

IMAGE PROCESSING OF FACSIMILE DATA REPORTING

INITIAL TECHNICAL ASSESSMENT

Prepared For

CASIC Committee on Technology Testing

by

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I. TECHNOLOGY DEFINITION

Facsimile Data Reporting includes any use of facsimile technology by respondents to return completed or filled out survey questionnaires or reporting forms to data collection agencies rather than returning them by mail, courier, or other means¹.

Image Processing is the use of computer software to recognize the electronic images (not paper reproductions) which are received by facsimile transmission, extract the data and store them directly into a database².

For the purpose of this assessment, Image Processing of Facsimile Data Reports (IPFDR) is defined as the process of receiving questionnaires, as an image file, via facsimile transmission, and using computer software to read the survey image files. The system must 1) be available, over the public telephone network, twenty-four hours a day, 2) be capable of determining the survey and respondent to which the questionnaire corresponds, 3) have the ability to display the document on a computer terminal for keying, and 4) have Intelligent Character Recognition (ICR) capability³. Additionally, the system should have the capability of FAXing the survey instrument, an advance notice, or a nonresponse reminder to the respondent. Finally, the system should be able to perform all the above system requirements in a completely paperless environment.

¹The use of facsimile technology for return of questionnaires has grown rapidly in recent years, especially for establishment surveys. Sometimes this method of return is initiated by respondents as simpler, faster, or more convenient for them. Other times, it has been suggested or encouraged by the collection agency as an alternative to return of forms by mail.

²When collection agencies receive survey returns by facsimile, most currently produce a paper copy of the form generated by the FAX machine. This FAX paper copy typically is then processed by the same methods as forms received by mail, usually clerical key entry. Paper processing of FAX returns is not the subject of this report.

³Ability to recognize hand-printed numbers and letters (both upper and lower case), as well as typed responses and checked or filled in boxes and circles.

II. QUESTIONS/ISSUES

1. **Stage of Development, Stability of Technology. Is this an emerging, untested technology, a well established one, or something in between?**

In assessing the "Stage of Development" of IPFDR, two areas are considered;

a) facsimile technology used to receive the transmitted forms and b) ICR technology which converts the image files⁴ to ASCII.

- a) The facsimile technology is well established. There are numerous companies manufacturing facsimile machines. "Currently, there are at least 60 U.S. based companies manufacturing fax modems" (Skipinker, 1992). In recent years, we have seen the introduction of the less costly FAX board. These boards enable personal computers to send and receive facsimile copies (See Attachment 5). Image files received via facsimile are stored either in one of several TIFF formats⁵ or some other image format. Perhaps the best evidence that this is an established technology is the fact that one can purchase a FAX board for under one hundred dollars.

- b) In May of 1992, the Census Bureau sponsored an ICR Conference at NIST (National Institute for Standards and Technology). The results of the conference (see Attachment 3) suggest that the software to recognize hand-printed alphanumeric text is usable but still needs development. The NIST results suggest that these products are at least 95% accurate at recognizing hand-printed numbers, at least 90% accurate at recognizing upper case hand-printed letters and 84% at recognizing lower case hand-printed letters. It should be noted that the NIST images were obtained by scanning, and that these results might not be duplicated when performed with FAXed images (see footnote 10). On the other hand, no special instructions were given to the respondents in order to increase the accuracy of the recognition software.

In addition to hand-print recognition, some of the "lower level" features of an IPFDR system include displaying of form images on a computer terminal for clerical keying, automatic check-in of survey forms⁶, and Optical Mark Recognition (OMR) - i.e., the ability to recognize checked or filled-in boxes.

⁴These are the FAX files received by the system.

⁵See Alfred Poor, *PC Magazine* December 17, 1991 for a detailed introduction to TIFF files (Attachment 1).

⁶That is, the system can be configured so that forms are identified and processed as soon as they arrive into the system.

2. **Range of Potential Applications. Interviewing, copying records, listing/sampling, archiving, accepting diagrams, portability, etc.**

There are currently numerous applications of both facsimile and ICR technology. Some of these involve data capture and deposit, advertising/marketing, polling, and inventory control. (See Attachment 2). The Bureau of Labor Statistics (BLS) has recently used facsimile technology as a substitute for telephone and mail to notify Current Employment Statistics Survey (CES) establishments of the approaching reporting deadline (Rosen, 1992).

Statistics Canada receives survey forms from approximately 5000 respondents by FAX each month. Several survey questionnaires are received each month in Industry and Business Divisions at the Census Bureau. Industry Division's M3 survey has approximately 3000 respondents; of these, approximately 900 report by FAX. Business Division receives 1.5%, 2.6% and 5.5% of its survey forms from its Service Annual Survey, Motor Freight Transportation and Warehousing Survey, and Annual Communication Services Survey respectively.

