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# A SYSTEM FOR EVALUATION OF ANALYTICAL PLOTTERS

Abstract:

The report reviews the objectives and scope of the Working Group II-1, its composition, the method of operation, and the main activities.

The evaluation system comprises guide lines for collection of the relevant information, a strategy for rejecting the unsuitable A.P. variants, and a procedure for evaluating the technical and economic feasibility of the remaining A.P. variants. The system is versatile and flexible, and it tends to fulfil the need of the potential users and managers for an objective evaluation of A.P.'s prior to their purchase.

## I. Introduction

The Working Group (W.G.) was initiated by the President of the Commission II, Mr. M. Baussart, in summer 1977. The basic objective has been to conceive a systematic procedure for the evalutation of analytical plotters (A.P.), which is supposed to be applied prior to A.P. purchase by the users. The W.G. was formed with the following in view:

- Diversified professional background, by including representatives of the users, the manufacturers, and the research institutes.
- Broad geographical coverage, to involve as wide a range of users' experience and environmental conditions as possible.

The list of the W.G. members is presented in appendix 1.

The plan of work, progress reports, and other related information was communicated to the W.G. members in a number of newsletters. Several members contributed original reports, comments, and/or responded otherwise.
The W.G. held three meetings, the first being in Paris, 1978, combined with the Commission II Symposium. The second meeting was in Stuttgart, September 1979, for the European sub-group, and two months later another meeting was held in Ottawa, for the American sub-group. A further meeting has been scheduled for April 1980, in Washington, at the occasion of the A.S.P. Analytical Plotter Symposium.

At the Commission II Symposium in Paris, our W.G. held a session which covered several presentations of papers (appendix 2) and a general discussion (1).
For the Hamburg Congress, two W.G. sessions have been scheduled; one will be devoted to the presentation of papers and the other to discussions. Papers will be presented by Dr. Z. Jaksic - selected problems and check-out procedures for Analytical Plotters, Dr. L.W. Fritz - on testing and calibration procedures for A.P.'s, Mr. M.L. McKenzie - on A.P. evaluation guide, Dr. Ing. D. Hobbie - on check-out and testing routines of the C-100 Planicomp, and Dr. Dubuisson - on the study of comparative economics and analytical expansion. The discussion will be centered on the A.P. evaluation system and related problems.

The overall objective of the W.G. was identified in the users' realm, i.e. the potential need for an adequate evaluation of A.P.'s prior to their purchase. This need emerges from the gap between the complexity and sophistication of A.P.'s on one side, and the corresponding experience and knowledge of the user on the other. The need is strengthened by the fact that the initial investment is high, and the requirements, capabilities, and limitations of A.P.'s differ considerably from those of the analogue instruments. Hence, the evaluation system, to be conceived, should be user's oriented, i.e. the approach should be pragmatic and should not preassume broad experience with A.P.'s and profound theoretical expertise.
The user's views encompass several facets which can be classified into two main groups, i.e. the external and the internal group (fig. 1). This classification may serve as a frame of reference for identification of both the evaluation criteria and the information items to be acquired and subsequently evaluated.

An evaluation system should, in principle, meet two basic requirements:

- It should be detailed enough - to respond to changes in significant influencing factors;
- It should be easy to handle - to be accepted by the potential users.

