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# A SYSTEM APPROACH TO CONSERVATION AND CULTURAL RESOURCES MANAGEMENT. PHOTOGRAMMETRY AS A BASE FOR DESIGNING DOCUMENTATION MODELS

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**KEYWORDS**: conservation, system approach, information system, metamodel design

**ABSTRACT**

A system approach is used to define the area of conservation and cultural resources management as a field of activities comprising local as well as global issues, concerning public and private properties and organizations, focused on small treasured artefacts as well as large natural environments. The application of a metasystem paradigm enables through a process of abstraction, a deeper understanding of complex systems such as the conservation area. Dysfunctions could be described and understood, and hence target for management procedures supported by an information system, yet to be designed.

The conservation system is described through three organizational levels; the operational level, the tactical level and the strategical level. These levels differ in their problems of concern and decision rationalities, thus having impact on the requirements of an information system. The three levels concerns all conservation sub-systems, or rather control systems, where each control system has developed specific routines and standards for the flow of data, information and knowledge, supporting the decision making process.

The paper rounds up with identifying the problems in launching a general information system for the conservation area and in what respect photogrammetry and other imaging techniques can constitute basic functionalities in such a system.

## 1. INTRODUCTION: DOCUMENTATION

Documentation can be defined as a process which produces written, printed or other kind of material, furnishing data and information from which knowledge might be derived. The concepts of data, information and knowledge can be defined:[1]

<u>Data</u>; *The input stimuli entering the cognitive process, in form of letters, numbers, lines, graphs and symbols etc., used to represent events and their state according to formal rules and consents*.

<u>Information</u>; *That portion of input stimuli retained as knowledge. The cognitive state of awareness (as being informed, having knowledge) given representation in physical form (data). This physical representation facilitates the process of knowing*.

*Information is a subset of data*.

<u>Intelligence</u>; *That portion of information used by the decision process for decision making or action. Intelligence implies an active involvement and understanding and the ability to extend the levels of understanding to meet life's contingencies.*

*Intelligence is a subset of information*.

Information has a vital role as a regulation of systems, as counteracting entropy, i.e. the disorganization of a system. Information has the objective to increase organization, regulation and control of a system.[2] Hence information can be seen as an instrument in the decision making process within a system. *Cognitive processes* are mental functions that act to separate information from data, and *decision processes* are such functions that convert information into intelligence. In order for a message to achieve a function in a goal oriented setting for decision making and system control, data, information and intelligence need to be conceptualized in terms of different types of rationalities.

### 1.1 Documentation as a research process

The problems occurring when attempts are made to introduce photogrammetry as a method for documentation in conservation, are depending on lack of a general attitude of problem orientation in the operative functions of conservation, and specifically so when considering documentation in its practical applications. This is further reflected by the lack of a generally accepted theory applied throughout the conservation field, implying how documentation and information management might be operated. A more apparent awareness on the need for problem identification, might have been illustrated in several operations in conservation, through questions like:[3]

- for whom and in what situation is it a problem,
- why is it a problem,
- when and under what conditions is it a problem, and
- how does the problem occur.

There have been many discussions on strategies for documentation within the conservation area. Mátyás Szabó states in *Some Aspects of Museum Documentation* that “The supposition that data is not affected by age or by lessening value, but that it lies in the archives and becomes more valuable every year, is one of the most dangerous assumptions of the museum profession. /.../ Different demands should beforehand be placed at the planning stage on forthcoming research material, including a basic formulated problem which has as its main aim the arrangement of data in a meaningful sequence."[4]

John Bold at the *Royal Commission on the Historical Monuments of England* (RCHME), has expressed their approach to documentation as:[5] "Any record made will only be of lasting value if knowledge, observation and analytical intelligence have been brought to bear. Questions must be asked, hypotheses constructed and answers sought. The results must then be presented in a form which others can test; a process analogous to that of the natural scientist. Without analysis we have a mere inventory of phenomena."

Nordbladh and Rosvall identified the importance of a scientific-scholarly approach, when advanced measuring techniques are introduced within the fields of cultural history and conservation.[6] Problems occurring are based on an evident inability to communicate over the boundaries between sectors in society, and results, for the cultural historical side, in a controversial need of having a given problem expressed explicitly - i.e. defined in precise terms. For the technicians — such as experts on advanced measurement techniques, e.g. photogrammetry — there is on the other hand a tendency of applying modern techniques irrelevantly on objects within the area of conservation.[7]

The vectorized analysis, e.g. equidistance curves describing a relief, has normally been considered as the primary representation form. In several situations however, the photographic stereo pair as such might be sufficient for initial analysis of the problem at hand. Especially so when the technological development has brought about a digitisation of the entire process, enabling a considerable increase of possible output forms, including different photographic representations.

### 1.2 Documentation and conservation

The complexity of the conservation area as a field of study makes it easy to be lost in practical questions concerning operative functions. This becomes yet more evident when looking on how documentation and information management are organized, or rather, weakly organized within conservation and cultural heritage organizations. It is easy to put in words *the conservation field* or *the conservation area*, implying the presence of a consistent system linking all diverse aspects of conservation together.[8] This impression is further supported by the fact that many questions of conservation are matters of national and public importance, thus directed by governmental administration through authoritative public bodies. But bearing in mind for example the constant conflicts between preservation interests, and interests representing other sectors of society — resulting e.g. in gentrification, unnecessary deterioration, demolition or misuse of movable and immovable cultural property — it is easily perceivable that there is no such consistent system. The base for establishing a conceptual understanding of a conservation system rests on common tools for documentation, enabling free retrievability and representability of information within different application areas. Quality as a basic concept for needed standardization is in this respect fundamental for developing documentation tools.

It is possible to say that the preservation of cultural heritage normally is carried by a rather chauvinistic attitude, from local to international levels, at least concerning monuments. Chauvinistic in the sense that for several nations is the identification[9] of national monuments[10] linked to the formal establishment of the state in question. Hence the preservation and conservation of the monument is a matter for the specific country and not as such a base for international co-operation. It is further possible to find conflicts characterized by dissimilarities between objectives of central vs. local functions, e.g. questions on funding, and issues related to policies for dissemination of resources. The conservation field obviously consists not of one coherent system, but of several systems and subsystems within them. These systems do not necessarily have well defined links to each other, but often lead to a number of malfunctions on all levels: Not co-ordinated operative functions or a total lack of such; A lack of models applicable for the whole conservation area; Frequently counteracting goals between cultural conservation on one hand and environmental protection on the other, just to indicate a few principal dysfunctions.[11] When studying how information is recorded, processed, stored and distributed within this sector, such malfunctions are obvious and most probably a direct cause to the poorly established consistency throughout the field.

