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# CASTOR - A COOPERATIVE INITIATIVE TO UPDATE URBAN STREET NETWORK FILES

**Abstract:** Street address network files are a valuable component to any municipal GIS, supporting a range of applications such as routing, address matching, emergency vehicle dispatch, and geocoding of municipal data. Street network files have been available from Statistics Canada for large municipalities since 1971.

An initiative has recently been launched by Statistics Canada to develop partnership arrangements with other government authorities and the private sector, for the creation of a Computer Assisted Street TOpology Revision capacity.

The objectives of the CASTOR project are to improve the timeliness and quality of the street centreline network files used by Statistics Canada, and to increase the usefulness, range and scope of applications for other government authorities. The project involves putting in place a micro-computer based capacity to facilitate distributed street network file revision and to support other GIS applications for CASTOR participants.

This paper gives a report on the concept, pilot projects, progress to date, and the expected benefits to all parties.

## INTRODUCTION

This paper first provides background on the street network files maintained by Geography Division of Statistics Canada (STC) for the purpose of providing geographic support to the Census and other applications. It then describes some of the powerful usages of these files both by STC and by other agencies. Next, it looks at recent efforts to extend the coverage of these files and maintain their currency. Based on these experiences, the paper then describes the CASTOR project, its objectives and plans for trial cooperative projects. The reactions and ideas of users and vendors as well as other governmental agencies are actively being sought.

## BACKGROUND

### The Area Master File

Statistics Canada initiated the creation of digital street network files prior to the 1971 Census as a tool for retrieval of census data by user specified area. These Area Master Files (AMFs) contain a logical representation of all city streets and other geographic features such as

railway tracks, rivers, and municipal boundaries in machine readable form. The AMF corresponds in function to the GBF/DIME file created in the U.S. during the same period, and with the TIGER file (Broome, 1984) prepared for the 1990 Census. There are, however, differences in structure, since the DIME file is based on the block, whereas the AMF is based on the block-face.

Large urban areas (population 50,000 or more) are divided into block-faces. A block-face consists of one side of a street between two successive intersections. These block-face spatial units are small enough that when aggregated they become good building blocks for approximating any user identified query area. Each block-face is assigned one central x-y UTM coordinate, to which files of households or persons can be coded, i.e. geocoded. A user needing information from a geocoded file outlines the area of interest on a map. This area is digitized and becomes a special "query area". All block-face centroids falling within this area are selected. The corresponding statistical data from the Census are aggregated for the selected group of block-faces.

AMFs now exist for the large majority of urbanized centres in Canada. As of June 1990, this constituted coverage of 395 municipalities, with over 61% of the Canadian population. The current coverage is shown in Table 1. Since 1985 the number of municipalities has increased from 204 and the land area has almost doubled - although it is still less than 1% of the total Canadian landmass. In Ontario the land area covered has doubled because of files created by a number of regional police forces.

