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Remote Sensing and Urban Information Systems

The case of the Wichita Falls, Texas, Municipal Information System.

Introduction

This paper develops perspectives and contexts associated with remote sensing and computerized urban information systems, with the Wichita Falls, Texas, Municipal Information System (MIS) Project serving as focus.[1] The primary thrust of the paper is to relate some on-going and proposed remote-sensing-and-photogrammetric-based municipal operations to a current, major, and possibly precedent-setting MIS research and development project. As such the paper is aimed at both the potential users of remote sensing and photogrammetric products and techniques, and the scientists and technicians performing related R&D in the fields of remote sensing and photogrammetry.

Abstract: *For the most part the conceptualization, design, development and implementation of urban-oriented remote-sensing systems and computer-based information systems have evolved as independent processes. As a result, neither systems field has yet made the kinds of contributions to urban management that could be made were they proceeding in concert rather than in parallel. By linking both fields through the Wichita Falls, Texas, Municipal Information Systems Project this paper attempts to provide and account for some of the perspectives and contexts that may exert major influences on urban-oriented remote sensing R & D approaches and activities over the next decade.*

Although a section of the report deals with the MIS project and the City of Wichita Falls, it's appropriate at this point to mention several aspects of both which render them particularly significant as case studies. Firstly, the City of Wichita Falls has pioneered in terms of computerized decision making, and electronic data generation, processing, dissemination, and application. Secondly, the Wichita Falls Consortium was provided with funds by the Urban Information System Inter-Agency Committee (USAC) of the U.S. Federal government to develop an integrated municipal information system. Thirdly, if the Wichita Falls and other projects (one total system and four subsystem projects) are successful in pointing the way with respect to any of a variety of research and development topics, they will undoubtedly set precedents which will be followed by a number of other cities.

The City of Wichita Falls is regarded as a particularly appropriate case study, therefore, as it could yield insights about urban information systems for the future, and thereby provide a futuristic context for remote-sensing research. As remote-sensing activities at the applications levels in Wichita Falls are governed by the larger system in which they operate, these activities *per se* are not regarded as crucial to developments in the field in general. They are important to the thrust of this paper, of course, and are covered in as much detail as space permits. The fact remains, however, that in order to appreciate and develop the role of remote sensing in an information system context, one must have an understanding of this larger context. As shown below, there are also advantages to be gained if both the conceptual and pragmatic aspects of the larger context are considered.

Remote Sensing of Urban Phenomena

It is a well-established fact that remote

* The views expressed here are those of the author and do not necessarily represent those of the Ministry of State for Urban Affairs.

sensors (imaging and nonimaging) can be used to generate data on a variety of urban phenomena, and, as evinced by numerous articles and reports, we are in the midst of a dramatic upsurge of interest in this topic, much of it being directly tied to experimentation with technological innovations and refinements.[2] It is also clear, however, that increased attention is being paid to the remote sensing or non-contact approach in part because of dissatisfaction with other methods of data acquisition, such as field surveys conducted by Federal, State, local or other agencies. These observations will not be elaborated upon here because they have been documented elsewhere.[3]

In addition to the numerous articles on data generation by remote-sensing methods, a number of paradigms for incorporating remote-sensing data into urban data or information systems have been suggested. Two of these are shown in Figures 1 and 2 as conceptual frameworks for accomplishing that end. Figure 1 provides a perspective of the *total system* and Figure 2 provides more detail about the data base development relationships involving field survey and remote sensing methods of data acquisition. Hence, although Figure 1 isolates the remote-sensing arm of data acquisition for illustrative purposes, field survey and remote sensing methods are related in Figure 2. The two data flows in Figure 2 could be integrated by a joint sharing of the data processing facility or by a merging of output data or information. A third diagram relating field surveys, generation of data from daily operations, and remote sensing would be a next step in developing a framework for a comprehensive inventory of data acquisition alternatives. The following sections of the paper provide bridges between the remote-sensing approaches and activities noted above, and some of the kinds of activities which may have marked impacts on the remote-sensing field.