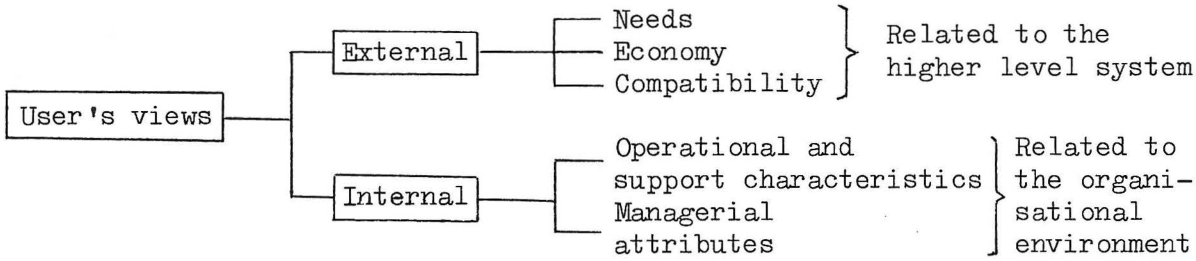


Fig. 1: Classification of the user's views

In practice one should look for the best compromise between these contradictory requirements.
It seems appropriate to emphasize that our W.G. has aimed at the development of a suitable system for evaluation rather than to perform a comparative evaluation. This involves primarily critical analysis and creative thinking. However, experimental tests or trials are inevitable for verification purposes. The contents of this summarising report have been restricted to the overall considerations, the two basic constituents of an evaluation system, i.e. the information and the value model, and some conclusions.

## II. Overall considerations

Before the purchase of an A.P. the potential user is assumed to have performed the necessary analysis, which cover the following stages:
- Preliminary inquiry - for a brief overall acquaintance with the problem area, and the subsequent crude assessment of the feasibility;
- Identification of the real need;
- Collection of more detailed pertinent information;
- Evaluation.

Of central importance is, obviously, the evaluation system. A well conceived system should meet the following requirements:
- The information for evaluation should be correct, sufficient and well structured;
- The evaluation procedure should be systematic, objective and adapted to the quality of information;
- The system as a whole should be flexible and dynamic.

Flexibility is attainable by implementing a multi-level approach, permitting a graduated evaluation between coarse and fine, and an open-endedness of both the information items to be evaluated and the evaluation criteria.
Dynamic capability is required for adaption to the changing state of the art and organisational environment with time.
The rapidly changing state of the art environment, stemming from the magnificent achievements in digital technology, enhances the need for refined evaluation. The latter is, however, a basic prerequisite for improved quality of decision making.

The introduction of A.P.'s in photogrammetric production has changed the professional environment. The changes are reflected in the new system
- capabilities, i.e. qualitative (new fields of application) and quantitative (higher accuracy and time-efficiency);
- limitations, e.g. reliability, life time of components, support, etc.;
- requirements, i.e. operational (higher level interaction), support (software, hardware).

When conceiving an evaluation system an important consideration is its rationality. As complex and sophisticated systems are unattractive in practice, simplifications are necessary. If applied in a well controlled manner, the evaluation results will not be distorted significantly. To this end, some guide lines can be given:

- Those influencing factors about which information is not available, can be suppressed;
- The factors with an equal effect on the values of all A.P. variants considered, can be excluded;
- Evaluate sequentially "from coarse to fine", i.e. reject consecutively the evidently unsuitable variants (fig. 2).

The overall concept of the evaluation system is represented, much simplified, in figure 3. The two components, i.e. the information and the value model, should be matched to the objective of the evaluation - and thus they should be mutually balanced. The figures 2 and 3 are generally valid and thus are applicable to the evaluation of any man-made system.

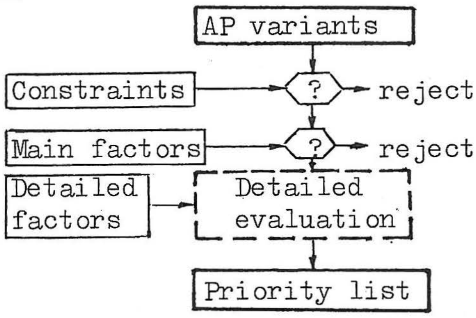


Fig. 2: Sequential evaluation "from coarse to fine"

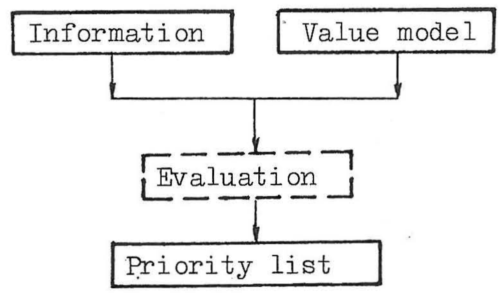


Fig. 3: Concept of value system

In the following, the two components of the evaluation system, i.e. the A.P. related information and the value model will be outlined.