TABLE 1. THE 1989 AREA MASTER FILE COVERAGE BY PROVINCE/TERRITORY

| | # OF MUNICIPALITIES | | | 1986 POPULATION | | | LAND AREA ($KM^2$) | | |
|---|---|---|---|---|---|---|---|---|---|
| PROVINCE/TERRITORY | TOTAL | COVERED | % | TOTAL | COVERED | % | TOTAL | COVERED | % |
| NEWFOUNDLAND | 405 | 2 | 0.49 | 568,349 | 97,601 | 17.17 | 371,635 | 102 | 0.03 |
| PRINCE EDWARD ISLAND | 125 | 0 | 0.00 | 126,646 | 0 | 0.00 | 5,660 | 0 | 0.00 |
| NOVA SCOTIA | 118 | 3 | 2.54 | 873,176 | 186,830 | 21.40 | 52,841 | 178 | 0.34 |
| NEW BRUNSWICK | 287 | 16 | 5.57 | 709,442 | 223,187 | 31.46 | 71,569 | 2,173 | 3.04 |
| QUEBEC | 1,643 | 116 | 7.06 | 6,532,461 | 3,827,328 | 58.59 | 1,357,812 | 6,263 | 0.46 |
| ONTARIO | 956 | 114 | 11.92 | 9,101,694 | 6,838,449 | 75.13 | 916,734 | 19,853 | 2.17 |
| MANITOBA | 293 | 9 | 3.07 | 1,063,016 | 625,755 | 58.87 | 547,704 | 3,296 | 0.60 |
| SASKATCHEWAN | 953 | 5 | 0.52 | 1,009,613 | 355,528 | 35.21 | 570,113 | 974 | 0.17 |
| ALBERTA | 437 | 3 | 0.69 | 2,365,825 | 1,269,666 | 53.67 | 638,233 | 1,484 | 0.23 |
| BRITISH COLUMBIA | 689 | 127 | 18.43 | 2,883,367 | 2,082,214 | 72.21 | 892,677 | 15,779 | 1.77 |
| NORTH-WEST TERRITORIES | 72 | 0 | 0.00 | 52,238 | 0 | 0.00 | 3,246,389 | 0 | 0.00 |
| YUKON | 34 | 0 | 0.00 | 23,504 | 0 | 0.00 | 531,844 | 0 | 0.00 |
| CANADA | 6,012 | 395 | 6.57 | 25,309,331 | 15,506,558 | 61.27 | 9,203,211 | 50,102 | 0.54 |

A major initiative is under way in cooperation with the province of British Columbia to significantly expand AMF coverage in that province in time for the 1991 Census. The proposal is to create AMFs for all urban areas with a population in excess of 10,000.

Because of the AMF's advanced topological network structure (Geography Division, 1988) and content (nodes, coordinates, block-face centroids, names and address ranges), and because the AMF now serves as the base for almost all census geography operations where it exists, additional applications are now coming on stream. However, there are some applications that are limited by

the data that are captured. For example, vehicle routing algorithms require information regarding one-way street directions. Other applications require postal code information.

AMF applications within Statistics Canada

In addition to customized Census data retrievals, Statistics Canada is using the AMF as a major source for generating a number of other products described below.

1. Computer assisted maps: For the 1986 Census 1200 census tract collection maps were produced from the AMF at a price of under $50 each, compared to $200 for traditional manual drafting (Yan et al, 1988). For the 1991 Census approximately 25,000 collection maps are being produced from the AMF at the enumeration area (EA) level, at an equally significant cost reduction (Ross et al, 1989). Special-purpose ambulance dispatch maps were produced for the Ontario Ministry of Health in-vehicle map book (Ontario, 1985). Street maps showing block-face data such as population counts and membership counts were produced on a cost recovery basis for clients such as a credit union in Edmonton and a cooperative in Saskatoon.

2. Postal Code Products: By linking the AMF block-face to the six character postal code, a number of products have been generated, including standard census publications and a Postal Code Conversion File (Puderer, 1984; Geography Division, STC, 1989). Individual coordinates and geographical areas are assigned to each postal code in AMF areas based on the corresponding block-face centroid.

3. Street indexes: The AMF is used to generate street name and address lists indexed to standard census geography (census tract, enumeration area) as well as to user-specified geography (taxi zone, police district, etc.). The links to standard geography support a telephone answering service at census time to assist in identifying for the public the appropriate enumeration area for their household.

4. Address Register: For the first time, a dwelling address register is being constructed for the 1991 Census within certain areas covered by an AMF. The objective is to reduce the undercount from the census by providing a check on dwellings (such as basement or rear-entry suites) which might be difficult to see from the road. The AMF plays a key role in establishing the link from individual address to block-face, block, and enumeration area (Drew et al, 1987, Schut, Haythornthwaite, 1989).

5. Labour Force Survey: Block-face counts are used after each Census to adjust and improve the area-based sample used by STC for the monthly Labour Force Survey (LFS) which estimates employment and unemployment figures.

6. CADP: The Computer Assisted Districting Project is an automated system to produce EAs for the Census. AMF features are combined to form blocks. These blocks are aggregated using various complex algorithms to satisfy the required criteria for EA delineation. CADP was used to generate EA boundaries for over 70 Federal Electoral Districts for the 1991 Census. It is expected that this system will have other applications involving the delineation of areas (e.g. LFS clusters, voting areas, etc).