The City of Wichita Falls—Computerized Municipal Government

This overview of the City focuses on those aspects of city government that are directly related to the theme of this paper, that is, they have implications for both short- and long-run developments in the remote-sensing field. The City has long been committed to the use of electronic data processing equipment (EDP) in decision-making, and for data generation, processing, dissemination and application, and is even more heavily committed now as the MIS project approaches completion.[4] To some, Wichita Falls might appear to be an atypical city due to its rapid adoption and innovative use of EDP equipment in its operations/control/planning ac-

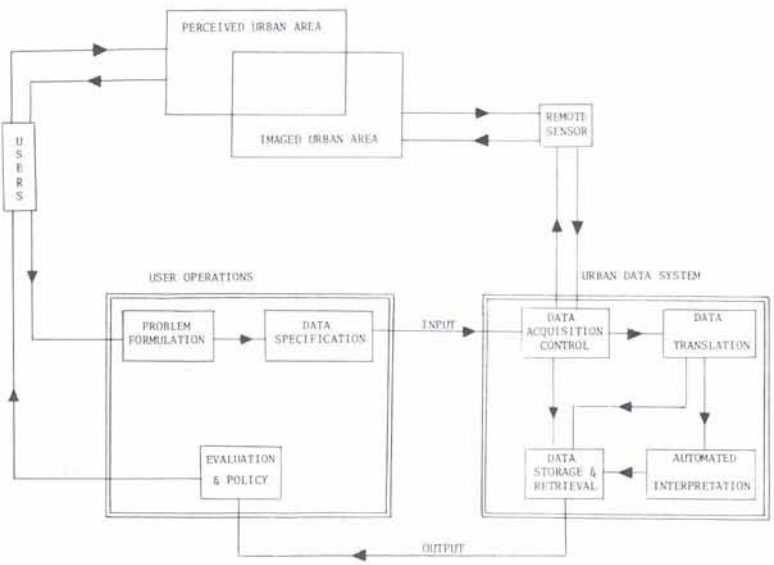

Fig. 1. A framework for the collection and processing of urban data using remote-sensing imagery. (Source: E. G. Moore and B. S. Wellar, "Urban Data Collection by Airborne Sensor," Journal of the American Institute of Planners, 35, January 1969, p. 38.)

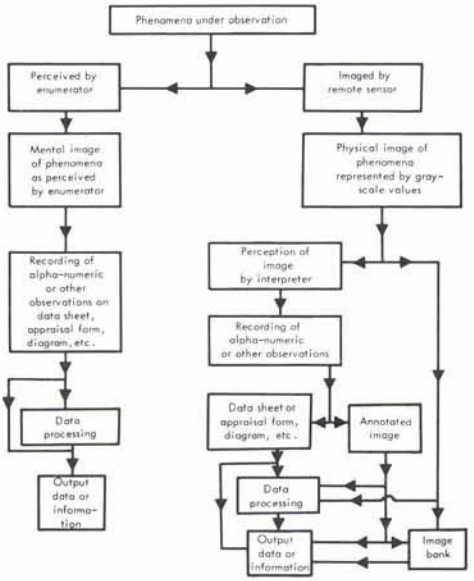

FIG. 2. Flowchart depicting relationships between contact and non-contact methods of data acquisition and development.

tivities, but it is apparent that this is the route that increasing numbers of cities have taken in the last decade or so.[5] And, if the MIS project achieves its goal regarding transferability of products, processes, and learning experiences, Wichita Falls will be rapidly joined by other cities attempting to implement comprehensive, integrated municipal information systems.[6]

The City of Wichita Falls, Texas, is located in north-central Texas and has a current population of about 100,000. The City currently utilizes two computers, an IBM 1800 and an IBM 360 model 30.[7] The 1800 is used primarily for controlling about 80 traffic lights in the downtown area and was the first such system established in the U.S. Major applications on the 360 include fiscal accounting, land use records, street records, utility billing, and the development and use of a critical path network for public facilities construction.[8] Some of the computerized activities as of 1969 in Wichita Falls that are, or have been, related to remote-sensing operations include engineering calculations, right-of-way acquisition, street inventory, land use records, and traffic engineering.[9]

