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Reflections on the

benefits and potential economies

of geographic data standards

A study made on the instructions of the Directorate of cadastral surveying, Swiss Federal Office of Topography

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Introductory note

As mentioned in the Summary, these "Reflections on the benefits and potential economies of geographic data standards" are intended to make the importance of technical regulations and their coordination known to a wider public. The intended audience includes all those involved directly or indirectly in the exchange and analysis of geographical data, from interested politicians to senior management to the leaders of project teams.

The need for action emphasized here can be described as *large and urgent*. However the editor wishes to point out that the opinions expressed by the consultants in this report are not necessarily those of the client, the Swiss Federal Office of Topography.

Wabern, April 2000
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SUMMARY

If geographic data standards are not applied, economic losses follow.

Geographical system standards in general offer *significant potential benefits*. In their absence, or if they are inconsistently applied, economic loss and damage is inevitable. In this report on “Reflections on benefits and potential savings” this already well-known fact is demonstrated on the basis of empirical investigations of the benefits. These reflections are directed not only to a technical audience in the field of land and geographical information systems, but should also be made known to a wider public.

In the Swiss geographical information market in recent years, *several million Swiss Francs* have been wasted annually, and continue to be wasted. One reason for this is that the existing geographical data standard, INTERLIS, *is not applied sufficiently widely or consistently*. (Note: the Swiss INTERLIS standard is a data exchange mechanism for land and geographical information systems.) The losses demonstrated through four case studies from the official cadastral survey become very much greater if all geographical data currently being generated in the open market are also considered.

If legal requirements and technical standards are not modified within a reasonable time and if in the future all participants in the geographical data market do not coordinate their work, the damage to the economy will become *intolerable*. It is assumed that, in this situation, society will eventually demand improvement.

Immediate measures to avoid this loss and damage

Thanks to its favourable starting point, Switzerland can immediately bring about the most urgently needed improvements in the efficiency of handling geographical data, through consistent application of the existing *regulations and standards* by the responsible authorities.

Producing benefits for the future with geographical information standards and coordination

Even such obvious geographic data as administrative boundaries, buildings, addresses and place names, traffic routes or land use, etc. is not generally available in accordance with a uniform definition. It is captured and kept up to date by government, quasi-governmental and private organizations in dozens of ways, mostly slightly different from each other. It is thus obvious that, through proper coordination and the use of geographic data standards, an increase in efficiency and substantial cost savings could be achieved. At the same time both the quality and currency of the data could be improved.

Coordination means that both initial capture and each subsequent update of such data is carried out only once. The data would then be made generally available, for example over the Internet, and could thus be used in a variety of ways. In the context of this coordination the technical and organizational rules should be set up in the interests of creative competition so as to allow a decentralized, mixed economy solution in which all participants have the maximum freedom of choice of systems to install.

The success which could be achieved through the introduction of geographic data standards and the Swiss “INTERLIS” standard in official surveys, should now also lead to this development in other areas of geographic data. With the extended standard “INTERLIS 2” the necessary technical conditions are already in place.

In order to achieve the desired effects, all official bodies interested in a particular data type should be obliged to follow the coordinated method, to support appropriate projects and to arrange their own projects in such a way that they contribute to the coordinated action. So that these efforts do not fail as a result of their higher short term costs compared with the continuation of the uncoordinated situation (while benefits would only become apparent in the medium term), some initial assistance is required.

Such initial assistance could be to treat a particular type of data, for example buildings, addresses and place names, as a pilot project. The technical measures would have to be so structured as to be adaptable as easily as possible to other applications.

1 Overview

Geographic data gains ever greater significance because the environment is, inevitably, a central factor in our lives. With the growth in performance of *geographic or land information systems (GIS/LIS)*, geographic information can increasingly influence everyday work, provided that the appropriate data are available and accessible.

Today, spatial or geographical data (sometimes called *geodata* for short) still mainly implies maps and plans. However, structured, presentation-neutral geographic data is gaining increasing importance. Thus a wide variety of organizations hold spatial data covering buildings, roads, addresses, water, utilities networks, property ownership and planning restrictions, and so on. When, for example, a new building is erected, numerous databases require modifications which are generated through a variety of channels and in most cases are processed manually. It is obvious that the currency, and often also the quality, of the different datasets suffers, even though the procedures involve substantial expenditure, borne in most cases by the federal government, cantons, communes or quasi-governmental institutions and thus ultimately by the public.

The ideal situation could be achieved if each change in the real world could be input just once, with as simple a procedure as possible, into a system and then made available to all interested parties.