## 2. SYSTEM APPROACH

The system approach presents a methodology to understand organizations and other man-made systems, to identify problems and to design models for solving problems, but also to redesign entire systems. The application of system approach to the field of conservation has been studied by van Gigch[12], Rosvall and van Gigch[13], van Gigch, Rosvall and Lagerqvist[14], and Lagerqvist[15].

### 2.1 Studying the existing system

van Gigch argues that "one of the most difficult problems in implementing the system approach is the existence and structure of the existing system",[16] since the *old system* in place constitutes an impediment to implementation of redesigns. When applying a system approach, the ability to define relevant problems within the systems studied becomes a strategic task.[17] The identification and formulation of problems are based on a process of abstraction, which implies:

- to isolate or separate certain characteristics from all others,
- to find commonalties, and
- to find the general and the universal.

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By abstracting, the level of inquiry might be raised from the lowest level of abstraction as a description of the present system, to a higher level of abstraction conceptualizing the ultimate purpose of the studied system, following in principle the system levels as described in Fig. 1.

| |
|---|
| **The Level of Metamodelling**<br>This is the *policy* or *strategic level* which, when applied on the conservation area, constitutes a level above organizations and conservation sub-systems. This level is concerned with *generic problems*, regardless of their origin |
| **The Level of Modelling or method development**<br>This is the *tactical* or *object level* of an organization. On this level models are designed in order to meet identified problems at the intervention level. In the academic world this level implies the principal activities of "normal |
| **The Level of Intervention or implementation**<br>This is the *operational* or *technical level* of an organization. This level constitutes Reality, where problems regularly are solved on a daily basis by implementing well worked out methods and procedures which originate from development |

*Fig. 1. Modelling and metamodelling hierarchy*

The purpose of the conservation field, where the information management is an inseparable part, constitutes the base of study where different system levels need to be defined:[18] *the subsystems*, *the system*, and *the whole system.*

By *subsystems* are understood the different agencies of a total system (see below), and the level where they are working independently as self-contained and self-sufficient organizations fulfilling their specific tasks. Examples on such agencies in conservation could be museums, conservation studios, architect offices, urban planning departments, etc. Such agencies tend to regard themselves as the system, and other agents as interfacing systems or environments.

The *system* – or total system – implies a level where agents are assembled through a common goal, to form one system. On this level operates the decision maker or the system manager. Concerning the conservation area this level is only vaguely present in a rather tentative manner, through the perspectives and concepts thus far discussed and developed in a scholarly frame[19]. Hence the broad perspective describes more of a potential conservation total system rather than an actual existing one, with routines for decision making and system management. Although the increased awareness during the last decade concerning air pollutants and their deteriorating effect on all kinds of natural and man-made objects, has lead to the recognition of the necessity to combine efforts in order to achieve positive results, regardless of former professional and scholarly-scientific boundaries.[20] The authoritative national public conservation bodies, might be able to fulfil such managerial functions in the future, today however they could rather be identified as independently working subsystems.

By the *whole system* is understood the level incorporating the total system and interfacing systems which through their activities have bearing on functions within the total system. Problem at hand within the total system might affect or be affected by activities within the interfacing systems, however outside the direct control of the managerial function of the total system. Such interfacing systems could be political system, educational system, industrial system, or economic system.

These system levels are seldom consciously apparent for practitioners functioning on sub-system level. More often the specific sub-system is apprehended in concepts pertaining to total system as well as whole system boundaries, but without the explicit discrimination of problems and functions in regards to such defined areas.

On the subsystem, system and whole system levels, activities are performed which relate to four areas needed to be understood when applying the system approach to organizations.[21]

- *Defining the boundaries of the whole system and of the environment.*
  By the *whole system* is understood a frame comprising all systems, regardless of formal organizational boundaries, which affect or will be affected by specific problems, i.e. in this context how to improve documentation and information management in conservation. The *environment* consists, then, of such systems which are not parts of the whole system, i.e. systems which do not affect or will not be affected by a specific problem or question and the operative functions and models used to handle that problem or question.

- *Establishing the objectives of the system.*
  The definition of the boundaries for the whole system might be regarded as a consequence of establishing the systems' objectives. It could be that the objectives of one element in a sub-system do not necessarily need to be the same as for the whole system, however they probably coincide in the general direction of their intent. For example, when recording data concerning a specific building, the objective in several cases could be to increase the level of knowledge concerning the specific building in question, or the built environments at large, and to preserve the recorded data. The documentation might not necessarily, however, imply an objective to preserve the building as such. The fact that thoroughly recorded data exist, might be used as an argument both for preserving the building in question as well as for pulling it down.

- *Determining the program-structure and the program-agent relationships.*
  Determining the program-structure implies an identification of activities with similar objectives. By grouping agents or organizations to such programs according to their functions, they form components of the system. These components do not necessarily follow traditional or organizational boundaries but they share the same objective programs.
  In the case of this study, the program-structure concerns documentation methods for recording data on cultural resources to be used within the field of conservation. This implies primarily to fulfil and improve functions in conservation interventions, as described below in this paper.

- *Describing the management of the system.*
  The system management includes all activities and all decision makers and agents involved in planning, evaluation, implementation, and control of the system design.

**2.2 The metasystem paradigm**

The concepts of data, information and intelligence need to be understood as components in processes for decision making in a system. The cognitive and decision processes enabling the conversion of data into intelligence, constitutes the behaviour for decision making within a system. This particular behaviour is justified by four types of rationalities. The rationalities are concerned with the structure, content, form and ends, and need to be all present in order to achieve goal-oriented decision making:[22]

- The *structural rationality* guides the establishment of a structure of organizational decision making.
- The *substantive rationality* concerns question of ‘content’, ‘substance’ and ‘knowledge’ which guide the outcome of actions within a certain system.
- The *procedural rationality* concerns choices of procedures by which decisions within a certain system are taken.
- The *evaluative rationality* refers to the goals set up by
  decision makers[23] and/or the criteria by which goal fulfilment is defined and evaluated.

Following the argument that information provides control, regulation and organization in a system, the decision making process can be seen as a control system.[24] A general model for control and metacontrol can thus be presented as in Fig. 2.[25]

Regarding the above as a general lay-out the intent is to provide a background for:[26]
- identifying control system’s;
- identifying metacontroller, controller, controlled system, environment for a specific control system;
- differentiate between data, information and intelligence flows;
- identifying major foci of decision making;
- identifying the functionalities of the four kinds of rationalities;
- diagnosing whether appropriate rationalities are available for making decisions;
- trace and diagnose cases of system failure in the perspective of the needed rationalities.

