INTEGRATED PHOTOGRAMMETRIC SYSTEMS
Working Group II-6 Report

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ABSTRACT

The report reviews the needs and the aims for integration of autonomous photogrammetric components into larger systems. It summarizes the Working Group terms of reference, and the main constituents of the integration are discussed. Moreover, an outline is given of the integration process and of some problems involved. Finally an outlook is presented in the area of integration, and a recommendation is given concerning Working Group II-6.

INTRODUCTION

The need for integrating photogrammetric components into sub-systems and further into larger entities emerges from the changing technology, especially in micro-electronics and communication techniques, and the increasing demand for geo-information products.

The changing technology promotes the transition from small, simple components toward larger, complex systems, the integration of analogue, analytical and digital techniques, optimizing the overall information production and support, unification of information and data from different sources into a homogeneous data base, and conditioning of data bases for optimal management, processing, updating and upgrading, presentation and communication.

The demand for comprehensive, up-to-date geo-information of sufficient quality, needed for problem solving in various users'domains, is steadily increasing. The demand increases exponentially with the "map scale", i.e., the degree of detail of geo-information. Moreover, the trend in demand also reflects the transition from full (primary) modelling towards the differential modelling of terrain features.

The general aims of the integration reflect the needs for integrated systems. These aims are:

- To meet the growing demand for geo-information products in conjunction with the problem solving models in different users'domains;
- To optimize the geo-information production and creation of data bases, their updating and extension, management and processing, presentation and communication, all in the context of the changing information technology.

TERMS OF REFERENCE

The domain of Working Group II-6 is defined by six main terms of reference:

1) Concepts and system models
2) Design and development (of new systems)
3) Existing integrated systems
4) Performance and reliability studies (for system development and its operation)
5) Evaluation (priority ranking)
6) Impacts of integrated systems (on environment, compatibility, support).

These terms are differentiated further (appendix 1) and were reviewed in [1]. Because time has been limited and the total area is complex and broad, the effort of the Working Group, has been focused on three sub-areas of main interest, i.e., items 1), 2) and 3) of the above list.

Concepts and system models call for fundamental studies, addressing expert systems, communication and systems engineering, and several other disciplines. Concepts and models have great impact in the "design and development" of new systems.

Design and development is a domain of the system producers. At present most of the activities in integrated systems pertain to this sub-area, though the required concepts and system models have still to evolve to reach the state of maturity. Thus the two terms form a feedback loop, and should therefore be considered in conjunction.

Existing integrated systems address the operational and support characteristics. They concern issues such as performance, reliability, flexibility, ergonomic factors, etc. For system optimization, feedback should be provided to "design and development".

The remaining three terms of reference 3), 4) and 5), have not yet received much attention because of limited time and resources.

CONSTITUENTS OF INTEGRATION

The terms "integration" implies unification of the parts into a homologous whole. It comprises a systematic approach, dominated by the wholeness, which leads to an optimum overall system.

The basic constituents of integration can be summarized as follows:

- Professional fields (involving multi-disciplinary integration):
  a) basic disciplines (providing knowledge for b and c),
  b) disciplines of geo-information technology,
  c) disciplines of geo-information users.
- Organisational environment (context).
- System functions:
  . for design and development of integrated systems,
  . for integrated system operation and support.
- Hardware components (analogue, analytical, digital).
- Software (modules, subsystems).
- Interactive and automatic capabilities.
- Information and data (input-output models).
- Production lines.

- Quality control.

Integration implies structuring, whereby structures pertain to information and data, procedures (or algorithms), hardware, and their interactions (figure 1). Hence, all these structures should be divided and optimized collectively rather than as isolated components.

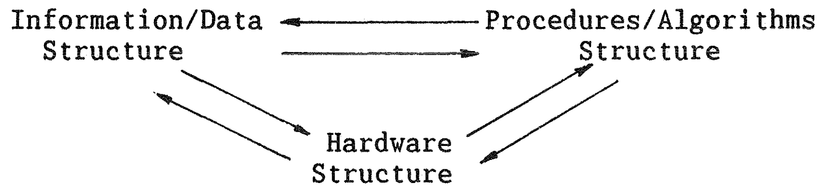

Fig. 1: Structures and their interactions

INTEGRATION PROCEDURE

The procedure for system integration comprises three main stages:
1) Formulation of the objectives,
2) Design and development,
3) Assessment and optimization.

These stages are strongly interrelated.

The objectives of integration should reflect the context of the overall system (external environment, evolution in the system area, etc.), the desirability (general policy), and the feasibility (technical, economic) of the system under consideration.

The design addresses functional and technical (methods and means) requirements for the operational and support systems, and selection of the corresponding concepts and models. The required functions, methods and means are strongly interrelated. Hence, the design process is iterative.

