# EXPERIENCE OF CREATING A MAP INFORMATION SYSTEM TO INTEGRATE PHOTOGRAMMETRIC, GEODETIC AND REMOTE SENSING DATA

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## ABSTRACT

The mapping/geographic information systems at present on the market developed by manufacturers usually can not meet the individual requirements of every photogrammetric/remote sensing organization. The paper describes the real experience of creating a map/land information system by the author to integrate photogrammetric, geodetic and remote sensing data. The often arised problems and their solutions are discussed, including the concepts of data integration, the reconfiguration of hardware, the redesign of system, interface and data base, and the programming of new software. This system is on a map production line now.

## 1. INTRODUCTION

There are a number of map information systems on the market developed by manufacturers of photogrammetric instruments and/or computer graphics systems. Such map information systems usually can not meet some special requirements of individual photogrammetric/remote sensing organization, especially to integrate photogrammetric, geodetic and remote sensing data /1/ /2/ . In this case, the system analysis and system design become very significant, because without a properly designed system, the most sophisticated hardware is virtually worthless. The author has designed and created a rather complicated map information system with success by following a specific methodology which exists today for analyzing, designing, implementing, and evaluating new computer/information systems /3/ /4/.

## 2. SYSTEM ANALYSIS

Problem definition is the first and perhaps the most important step in the system analysis. The basic requirement of this map information system has been defined as Figure 1. The integration of photogrammetric, geodetic and remote sensing data was the main cosideration. Using interactive graphics workstation for editing digital map database and for inquiring map information are the heavy load of this system. Finally, there should be a high capability of map production, either in line form or in orthophoto form.

The second step for the system analysts is often to gather data on the operations. In short, they must find out where they are before they can figure out where they want to go. It's likely that preliminary facts were gathered during the problem definition step. But more details are now needed. In our case the

