the filing deadline is the measurable criterion to determine system success. Field data entry must be minimized before the system can help inspectors. Because of this, replicating header information onto the TP349 and TP350 forms on the laptop is a top priority. To get more input from users, additional inspectors from other regions should be included in the project.

Data collected by the NYSDOT bridge inspection program includes comments, photographs, and diagrams (along with other methods to document bridge condition). No single device can be designed to automate all aspects of inspection documentation. It is currently believed that this system will provide benefits to inspectors via time savings.

According to the Data Entry Unit of the Computer Services Bureau, the Department spent $28,806 to keypunch inspection reports during the period December 1989

Figure 2. Time required for inspection reports to reach the Main Office.



through November 1990. If an automated system was implemented for all state and consultant inspection teams, considerable savings to the Department would result by eliminating the keypunch effort.

It has been shown that the pre-edit-checks and edit-checks can be performed in the field. The significance of assuring data quality at the source cannot be overstated. If this concept is implemented, verified inspection data should reach the BIIS data base an average of 19.5 calendar days sooner than now. In addition, the quality control and liaison engineers could spend their time on more advanced data quality issues instead of performing edit-check functions.

During the study of policies and procedures of the Inventory and Inspection Units, considerable information concerning processing times was developed. This information is detailed in Appendices A, B, and C. Figure 2 shows the time required for bridge inspection reports to reach the Main Office.

Currently, regional offices receive their bridge inspection data by downloading from BIIS on the Main Office mainframe. Because of the considerable processing time required for inspection information to enter the BIIS, it is out of date. On the other hand, if the proposed system were implemented, regional personnel could access raw inspection data immediately to build a real-time database. Although these data would not have passed all of the Main Office checks, they might still be useful for planning purposes. In other words, mostly good data might be better now than perfect data three months from now. And, as verified inspection information enters the BIIS, it could be sent to the regions to update their databases.

Hand-held computers offer considerable promise. By eliminating the clipboard, all legibility problems vanish. By automating comments, great time savings for the inspectors will appear. Just as significant will be automated access to those comments, which will increase the use of the inspection reports. These devices should be investigated further.

Changing the bridge inspection process by adding automation may change other practices in ways that have not been foreseen. Effort outside ER&DB needs to be expended to determine how to gain the maximum benefit from automation of bridge inspection documentation.

RECOMMENDATIONS

A management systems review of the Bridge Inventory and Inspection reporting process should be conducted to further evaluate the benefits of using automated data collection.

APPENDIX A. INSPECTION REPORT PROCESSING TIME AND ERRORS

TIME REQUIRED TO PROCESS INSPECTION REPORTS

Processing time requirements at several stages within the established procedures were studied to assist in determining when an automated system would be most beneficial. The figures stated here pertain <u>only</u> to bridges both inspected and submitted in 1989. All times given are measured in calendar days, not business days.

A total of 1267 bridges have both the report completion date and the Q.C. review date in the MicroBIIS data base. (The rest were not listed in sufficient detail to be usable here.) These data, from Regions 5, 7, 9, 10, and the Thruway along with consultants in Regions 1, 2, 4, 5, 6 and 9, were used to determine the average number of days required to prepare and review inspection reports.

Data in the MicroBIIS file include dates of report preparation, quality control review, and preparation of submission. The following linear graph illustrates the average processing time at each step:

```
          34.3              33.7              18.5                =    86.5
   I----------------I----------------I----------------I               days
Inspection        Report            Q.C.          Submission           total
   date          completed          review           memo
```

The average time between the inspection date and submission to the Main Office is 86.5 days. Of the 1267 bridge reports tracked, 979 (or 77.3 percent) failed to meet the 60-day filing objective.

Inspection reports may include photographs, diagrams, scour tables, comments, and special documentation. Because of this, a complete inspection report cannot be generated at the site. Inspectors often defer completion of reports in order to maintain bridge inspection schedules. An average of 34.3 days are required to complete an inspection report.

The importance placed on maintaining inspection schedules affects communication between inspectors and the quality control engineer. The problem is compounded when inspectors and the Q.C. engineer are working out of different offices. An average of 33.7 days are required to review, discuss, and amend inspection reports. An average of 18.5 days are needed to prepare a submission of at least 25 reports, in accordance with Technical Advisory 87-02.

An additional 2083 inspections were tracked through submission review lists, liaison engineer tracking reports, and BIIS error reports. This data set cannot be broken down to determine the number of days needed to complete or quality control inspection reports. Data from state forces in Regions 2, 3, 4, 5, 6 and consultants in Regions 1, 2, 6, 7, 8, and 9 include inspection dates, submission memo dates, liaison review dates, Electronic Data Processing (EDP) dates, dates reports entered the edit-check program, and dates reports were entered onto the BIIS.

The average processing time between the inspection date and submission to the Main Office using these data is 75.1 days. Of the 2083 bridge reports tracked, 1328 (or 63.8 percent) were not filed within the 60-day objective, as shown in Figure 2.