AMF applications at other agencies

Bridgehouse, GIS Manager of the Ontario Ministry of Health, in a recent article (1989b) stated that

> "it goes without saying that the AMF is an essential building block for the emergency services database...The application of the Area Master File components, whether at a dispatching support level or an analysis and planning level is infinite".

A growing number of agencies are utilizing the AMF as a source for multiple applications, primarily geo-referencing, transportation and mapping. Calgary (McNabb, 1982) and Winnipeg are two cities which have been using the AMF for geo-referencing and planning for several years. Other areas such as Metropolitan Toronto, the Regional Municipality of Ottawa-Carleton and the County of Oxford, Ontario are more recent users, but view the AMF as one of the "cornerstones" of their information and mapping systems. Appendix 1 lists a number of applications of the AMF at other agencies.

A number of applications of the AMF were described at the 1985 URISA conference and the first (Canadian) National GIS Conference. These include computer-aided dispatch, address validation, and operational support to a number of police forces (Ford, 1989), mapping and geo-referencing to ambulance operations (Bridgehouse, 1989), transit planning, and overall geo-referencing and planning support for Metro Toronto (Smith and Silva, 1989). A recent article described the use of the AMF in conjunction with other sources for decision-making support in selecting an appropriate location for a new fire station in Woodstock, Ontario (Ottaway, 1989). The City of Fredericton, New Brunswick is one municipality that uses the AMF in a joint communications/dispatch system for its fire and police departments. This system serves as a pilot project for all of New Brunswick (Yan et al, 1990).

### System vendors using AMFs

A number of vendors, recognizing the potential of the AMF to support a range of applications have built interfaces to their proprietary software systems. Furthermore, some of these vendors are now direct value-added distributors of AMFs in a format appropriate for their system. Vendors who have recently begun to exploit the AMF are GIRO (GEOROUTE), COMNETIX (CONSTABLE), Generation 5 Technology (MUNMAP), Tydac Technology Inc. (SPANS), Sammammish (GEODOM) and MAPINFO. This is in addition to the vendors listed below who have supported AMF interfaces for some time: Intergraph, ESRI (ARC/INFO), Criterion Inc. (LandTrak), ACDS (GRASS), and Versaterm Systems (VERSACOM,VERSADEX).

## THE BENEFITS AND CHALLENGES OF JOINT PROJECTS

During the past few years there has been a significant increase in the volume of digital spatial data available in Canada, especially from federal, provincial, and municipal mapping agencies (Tomlinson, 1984; Plunkett and Jiwani, 1989). In many cases, digital data are now available for areas within the AMF coverage program. To avoid duplication and reduce overall AMF creation and maintenance costs, Statistics Canada is looking into digital data sources and updating programs of sister mapping agencies. This division of responsibilities compares with the working relationship between the U.S. Geological Survey and the U.S. Bureau of the Census in the joint TIGER/USGS project described by Marx (1983) and Callahan (1984). A number of experiments with other agencies have been undertaken in recent years. (See Appendix 2)

A 1985 paper (Yan et al) describes in detail the joint project with Energy, Mines and Resources Canada (EMR) which successfully created an AMF for the city of Lethbridge, Alberta directly from an EMR file containing digital topographic features. This project was one of several that has demonstrated that there are payoffs from joint projects, although careful planning and coordination are required. A second project led to the efficient joint creation of an AMF for the city of Woodstock in conjunction with the local government and the Ontario Ministry of Natural Resources (Parker, 1987). Others involved creation of an AMF for Ste-Marthe-sur-le-Lac, Quebec from structured EMR 1:50,000 scale topographic data (Richer, 1989), and creation of an AMF for Red Deer, Alberta using data from the Alberta Bureau of Surveying and Mapping with help from EMR. Given the increasing range of applications of the AMF at Statistics Canada and other agencies, and the growing interest in AMFs elsewhere, there is a need to increase the coverage and currency of

AMFs. With more GIS data sources and increasing expertise of other agencies, new ways are being examined to tap this potential.