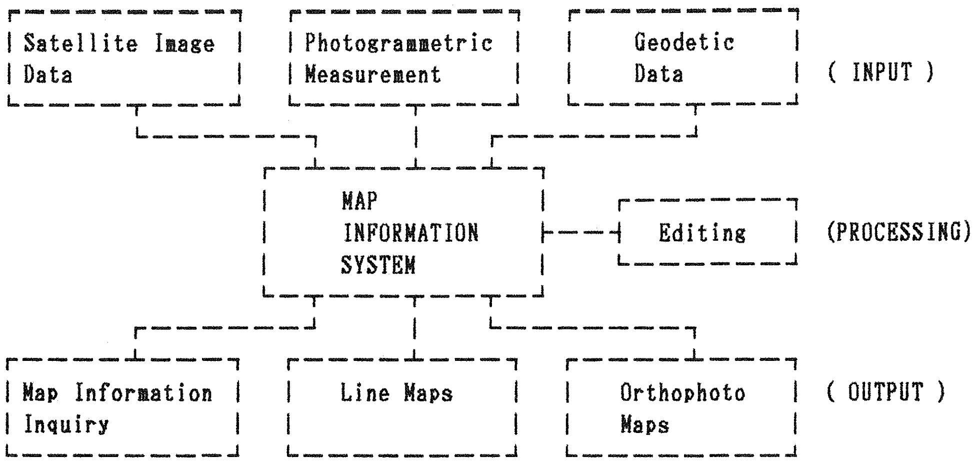


Figure 1 Problem definition

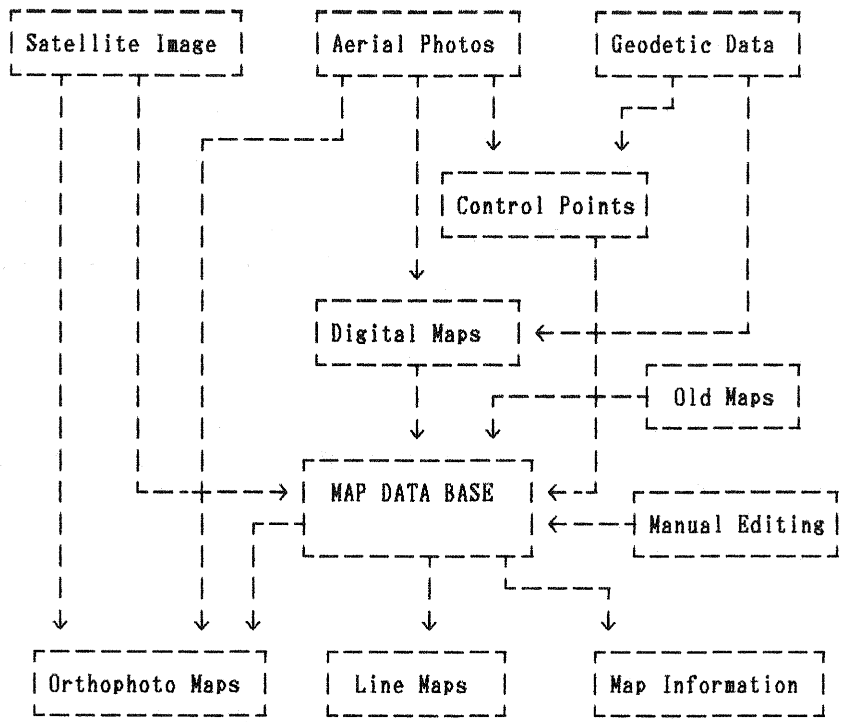


Figure 2 Data flow diagram

following general questions about the system has been answered:

1. What output results are being achieved? The form, content, purpose, and use of maps and other output results should be determined, and the frequency, quantity, accuracy and timeliness of the output should be checked.

2. What processing procedures and resources are being used to produce this output? The photos and other data being processed, the frequency, volume, and accuracy of this processing, the sequence of steps being followed, the people and departments doing the work, the processing and storage equipment being used, the cost of the processing -- these and other matters should be checked.

3. What input data are used to produce output results? The source, form, and volume of input data should be understood. The frequency of input, the accuracy of the input, and the input cost should also be known.

We recognize that these questions refer to the input/processing/output components found in any information system. But the input to output sequence is often reversed during system analysis for a map information system because the analysts need an early understanding of output before we can properly separate and analyze the processing and input functions that are relevant to the output.

The data flow diagram illustrated in Figure 2 has been drawn up during the data-gathering stage. It is used to record the flow of data in the system, from the originating source, through a number of processing operations and machines, to the output results. The flow diagram may help an analyst acquire a better understanding of the procedure than would otherwise be possible. It can also help point out possible bottlenecks in the data flow of the system.

## 3. SYSTEM DESIGN

After evaluating the analysis report, we proceeded to the system design phase. During the system design phase, we decided how to produce an efficient (economical) and effective (relevant and useful) system. To do this, we had first to determine feasible alternatives and then settled on a single set of detailed specifications for the problem solution. This was not easy! As Figure 3 shows, there were many factors that have a bearing on the design task. These factors present practical limits to the number of system alternatives that can actually be evaluated. For example, the old maps are one of the input form, then the automatic scanner must be included in the system.

The selection of a map information system requires consideration of factors unique to map information. These idiosyncrasies, necessary for the full realization of map information system, demand special attention as a separate and distinct field of computer applications. Designing a map information system is quite different from designing a general-purpose computer system

First, there are techniques of man/computer interaction. Secondly, more economic significance has to be attached to certain features of system design as they impact on effective information exchange -- e.g. between analytical stereoplotter and main data base.