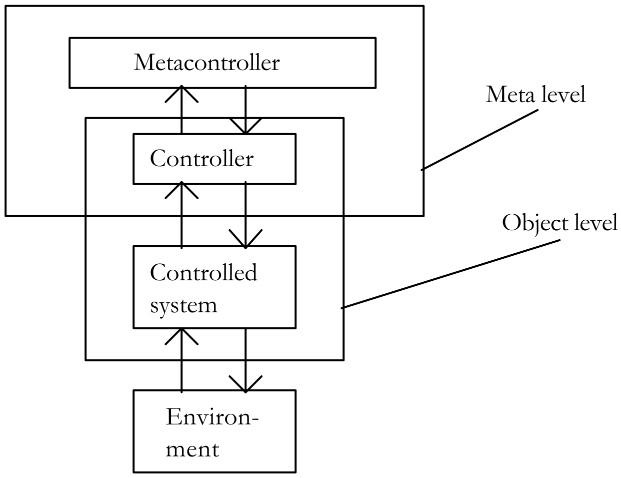


*Fig. 2. A general model for control and metacontrol.*[27]

**3. CONSERVATION**

Conservation as an academic discipline is not as widespread internationally as "normal" science disciplines, and when established it is normally focused on one or a limited number of the diverse fields composing the whole area, e.g. paintings conservation, architectural restoration, or protection of natural environments.[28] Concerning the possibilities to perform research and PhD-studies in conservation, the number of universities are even lesser, leading to a lack of a commonly established core curriculum for the discipline conservation. A broad approach to conservation science would imply long-range research devoted to material, intangible and anthropogenic conditions, with the objective to generate cross-disciplinary integrated knowledge and to develop operative methods and far reaching explanatory models of global capacity for the area.

It could be argued that the future survival of society need to be based on a broadly established conservation policy. Different resources — e.g. natural, social, economic — are not unlimited. Urban and land-use planning might be anticipated to increasingly larger extent be ruled by approaches where preventive, preserving and recycling ideals compose a general base. Buildings, built environments and other existing physical structures will hence reach increasing importance as major resources for the benefit and future development of the societies in which they are used. The combination of sensitive restoration techniques with suitable adaptation, in order to reach sustainable development and equal social conditions, therefore constitutes the very base for urban and regional planning. Natural and cultural landscapes must be regarded as integrated issues, as well as the management of monuments and solitary buildings can not be distinguished in a principle point of view from built environments of a more ordinary and sometimes anonymous character. The preservation of artefacts must likewise be regarded in relation to the surrounding environment and in longer time perspective than what has been considered normal until now.

At the symposium "*Air Pollution and Conservation*" in Rome 1986, the following definition of conservation, attributed to Sir Bernard Feilden, was formulated in the Final Statement:[29]

> *Conservation may be defined as the dynamic management of change in order to reduce the rate of decay. The cultural, scientific, technical and natural heritage and resources must be considered as authentic documents and valuable components. Interventions should be limited to actions strictly necessary to insure the continuing conservation of this heritage, but the techniques and materials used should not impede future treatment or examination. Conservation requires comprehensive socio-economic, legal and cultural planning, integrated at all levels.*

The on-going process of decay and damage to cultural resources describes a complex system combining man-made causes and more or less natural processes. Examples could be ultraviolet sunlight, seasonal temperature changes, effects of animals, natural disasters, pollution, vandalism, theft, pressure from tourism, poor conservation, and of course pure stupidity. Due to these causes it is clear that conservation has far more implications than only restricted to more or less technical-scientific questions concerning material aspects of cultural property. It is thus possible to identify similarities in questions of preservation between cultural and historical resources on one hand and natural and biological resources on the other.

### 3.1 Operational level of conservation

The cultural environments and artefacts in focus for the operative functions of conservation are "embedded" within each other in a system of hierarchically organised sub-systems, see Fig 4. The subsystems are ranging from a traditional apprehension of conservation as concerning cultural artefacts to more general views on sustainability and recycling. Within the subsystems indicated, different operators are active with tasks, problems and routines, specific for respective system. Actions in one subsystem will according to systems theory, ultimately affect the other subsystems and consequently the whole system, where the results might not necessarily be co-ordinated nor wished, thus resulting in an increasing inefficiency.

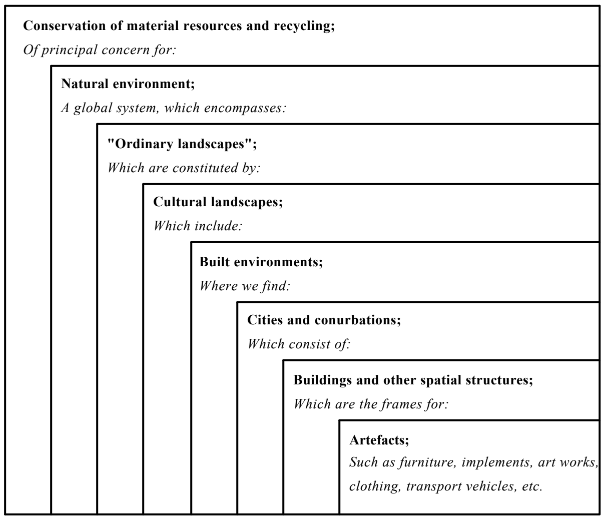


*Fig. 3. Conservation subsystems.*[30]

Documentation in conservation has up to now been developed solely as an operative function within some sub-systems — normally non-compatible with each other — of the intervention level of the conservation system. Argued for here, is the modelling of a documentation process enabling a system design for information management. Such documentation process must support and improve the practice of conservation interventions of different types: preventive measures, preservation, consolidation, restoration, reproduction, and reconstruction. The implications of these actions are described by Feilden and Jokilehto in *Guidelines for the Management of World Cultural Heritage Sites* by UNESCO[31] and also by Weeks and Grimmer[32] in *The Secretary of the Interior's Standards for the Treatment of Historic Properties*.