The primary benefits of such cooperative agreements have been:

- increased AMF coverage for the benefit of all current and potential users at a reasonable price;
- improved accuracy and currency of AMF information (note, that since the Postal Code Conversion File is moving to a quarterly update, there is pressure to update the AMF quarterly as well);
- improved range of applications through the sharing of ideas and methods;
- increased accessibility to and reduced price of STC geocoded data retrieval through direct user supply of digital query area boundaries.

The challenges of these and future joint projects include:

- to move towards standards of nomenclature and definition;
- to reduce the cost of ongoing maintenance;
- to increase the compatibility and sharing of data sources.

Currently, collaboration is being actively investigated with a number of provincial mapping agencies and other federal agencies.

The next two sections describe a new approach to joint projects aimed at smaller agencies to take advantage of advances in micro-computers and the development of new inexpensive yet powerful commercial GIS packages over the last five years.

## THE CASTOR CONCEPT

CASTOR - Computer Assisted Street TOpology Revision - is not so much a system in the traditional sense as a framework within which one or several systems can exist. The aim of any of these systems is to simplify and accelerate the exchange of digitally encoded street related information. As an increasing number of local authorities are using some form of GIS in their regular operations, and as smaller municipalities can now afford to consider using GIS (due to the ever decreasing cost of hardware and software packages) it is imperative to soon implement a two-way exchange mechanism to overcome the proliferation of incompatible data structures and/or file formats.

Thus, Statistics Canada proposes to work with Provincial, Regional and Municipal Government agencies, as well as with GIS software vendors, to identify and test various ways to automate the creation and maintenance process. When a municipality does its regular update of its own municipal map by its own planning department it could generate a copy of either the full file or all the changes and additions in a format that could be input to STC to update the AMF. STC would also make available to the municipality a revised AMF in digital form, if there were changes from other sources. STC would also undertake to geocode census data to reflect the most recent updates received from the participating agencies. This would provide benefits to the participating agency in terms of customized census data.

The inclusion of software vendors in the project is essential to ensure that an efficient street update facility and a comprehensive AMF import/export facility are put in place. Perhaps a dozen vendors already have an AMF import facility, but very few, understandably, have an export facility which is an essential ingredient of the two-way exchange. Although the specific content and form of the exported data files have yet to be finalized, they will be kept as simple as possible to ensure ease

of implementation by the software vendors and to encourage compatibility with most existing GIS and data base management packages. Preliminary thoughts indicate that coordinate data will be stored separately from attribute data with the files linked by unique matching id numbers. This definition will be resolved as part of the proposed pilot projects.

As the concept has been developed, several knowledgable persons from provincial and local government have agreed to serve as advisors to the CASTOR team, to assist in technical review of the concept and to advise on strategy and user needs.

## CASTOR OBJECTIVES AND PLANS

A pilot project has been run in which data was acquired for a new subdivision of a large municipality using the Global Positioning System (GPS). The driver of a vehicle equipped with a satellite receiver covers the streets of the area being captured, recording the names of streets and cross-streets along with left and right address information into a laptop computer as he/she goes from block to block. Each time there is a change of direction or an intersection or a point feature that needs to be geocoded he activates the receiver which picks up signals from 3 or more separate satellites. The computer calculates the position on the ground (in Lat/Long) via a triangulation formula which takes into account the exact position in space of each satellite and the time differences of the signals from each of them. Different amounts of signal refraction are allowed for, etc., with the end result of positional accuracy to within 5 metres which should be sufficient for the AMF. A full report on this and other trials of GPS for geocoding is scheduled to be be presented at GPS90 in Ottawa in September, 1990.

Another pilot project is under consideration between STC, a regional government in Ontario and a GIS consultant to develop and test a basic system to prove the viability of the concept. This project will be focused on the actual methodology and procedures required to update an existing AMF using the facilities and GIS software in place within the municipality. Topics to be covered include the addition of new subdivisions and the verification and correction of address ranges within the older established parts of the towns. While an updated AMF will be created that can be sent back to STC for quality checking and to produce more up to date maps of the region, the primary benefit from this pilot will be a documented Procedures Manual showing all the necessary steps for a medium sized organization working with a micro computer GIS software package to get into the GIS business and to benefit from use of the street centreline file. It is expected that the Procedures Manual will be useful in almost any hardware/software combination with minor tailoring and not only the specific environment for this test as the Procedures Manual will apply to the clerical and field procedures to a greater extent than to the computer system technicalities.