The Swedish government is currently using ICR technology as a replacement for data keying of parking violation reports. Currently the system identifies 2,000 - 3,000 characters an hour using a PC 386/486 level networked microcomputer system.

According to Bill Nicholls, Statistics Sweden is exploring the application of ICR technology to surveys, especially enterprise surveys with one-page forms similar to many of those used by the Census Bureau's Industry Division.

The Wyoming Department of Revenue recently used ICR technology to develop a data capture and deposit system (DCSD). This system was used to recognize hand-printed state tax forms and then store the data into a database. For both this and the Swedish examples, one sets a lower bound for the level of confidence for each character which is to be recognized by the ICR. If the ICR's level of confidence falls below this lower bound, then the related form is displayed on a computer terminal and the doubtful character is flagged for clerical verification. It is their intention to integrate the data capture and deposit system with a FAX server. "The fax server will accommodate inbound tax returns filed electronically in the future. Outbound fax transmission provides a general purpose, low cost communication vehicle to other departments and to remote users" (Farmer, 1992). Several banks use ICR software to perform check processing. The postal system uses ICR software produced by AEG, Inc. to sort mail (see Attachment 2).

Each month, *PC World* magazine conducts a survey of its readers. Respondents are asked to indicate whether they read a specific article and the degree to which they found it useful. After answering the questionnaire, respondents are asked to FAX it back to *PC World*. The FAXed-in image is then interpreted by ICR software and the

responses are stored in a database (See Attachment 3).

This October, AT&T developed a FAX Image Recognition SysTem (FIRST) for the FTS2000 Service Order Requests. FIRST will process customer service requests for FTS2000 Authorization Codes originating from customer fax machines⁷.

ICR technology is also used in pen computing.

3. **Initial Investment Required. How much does it cost to begin working with/exploring the technology? Include procurement, training, staff costs, etc. Do not include use for data collection costs.**

Two different systems were investigated for cost. The first uses a software implementation of neural networks to do the ICR. The second uses a neural network board for the ICR.

Estimate 1:

The costs used here are those for Nestor Inc.'s ICR and related software and hardware.

Software: \$6500

- Cardiff Teleform Forms Creation and ICR Software with Developer's Toolkit ⁸	\$4500.00
- ScanFix's Image Optimizer ⁹	\$1000.00
- Development/Integration Software	\$1000.00

⁷Both PC World and AT&T's use of Image Processing are paperless. The electronic image files are interpreted by the ICR software as soon as they arrive. The extracted data is then stored directly to a database.

⁸The developers toolkit is used to integrate Cardiff Teleform with other Windows products. Cardiff Teleform uses Nestor Inc.'s ICR software.

⁹This software serves several purposes: it is used to remove background noise from FAXed images, as well as to re-align images which were fed into a FAX machine at an angle. It also performs forms removal which is the removal of vertical, horizontal and other lines which aid the respondent in completing the form. The removal of these lines greatly reduces the amount of disk space required to store the images.

Hardware¹⁰: \$7000
 - PC 80486 Tower Configuration
 1.2 gigabyte hard disk
 32MB RAM \$6500.00
 - Intel SatisFAXtion 400 FAX Board \$500.00

Total cost of hardware and software: \$13,500.00

Staff Cost:

Training: Two months self study. Development of programs to perform software/system interface - Programmer 2 months \$15,000

Estimate 2:

The costs used here are those for the HNC ICR development kit and related software and hardware. The primary difference between this and estimate 1 is that HNC's product includes a special neural network board which is inserted in the computer's chassis.

Software: \$2,000
 - ScanFix's Image Optimizer \$1,000.00
 - Cardiff Teleform:
 Forms Creation Software: \$1000.00

Hardware: \$29,000
 - HNC's Balboa 860-OCR \$20,000
 Maintenance \$2000.00/Year
 - PC 80486
 Tower
 1.2 gigabyte hard disk
 32MB of RAM \$6,500

¹⁰The Wyoming Department of Revenue's Data Capture and Deposit System was initially configured using an 80386 personal computer; however, the intention is to switch to an 80486 for the increased speed. The system also has a 1.2 gigabyte hard disk which the department has determined to be adequate to handle the large image files. An overview of Wyoming's Data Capture and Deposit System can be found in Attachment 2, Applications.