In addition to these activities, the City of Wichita Falls also engaged in several programs that merit the attention of persons investigating urban applications of remote-sensing devices and techniques. One of these programs was the comprehensive land use survey, which included coding land use data for electronic data processing using the IBM 360/30:

> Data for the information system are being obtained from base maps, Tax Department records, and a complete field survey. For every parcel of land within the metropolitan area, a minimum of three data records will be maintained: parcel data, building data; and activity data. The activity or activities of each parcel will be coded using the "Standard Land Use Coding Manual" as prepared by the Bureau of Public Roads and the Department of Housing and Urban Development. The information system is being designed for expansion into the 12 counties included in the NORTEX Regional Planning Commission.
>
> Data which have already been placed on tape are currently being retrieved for analysis in conjunction with the Wichita Falls Solid Waste Disposal Study. . . . A system has also been devised whereby update procedures for the data base are continuous and are handled routinely as a cooperative effort between municipal departments. The information system will eventually become the basic source of data for implementing systems management in Wichita Falls.[10]

The activities noted above are similar to those mentioned in the literature in terms of being candidates for data generation by means of remote-sensing techniques, and some are in fact reported on by means of remote sensors, airborne and otherwise. An important point that should be appreciated, however, and in which will be addressed below, is that there is competition for scarce resources. Hence, if the remote-sensing approach is used to analyse problems or to provide data it is usually only because it enjoys a tested advantage over alternative methods for dealing with the above kinds of activities.

THE USAC MUNICIPAL INFORMATION SYSTEMS PROGRAM

The Federal Urban Information System Inter-Agency Committee (USAC) was established on September 10, 1968, by the Secretary of the Department of Housing and Urban Development, and is composed of representatives of the following agencies: Department of Housing and Urban Development, Bureau of the Budget, Department of Transportation, Department of Health, Education and Welfare, Department of Labor, Department of Commerce, Department of Justice, Office of Economic Opportunity, and Department of the Army, Office of Civil Defense. In 1969, Request for Proposals No.

H-2-70 for Municipal Information Systems was released, and contained the following statement as to the objectives of the Federal program:

This research and development program encompasses the following objectives:

- To improve the information and decision-making capabilities of municipalities.
- To provide a broader approach in the research and development of municipal information systems, specifically the following: to encourage the standardization of data and inventories of data, both vertically through successive levels of government, and horizontally at each level; to develop economic solutions to the problems of data acquisition, data management, and data use; to develop solutions to the problems generated by sensitivity of information, e.g., protection of confidential information; to develop solutions to the problems of subsystem and system linking, both vertically and horizontally, e.g., the technique of facilitating systems compatibility and/or interfacing.
- To learn more of the impacts of the implementation of municipal information systems, e.g., their implications for administrative organization and behavior.
- To provide for expansion and interfaces with other public or private systems, and for interfaces with existing municipality-related planning agencies, e.g., in urban transportation and comprehensive area planning.[11]

Response to the request for proposals (RFP) amounted to about 100 proposals, of which six were awarded contracts. The Consortia associated with the cities of Charlotte, North Carolina, and Wichita Falls were awarded three million dollars each to conceptualize, design, develop, and implement integrated municipal information systems over a three-year period, 1970-1973. The Consortia that were awarded contracts (half a million dollars and two-year contract period) to develop municipal information subsystems were Dayton, Ohio (Public Finance), Long Beach, California (Public Safety), Reading, Pa. (Physical and Economic Development), and St. Paul, Minn. (Human Resource Development).[12]

At the time of this writing it is apparent that other cities, states, regional groups, etc., are interested in the findings of the various projects, but are not necessarily refraining from doing their own information systems R&D.[13] And, although much of what is being done in the field parallels the guidelines of RFP H-2-70 of USAC, there are a number of alternatives being explored. One common characteristic of all information systems research with which the author is familiar, however, is the increasing emphasis on computerization and automation in decision-making, and in data generation, processing, dissemination and application. Consistent with the concluding statement in the preceding discussion about Wichita Falls is the reminder that remote-sensing scientists have much to gain from an appreciation of the USAC concept, and the scope and direction of urban information systems research, development, and implementation.