Economic assessment is an important aspect, and will be examined in terms of these different approaches covering both human resources and non-salary dollars, looking at different scenarios such as the cost of different revision cycles as compared to current maintenance costs. Also costs will be looked at for performing different percentages of the maintenance using the CASTOR approach as opposed to the conventional approaches.

Other pilot projects being considered include looking at ways to improve the coding of addresses for the Address Register for those streets and subdivisions not yet included on AMFs, but already needed for the purposes of the AR.

A separate, bue parallel activity of the project will be to develop a detailed specification of the complete import/export mechanism. This will open the program to all suppliers of GIS systems to submit their product for inclusion on a list of acceptable software products from which municipalities would be able to choose a system that meets their needs both from a functionality and cost basis, while satisfying STC's needs at the same time. One key aspect of this specification will be a flexible yet standardised import/export format that will be relatively simple to implement

yet will allow for future evolution as system requirements change. The specification will include a benchmark AMF update requirement against which participating vendors will be examined to ensure compliance.

In addition to the contact with local government agencies, agencies which have a major interest in the ongoing use of an up-to-date digital street network file are being approached regarding possible participation in CASTOR. Discussions have been held with Canada Post Corporation (who are interested in the AMF as a potential source for mapping and routing), the Ambulance Services Branch of Ontario Ministry of Health and others.

## CONCLUSION

The street network files maintained by Statistics Canada have proven to be useful to a growing number of external agencies over the last twenty years. Given the rapid increase in digital geoprocessing capability, there is a growing potential and interest to create and maintain these files in local agencies and in other agencies who need the information to be very current. Statistics Canada, as part of a long term objective to increase the availability of block-face level statistical data, has undertaken several joint digital file creation and maintenance projects. The department wishes to expand the number and streamline the scope of these activities through the CASTOR initiative. User and vendor participation and feedback is solicited for the benefit of all parties.

## Appendix 1.

## SELECTED APPLICATIONS OF AMF BY OTHER AGENCIES

| AGENCY | APPLICATION OF THE AMF |
|---|---|
| City of Winnipeg | Geocoding base for planning computer-assisted dispatch of Emergency Vehicles, transit planning |
| Metropolitan Toronto | Mapping, Transit<br>Base for Planning and Georeferencing |
| City of Edmonton | Street centreline for mapping |
| Several Police Forces (Ottawa, Peel, Durham, York, Niagara, Hamilton-Wentworth, Halton) | Computer look-up of addresses and assignment of police districts<br>Computer-assisted dispatch<br>Geocoding of police records |
| City of Fredericton, N.B. | Base for dispatch, communications and analysis for the Fire and Police depts. |
| Diamond Cabs, Toronto<br>A Pizza Company | Customized street index to aid vehicle dispatch |
| MacLaren Engineering, Toronto | Ambulance maps and street guide |
| Ontario Ministry Of Health,<br>Emergency Health Services<br>Trillium Data Group Ltd. | Ambulance maps and computerized street index |
| Canada Post Corporation | Geographic test for postal code mapping & route optimization |
| City of St. Catharines<br>Engineering Department | Street distance reports |
| Ontario Ministry of Education<br>Quebec school boards<br>GIRO Inc. Montreal | Routing and scheduling for school buses and transit operators |
| REMAX Realty of Quebec<br>GEODOM | Base for a commercial system for realtors and others |

Appendix 2.