<u>Preventive maintenance</u>;[33] *Establishment of measures and routines in order to minimize the effects from degrading, deteriorating and destructive forces, e.g. reduction of vandalism or air pollutants at source. Measures consists of administrative and accountancy procedures for identifying recurring problems, essential parts in the preventive maintenance strategy are documentation and scheduled routines for inspection.*

<u>Protection</u>;[34] *Actions which provide the conditions for a cultural object to survive. These actions can be legal — legislation, planning norms, etc. — or physical, e.g. shelters, coverings, or sometimes removing the object to safety.*

<u>Preservation</u>; *To keep cultural property in its existing state, with repairs when.*[35] *The act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Works should generally be focused upon the ongoing maintenance and repair of historic materials and*

*features rather than extensive replacement and new construction.*[36]

Consolidation;[37] *To ensure continued durability of structural integrity of cultural property, by application of supportive materials into the actual fabric.*

Restoration; *To revive the original concept or an earlier, defined phase, or improve the legibility of the object by e.g. systematic cleaning or replacement of components.*[38]

Anastylosis ;[39] *Aims to make the spatial character of a ruined structure more comprehensible by reinstating its lost original form, using the original material which is located at the site and is in satisfactory condition. Anastylosis as an intervention refers in general to structures consisting of clearly identifiable components.*

Reconstruction;[40] *The act or process of depicting, by means of new construction, the form, features, and detailing of a non-surviving object for the purpose of replicating its appearance at a specific period of time and in its historic location.*

Rehabilitation;[41] *The act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values.*

Infill;[42] *Is used concerning urban sites and aims to re-integrate the lacunae in the urban fabric by contemporary constructions and designs, but taking also into consideration the design of their historic context.*

Apart from these defined phases, an important practice of preventive nature is maintenance, which has been defined as "*the process by which a building is kept viable for the benefit of its users*".[43]

Before an intervention, as related to above, can be performed a number of steps have to be carried out and where different documentation techniques form a substantial part. Weaver[44] identifies three main steps or phases:

- recordings as a back-up of historic structures and buildings if they should be damaged or destroyed, or to be used through a valorization process in a societal context;
- recordings in order to prepare conservation contract documents; and
- recordings as a monitoring device in order to detect changes which occur with the passage of time or because of external forces.

The preparation and implementation of a conservation contract can be further divided into a number of steps, where each has its specific requirements of data and information through different representations:

- The first phase is where decision on an object to be subject for preservation action is made. Photogrammetry provides the base for needed data and information: as "ordinary" photos, photographic stereo pairs, ortophotos, 2D-drawings, 3D vectorized models, or rendered 3D models.
- The next phase is concerned with identification of the problem to be solved through preservation action, thus constituting a scholarly-scientific research phase.
- This leads to a process where the intended conservation intervention can be planned and designed, underlying the formulation and preparation of a contract. In a flow of data and information this phase can be regarded as a process transforming the result of previous phases into knowledge formalized as e.g. drawings and specification for procedures and materials.
- The intervention is carried out with interim and final inspections, with recordings of the process, deviations from original plan, and the final result.
- After finalized intervention follows continuing monitoring and maintenance procedures.

**3.2 Tactical level: Intervention principles**

Following the reasoning of Brandi[45] and the cross-disciplinary overbridging characteristics of conservation — both in an academic disciplinary sense and as an area of operative functions — the implications concerning the management of cultural resources leads to two demands:[46]

*Respect for the original,*
*which is a conservation demand and requires:*

a) a minimum of interventions,
b) use of original materials,
c) substitute material should be similar to the original,
d) new materials should not result in damages,
e) all interventions should be "retreatable",[47] rather than "reversible",
f) a copy should be possible to distinguish from the original, and
g) all interventions should be documented

*Long period of service life,*
*which is an economical-technical demand and implies:*

a) an apprehension of time of service life in centuries rather than decades,
b) continuos maintenance,
c) functioning constructions should not be changed,
d) used materials should have known qualities,
e) reversible technique, and
f) interventions should be documented and motivated

### 3.3 Strategic level: Values and valorization process

The valorization[48] as such has become such an integrated part of the operative functions in conservation, especially concerning the built environment, that it is looked upon almost as an unquestionable part of the work. We can in this respect recall that Feilden has stated that valorization is at the base of all conservation.[49] Brandi, further, states in his theory of conservation that cultural objects have to be valued as either being works of art, or objects for everyday use.[50]

However, difficulties might arise when valorization becomes such an important part of operative functions that a tendency towards inoperability of such functions can be understood. The concept cultural historical value has been used, or tried to be used, during the last decades as an instrument for discriminating between what has been judged preservable, and those structures and artefacts considered to be of lesser interest for the conservation area. Valorization is necessary, but when used with the intent to distinguish in an "objective" manner the preservable from the less preservable, it reflects a restricted conservation concept. The idea of a value objectivity might be criticized, from at least the following aspects:[51]

- Valorization varies over time and follows the aesthetic ideals which characterize society.
- Valorization is dependent on the background, objectives and previous knowledge, of the person(s) making the valorization.
- Different values assigned to a building might be contradictory.

The interpretation and documentation of an artefact must be regarded as the professional activity of conservators, based on scholarly-scientific principles. This activity is focused on the single artefact, the solitary monument or any other kind of physical structure, i.e. the traditional apprehension of conservation practice. These descriptions and interpretations should be made excluding the assigning of values. The objective is to produce information and knowledge based on studies of cultural historical artefacts, buildings, etc. The process of valorization is an important task but has to be made in a societal context, as a democratic process integrating cultural and historical heritage as forces in the continuous development of society.

van Gigch and Rosvall[52] argue that Conservation Ethics is rooted in cultural value and historical value, and that conservation in this respect not only concerns cultural property but encompasses also the preservation of natural heritage.

Following this,[53] a system of values might be distinguished prevailing in conservation:

Knowledge values; *Values which provide the base in need and reality for anything which has to do with cultural heritage as a necessary component of any civilization; i.e. as observed in a longitudinal perspective, normally under relatively stable conditions.*

Emotional values; *Values which allow us to affix desires to certain things, i.e. as apprehended on individual level, concerning intangible existential dimensions, often of collective concern.*

Economic values; *Values which relate to local or general norms established by society, by asking "How much does Society (or at least one individual) value this things?"*

Use values; *Values which focus on the degree to which individuals and society at large accept an object and the use of it, or not, i.e. as understood on an operative level within a "market" exchange system, i.e. as defined on society level.*

These values describe the complex context where human activities, structures and conceptions are subject to constant use, reuse, change, decay and destruction, in culturally pluralistic settings. Culture is here understood as a generalistic and anthropologically based perspective, comprising the entire cultural system, but also as a technical perspective referring to material manifestations of culture as pertaining to "Fine Arts".