Municipal Operations/Control/Planning and Remote-Sensing Activities—Prior to the MIS Project

A questionnaire was used to determine some of the uses of airborne remote sensors in Wichita Falls prior to the MIS project. Several of the questions asked and responses to them are contained in Table 1.[14] On the basis of other materials prepared on this topic the applications appear to be typical of those performed in a number of cities.[15] One use which is not reported is an analysis of traffic flows, but this is due to the City's use of ground detectors and the IBM 1800 to monitor and synchronize traffic flow.

The bases for using remote-sensing methods to acquire data, prepare base maps, or to contribute to analyses fall into several well-known categories: time, cost, detail, accuracy, and multiple uses of data sources. In one instance there was simply no alternative, and in another the respondent flatly stated that it was the best available method for performing selected tasks. These reasons are familiar to practitioners who face limited budgets, schedules, and other constraints, and they must be borne in mind by those who would prescribe remote sensing for one or a whole host of tasks. It is most interesting to note, for example, that remote sensing was not used to acquire housing-environment data, although that method is used in a number of cities. As far as Wichita Falls is concerned it seems that housing-environment data needed as of 1969 could be better obtained by other means, that is, as output from the existing computerized data base.

Municipal Operations/Control/Planning Activities—During the MIS Project

The same questions were used to examine this phase of the MIS project, with the tense shifted from past to present. For the most part the respondents noted little or no change

TABLE 1. USE OF REMOTE-SENSING IMAGERY IN WICHITA FALLS—PRIOR TO MIS

Activity/Department	*Nature of Activity*	*Kind of Imagery Used and Scale*	*How is Imagery Used*	*Why is Imagery Used*
Traffic Studies, Plan Layouts/Traffic	Accident studies Pedestrian studies	Aerial photo 1 = 2400 1 = 1200	As overall map of area, plotting and analyzing distribution of traffic flow and traffic and pedestrian accidents, as general plan layouts for: 1. signs 2. markings 3. signals	Best method available
Base and Strip Map Preparation/Civil Engineering	Determine vertical elevations of objects and topography, horizontal location of objects and topography	Aerial photo Contour maps, 1 = 2400 Strip maps, 1 = 480	To determine most feasible alignments for street construction. To determine elevations, drainage areas, location of proposed storm and sanitary sewers, and existing topography	It is most practical method, as it would take considerably more time and effort to do the same work by other methods. Also, problems of entering private property, traffic, and inaccessability are lessened considerably.
Street and storm drainage Construction/Public works	Design and drafting of construction drawings used in development of City street and storm sewer plans	Aerial photo Scale varies 1 = 2400 most often used	As basis for street plans (enlarged to scale 1 = 480) with street right-of-way and necessary alignment and construction data drafted upon transparent, reproducible sheets. As basis for City Storm Drainage Plan, a master plan book of storm drain designs.	Economy Time Display of cartographic details that are not feasible by standard survey methods
Planning Administration/ Planning	To control and maintain files on subdivisions within the City proper, and within its extraterritorial (e.g. regional) jurisdiction.	Aerial photo (uncontrolled) 1 = 12000 and 1 = 24000 Topo maps (controlled) 1 = 2400 1 = 1200	Presentations and displays Recording of growth patterns Drainage studies Base maps for land use data bank New subdivision layouts	Only way to study drainage problems without cross sections and levels of each tract of land. Ease of getting displays and presentations ready for showing

TABLE 1. (*continued*)

Plan formulation/ Planning	Short and long range comprehensive planning. Enforcement of development codes, such as subdivision regulations	Aerial photos (uncontrolled) Topo maps (controlled)	Preparation of base maps Comprehensive base for analysis of (a) concentrations of vacant land (b) overcrowding of housing (c) impact studies	No alternative
Engineering planning/ Engineering public works	Determining location of facilities and utilities, and right-of-way acquisition planning	Aerial photo (mosaic sheets) 1 = 6000 (topo sheets) 1 = 2400	Mosaic sheets used to prepare City maps for locating facilities and utilities. Topographic sheets used to prepare right-of-way maps and planning sheets.	Conserves engineering man hours. Provides detail and accuracy not available by other means

in uses of remote sensing during this period of the project. This may indicate the staying power of remote sensing to perform selected tasks. Likely as that may be, lack of change is in part tied to MIS work focusing on the hardware-software configuration, and on the further automation of tasks associated with administration, payroll, welfare, etc., where numerous data are involved on a day-to-day basis. The Wichita Falls project is probably typical in this respect, so that the available documentation on phasing, priorities, and related topics provide precedents for any other group planning a joint information-system/remote-sensing development program.[16]