The average number of days for each stage to update reports into the BIIS data base is as follows:

```
         75.1          48.1        9.6        9.9        6.9            =   149.6
    I--------------I----------I---------I---------I---------I               days
Inspection      Submission    L.E.       EDP        Edit-     BIIS          total
   date         memo date    review                 check
```

These data were obtained by calculating the number of days that had passed between each stage of the inspection process. This effort involved reviewing many pages of Inventory and Inspection documentation. This was necessary because no automated system is now in place to track inspection reports through all phases of generation and processing.

Note that the total time from inspection to submission of 86.5 days determined from regional MicroBIIS information does not agree well with the total time of 75.1 days determined from Main Office Inventory and Inspection documentation. This is because these data sets were used as available, and were not selected from the general population of bridges inspected in 1989 by any random sampling process.

TRACKING ERRORS

Before each report is reviewed by liaison engineers, each submission is reviewed for compliance with Technical Advisory 87-02, and then forwarded to an auditor who reviews reports for compliance with edit-check program standards.

Of 12,000 reports reviewed by the auditor between November 25, 1988 and December 31, 1989, 1,150 (9.3 percent) contained errors. Some 690 were rejected because of edit-check errors -- blanks where numbers are expected, invalid numerical ratings, etc. An additional 83 reports were rejected for legibility problems. A total of 773 erroneous reports (or 67.2 percent) would have been eliminated by the proposed system. The prevalent reason for rejecting the remaining 377 reports was evenly split between missing photographs and missing signatures. Minor problems detected at this stage are often resolved using the facsimile machine or telephone. After auditor review, reports are forwarded to the appropriate liaison engineer to approve reports for processing by EDP.

Once the reports have passed these stages, submissions are batched and forwarded to be keypunched onto tape, then read by the edit-check programs. Each batch contains an average of 366 reports. Inventory and Inspection policy is to disallow all reports in the batch from being updated on the BIIS if any errors are detected by the edit-check program.

Sixty-six of the 5,856 reports (or 1.1 percent) submitted during 1989 were rejected by the edit check program. Although the error rate is small, each of the 16 batches had at least one error, preventing the batch from being uploaded onto the BIIS. An additional 6.9 days, on average, are required to correct mistakes and re-enter inspection reports onto the data base. Forty-five of the 66 errors were traced back to the regional office for correction. The predominant edit-check error was an incorrect or missing contractor code, which would have been caught in the field by the proposed system. The remaining 21 errors were incorrect keypunching.

Significantly at least five people -- the inspector, the quality control engineer, the auditor, the liaison engineer, and the BIIS manager -- spend various amounts of time seeking and correcting errors the proposed system would eliminate in the field, freeing them for more significant tasks.

APPENDIX B. DATA USED TO DETERMINE REGIONAL OFFICE PROCESSING TIMES

Data retrieved from MicroBIIS to determine average number of days to complete inspection reports, perform quality control, and prepare submissions.

REGION	INSPECTION GROUP	NUMBER OF REPORTS
1	Wilber-Smith	29
2	Stetson-Harza	320
2	Clark	316
5	State	42
5	DeSerio	8
6	Bergman	1
7	State	86
2	State	321
9	IKW	19
10	State	84
Thruway		67

	Total	1,293

SUMMARY STATISTICS

Averages:

```
        34.3              33.7              18.5              =   86.5
  I----------------I----------------I----------------I            days
Inspection        Report           Q.C.         Submission        total
   date          completed        review           memo
```

Std. Dev.	29.4	30.2	15.6	33.5
Variance	865	914	245	1122
Minimum	0	0	0	11
Maximum	139	161	120	219

Note that processing times vary widely and a given report could pass from one stage to the next in the same day (0 time) or could require months.

APPENDIX C. DATA USED TO DETERMINE MAIN OFFICE PROCESSING TIMES

Data gathered from Inventory and Inspection Unit documentation.

REGION	INSPECTION GROUP	NUMBER OF REPORTS
1	Wilber-Smith	148
2	State	39
2	Stetson-Harza	157
3	State	143
4	State	209
5	State	184
6	State	251
6	Bergman	240
7	Maniktala	171
8	Lichtenstein	334
9	IKW	210

	Total	2,086

Note: 2,083 reports were usable in determining averages. Three reports were unusable because data were illegible.

SUMMARY STATISTICS

Averages:

```
              75.1          48.1        9.6        9.9        6.9         =  149.6
   I--------------I----------I---------I---------I---------I       days
Inspection      submission    L.E.       EDP       Edit-      BIIS       total
   date         memo date    review                check
```

Std. Dev.	40.0	33.1	13.9	3.6	6.4	46.7
Variance	1602	1095	194	12.9	41	2179
Minimum	4	2	0	6	0	48
Maximum	250	139	74	22	23	303

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