## III. Information

The information to be evaluated should be sufficiently accurate and comprehensive, and it should be well structured. The structure should be taylored to the value model. A suitable structure is attained by classifying the information items into the overall and the specific category (fig. 4). Each of them can be further subdivided into several hierarchial levels (2).

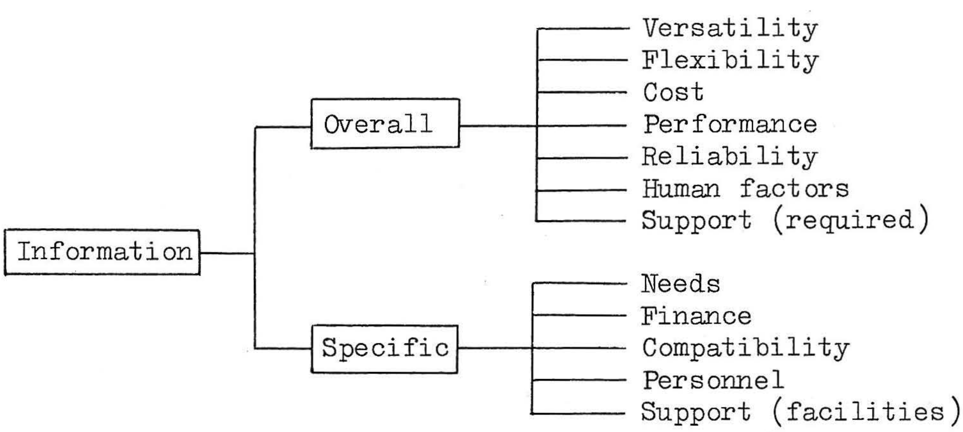


Fig. 4: Hierarchial structure of information items

For the collection of information in an organised manner, well structured check lists should be compiled. Such lists should cover all relevant items of information. The sources of information are partly external (e.g. documents, consultations) and partly internal (inquiries, check-out, testing).

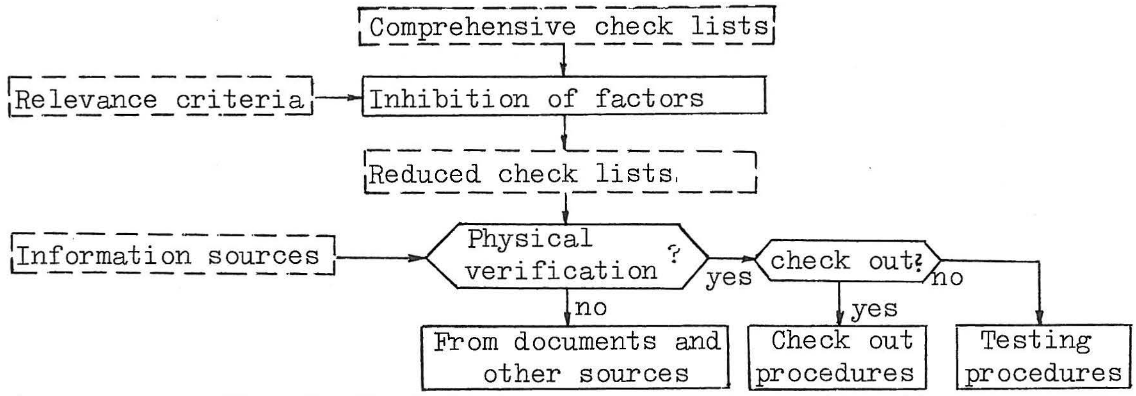

Fig. 5: Check lists and sources of information

The check lists represent a frame of reference to identify which items require a physical verification by check-out or testing processes (fig. 5).