Although no changes are occurring in uses of remote-sensing imagery (aerial photography) the MIS project has had a definite influence on what the City would like to do in terms of integrating its computerized decision-making and automated data handling system with its remote-sensing capability. Evidence of the impact is illustrated by a City proposal to the Texas Department of Highways for a joint City-State effort to develop a mapping and survey system of an advanced nature utilizing monumentation, aerial photogrammetry, and geocoding. The major elements of the proposed research project are summarized as follows:

Project Description. The creation of a mapping and survey system would consist of three phases: monumentation, aerial photogrammetry, and geocoding.

Monumentation. A monumentation program will be undertaken to establish a network of monuments from which all survey lines would originate and terminate. Monuments would be on a spacing that would not entail extraordinary costs for development and routine property surveys to be tied.

Two levels of monuments would be established. First-level monumentation would have control points at 5,000-to-6,000-foot intervals. Second-order engineering accuracy is proposed for this level.

A second intermediate level of monumentation would also be established. The second level would serve as tie-in points for small surveys at the parcel level. The engineering accuracy proposed for the second level of monuments is third-order accuracy.

AERIAL PHOTOGRAMMETRY

In phase two the series of monuments will be utilized as control points for an aerial reconnaissance survey. This survey will allow the creation of planimetric maps (200 ft. per inch) with a contour interval of two feet.

It is hoped that the Texas Highway Department will aid the City by providing the aerial photography flights and the production of a comprehensive set of base maps. It would be the responsibility of the City of Wichita Falls to update and maintain these maps. Updating would result as a function of daily city operating procedures such as platting and issuance of building permits.

GEOCODING

Following the photogrammetric project and the production of comprehensive base maps, the City of Wichita Falls will draft additional city information onto the maps. Examples of additional information include parcel boundaries and addresses and geographic coordinates for all street intersections. The amount of additional information to be added depends on available financial resources. If additional funds from the federal government are available, the base map information could be integrated into the Geographic Base Index System (GBIS) that is being developed as part of the "Municipal Information System" project. The GBIS is an indexing system constructed of a series of street segment descriptions. These descriptions use a line encoding scheme developed by the Census Bureau, commonly referred to as DIME (Dual Independent Map Encoding). Each street segment contains high and low address ranges and geographic coordinates. Thus, all data pertaining to a specific geographic space is identifiable and addressable through this index.

The geographic coordinates describing each street segment were calculated from the Census 1970 Metropolitan Map Series (800 ft. per inch). Because of the scale and lack of precision of these maps, the GBIS is limited to non-engineering applications. The major limiting factors are as follows:

> Under the very best control situations, coordinate assignment can not exceed the inherent accuracy of the Bureau of the Census Metropolitan Map Series.
>
> The accuracy of the digitizing operation is limited to the clerical ability of the operator to place the cursor of the digitizing machine accurately over the node for which X and Y coordinate values are being recorded.

As a result of these limitations, coordinates have been found to be 50 feet off in either direction. With the integration of new street segment geographic descriptions digitized from a set of comprehensive base maps, these deficiencies will be eliminated allowing GBIS engineering applications as well as comprehensive planning applications.[17]

The preceeding paragraphs serve to make one point very clear as far as remote sensing in Wichita Falls is concerned: aerial photogrammetry is an integral part of the proposed advanced level mapping and survey system. Hence, although remote sensing will not undergo any major direct changes in terms of use in O/C/P activities during the MIS project, aerial photogrammetry will likely play an increasingly important role in the development of the City's data base, and thereby provide a basis for additional aerial photography uses after the MIS project formally ends.