- Intel SatisFAXtion 400
FAX Board \$ 500.00

Total cost of hardware and software: \$31,000.00

Staff Cost:

Training: two months self study. Development of programs to perform software/system interface - Programmer 2 months
\$28,000

4. **Ease or Difficulty of Setup or Authoring. How much work is necessary to prepare it for use in a specific survey at the present time?**

The HNC product, Balboa 860, comes equipped with two software development kits. The first, "QuickStrokes", uses screen prompts and menus. It is designed for quick development of applications. The second development kit comes with a C compiler, Fortran compiler, assembler, linker, debugger and simulator. It is used to design more complicated applications. According to Earl Atwood, Director of the Technical Division of the Wyoming Department of Revenue, the advanced development kit requires an above intermediate level knowledge of C." Technical support is available (see Attachment 4).

Cardiff Teleform includes a Microsoft Windows 3.1 user interface which permits immediate use with no programming. This was verified at a demonstration given at the Census Bureau. Cardiff Software supplied us with a user's guide and a demonstration disk of their product. In less than one hour, we were able to design complete forms, display images, and perform the verification procedures. It should be noted however, that several features of the software, such as use of the development tool kit and integration with a database, could be verified only with the complete product. Finally, Cardiff Teleform uniquely identifies the forms for each survey, hence it is possible to conduct several small surveys at once with this product. Technical support is available.

5. **Reliability of Technology. How frequently/accurately does it actually accomplish what it is supposed to do at the present time?**

Reliability of ICR:

The reader is referred to item II.1.b and Attachment 3 for the NIST results¹¹.

Reliability of FAX Boards:

There are a number of quality control precautions built into FAX modems/boards which help to ensure data quality. "In late 1991, modem companies started delivering products that conformed to a revised signaling standard called V.32bis. Modems following this standard offer faster signaling than V.32 models¹² and smoother fallback to a greater choice of speeds.... The newer V.32bis modems more extensively analyze the connection to determine immediately the best usable signaling speed - choosing from among 14,400, 12,000, 9,600, 7,200, or 4,800 bits per second. The specification also provides for a way the modems can agree to fall forward (speed up to a maximum 14,400 bps) if the line conditions improve" (Derfler, 1992).

6. **Respondent Acceptance. How do respondents (of different kinds) regard use of technology?**

Recently, the Bureau of Labor Statistics conducted a pilot test to ascertain the availability of FAX machines and a willingness to receive FAX messages in lieu of the traditional mail advance notice postcard and telephone reminder call. At the same time, a "control" group was selected for comparison. "About 80% of the units in the test panel had FAX machines that were convenient to them and were willing to participate in the test" (Rosen, 1992). No document was found which specifically dealt with respondents regard of facsimile technology; however, as mentioned earlier, the Census Bureau currently receives several hundred survey forms each month by facsimile transmission.

¹¹Note: Nestor released a new version of its ICR software in summer '92. According to Arthur Gingrande, Director of Marketing for NESTOR, the new product will enable one to designate fields as alphanumeric, numeric and alphabetic. The current version only allows for numeric and alphabetic. HNC failed to attend the NIST conference. A demonstration of the product was given at the Census Bureau. It is important to note that at the time of the NIST conference, the HNC product could not recognize lower case hand-print; however, the ability to handle lower case hand-print was added in summer, 1992.

¹²The previous standard.

7. **Interviewer (field staff) Acceptance. How do interviewers and other users regard the technology? What are effects on morale, interviewer turnover, etc?**

Not applicable.

8. **User Training Required. How difficult is it for respondents, and/or interviewers, and/or other field staff, to learn to use the technology? Describe the amount and level of training necessary to use it.**

The respondents will be doing no more than completing a survey form and FAXing it back to the Census Bureau. Additional training of respondents should be minimal and restricted to an effort to get the respondent to print clearly and to use the proper writing instrument, i.e., a dark colored ball point pen.

In both the HNC and the Cardiff demonstrations given at the Census Bureau, examples were provided which successfully showed the ease of use of the software for clerical visual verification. This was confirmed by Earl Atwood of Wyoming's automated DCDS project: "No more than a few minutes of demonstration was necessary to teach our workers to perform the verification procedure¹³."

9. **Effect on Coverage. What are the limitations for population coverage that may be induced by the technology?**

"FAX machines are widely available and used throughout the private sector" (Rosen, 1992). J.B. Miles, in a recent article in *Government Computer News*, estimated that sales of stand-alone FAXes will rise to 1.7 million in 1992 and over 2.4 million in 1994. Mark Skapinker, in a recent article in *Computing Canada*, estimated that computer fax devices (stand-alone, local-area network and mainframe-centralized) will swell to more than 8 million units by the year 1995.