The aim of check-out routines is to gain qualitative information on those relevant items, which are insufficiently documentated and/or when the user considers it desirable for some other rational reason. The answer from a physical verification is usually a confirmation or negation, though a few intermediate steps are also possible.
The check-out routines are classified, like the check-lists, into the overall and the specific category (2). The overall category concerns partly the flexibility, performance, reliability, ease of operation, and the support, whereas the specific category is represented by the internal compatibility. As in due time the experience and insight will increase, the need for check-out routines will presumably decline.
More about the check-out procedures is reported by Z. Jaksic in his invited paper (3).

Testing procedures provide quantitative information, and are usually much more involved than the check-out routines. Since, for obvious reasons, the tests prior to the purchase cannot be extensive, they should be restricted to the most important items only. The comprehensiveness of such tests and the effort required should be balanced. The different tests can also be classified into the overall and the specific category; however, they should be priority ranked. For the users, the overall tests seem to be of the primary interest (2). It is purposeful to differentiate each category further into tests for the devices and tests for the procedures. In order to increase efficiency, several tests can be combined, e.g. of procedures, software, performance, and ease of operation. Moreover, reliability tests can be restricted mainly to the devices.

Prior to the purchase of an A.P. the user may not yet have sufficient experience in testing. In such a situation it is preferable to rely upon the tests performed by, or in close cooperation with, an experienced operator.
A more comprehensive report on the testing procedures is presented by L.W. Fritz (4).
The information collected in an organised manner from the different sources represents the input for evaluation. The quality of evaluation should not be lower than the quality of the input information.

## IV. Value model

The aim of evaluation is priority ranking of the A.P. variants, after excluding the inferior ones. The evaluation process should therefore be modelled adequately. A feasible approach represents the multiple factor method, as it is general, flexible, and tends to make evaluation transparent and objective (5). The major steps in formulating the value model are shown, simplified, in figure 6.

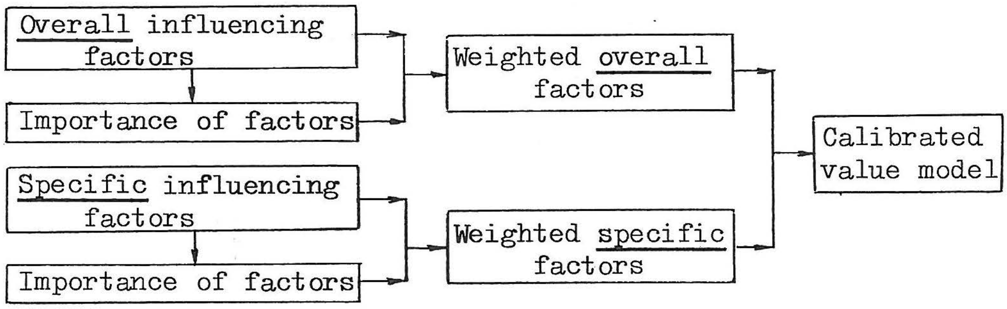


Fig. 6: Formulation of the value model

The overall and the specific factors refer to the items of information shown in figure 4. The corresponding hierarchial tree of several levels forms, in combination with the multiple factor approach, a multi-level value model. The multiple factor approach can be applied to any level - thus permitting a coarse evaluation (in the highest level), a fine evaluation (in the lowest level), or an intermediate evaluation.
The concept of the multiple factor method is illustrated schematically in figure 7. The dimensions of the evaluation matrix, which is composed of the

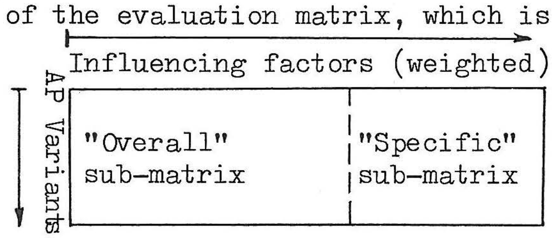


Fig. 7: Scheme of an evaluation matrix.

overall and the specific submatrix, are determined by the number of A.P. variants and influencing factors.
In a multi-level structure, an evaluation matrix is assigned to each level (2). The evaluation, however, needs to be carried out only at the lowest desirable level. When structuring the information items and thus the influencing factors, the mutually dependent factors should be grouped together; the groups as such should be as indepndent as possible. During assessment the common issues of the factors within each group should be encountered only once, i.e. the first time they occur in the sequence. This prevents an overemphasis of the common issues which are inherent in the different factors.
For each matrix element, i.e. the A.P. variant and the influencing factor, the corresponding figure of merit is assessed by examining the corresponding input information. The assessment implies a subjective conversion of the collected information into the figures of merit. After assessment of all the factors, the corresponding weighted averages can be calculated for each A.P. variant.