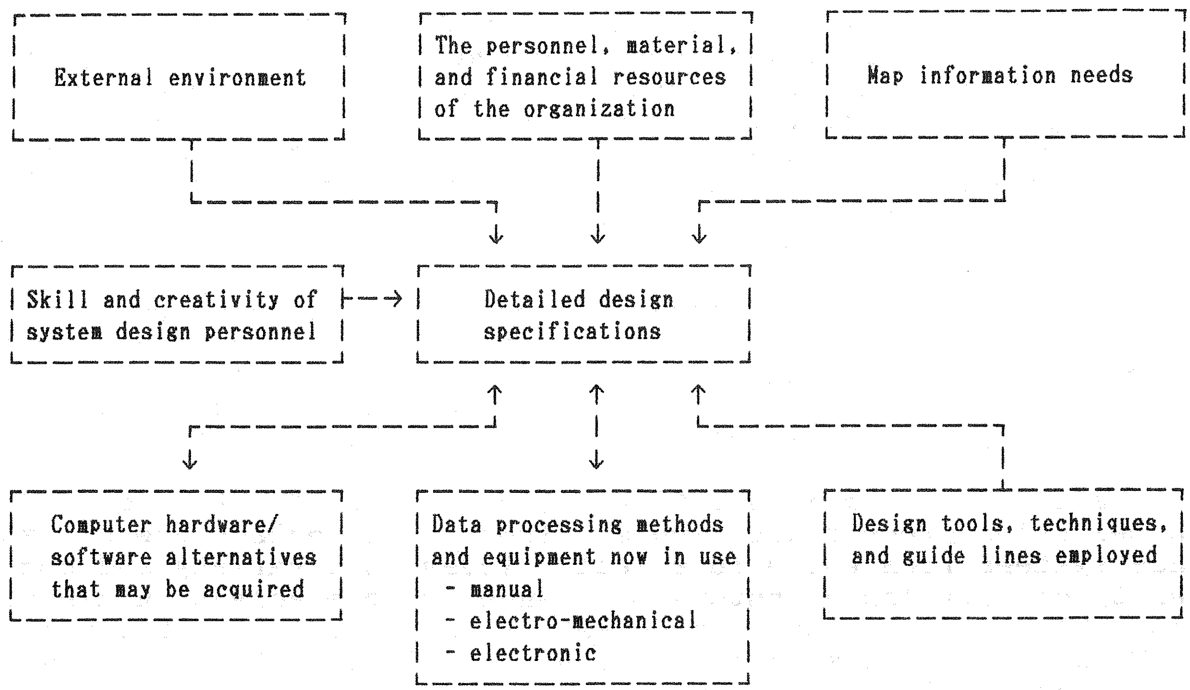


Figure 3 Factors of system design

No individual is to be envied who has to determine which system is best suited to his organization. The marketplace offers so many variances in hardware and software capabilities that a novice is quickly confused and overwhelmed. The ramifications of each choice are multifaceted and complex, and hasty decisions may prove disastrous. Correct assessment of our needs and vendor capabilities was crucial to achieving the map information system goals.

It´s important to determine the needs precisely; to obtain excellent, informed counsel; and to visit organizations using map information systems to assess their effectiveness in application similar to yours. Without this assessment or confirmation of the specific map information systems you are considering, a vendor list of hardware and software features may not be a realistic approach to system selection. It´s better to consult vendors and users, and compare their responses.

Some facts are evident:

1. Map information software do exist, but in a developmental stage.
2. New hardware is coming, such as high-resolution color graphics terminal, automatic scanner, etc., capable of enhancing map information system.
3. We are rethinking our traditional graphic requirement as

it becomes more experienced in use.

4. Educational institutions are not providing graduates with the technical expertise necessary for use of map information systems.
5. The manual drafting workforce is diminishing in numbers and expertise. Replacing valuable expertise is expensive, when possible.
6. Map information systems provide a viable answer to shrinking manpower resources and productivity. Map information system is now cost-effective in several photogrammetric/remote sensing organizations.
7. Industry has always found the means to minimize problems by optimizing technology. Past achievements will be the springboard for advancing technology of the map information system.

After the objectives have been defined, it is still necessary to select the optimal system to attain them. there can be a number of possible combinations and mixes of equipment and tasks to be performed. It has required a full-time staff in our organization to study all makes and models of available equipment.

Years ago, when map information systems were first developed, the selection process was simple. There were perhaps one or two crude systems from which to select. Today, the variety and complexity of available systems make such simple selection almost impossible. How, then, can we make a sound choice with minimum risk? Our method was to start with a complete list of each system's capabilities -- hardware, software, expandability, general support, installation, documentation, and vendor experience. Such a list included the following hardware:

1. Main-frame computer
   (1) 2 x Central processing units @ 10MB
   (2) Memory expansion 10MB
   (3) 5 x Disk drivers
   (4) 3 x Magnetic tape drivers
   (5) 5 x Line printers
   (6) 2 x System consoles
   (7) 10 x Alphanumeric terminals
   (8) 5 x Color graphics terminals
2. Graphic workstations
   (1) 4 x Dual color screen graphic editing workstations
   (2) Hard copy unit
   (3) High accuracy flatbed drafting table with scribing, engraving and cutting tool, and photo exposure device
   (4) Pen plotter
3. Photogrammetric workstations
   (1) 4 x Analog stereoplotter workstations
   (2) 4 x Analytical stereoplotter workstations
4. Remote sensing workstations
   (1) 2 x Color image processing workstations
   (2) Photo scanner/writer
   (3) Digital camera
5. Map digitizing workstations
   (1) Automatic scanner
   (2) Large-surface manual digitizer
6. Geodetic workstations