## 4. CONSERVATION INFORMATION SYSTEM

An information system for application in the conservation field, must be considered partly as a sub-system within the conservation system, partly as a system on its own with operational, tactical or modelling, and policy levels. As such it might be applicable in principle in any societal context of concern and not only in the conservation area. However, as illustrated by earlier attempts to apply photogrammetry within conservation as a documentation methodology, the formulation of principles, strategies and objectives for an information management system must to a certain degree be based on the concepts ruling the area for its application.

The management of an information system has the objective to provide mechanisms for controlling the parent system. Following the application of the metasystem paradigm, the principles for a Conservation Information System should describe the control systems and their components; the different flows of data, information and intelligence; the objectives of the conservation system, i.e. the major foci of decision making in the parent system; the four kinds of rationalities for goal-oriented decision making.

### 4.1 Conservation control systems

It could be argued that the broadened understanding of conservation as a comprehensive system, hardly exists

in reality outside the ability of the academic field to represent the “real world” through scholarly-scientifically designed models resulting in organized structures. The different sub-systems composing the conservation system do however exist, and may therefore be studied as a structure composed of certain control systems.
Four different conservation control systems, can be defined in principle:

- Museum objects.
- Buildings and built environments.
- Archaeological sites and excavations.
- Natural environments and cultural landscapes.

There are no absolute boundaries between them and specific objects might be transferred between the different sub-systems. The most obvious example is an object found during archaeological excavation, and eventually achieving a role as a museum object. The handling of certain built environments is in several cases possible to integrate with management of archaeological sites and cultural landscapes. As specific areas they are however quite distinguishable, in regards of intervention level and object level. The agents acting on these levels either as practitioners or managerial controllers, are mostly possible to define as belonging to specific academic disciplines and/or belonging to certain organizations. The museum curator for example, is seldom confronted with issues pertaining to preservation of cultural landscapes, sustaining biodiversity, or choosing between different alternative material components to be used in a restoration task. A landscape architect is seldom or never troubled with how to best exhibit e.g. the industrialization of printing technology.
Archaeological excavations are certainly executed by archaeologists who in most cases are organized as a part of a public body, specifically oriented towards the area. The management of museum objects is of likewise obvious reasons supervised by museums.

The agents active within the control systems can in principal belong to either of two groups: Those who work full-time with practising and/or managing conservation issues or those who partially in the line of their ordinary tasks indirectly come into contact with conservation problems.[54] Examples on the former would be: antiquarians, archaeologists, architectural conservators, archivists, conservators of collections, curators, ecologists, heritage recorders, heritage sites managers, museologists, and museum managers. In a complex societal system as the conservation system, these professionals mostly act as practitioners or managerial controllers, i.e. they operate results. In some singular cases however, they also might fill the role of strategic controllers, i.e. decision making on policy level, and then mostly within the scope of the controlled systems.

Examples on professionals which might be involved indirectly, to different degrees, in conservation work might be: architects, biologists, building surveyors, chemists, craftspersons, engineers of all sorts, geographers, geologists, hydrologists, landscape architects, politicians, sociologists, and urban planners.

Following a definition of conservation in its broadest sense, it is difficult to determine the border between the whole system and the environment, since most societal functions will affect or be affected by problems or questions within the conservation system. However, this border can be seen as a consequence of establishing the objectives of the conservation system. Valorization might be regarded as a process where information, experience and knowledge from the conservation field are confronted with other societal demands on the use and reuse of objects and environments. Hence valorization could be understood as constituting the border, although wide and vague in contour, to the environment.

**4.2 The objectives of the conservation system**

The aim of the conservation system is to reduce the rate of decay on cultural, scientific, technical and natural heritage and resources, since they function as authentic documents and valuable components for the benefit of societal development.
In order to achieve this aim decisions are taken in order to control interventions, which are:
Preventive maintenance, Protection, Preservation, Consolidation, Restoration, Anastylosis, Reconstruction, Rehabilitation, Infill, Maintenance.

These activities have the objectives to:

a) respect the original, whether of material or intangible nature, and thus constitutes a cultural historical conservation demand;
b) achieve a long service life, which describes a economical-technical conservation demand.

This apprehension of aim and objectives concerns what might be defined as the internally oriented focus of the conservation system. In the process of achieving results answering to demands according to this general focus, this includes activities and agents positioned externally to a varied degree as illustrated in the previous section. Following the concept of information within a system[55] the internal orientation cover Data (signals and messages entering a cognitive process) and Information (the portion retained as knowledge through the cognitive process) and Intelligence (the portion of information used by the decision process for decision making).

The nature of the conservation activity is to a large extent however externally oriented. The application of data and information acquired from and through objects and environments of various kinds, in most situations

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concerns interactivity, and sometimes confrontation, with other societal interests. As a frame for this meeting between conservation and its counterparts rests a process of valorization, where the outcome normally decides what actions are possible to take for the conservation practitioners within a societal context. The principles for the valorization process has not yet reached a level of abstraction, enabling a comprehensive fulfilment of assigning values to cultural resources without severe contradictions between externally as well as internally formulated demands.

**4.3 Data, information and intelligence flows**

The aim of a Conservation Information System is to enable the establishment of a common agreement of the aims and objectives of the conservation system. The objective of an information system is to serve and provide control within a parent system. This is achieved through application of a number of levels for recording objects, where each level corresponds to a certain degree of information density. Hence an hierarchy of eligible levels of accuracy might be composed, providing advice and choices of methods and instruments based on a definition of the documentation task. The cognitive processes can therefore be related to not only the mental functions retaining knowledge out of data flows, but as much providing the base for recording data. If artefacts, objects and environments, composing the cultural heritage, are to be included as components of the information system, then the uncontrolled flow of data can be defined as the thoughts, ideas, reactions, etc., coming to surface when we as societal individuals are confronted with the historical remains. The organization of describing and recording this heritage, within a conservation frame, is a cognitive process.

1. *The first level* would be composed of the following components:

1.1 Definition of an object according to *category for purpose and/or function* following the principles established by "Outline of Cultural Materials".[56] Several categories might be assigned to one object, depending on the nature of the object in question.

1.2 *Photographic representations* of an object by use of photogrammetrical principles.

1.3 For buildings, real estate and other forms of immovable cultural property, *real estate data* should be included provided by the Central Board of Land Survey (as a national public body following the Swedish example), giving legal, administrative, economic and cartographic information. The minimum level would be the property denomination and the position through geotopographical co-ordinates. When applicable this might be used also for movable objects, e.g. artefacts from an excavation site, interior objects as inseparable parts of a building, etc.
For movable objects this level is otherwise concerned with *acquisition data*, following the CIDOC minimum

2. *The next level* would increase the amount of information, as follows:

2.1 Detailed definition of an object according to *sub-categories for purpose and/or function*, following the principles as in A, where an object might be assigned several sub-categories.