Municipal Operations/Control/Planning and Remote-Sensing Activities—After the MIS Project

Due to their current heavy involvement in the MIS project, plus considerable uncertainty as to the full impact of the system when it is fully implemented, most users of remote sensing imagery were reluctant to discuss post-project activities. For the most part it was anticipated that current activities based on aerial photography (Table 1) would prevail for some time to come. These users are not yet closely tied to the main thrusts of the MIS project, so it is likely that their assessment will be borne out.

As noted in the previous section, however, a proposal has been prepared for the express purpose of integrating monumentation, photogrammetry, and geocoding in an advanced level mapping and survey system. The system would be based on Texas State Plane Coordinates together with state, city, and private surveys. A direct product of the work would be precise, updated engineering maps, with updates primarily resulting as a function of daily city operating procedures. It is expected that the maps would eliminate the need for expensive, recurrent surveys in highway and other public works projects. With the completion of the geocoding phase, accurate computer calculation of distances and areas could become a reality. The ability to make such calculations would make the following kinds of highway planning, construction, and maintenance activities possible:

- ★ Shortest path/least cost determinations could be computer analyzed with a potential savings of thousands of dollars.
- ★ Existing highway networks could be continuously monitored, allowing maintenance scheduling in complete compatibility with traffic flows.
- ★ Planned expansion of the transportation net-

work could be simulated and evaluated allowing a constant and continual updating of master traffic plans.

★ Costly delays due to the lack of clear title to property owners could be eliminated.

★ Excess right-of-way purchases could be eliminated.[18]

Another important benefit which could be derived from this project is the potential transferability of the system to all Transportation Study Areas. The mapping survey system lends itself particularly well to standardization, for the technique and logic of the system would be transferable to all other communities which have the 1970 Census Dual Independent Map Encoding (DIME) file, i.e., all metropolitan areas in the State of Texas, as well as numerous metropolitan areas in other states.[19]

Implications of Remote Sensing in an Urban Information Systems Context

Certain experiences are shared only by those who have worked with a real rather than imagined system, and have faced problems of budget constraints, priorities, technological change, and a host of other things that go into the operating of a city or any unit of government. The following observations, which are based on an analysis of O/C/P and remote-sensing activities in Wichita Falls, and on previous experiences with other cities and the USAC project, are presented as preliminary, selected inputs to the dialogue which must continue to evolve between system designers and developers and users if the implications for remote sensing in an information systems context are to be fully explored.

- Computerized decision-making and automated data handling are becoming increasingly prevalent in U.S. (and other) cities. For selected tasks, data inputs and analyses will continue to be based on aerial photography and photogrammetry for some time, and will involve a mix of manual and automated methods of data generation, processing, dissemination, and application.[20]
- The rapid technological advances in computer hardware-software configurations used to generate, process, disseminate and apply data are having a direct bearing on the necessity of field surveys, and on the need for photographic coverage. For example, if the present USAC program succeeds, and most of the data needed by decision makers are generated by by-products of city's daily operating procedures, the need for formal surveys and photographic overflights may diminish considerably.
- There is a necessary, increasing interest in the development of intergovernmental flows of data, standardized or core data bases, and compatible systems for data interchange. The extent to which the data elements, items, formats and systems are oriented to operations and contact methods of data acquisition (questionnaires, enumerators, periodic statements of progress or status) will have a marked impact on remote sensing as a factor in not only urban studies, but in interurban and intergovernmental studies as well. Precedence and competition for scarce resources, therefore, will continue to play major roles in determining the methods whereby data are generated, processed, disseminated, and applied.
- Precedents are dislodged, as a rule, only if superior methods of performing tasks are convincingly portrayed and thoroughly documented, and then only after what may appear to be an unduly long gestation period. There is great need for an extensive, documented, cost-benefit or cost-effectiveness matrix relating tasks to be done and methods for resolving them. Frequently, piecemeal evidence (what holds in Chicago, Montreal, or Wichita Falls may or may not hold elsewhere) is all that is available to compare remote sensing and alternative methods of resolving problems where both the former and latter approaches may be applicable. Major advances may have to wait until such a matrix or array of matrices is prepared.