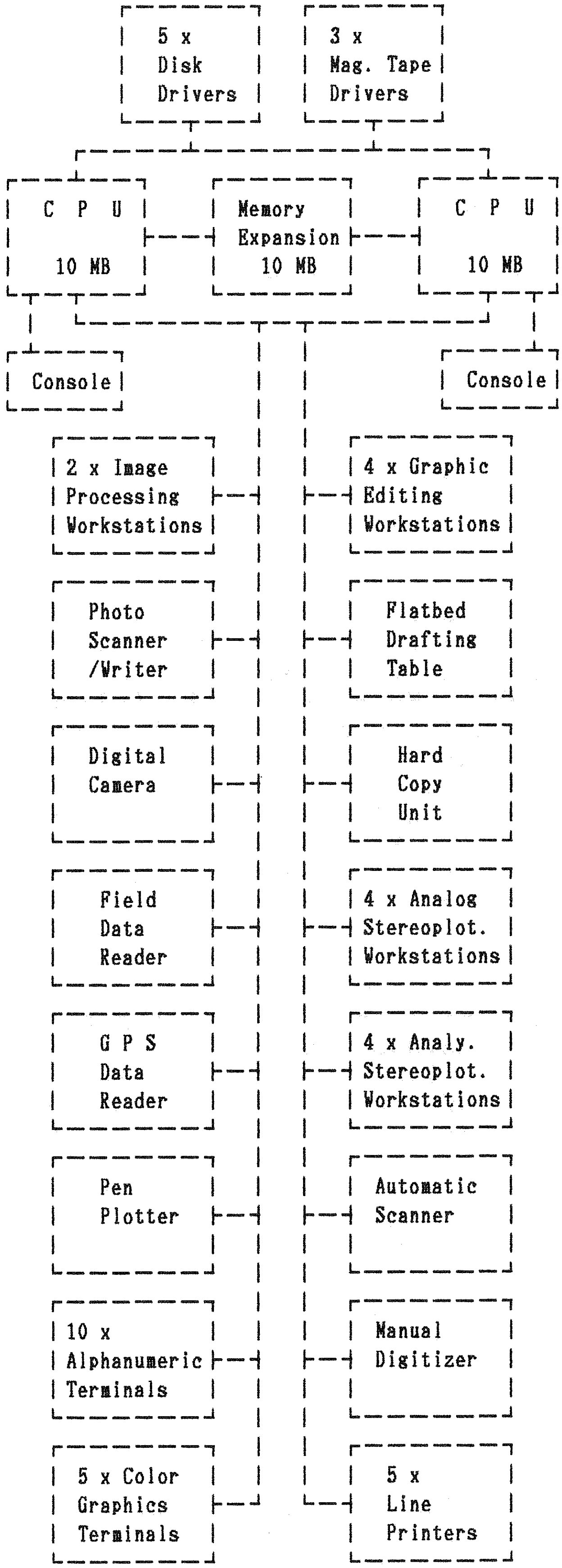


Figure 4 Hardware configuration

(1) Field data readrer
(2) GPS data reader
7. Uninterruptible power supply

Figure 4 shows the hardware configuration. Such lists (software list in section 4) covered our requirements completely, it provided a sound basis for selecting a system, whatever its size complexity. If any item on the vendor's list was not considered desirable or was irrelevant to our proposed applications, we simply attached a value of zero to it. Once the list of system capabilities had been completed, we began evaluating various vendors' systems, using the following procedure:

a. Select hardware and/or software modules from the list if absolutely mandatory, and require the vendor to supply them without variation. Any vendor that cannot supply a mandatory item would be automatically eliminated.
b. Take those modules that we require and which are included on the list, proportional to their weight of importance to the system.

For example, the flatbed drafting table had been assigned a weight of 20% in the overall system under consideration. Then we considered individual features of the drafting table and assign weights to each. We assigned the following weights: plotting speed, 20%; plotting area size, 20%; resolution, 20%; repeatability, 10%; accuracy, 10%; plotting quality, 10%; and tools, 10%. When these calculations had been completed, the point score of the drafting table was added to other mandatory elements of the system. Finally, a system was officially selected and installed. Once the system design phase had been completed, the project entered the system development phase.

## 4. SYSTEM DEVELOPMENT

The first installations of many organizations are normally turnkey systems for both hardware and softwar. This is often due to the user's lack of familiarity with iteractive graphics technology as well as fear of "fouling up" the system. The initial installation is usually justified, purchased, installed, and brought on-line to a specific timetable which does not allow for software education or development. However, there is generally a need to add to or modify some of the software to tailor the system to the organization's specific needs. Expanding the facility, as well as addressing new endeavors outside the original scope of work, may also require software development. To respond to the need for special software support, there are three alternatives: return to the vendor and purchase his services, add programmers to the staff, or purchase the services of a subcontract house.

Tha author himself is a senior system analyst and programmer in both fields of photogrammetry and interactive graphics. Therefore we have chosen the second way, i.e. to develop new software by ourself. It is extremely difficult to define planned requirements, receive the software developed by vendor, and expect it to work without some minor or major changes. Good functional software is usually the result of repetitive action between the vendor and the user. This is difficult if the vendor is not intimately knowledgeable with the specific application or is located many miles away and daily conversation is limited to the telex. The other notable advantage of having staff programmers is the local control of software development priorities and schedules.