2.2 Description of the *historical development of the functions* and/or *purposes* of an object.

3. *The final level* comprises components for the most detailed description, also referring to intangible dimensions, in this scheme on the basic functionality, of an object:

3.1 *Description of form, colour, material, technique and execution* represented in an object, their present status and the historical development, giving regards to stable structures as well as evolving and disappearing elements as identifiable during the objects life-time. The description is intended to be made primarily by photographic techniques and a key word list organized as a thesaurus with hierarchical levels

3.2 *The object and its environment.*

*Fig. 4. Three basic levels of object description.*

The application of photogrammetric methodology in this context, provides a cognitive process characterized by its ability to ensure a high degree of eligibility between different forms of representing information. If calibrated cameras have been used, and the normal case has been followed, and a sufficient amount of control points have been recorded and signalled in the photos, then it is possible to chose between highly accurate and more low-cost representations.

A three level-system can be described following Fig. 4, as constituting a basic structure for a Conservation Information System's cognitive processes. Based on this structure different applications for acquisition, processing and representation of data should be generated. These applications can be of three principal forms:

- Application models which are developed and established in order to respond to internal conservation demands, e.g. exhibition planning, management of conservation treatment cycles, artefact acquisition recording, etc.
  Needed to be developed in such internal context are models which combine the identification and availability of historic information material accumulated over centuries, and current documentation.[57]

- Models which are developed through co-operative efforts between agents from the conservation system and from interfacing systems.

- Models which are developed by agents representing interfacing systems, e.g. production of different forms of didactic material, development and production of transport containers for sensitive artefacts, production of instruments, solvents, tools, etc. for use in conservation operations.

These models can be described with perspectives formulated as *information character*, *information density*, and *object properties*.[58]

*Information character* concerns the type of data which are to be acquired. *Information density* concerns how data within the different information categories have different detail levels and the optional possibilities in the recording/acquiring situation.

- *Data available in archives*; i.e. not printed or published but readable on different kinds of data carriers (drawings, photos, audio tapes, etc.).
  The retrievable data have been given a certain *density*. When searching through archives a detail level is possible to chose by focusing on one type of data carrier or a combination of several.
- *Data available in literature*; i.e. published data, implying that such data previously have been characterized as information or as results from a decision making process. Presented data is in principle of high density.
- *Verbal data*, in principle recorded as:
  Data recorded through interviews; data can be acquired either through *structured query forms*, or by a *free conversation*.
  Data acquired through verbal description of properties; data can be recorded in *free text*, or by *standardized keywords* to be used through a form.
- Data represented by *graphic description*, i.e. analogous representations. The recorded data can be given representation through *photographs*, which could be *analogous*, choosing between selective/thematic or total/general, and *analytical*, e.g. IR, UV, X-ray; *measured drawings*, with relevant level of accuracy (precision, fidelity and reliability); and *sketches*, including also e.g. not measured floor plans, sections, etc.
- Data recorded through *analytical numeric description* of properties by measurement based on choice of *accuracy* (precision, fidelity and reliability).
- Data representing properties or environmental factors of an object through taking samples, can in principle be of *destructive*, or *non-destructive* nature, and can be sampled *once*, *occasional*, or during *systematic long-term* studies.

*Object properties* concerns the qualities of the recorded object and could be divided in two principal groups:
- *Material properties*, which could be of *stable*, *changing*, or *temporarily* nature.
- *Intangible properties*, which also could be of *stable*, *changing*, or *temporarily* nature

By combining the different levels of these perspectives, it is possible to create numerous models which are linked to the basic structure for a Conservation Information System's cognitive processes.

Decisions are made within the scope of each control system as internal functions, as well as on a level comprising more than one control system. For example might the preservation of an archaeological site be incorporated in a broader preservation plan, including the caretaking of cultural landscape and natural environment.(See Chapter 5) If an excavation of the site is an initial part of the preservation plan, then eventually object conservators and exhibition managers on a museum will have to be involved. Several control systems and controllers thus are present.

Based on available information for a certain object, and the nature of possible decision options, the confrontation of conservation interests and other societal needs in externally oriented applications should be made within the frame of a valorization process.

In several conservation operations it is impossible to distinguish a metalevel control system or even designate a metacontroller. For a chain of events in chosen question, or situation needing decision on different levels in conservation, it is most probably not possible to define an ultimate metacontroller. Within the scope of a Conservation Information System a metacontrolling function is needed for promoting relevant standards. The operations management of CIS should be organized through a decentralized structure, where regional and local conservation bodies, i.e. regional and larger local museums and conservation administrations at county government levels, function as managers in close contact with development, establishment and operative use of different applications.

**4.4 Decision making rationalities**

The cognitive and decision processes which convert data into intelligence, are given justification through four rationalities.[59] To identify the flow of rationalities providing input and output for decision making on different levels, the problem of concern and universe of discourse has to be identified and related to corresponding organizational and control levels. The conservation field as a complex societal system is not easily transformed into schematic abstractions as attempted below. Different organizational levels could comprise different control levels at different times and even at the same time. The benefit of abstracting the functionality of decision making in conservation, and the kinds of rationalities justifying it, is that it provides the frame for the operationality of a Conservation Information System.

| *Organizational level* | *Control level* | *Problem of concern* |
|---|---|---|
| Policy level | Meta level | *What* should be subject for conservation management and interventions. |
| Tactical level | Object level | *How* should conservation interventions be performed. |
| Operational level | Lower level | *When* should it be performed. |

*Fig. 5. The problems of concern related to organizational and control levels in conservation.*

Understanding the conservation field as a system conservation is organized in different levels where different levels of control are imposed on problems of concern for the organizational level in question, see Fig. 5.

For each organizational level the rationalities as input for decision making can be described, and the resulting output in the shape of decision with a certain destination. *On the operational level* the problem is concerned with decisions on when interventions should be performed. In doing so, the general agreements, specifications and standards on how interventions are to be performed, must be followed which constitutes the universe of discourse.

This leads to a description of rationalities *on operational level* (see Fig. 6).