Summary

This paper presents a mix of the conceptual and applied aspects of information-system and remote-sensing system research and development, with Wichita Falls, Texas, as a case study. A major challenge to the evolution of both fields is to combine effectively research and development so that we build for the future, without ignoring the present, and without being unduly constrained in outlook by what is done at present.

[1] Although the paper is primarily concerned with computer-driven municipal information systems, a number of the concepts and applications are equally applicable to manual systems.

[2] *See,* for example, Council of Planning Librarians: *Exchange Bibliographies 66, 119, 166,* 222 (Monticello, Illinois); K. Dueker and F. Horton, "Toward Geographic Urban Change Detection Systems with Remote Sensing Inputs" in *Proceedings, American Society of Photogrammetry,* 37th Annual Meeting (Washington, D.C., 1971), pp. 204-218; A. Manji, "Uses of Conventional Aerial Photography in Urban Areas: Review and Bibliography," *NASA Technical Letter—118* (U.S. Geological Survey, Washington, D.C., 1968); E. Moore and B. Wellar, "Urban

Data Collection by Airborne Sensor" in *Journal of the American Institute of Planners,* Vol. XXXV, No. 1, 1969, pp. 35-43; B. Wellar, "Monitoring and Reporting Change in Urban Housing and Its Environment," *Proceedings, American Society of Photogrammetry,* 37th Annual Meeting, (Washington, 1971), pp. 174-203; and B. Wellar, "Recent Developments in Urban Data Generation Via Remote Sensing Techniques" in *Urban and Regional Information Systems: Federal Activities and Specialized System,* Proceedings of the Sixth Annual Conference of the Urban and Regional Information Systems Association, J. R. Rickert (ed.) (Center for Urban Regionalism, Kent State University, 1969), pp. 258-277.

3 *See* L. Bowden, "Remote Sensing of Urban Environments in Southern California," *Proceedings, American Society of Photogrammetry,* 36th Annual Meeting, (Washington, D.C., 1970), pp. 363-373; Los Angeles Community Analysis Bureau, *A Practical Method for the Collection and Analysis of Housing and Urban Environment Data: An Application of Color Infrared Photography* (Los Angeles, Calif: Study Development and Programs Division, 1970); Moore and Wellar, op. cit. (see footnote 2 above); President's Commission on Federal Statistics. The Report of: *Federal Statistics, Volumes I and II* (Washington, D.C., 1971); Wellar, op. cit. (see footnote 2 above); B. Wellar, A Program for Selection and Acquisition of Housing-Environment Data (unpublished Ph.D. dissertation, Northwestern University, Evanston, 1969); and B. Wellar: "Data Acquisition: Bane of Information Systems Development?", in *The Past, Present and Future of Urban and Regional Information Systems.* Proceedings of the Eighth Annual Conference of the Urban and Regional Information Systems Association, J. Rickert editor (Center for Urban Regionalism, Kent State University, 1971), pp. 456-469.

4 At the time of this writing a two-million-dollar extension of the contract was under consideration, so that the duration of the project will probably be from 1970 to 1975, as opposed to the original period of 1970-1973.

5 Examples of operations/control/planning activities are: utility billing, accounting, assessing and traffic flow assignment; measurement of performance against plan and adjustment as necessary and appropriate, particularly as part of management activities; and comprehensive land use planning, subdivision platting, monitoring street and alley openings and closings, respectively. In some municipal governments there may be a research group distinct from the planning arm, and if this is the case the O/C/P acronym could read O/C/P/R or some variation thereof.

6 For a statement on the conceptual bases of the Wichita Falls MIS project see Wichita Falls Consortium: *Phase II Report, Volume XII—Conceptualization Themes,* Prepared under the terms of Contract No. H-1217—Municipal Information Systems, USAC, U.S. DHUD, (National Technical Information Service, Springfield, Virginia, 1970).

7 At the time of writing the Wichita Falls Consortium was involved in upgrading the data processing facilities to the status of an IBM 370 145 system.