Such an idea immediately raises the suspicion that, to reach this goal, a gigantic centrally-controlled database would have to be built, a kind of supertanker which can react only with difficulty to practical everyday needs. In addition, progress in computer science suggests alternative solutions: instead of a central system, various independent subsystems (so-called *federalist systems*) would cooperate with each other. A substantial advantage of such independent subsystems is that they can be set up on the basis of a variety of different products and can also have completely different life cycles. It is however obvious that independent systems can only cooperate in this way if the work is *coordinated*.

Geographic data standards provide effective means for this coordination. These are standardized tools with which the geographic data can be precisely described. From this *data description*, data exchange and data storage *formats* can be derived. Thus communication about data is perfectly regulated and misunderstandings over the content and meaning of data are reduced to a minimum.

This study examines the topic from a variety of perspectives. First some typical tasks and problem areas are described in detail (*Section 2*) and the reasons are sought for why the available possibilities have remained in many ways unexploited (*Section 3*). This is followed by a summary of the twelve possible benefits which would result from the introduction of standards (*Section 4*). Next, possible geographic data standards are briefly presented and the proposed action in the official cadastral survey with INTERLIS is described in detail (*Section 5*). In the next section, user experience in the official cadastre is described by means of four case studies (*Section 6*). Finally, based on the benefits and potential savings deduced from the case studies, two tentative projections are presented, together with our conclusions (*Section 7*).

2 Typical tasks and problem areas

2.1 Multiple use of data

As already outlined, particular types of data are ideally captured and stored by one organization. Others may then wish to make use of this data. It would then be natural to make the data available to other organizations. This immediately gives rise to other problems.

2.1.1 What systems are used by supplier and user?

Since a variety of systems are available in the marketplace, it is likely that the supplier and the users have installed different systems. It is then obvious that data exchange must be examined closely. But even if the same systems are used, data transfer problems can develop, since the supplier and the user may have set up different applications on the basis of the same products. For example, the supplier and the user may have different perceptions of how a building is described.

2.1.2 What medium is used to transfer data?

Depending on the quantity of data, the frequency of transfer, the systems involved and other aspects, diskettes, CD-ROM, magnetic tapes or telecommunications may be used. A variety of other details must also be specified.

2.1.3 In what format is the data to be supplied?

First the type of format must be specified: is the data to be transferred as pure images, as vector graphics or as structured data? Once this is settled, a number of further parameters should also be defined. Thus, for example, raster images should be associated with clearly defined colors.

2.1.4 What meaning does the data have in the specific application?

With the definition of the format, only the form is fixed: neither the content nor the meaning of the data is defined. Thus, for example, a declaration that data is to be exchanged in DXF contains no indication of what data is held in which layers. It is advantageous if such definitions are formalized rather than being given as ordinary text. However this is by no means the case with all exchange procedures.

2.1.5 What happens to the data when it is modified?

If all these matters are defined, a further question soon arises: what happens if the original data is modified because of a real-world change? Should all users be re-supplied with the data? Should this take place after each change or only at lengthy intervals? Is it possible for the user to receive only the changes each time, rather than the whole dataset? Or, particularly with smaller quantities of data, would it perhaps be even better for the user not to hold the data permanently but to receive it from the supplier only temporarily while it is in use, thereby avoiding problems of updating?

For most of these questions there are no definite, generally applicable, permanent responses. In each situation, depending upon the current state of the constantly changing technology, different solutions are correct.

2.2 Decentralized data processing

Even if certain data is held by a central body such as a canton, it may be desirable for this data to be captured or even kept up to date by another organization such as a local survey company. Proximity and local knowledge as well as considerations of competition are substantial advantages of such decentralized processing.

As with the supply to data users, similar questions arise. Typically the person involved in revision receives a section of the current data from the data owner or operating authority, carries out the necessary update and returns the new version, or alternatively the changes only. It is obvious that the revisers must have the same perception of the data as the owner and that a data exchange procedure must be established.

2.3 System changes

The questions outlined normally arise when an organization interested in geographic data wishes to install a new system. How can the existing data be moved over from the old system? This question is particularly important where highly detailed geographic information already exists, because the acquisition cost of such data is very high and may exceed system procurement costs by a factor of a hundred.

It is essential to establish that the data really can be entirely taken over from the old system, because a partial transfer, with subsequent manual reprocessing, leads to substantial costs.

Anyone who examines, for example, a land registry plan, an overview plan, a zone plan, or the national map at different scales, will recognize the same landscape features and names again and again. This is of course understandable, because the different maps and plans all represent the same geographical space. They only differ in scale or in their intended use. Since at smaller scales less space is available to show a specific geographical area, items are omitted, simplified or summarized. In cartography this is known as generalization.