RETURN

| Input/Output | Description | Origin/Destination |
|---|---|---|
| Input | | Origin |
| Structural rationality | Instruction on how to organize the structure of the operations level, i.e. who decides, what is decided and how, when are decisions made. | Meta level (strategic or tactical level) |
| Evaluative rationality | Criteria by which operational objectives such as respect for the original and long service life, as well as costs and quality, are determined. | Meta level (strategic or tactical level) |
| Substantive rationality | Specifications and standards for how Interventions are to be performed. | Strategic level and tactical level |
| Procedural rationality | Methods and procedures by which specifications and standards are implemented. | Strategic level and tactical level |
| Output | | Destination |
| Intervention decision | Decisions on the application of a certain intervention. | Operational level |

*Fig. 6. Decision rationalities on operational level*

*On the tactical level* the problem is concerned with decisions on how interventions should be performed. In doing so the universe of discourse is to decide on standards and specifications for how interventions are to be performed, within the scope of what have been considered being subject for conservation interventions. This leads to a description of rationalities *on tactical level* (see Fig. 7).

*On the strategic level* the problem is concerned with decisions on what should be subject for conservation management and interventions. In doing so the universe of discourse is to decide on how the conservation field define its area of interest and what constitutes for an object to be turned into subject for conservation interventions.
This leads to a description of rationalities *on strategic level* (see Fig. 8).

| Input/Output | Description | Origin/Destination |
|---|---|---|
| Input | | Origin |
| Structural rationality | Instruction on how to organize the structure of the tactical level, i.e. who decides, what is decided, and how, when are decisions made. | Meta level (strategic level) |
| Evaluative rationality | Criteria by which the efficient allocation of funding and dissemination of heritage information, can be achieved. | Meta level (strategic and tactical level) |
| Substantive rationality | Scholarly-scientific, managerial and technical knowledge and expertise. | Tactical level |
| Procedural rationality | Methods by which scholarly - scientific, managerial and technical expertise are applied to the problem of developing standards and specifications for how interventions are to be performed. | Tactical level |
| Output | | Destination |
| Structure, evaluative and substantive rationalities for lower levels. | Decisions on structure, evaluation criteria and standard and specification for interventions. | Operational level |

*Fig. 7. Decision rationalities on tactical level.*

| *Input/Output* | *Description* | *Origin/Destination* |
|---|---|---|
| Input | | Origin |
| Structural rationality | Instruction on how to organize the structure of the policy level, i.e. who decides, what is decided and how, when are decisions made. | Strategic level (Boards of public bodies on strategic level) |
| Evaluative rationality | Criteria by which the use of allocated funding and the progress of knowledge, can be evaluated, and how the valorization process succeeds in providing the establishment of conservation interests in society. | Strategic level |
| Substantive rationality | All accumulated knowledge in relevant scholarly-scientific and technical fields. | Tactical level |
| Procedural rationality | Paradigms or methods and procedures by which scientific inquiry is conducted. | Tactical level |
| Output | | Destination |
| Structural rationalities for lower levels. | System structure | Tactical and operational levels. |
| Evaluative rationalities for lower levels | Criteria by which lower levels can determine principles for funding allocation and information management. | Tactical and operational levels. |
| A valorization process enabling a dynamic and creative preservation management of societal resources. | | Tactical and operational levels. |

*Fig. 8. Decision rationalities on strategic level.*

## 5. EXAMPLE

Decisions are made within the scope of each control system as internal functions, as well as on a level comprising more than one control system. To exemplify, a normal situation in heritage management has been chosen were several control systems are involved in a not always clear pattern. The situation concerns the decision making process, when an archaeological site should be excavated, the objects found should be conserved and exhibited, the site preserved co-ordinated with the preservation of the natural environment surrounding the site

On regional level[60] different sectors of society operates, through each sector's legislation, the demands and interests on the built environment in general. This would be the control system C1 (see Fig. 9) and where the planning board of the regional administration function as controller CR1.

For a number of societal areas governmental bodies act as managers on policy and standards level. Concerning cultural heritage C2 would be a control system and Central Board of National Antiquities (CBNA) the controller CR2, while the Central Board for Environmental Protection is the controller CR3 for the control system C3.

The county conservator on cultural heritage is situated in the planning board of CR1 as do the corresponding agent on natural environment. These two act as controllers of the systems C1-2 respectively C1-3. Control systems which simultaneously are part of C1 and C2 respectively C3. Their main control function concerns the funnelling of governmental funding for priority projects, in this example the excavation, conservation and preservation, co-ordinated between natural and cultural heritage interests, of an archaeological site.

The archaeological excavation, control system C2-1, is operated by CBNA regional archaeological office financed by funding from CR1-2.

In an early phase of the project are conservators involved in order to take care of findings and prepare them for exhibition and storage. Conservators could be part of a museum, control system C4, but might also operate as a private consultancy business. The control system concerning the objects conservation, C2-4, is included in C1-2 since the funding for excavation also must comprise conservation treatments.