8 As part of the MIS Project the Wichita Falls Consortium produced in excess of 6,000 pages of documentation depicting the City of Wichita Falls as data. The materials presented here were developed prior to the start of the MIS Project and as such might be regarded as representing only the tip of the iceberg. For information about the documentation see Wichita Falls Consortium: *Phase I Report,* Prepared under the terms of Contact No. H-1217-Municipal Information Systems, USAC, U.S. DHUD, (National Technical Information Services, Springfield, Virginia, 1970).

9 A full description of each activity may be obtained by writing to the author.

10 Wichita Falls Consortium: *Integrated Municipal Information System (IMIS) Proposal* Prepared by the City of Wichita Falls, Texas, The University of Kansas, and Booz-Allen Systems (BASYS) Inc., (Wichita Falls, 1969), Part D, p. 24.

11 U.S. Department of Housing and Urban Development: *Request for Proposals No. H-2-70 For Municipal Information Systems* (Washington, D.C., 1969), Part C, p. 11.

12 The USAC concept of four subsystems proved difficult to resolve in the Wichita Falls Project in terms of drawing subject matter boundaries, and operational usefulness. As a result, the four subsystems became sectors, and ten subsystems (Health, Human Development, Welfare, Education, Urban Transportation, Urban Development, Urban Environment, Law Enforcement, Disaster Control and Finance) were defined.

13 Data on the status of information systems research and development in the U.S. are contained in the proceedings and journals of the Association for Computing Machinery, Urban and Regional Information Systems Association, American Institute of Planners, and other organizations. A comprehensive bibliography on this subject is presently being compiled by the author as a project of the Special Interest Group-Standardization in the Urban and Regional Information Systems Association.

14 The responses to the questionnaire by Messers Ondrejas, Adams, Crawford, January, Lillard and O'Bannon of the City of Wichita Falls are greatly appreciated.

15 See, for example, S. H. Hadfield: "An Evaluation of Land Use and Dwelling Unit Data Derived from Aerial Photography," A report prepared for the Chicago Area Transportation Study (CATS) (Chicago, Ill., 1963); Los Angeles Community Analysis Bureau, op. cit. (see footnote 2 above); Manji, op. cit. (see footnote 2 above); Turpin, Robert D., "Evaluation of Photogrammetry and Photographic Interpre-

tation for Use in Transportation Planning," *Photogrammetric Engineering*, Vol. 30, 1964, pp. 124-130; and B. Wellar, op. cit. (see footnote 2 and footnote 3 above).

16 For illustrative documentation see, B. Wellar: *Evaluation of Selected Major Information System Research and Development Projects: Implications for the Wichita Falls, Texas* MIS: *Wichita Falls Consortium Phase I Report, Volume IV, Section 2*, Prepared under the terms of Contract No. H-1217- Municipal Information Systems, USAC, U.S. DHUD, (National Technical Information Service, Springfield, Virginia, 1970); Wichita Falls Consortium, op. cit. (see footnote 5 above); and Wichita Falls Consortium: *Phase II Report*. Prepared under the terms of Contract No. H-1217-Municipal Information Systems, USAC, U.S. DHUD (National Technical Information Services, Springfield, Virginia, 1971).

17 City of Wichita Falls, Texas: "The Wichita Falls Comprehensive Map and Survey System." (Wichita Falls, 1971), pp. 2-4.

19 For a discussion of transferability, standardization and geocoding as they relate to the Wichita Falls MIS project see Wichita Falls Consortium, op. cit. (see footnote 6 above).

18 Ibid, pp. 8-9.

20 Man and/or machine methods of data generation and image analysis are not discussed here as that topic is specifically addressed in other papers. See, for example, any of the *Proceedings of the Urban and Regional Information Systems Association* (Center for Urban Regionalism, Kent State University); T. Peucker; *Computer Cartography* (Association of American Geographers, Washington, D.C., 1972); R. F. Tomlinson (ed.): *Computer Based Geographical Data Handling Methods*. Proceedings of the UNESCO/IGU First Symposium on Geographic Information Systems (Ottawa, 1970); and B. Wellar and T. Graff: *Bibliography on Urban and Regional Information Systems:* Focus on Geographic Perspectives. Council of Planning Librarians Exchange Bibliography 316-317 (Monticello, Illinois, 1972).