The ranges of both the figures of merit and of the weights, should be predetermined. The objectivity of the evaluation can be increased by involving several neutral experts in weighting the factors and in assessment of the merits. These experts would be acquainted with the overall state of the art and with the specific organisational environment.
For an arbitrary evaluation matrix, the values can be calculated according to

$$V^T = PW^T$$

where W is the vector of weights, P is the matrix of figures of merit, and V is the vector of values. Thus, the <u>overall</u> and the <u>specific</u> feasibilities are

$$F_o = P_o W_o^T \quad \text{and} \quad F_s = P_s W_s^T$$

and subsequently the composite (or total) feasibility is

$$F^T = F_o F_s^T$$

The A.P. variants can then be ranked according to priority.

## V. Conclusion

Increasing complexity, sophistication and diversity of the new photogrammetric systems call for profound evaluation prior to their introduction in the production processes. This also applies to A.P.'s which have reached the stage of operational maturity.
An evaluation system consists of two basic ingredients, i.e. the input information and the value model. These should be balanced and mutually adapted. The information should be sufficient, correct and well structured, whereas the value model should be responsive, flexible and easy to handle.
An efficient strategy is to first reject the unsuitable system variants by applying simple, straightforeward criteria. For a detailed evaluation, the multiple factor method is feasible due to its rationality, flexibility and transparency. When combined with a hierarchial structure of the influencing factors, the evaluation can be graduated bewteen coarse and fine.
However, the method also has some limitations:

- Some of the influencing factors are interdependent
- Identification and structuring of the factors is subjective
- Assessment of weights and figures of merit are subjective and can be manipulated.
- Errors in assessment accumulate and, if the number of factors is great, the results might be distorted.

Nevertheless, these problems can be avoided if the method is applied with care, without bias, and, in particular, if several experts evaluate independently. Moreover, there is apparently no better alternative method.
The future need for formal, methodological evaluation might be governed by the following two contradicotry trends:

- The expertise of photogrammetrists in the area of A.P.'s will increase - which may tend to reduce the need;
- The complexity and sophistication of A.P.'s (and broader systems with the A.P. capabilities incorporated) will further increase - and thus the need will be greater.

However, regardless of which of the two trends will prevail, a methodological approach should not be subordinate to intuition whenever an important decision has to be made. Instead, intuition may be integrated, well controlled, into a methodological framework.
Before concluding this report, I suggest that the W.G. II-1 should continue the effort with upgraded objectives - having emphasis on software related problems, with a new chairman, and a different composition.

## Acknowledgement

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## Appendix 1: List of Working Group members

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Prof. Dr.-Ing. E. Dorrer, F.R.G.
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Mr. M.G. Loopuyt, France
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Dr.-Ing. M. Stephani, F.R.G.
Mr. C. Vigneron, France
Mr. H. Yzerman, Italy

## Appendix 2: I.S.P. Commission II Symposium, Paris, 1978. Working Group II-1.

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|---|---|
| Dubuisson, B. | Compatibilité des restituteurs analytiques avec l'imagerie digitale dans la restitution d'espace variés. |
| Forrest, R.B. | Analytical plotter capability integrated in larger systems. |
| Fritz, L.W. | A system for users to evaluate analytical plotters. |
| Jaksic, Z. | Notes on evaluation criteria and performance tests for analytical plotters. |
| Makarovič, B. | An introduction to the system for evaluation of analytical plotters. |