10. **Effects on Response Rate. What are the effects of use of the technology on survey response rates?**

The Bureau of Labor Statistics study showed no difference in the response rates of those sample units receiving reminder notices via facsimile from those receiving reminder notices via telephone and/or mail. No data was uncovered concerning respondents who reply by FAX verses mail; however, it is suggested by BLS, that for CES, a "FAXed in" survey system would increase the initial estimates since the mail delay would be eliminated. "It is estimated that 6% of mail forms are received 1 - 3 days after the initial cutoff date. If FAXed, these forms could be included for the

¹³Mr. Atwood suggested that there remain an open and active communication channel between the designers of the system and the users, i.e., those who will be performing the verification. The verifiers are the ones who will "develop an intuitive feel for how well the system is performing".

initial estimates." (Rosen, 1992) Thus, while actual response rate may not improve, the quality of the initial estimates may improve. No other independent studies were discovered.

11. **Confidentiality and Security.** What special problems (if any) does this technology pose for protection of respondent confidentiality and/or security of the Census Bureau's computers, programs, or data files?

Security

If the system (PC) is dedicated to FAX processing, it will then be accepting and sending only FAXed image files. There is no operational modem involved¹⁴, thus there is no way a respondent can interact with the computer's operating system. If an IPFDR prototype is built, the Bureau's ADP Security Branch should be asked to verify this, and until then, any prototype should be in a stand-alone mode. There is always the possibility that the respondent will FAX his/her responses to the wrong machine. As in the Electron Data Interchange project, the Census Bureau and the respondent could have a legal agreement indicating that the Bureau is responsible for data only after it has reached the Census Bureau and not for data FAXed to the wrong number. Statistics Canada also has such an agreement with its respondents.

Confidentiality

No data was found addressing the issue of how a respondent perceives the confidentiality of a mailed questionnaire versus a FAXed questionnaire.

12. **Cost per Case for Production Data Collection or Field Work.**

Once IPFDR is operational, its primary price factors will be the cost of the clerical staff¹⁵ needed to perform the verification/keying operation and the cost of an 800 telephone line. It is assumed that the Census Bureau will supply 800 phone numbers for respondents to use.

Cost Benefits of ICR:

If the ICR works at least as well as the results from the NIST conference indicate, we may assume that over 95% of the numeric responses will be interpreted correctly.

¹⁴It should be noted that while some articles refer to the PC fax boards as "fax modems," there is no operational modem as long as the related software is not loaded.

¹⁵The ICR software considered provide a level of confidence for each character recognized. The survey designer can set a lower bound for each field such that if the level of confidence falls below the preset lower bound then that character is flagged for clerical keying.

This suggests that the number of clerical keystrokes needed to process a form will be reduced significantly¹⁶. This form of clerical verification is a much easier task than keying and depends more on human vision and common sense and much less on repetitive manual dexterity.

Cost Benefits of FAX:

The cost of sending or receiving a FAX document depends on the rate of transmission of the FAX board, the time of day that the data is transmitted¹⁷, and the service supplied by the phone company. The cost of a single FTS2000 line is forty dollars per month plus nine cents per minute.

Using several survey forms and a PC equipped with a GammaFax Fax board, we were able to determine that an 8 1/2 X 11 inch single-sided survey form along with a cover page, can be faxed in 50 to 75 seconds. This is at a BAUD rate of 9600.

Several companies have recently produced FAX machines which transmit at 14,400 bits/sec as opposed to the 9600 bits/sec rate of current "top-of-the-line" boards (Morgan, 1992), (Derfler, 1992). According to Ken Camarro, author of *Fax Trend Report*, "There is going to be a lot of pressure to speed up even the lowest-cost fax machine and fax boards to 14,400bps, from the prevailing 9600bps, so that business fax units won't incur expensive phone bills when calling a residential fax This will not result in incompatibility because every unit will step down to 9600 if required" (*Communications News*, March 1991). Thus, the inevitable price increase of 800-lines will be offset by more efficient FAX modems/boards.

13. **Editing and Related Capabilities. Is it possible to edit, impute, weight, etc. concurrent with collection or capture?**

Most ICR software reviewed do not perform editing directly; rather, the product would have to interface with some other editing software. Cardiff's Teleform will read incoming data and automatically validate the entries against existing databases to increase accuracy. A direct link with another windows application may be established with the Windows DDE interface¹⁸; thus, a value may be interpreted by the Teleform software and sent directly to another Windows application for automatic editing.

¹⁶The reduction in clerical keystrokes will not be 95% since the clerk still has to use a mouse or special keys to either advance to a new item which cannot be interpreted by the software or to a new form.