A disadvantage of having staff programmers is the need to understand the program and file structure of the system which is usually regarded as secret by the vendor. This requires occasional coordination with the vendor.

Another need that in-house programmers must address is the development of interface software for different vendor hardware and systems. The individual vendor may not inteface to or market it. The responsibility for the feasibility study, as well as the INTEGRATION of brand "X" and "Y" hardware/software, is typically placed on our programmers. In these situations, according to our experience, vendors "X" and "Y" do not normally communicate with each other.

The following is a list of software in our map information system:

1. Software supported by the vendor
   - (1) Software for mainframe computer
     - a. Operating system
     - b. FORTRAN 77, BASIC, PASCAL, COBOL, C
     - c. Non-graphic database management system
   - (2) Software for map database
     - a. Graphic database management system
     - b. Graphic/non-graphic database integration
     - c. Interactive editing of map database
     - d. Automatic border matching
     - e. Coordinates transformation
     - f. Plotting software
   - (3) Software for photogrammetric data acquisition
     - a. Aerotriangulation
     - b. Software for analog stereoplotter
   - (4) Software for data acquisition from old maps
     - a. Automatic scanning and vectorizing
     - b. Manual digitizing
   - (5) Software for remote sensing data acquisition
     - a. Color image processing system
     - b. Enhancing and vectorizing
     - c. Loading remote sensing data into map database
2. Software developed by ourself
   - (1) Software for geodetic data acquisition
     - a. Data input from GPS system
     - b. GPS network adjustment
     - c. Data input from field survey
     - d. Loading geodetic data into map database
   - (2) Software for analytical photogrammetric data
     - a. Map editing on analytical stereoplotter /5/
     - b. File restructuring and load into map database
     - c. On-line connecting analytical stereoplotters to mainframe computer

(3) Software for Non-Latin languages (e.g. Chinese, Arabic, etc.)
    a. Enter data in Non-Latin languages into map database
    b. Displaying Non-Latin characters on screen
    c. Printing Non-Latin characters
    d. Plotting Non-Latin characters

It is common for a new facility to redefine, to redesign and to restructure the map information system provided by the vendor several times before satisfying its needs. To reduce the impact of this effort, communication with well-established facilities like us is recommended.

5. SYSTEM IMPLEMENTATION AND EVALUATION

After the hardware had been installed and the software had been developed, the system was tested to ensure that it integrates and processes data properly and produces the required output. The first step involved testing the functions of every equipment individually. Then it was tested by actually executing on the computer system. Specially prepared test data was used to ensure that the system will process all data correctly under all circumstances. Far too often the system are placed in production that are not fully tested, resulting in erroneous output being produced and sent to user.

We organized an inspection team and the inspection has been done according to all the above mentioned specifications and methods. The final system testing was as following:

1. Source data: satellite image, aerophotos, existing topographic map, GPS data, field data and nongraphic data, all in the same area.
2. Input device: image processing workstation, photogrammetric workstation, automatic scanner, digitizer, geodetic workstation and terminal.
3. Processing: Integrating all input data. Using graphic workstation to edit map database.
4. Output: (1) Using terminal to inquire map information.
   (2) Plotting the map on drafting table in scribing form in separate layers.
   (3) Producing orthophoto on image writer and orthophotoprojector.

After testing had been completed and the documentation prepared, The system was ready to de implemented and is running in a production environment now. Once the map information system had been implemented and in operation, a thorough audit or post implementation evaluation was conduct. This evaluation consisted of a careful analysis to determine if the system is, in fact, performing as it was designed to do; if operating costs are as anticipated; and if any modifications are necessary to make the system operate effectively.

An ongoing process after the system has been implemented is system maintenance. Maintenance consists of two major activities: (1) Changes to correct errors in the system; (2) Changes to give the system additional capabilities or to conform with organization regulations. Maintenance activities require a great deal of the time of many programmers and analysts. Systems which are well designed and well documented are much easier to maintain than those which do not follow good system design methodology and documentation standards.

## 6. CONCLUSION

In the short span of ten years, the new technology of computer graphics and database management has evolved which has already dramatically changed the way in which maps are edited and producted. A map information system which integrates photogrammetric, geodetic and remote sensing data has come true. A number of map information systems have been marketed by some manufacturers. But there is generally a need to add to or modify some of the hardware or software to tailor the existing system to the specific need of data integration. The system analysis and system design become therefore very important and significant. The author offered his own experience of creating a complicated map information system by following a specific methodology and hopes, by sharing the experiences, it can help us in meeting the the challenge of the new age.

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