## AMF CREATION/ MAINTENANCE ARRANGEMENTS WITH OTHER AGENCIES

| AGENCY | AGREEMENT | STATUS |
|---|---|---|
| City of Winnipeg, Manitoba | File Maintenance by the City of Winnipeg. Plotting by Statistics Canada. | In Production since 1983. |
| Several Regional Police Forces in Ontario | Coding by police. Digitizing and processing by Statistics Canada. | AMF creation is complete. Updating now being checked. |
| Metropolitan Toronto | Metro is maintaining a link to AMF for their planning network file. | Metro has updated their AMFs and passed to STC. |
| City of Edmonton, Alberta | Edmonton has added new streets. | Edmonton has passed updated file to STC. |
| Energy, Mines and Resources Canada | EMR furnished digital topographic data. STC added names and addresses. | Lethbridge and Ste-Marthe-sur-le-Lac AMFs are now complete. |
| Province of Alberta Bureau of Surveying & Mapping | Red Deer AMF created from ABSM digital file with help from EMR | AMF completed 1989 |
| Ontario Ministry of Natural Resources | Digitizing by MNR, street addresses from Woodstock | Woodstock AMF complete, ongoing maint STC & City |
| Ontario Ministry of Health | Pilot project being discussed | |
| Canada Post Corporation | Pilot project being discussed | |

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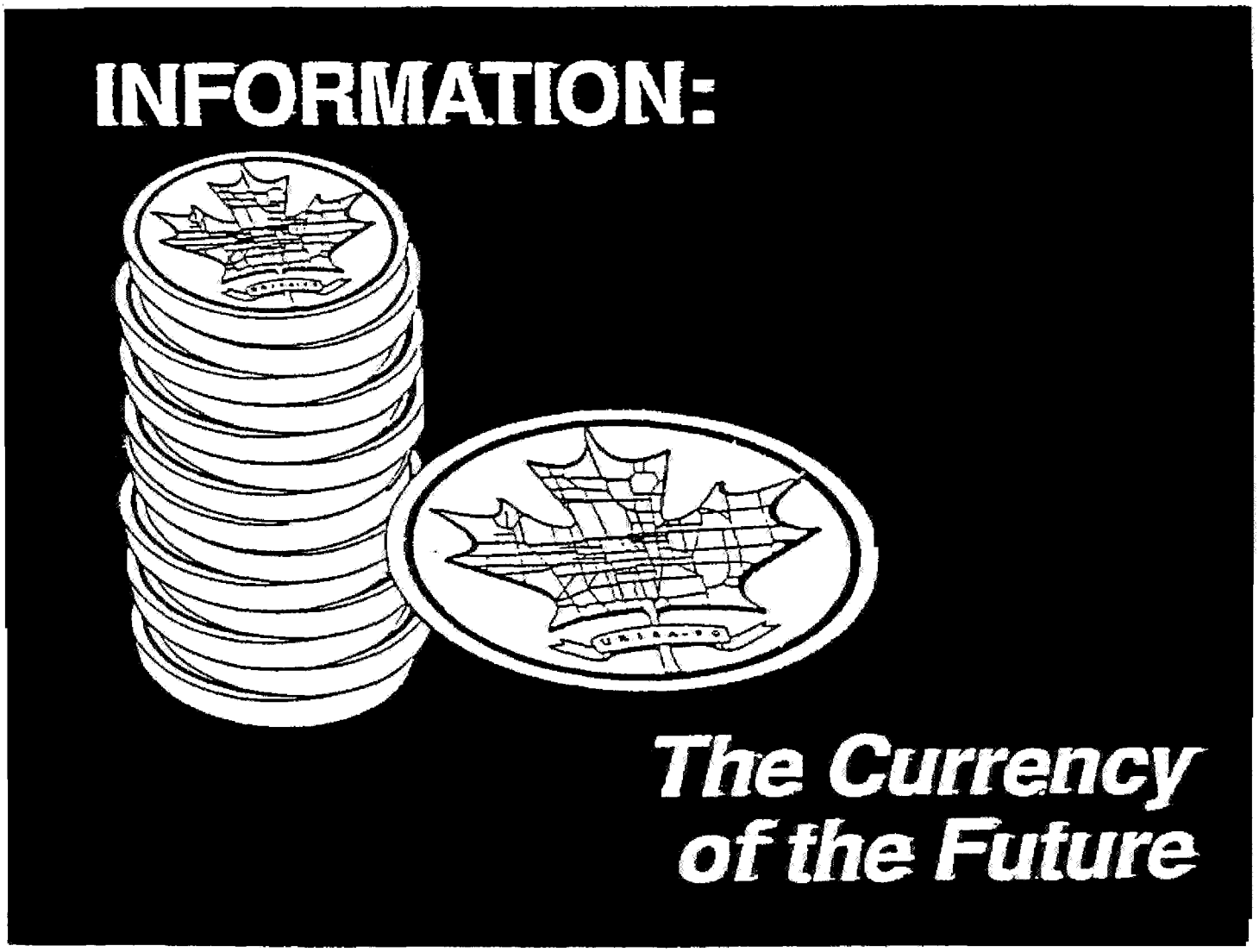