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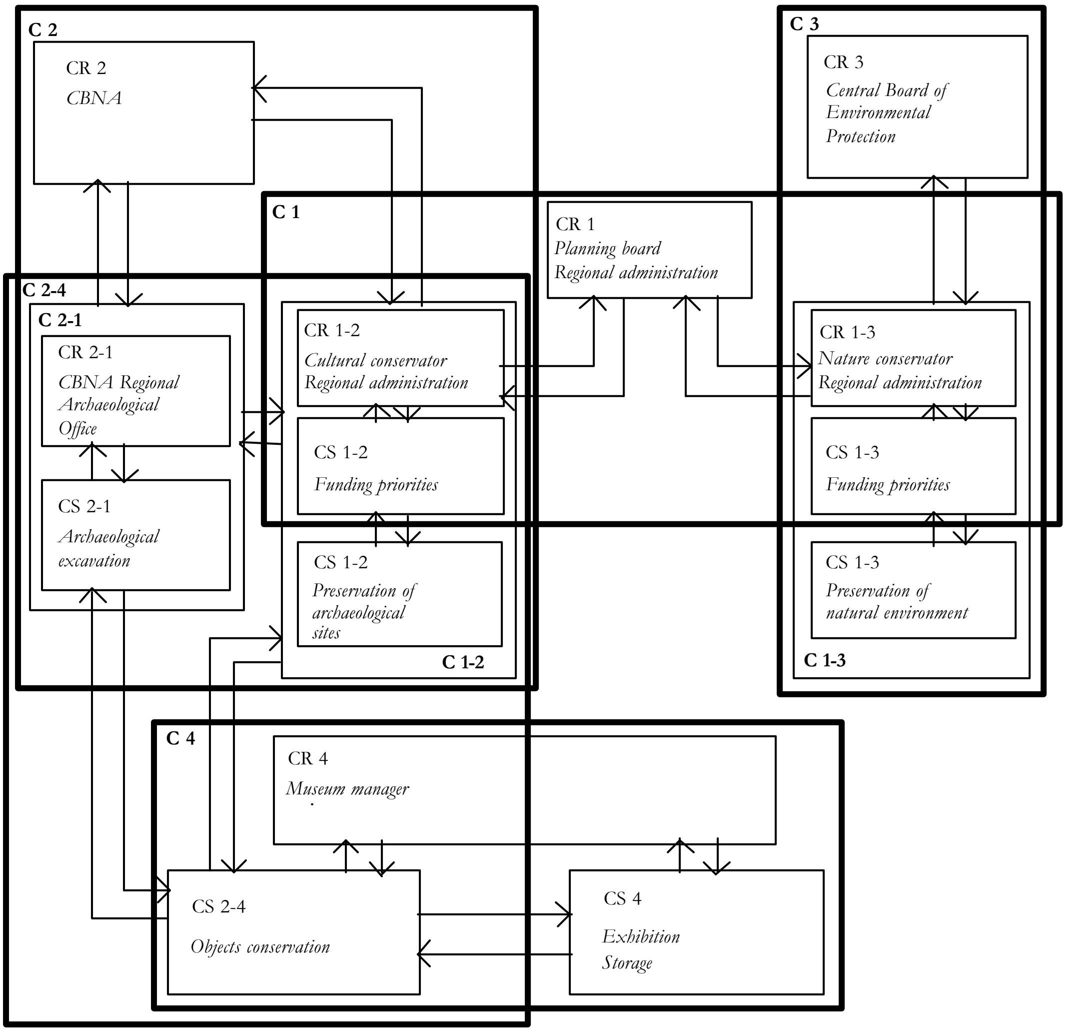


*Fig. 9. Schematic illustration of a hypothetical situation for decision making in conservation.*
*C - Control system, CR - Controller, CS - Controlled system.*

The continuos preventive conservation of the findings in the coming future, will fall under the economic decision of the museum management, thus being a part of the control system C4.

In the figure is the environment excluded for the sake of clarity. The related example should therefore be understood as an internal decision making process within the field of conservation. Previously has been stated that the conservation system is composed of four control systems. They are of principle nature, and might not correspond exactly to different operations in an example as the one presented above.

## 6. SUMMARY

The increased availability of powerful digital resources for developing and establishing different applications for processing data and presenting information in conservation, naturally might have a tendency to focus the interest towards technological issues rather than on data and information as such, and those dimensions which such data represent. Digitally created visualizations of a running dinosaur or a walk-through of the Altar of Pergamon,[61] easily hold our fascination for the technique and makes it almost overwhelming. It is difficult in such cases to see through the digital framework and comprehend the artefact or issue it has been applied to and why; what objective the digital system is intended to meet. It is further difficult to see how systems for documentation and information management, in this respect, can provide the managerial support needed for running, evaluating and developing museums, according to Keene.[62] Digital technology does however provide possibilities to establish networks with commonly shared information in specifically needed areas, as have been demonstrated by Thornes[63] concerning identification and recovering of stolen art objects, e.g. from museum collections. It is further necessary to point out the existing infrastructure as constituted by Internet, which enables simple and low-cost possibilities to establish network functions on local as well as global levels. Internet also offers possibilities to make presentations and virtual exhibitions and to receive on-line feed-back and discussion.

When taking a standpoint in the application of photogrammetry it is easy to go astray among the numerous possibilities for increasingly advanced representation options of the reality.. Analytical plotters and processing equipment for digital photogrammetry, can in several conservation applications be considered as "overkill". Extremely accurate measurement data is too often produced to very high costs, or is given expensive representation, which is not needed, and consequently might lead to decreasing possibilities to establish photogrammetry as a commonly operated technique for recording purposes in conservation practice. Highest accuracy does not necessarily equal high quality. Here is urgently important that the conservation field formulates standards for data acquisition.

The quality of an information system should be linked to the possibility to choose between different levels of accuracy and. When using photogrammetry as the primary photographic technique, a system of eligible levels is more or less automatically provided. However, the technique itself does not solve problems or provide the managerial skills needed for the museum sector. The success might be measured through the number of applications established, or the impact of these applications for the integration of conservation issues in other professional areas or societal functions.

Photogrammetrically recorded data can be reused repeatedly for different processings, and reach different sorts of representations of the recorded object. In this respect photogrammetry provides an optimization of the presentation strength, i.e. the same set of input data can be given any chosen form of representation limited only by available competence, instrumentation and economy — conditioned that the stereo pairs are possible to process including measurements giving full support on object scaling and rotation. The transformation possibilities are, following this presentation, substantial. The same set of input data can be reused for different representation forms on numerous occasions.

The important strategic role of photogrammetry within a Conservation Information System rests on the fact that it provides information which in its unprocessed form - with photographic stereo pairs including accurately measured control points - represents an information level which is easy to decode in a variety of applications.
Photogrammetry can therefore be regarded as an instrument for data and information flows with different operations for cognitive processes. Hence it might be a supportive measure for primarily the substantive, procedural and evaluative rationalities of decision making on operational, tactical and policy levels. These rationalities are concerned with the content guiding the outcome of actions, choice of procedures and the definition and evaluation of goal fulfilment. As illustrated by the case studies relations underlying decision making can be described in a variety of structures. Conservation need to be understood as a complex social system with different control system not always consistent in a longitudinally perspective, but with a congruent recognition of general aim and intent. Photogrammetric methodology and general imaging techniques has the ability to provide a flexible and at the same time compatible structure for managing data and information flows and the cognitive processes.

Representations from photogrammetric documentation can be produced successively, where each single phase implies an increased amount of investments in work and costs. At the same time photogrammetry provides opportunities for an optimization of economy, i.e. each "producer" as well as "consumer" can make relevant plans of investments with regards to aspects of accuracy, application area(s) for representations, and available instruments and competence.

The photogrammetrically recorded data are, in principle, reusable repeatedly in the different levels, and therefore it is possible to decide relevant level for representation, based on the problem at hand in various situations. Recorded data of certain age could, following this principle, be compared with newly recorded data. With recent technological development in mind it is nowadays possible to describe all forms for representations as digital applications. This includes low-cost systems for 3D-viewing of objects on the monitor through specific glasses, to sophisticated computer-intensive systems which enables e.g. 3D-animation's of an urban fabric.[64]

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