¹⁷It is possible to schedule transmissions so that they occur at off-peak hours.

¹⁸This interface is entirely background and would in no way involve the clerical verifiers.

14. **Additional Cost of Savings. What additional total survey costs or savings are obtained by changes which the technology introduces into the survey operations?**

The technology can be used to provide "an environment which significantly reduces the handling of paper based information, eliminates redundant tasks, ..., and automates the control of indexing, tracking, storage, and retrieval of documents ..." (Gerald Farmer, 1992).

No independent research was uncovered documenting the actual cost savings of an image data capture system with ICR over a completely paper-based system¹⁹.

15. **Effects on Estimates. Does the technology affect the level of the estimates?**

There should be no difference between a respondent completing a questionnaire for mail or FAX. In question 5, the reliability of both the facsimile technology and the ICR technology was considered extensively.

All the ICR software reviewed allows the user to set acceptance levels; e.g., each character converted from hand print to ASCII has an accompanying "level of confidence" which indicates the confidence that the ICR system has that the conversion is correct²⁰. The user may choose to accept as correct only those conversions which are above a certain level of confidence. According to Arthur Gingrande of NESTOR Inc., "ICR software has the advantage over human keyers in that it doesn't get tired. Hence, consistency is improved."

16. **Effects on Timeliness. Does the technology increase or decrease the timeliness of reporting or of the preparation of the estimate?**

Possibly, IPFDR can increase the timeliness of the reporting of data. As mentioned earlier, BLS found that it would be able to increase by 6%, the number of CES responses available for initial estimates if all the forms received by mail 1 to 3 days late, had been Faxed (Rosen, 1992).

¹⁹The actual cost savings will depend on several factors: the effectiveness of the ICR software, the effectiveness of the software used to correct form skewing and cleanup the form before it is sent to the ICR engine for recognition, the design of the questionnaire form, the design of the human/computer interface for the verification process.

²⁰This confidence is obtained by comparing the result to those obtained during the neural network training of the ICR system.

III. CONCLUSION (Preliminary until C²T² concurrence)

"Conventional fax has become ubiquitous. Like the copier a decade ago, it seems every business has conventional fax capability. Fast, cheap, convenient and efficient, fax has become a commonly accepted mode of business-to-business communication" (Radding, 1992). If the respondent has facsimile capability and if the ICR works well enough, IPFDR appears to be an inexpensive paperless alternative, or adjunct, to traditional data collection (MAIL, CATI, clerical transcription of data). It has distinctive advantages for both the Bureau and the respondent.

For the Bureau -

Advantages of IPFDR (without ICR)²¹ over mail collection are that it:

1. reduces cost of postage and envelopes
2. reduces mailout/mailback operations
3. reduces time lost in mail process

If ICR Works

1. reduces checkin operation
2. reduces keypunch and keypunch verification.

Advantages of IPFDR over CATI collection are that it: (If ICR works)

1. reduces the cost of supporting a large CATI work force (respondents are completing and FAXing forms)
2. possibly reduces scheduling and multiple contacts for calls and callbacks.

Advantages of IPFDR for respondents are:

1. reporting of data is done at the convenience of respondent, that is, respondents may FAX in data any time, day or night.
2. it is a fast and easy method of data reporting.

²¹There is sufficient ICR capability to identify the survey but not the respondent.

Limitations associated with IPFDR are that it:

1. requires respondents to have a FAX capability, which means it is primarily for economic surveys.
2. is self-initiated by the respondent (same problem as for mail collection)
3. initial cost of hardware and software.
4. the system must be monitored regularly to ensure that respondents can FAX data to Bureau.
5. Loss of CATI's personal contact.
6. Inevitably, there will be some forms sent by respondents which will not be readable, even after printing²². The respondent would have to be requested to re-FAX the questionnaire to the Bureau.

IV. RECOMMENDATIONS (Preliminary until C²T² concurrence)

While FAX is a well established technology, its use to build an image processing system with ICR capabilities is basically untested. We therefore recommend to the CASIC Manager, that a small scale feasibility study (proof of concept) be performed.

This feasibility study might include:

- a) a comparison of the accuracy of the ICR software against that of clerical keyers,
- b) a determination of the number of telephone lines needed to conduct surveys via facsimile,
- c) actual time required to setup IPFDR to handle a survey.

²²This can result if the communication lines are very poor, or if the respondent FAXed the wrong side of the form to the Bureau.

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Attachment 1: References

Attachment 2: Applications

Attachment 3: NIST Conference

Attachment 4: ICR

Attachment 5: FAX boards

Attachment 6: Quotes