VOLUME III

MICROCOMPUTERS • INFORMATION RESOURCES MANAGEMENT
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EXCERPT: PUBLIC SAFETY RELATED PAPERS

# U R I S A  P R O C E E D I N G S

Papers from the annual conference

of the

URBAN AND REGIONAL INFORMATION SYSTEMS ASSOCIATION

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Volume III:

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# INTRODUCTION

by Bijan Azad

The papers in this volume expand the conference theme, "Information: The Currency of the Future", by discussing the interdependence of today's and tomorrow's investment decisions in information technology implementation. To maintain consistency with the conference theme and program, the papers in this volume are organized by conference track into five sections. The number of papers this year is less than previous years. There are many reasons for this. My own view is that the GIS volume tends to absorb more papers than it once did and the criteria used by reviewers to publish papers have become more stringent.

The paper by Bennett falls neatly into the "Starting Right" track of the conference with it's emphasis on an approach to develop GIS needs assessment for the City of Winnipeg. Two papers, one by Dawson and Allen and the other by Stockton, fall into the "Managing Information" track. Dawson and Allen describe what happens when the mission of government agencies changes through reorganization from data collection to information management. This is an important shift and has significant consequences for the agency. The lessons are useful for similar agencies contemplating such change. Stockton presents the integration strategy of the City of Dallas, which is based on using one vendor's database management system (DBMS) product to enable the City to preserve its data investment in an already existing hierarchical DBMS.

The "Information Technology" track of the conference has the largest number of papers. The paper by Barrino-Smith is an application of computer-aided software engineering (CASE) methodology. Ferguson addresses the benefits of some of the innovations in the technology for converting maps from hardcopy to digital form. The paper by Garth is an excellent overview of developments in DBMS technology and their implications for GIS. Jackson describes the "nuts and bolts" of using a CAD (AutoCAD) "export" file format as a means of constructing a transportation network in digital form. The paper by Kruczynski explores the possibilities of using the global positioning system (GPS) in GIS coordinate-based database development. Lowe's paper deals with another application of CASE methodology, in this instance to "migration" to a new software/hardware platform. Finally, Parr presents a conceptual data model that attempts to be all-encompassing in satisfying the spatial information needs of the local government. The model is based on concepts which are prevalent in structured analysis and DBMS disciplines of software engineering.

Papers in the "Information Futures" section are more forward looking in considering the implications of particular information

technologies being adopted. The paper by Amer and Abouelmagd is very conceptual and aims at the heart of what it means for practitioners (architects in their case) to adopt such advanced technologies as expert systems. The other paper in this section, by Hamilton, assesses the benefits of digital "orthophotography and integrated vector/raster GIS".

One paper constitutes the final section of this volume - "Access to Information". Kenk and Hofmeyr put forward the strategy for development of land information infrastructure which maximizes opportunities for data sharing and exchange between and within the government agencies of the province of British Columbia. (In URISA track terminology this is information access.)

The collection of papers in this volume for the 1990 URISA Conference documents the importance of GIS to URISA and its members. The diversity of papers which address an array of issues, i.e., the use of CASE tools, GPS, Expert Systems, and Organizational/Institutional factors, points out that the field of GIS is not a single discipline. It is becoming clear, that for GIS efforts to succeed, there is a need for constant cognizance of the inter-related issues covered in these papers.

EXCERPT FROM TABLE OF CONTENTS, VOLUME III

* = Public Safety Related Papers

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