The development emerges from the design process. It concerns the resources, particularly the hardware, software, information and data, human operators, and their interactions. The process is iterative (from coarse to fine) and it forms a feedback loop with the design. In a developed system, the data base to be created and its access mechanism should be specified. The specifications emerge partly from the system itself (system related) and partly from the specific user's context (problem solving-related).

The outcome of the integrated system assessment provides insight and added knowledge required for the optimization process. Assessment and optimization are linked into a feedback loop.

PROBLEMS

The major problems is system integration concern the functional and technical requirements. They address the following issues:

1) Unifying fragmentary information and data (input) from different sources, differently structured, formatted and coded, into a homogeneous (master) data base.
2) Generating information products (output) conditioned for display, communication, and application in the users' domains.
3) Optimizing the overall process of data base creation, its updating and extension, management, processing and presentation (quality, speed, ergonomic factors, etc.).
4) Optimal use of the available resources (flexibility, compatibility, etc.)

Some further problems emerge from the specific organisational environments:

1) The existing state of the art and human environments (in a specific organisation), addressing both the system development and its operation and support.
2) Different impacts of the changing information technology in all levels of the organisation concerned.
3) Pressures to develop quickly an up-to-date integrated system, before the required supporting research (concepts, system models, etc.) is accomplished.
4) Focusing attention on the operational features and disregarding or underestimating the role of the support system.

OUTLOOK

The trends in the area of integrated photogrammetric systems can be summarized as follows:
1) The current systems are in a transitional state from the fragmentary or partly interconnected sub-systems to the future highly integrated systems;
2) The future systems will be better tuned to:
   . the broader context,
   . the specific users' needs,
   . the changing information technology.
3) A key factor in the future systems integration will be the expert systems.
4) Consistency and standardisation will be increasingly applied to:
   . information and data (structures, formats, codes, etc),
   . software (structures, languages, etc.),
   . hardware (special integrated circuits, local-area networks, storage media, etc.),
   . user interface systems;
5) The production lines will be optimized individually and collectively. The optimization addresses:
   . information and data structures,
   . internal and external communication,
   . quality control of both the processes (partial and overall) and of the products (intermediate and final).

6) Technical capabilities of the components and systems will be further improved. The improvements concern:
   - performance (quality, production rates),
   - reliability and security (hardware, software, data base),
   - flexibility and expandability,
   - ergonomic characteristics,
   - support facilities.

COMPOSITION AND ACTIVITIES OF THE WORKING GROUP

When establishing the W.G., the aim was to recruit members having different backgrounds, i.e., to cover the various facets of the integrated systems, representing different types of organisations, and working in different institutional environments. The response and attitude of the invited members has been very positive and constructive, though their contributions to the Working Group effort have been limited. The reasons emerge partly from the fact that the area of integrated systems is relatively new, and partly from restrictions on new information in the companies developing such systems.

The work has been carried out individually by the members. The work progress was reported at the colloquia in Rockville (USA), 1985, and in London, 1987. Formal papers were presented at the Commission II Symposium, Baltimore (USA), 1986 [1,..,8]. The papers presented at this Congress are listed in appendix 2.

Planning and coordination of the Working Group activities took place at several business meetings (in Rockville 1985, Baltimore 1986 and 1987, London 1987, St. Louis, and in Kyoto 1988), by several W.G. newsletters, and by personal communication with the members.

The working Group has been composed of the following members:
Dr. Mossad M. Allam (Canada, Co-chairman, Head of Subgroup 3)
Dr. John Badekas (Greece)
Dr. Gerhard Bauer (East Germany)
Mme. Dominique Bruger (Canada)
Dr. Ernest B. Brunson (U.S.A.)
Dr. James B. Case (U.S.A.)
Mr. Luis Cogan (Switzerland)
Dr. Atef A. Elassal (U.S.A. Head of Subgroup 2)
Mr. Lawrence W. Fritz (U.S.A.)
Dr. Clifford Greve (U.S.A.)
Mr. Karl Grabmaier (Netherlands)
Mr. Mahmoud Hassani (Netherlands)
Dr. Sigi Heggly (Switzerland)
Dr. Dirk Hobbie (West Germany)
Dr. Otto Hofmann (west Germany)
Dr. Zarko Jaksic (Canada)
Mr. Morris L. McKenzie (U.S.A.)
Dr. F.S. Kröll (West Germany)
Mr. Lin Xian Lin (China)
Mr. Svein E. Lonnum (Norway)
Dr. Mohammed M. Radwan (Netherlands)
Dr. Tony Schenk (U.S.A., Head of Subgroup 1)

Dr. Ulrike Stampa-Wessel (West Germany)
Mr. Lars Skog (Sweden)
Dr. W. Murray Strome (Canada)
Dr. Ashoki Sujanani (U.S.A.)
Mr. Christian Vigneron (France)

On behalf of Working Group II-6, I wish to express our gratitude to all members for their cooperation. Our thanks are addressed especially to the heads of the three Subgroups: M.M. Allam, A. Elassal and Tony Schenk, and to all authors of the papers.

RECOMMENDATION

The rapidly changing information technology accelerates the transition from autonomous photogrammetric instruments towards highly integrated information production, processing and communication systems.

To this end, a broad and orderly approach is needed, encompassing all significant facets of the integration as outlined by the Working Group terms of reference. The Working Group should stimulate and contribute to the further research and development in the area, review and upgrade the terms of reference, discern new insights and knowledge, and formulate the guidelines and/or recommendations for further action.

REFERENCES

[1] Makarovic, B., "Integrated Photogrammetric Systems" (tutorial), ISPSR Commission II symposium, Baltimore, USA, 1986;

[2] Schenk, A., "Concepts and Models in Photogrammetric Systems", ISPRS Commission II symposium, Baltimore, USA, 1986;

[3] Elassal, A.A., "Design and Development of Integrated Systems", ISPRS Commission II symposium, Baltimore, USA, 1986;

[4] Allam, M.M., "Digital Mapping System for Data Capture and Editing", ISPRS Commission II symposium, Baltimore, USA, 1986;

[5] Brunson, E.B., "Development of a Digital Revision Capability using Photogrammetric Technique at USGS", ISPRS Commission II symposium, Baltimore, USA, 1986;

[6] Edwards, D.L., "Terrain Data Base generation for Autonomous Land Vehicle Navigation", ISPRS Commission II symposium, Baltimore, USA, 1986;

[7] Stampa-Wessel, U., "Photogrammetric Data Collection as a Module of a Land Information Systems"., ISPRS Commission II symposium, Baltimore, USA, 1986;

[8] Stampa-Wessel, U., "Integration of Orthophoto Technique into a Land Information System", ISPRS Commission II symposium, Baltimore, USA, 1986;

Appendix 1

Working Group II-6: INTEGRATED PHOTOGRAMMETRIC SYSTEMS

MANDATE

1. Promoting research and development in the area of integrated information systems, with emphasis on photogrammetric collection and conditioning of geo-information.
2. Disseminating up-to-date information on achievements in the problem area.

TERMS OF REFERENCE

1. Concepts and system models.
1.1 Context and classification of integrated systems;
1.2 Systems' concepts, models and their feasibility;
1.3 Information and data structures;
1.4 Communication networks.

2. Design and development.
2.1 Evolution of integrated systems;
2.2 Design and development of new systems;
2.3 Hardware architectures and components;
2.4 Software structures and modules;
2.5 Interactions and human factors.

3. Existing integrated systems.
3.1 Hardware, software, information and data: analysis and amendments;
3.2 Performance and reliability (in operation);
3.3 Human factors (in operation)

4. Performance and reliability studies.
4.1 Theoretical analysis;
4.2 Simulation analysis;
4.3 Experimental tests: accuracy, time-efficiency, reliability.

5. Evaluation.
5.1 Influencing factors and value model;
5.2 Cost-benefit analysis;
5.3 Comparative studies.

6. Impact on:
6.1 Changing technological environment;
6.2 Changing organisational and human environments;
6.3 Compatibility (internal and external)
6.4 Support (required).

Appendix 2

Working Group II-6: INTEGRATED PHOTOGRAMMETRIC SYSTEMS

PAPERS CONTRIBUTED TO THE CONGRESS IN KYOTO

Allam, M.M.,	The role in Integrated Photogrammetric Systems in Geographic Information System Technology.
Brunson, E.,	U.S. Geological Survey's Modernization Program.
Elassal, A.,	Factors Influencing the Design of Modern Photogrammetric Systems.
Hattori, S./Shibasaki, R., Murai, S./Othani, H.	Stereo Matching Project in Japan.
Hofmann, O.,	A Digital Three Line Stereo Scanner System.
Konecny, G./Lohmann, O./ Skog, L.	A Digital Image Mapping System.
Makarovic, B.,	Context and Integration of Photogrammetric Production Lines.
Sarjakoski, T.,	ADA-Language as a Tool in the Development of Photogrammetric Systems.
Schenk, A.,	The Effects of digital Photogrammetry on Existing Photogrammetric Concepts, Procedures and Systems.
Stevens, A./Jackson, M./ James, W.	Integration of Satellite Imagery Using a GIS Toolbox.
Swann, R., Kauffmann, D.,	Results of Automated Digital Elevation Model Generation From SPOT Satellite Data.