At present generalized representations are usually produced as separate datasets. As a rule they are even initially captured and subsequently updated completely independently. Ideally, however, they could be derived from more precise (large scale) data. Even though this cannot simply be achieved automatically with today's technology, it can make sense to produce at least a rough version from the precise data. For certain applications up-to-dateness is more important than a cartographically correct representation. The cartography can be improved subsequently if necessary.

Similar considerations apply also to non-cartographic purposes. Thus, for example, different statistical information could be collected together from the precise basic data, then simplified and finally (perhaps still even graphically) displayed.

3 Reasons for the unexploited potential

The problems defined above indicate that substantial potential savings are available. Why are they not exploited more effectively? The most obvious reasons are technical. In addition, organizational, training and human factors are also involved.

3.1 Technical factors

The technical possibilities are continually changing. Typically the standardization which is so important for coordinated progress lags behind the technical developments themselves. It is not necessarily the best solutions which become established as de facto standards, but those which, for a variety of reasons, achieve wide distribution.

The geographical data field was long shaped by cartographic perceptions. In many places this is still the case. The planimetric cartographic product remains the center of attention, rather than the underlying data itself. This is not least because the generation of high quality graphics direct from the data is in part an extremely demanding process and calls for very abstract thinking. How much simpler it is, just to work on the cartographic portrayal. In the short term the cost for this may even be lower than for the capture of correct data, and some special cases may still be better handled in this way.

Much the same applies to data transfer. Without large expenditure, it is today possible to send smaller quantities of data in a DXF-, Excel or ACCESS format to interested parties and brief them verbally about the content and meaning of the data, so that they can prepare their systems accordingly. Even if in some cases further processing is necessary, it is quick and the results are satisfactory. However to set up and install such a process permanently can incur substantial costs and often the time to do so is simply not available.

3.2 Organizational factors

This applies even more strongly where different organizations are expected to agree on the structure and content of data, so that this data can be used jointly. Extensive discussions are necessary. In practice success is only possible if the people involved in the process have confidence in modern computing methods and are able to communicate effectively with the experts in the technical field, who will not normally be experts in information technology. Sometimes it may be most helpful if technical reasons can be advanced for starting work with an isolated dataset, because the familiar organization and environment is retained and better returns are thus achieved. The costs are borne indirectly by the taxpayer.

In Switzerland a special situation arises from the federal structure. The federation and the cantons often have different data needs. The different cantons' requirements also vary depending on their particular situation – rural or urban, etc. – and also for historical and organizational reasons. Those involved may be afraid of the uniformity which cooperation could imply, and, often quite rightly, will reject it. For this reason activities are sought through which, for example, a federal solution may be completed using elements which meet the needs of individual cantons. The same applies to the large cantons with their communes.

4 Benefits

Factors which are relevant to the application of geographic data standards can be identified within four areas:

1. *Benefits from guaranteed permanence*: Efficient and permanent safeguarding of geographic data is only possible through the application of standards.
2. *Benefits from clear descriptions of data*: Geographic data standards yield significant savings through clear descriptions of the data to ensure compatibility.
3. *Benefits from multiple uses of datasets captured once only*: Geographic data standards prevent duplication of effort by enabling repeated use of the same information.

4. *Benefits from free and open competition*: Geographic data standards contribute to cost savings, because they can help to ensure fair, free and open competition in the processing and management of geographic data.

In particular, fear of competition causes many vendors to resist binding standards for geographic data, since they think this could lose them their advantageous position in the market.

4.1 Benefits from guaranteed permanence

4.1.1 Benefit factor A: Avoidance of loss of data

Geographic data is costly to acquire. In spite of the development of new techniques for data capture, it cannot be assumed that the cost of acquiring data will be reduced. It is thus necessary to ensure that the data can survive all changes which might affect it. It must not be possible for changes in information technology, the failure of systems or companies, or the further development of data models to harm the data itself. Moreover staff changes must not mean that data can no longer be correctly interpreted.

These requirements can be met only through precise description of the data together with clearly defined formats, in other words by the observance of geographic data standards.

The benefit from the elimination of data losses arises from the fact that once captured, data should never have to be acquired again. If the replacement of data which has been lost or can no longer be interpreted can be avoided, the gain is significant.

4.1.2 Benefit factor B: Avoidance of fall-off in data quality

Geographic data undergoes continual change. Man's activities lead to continuous alterations of his environment. When data which describes this environment is modified there is a danger of degrading its quality. Data records which can no longer be unambiguously interpreted lose practically their whole value.

Precise description in accordance with a defined geographic data standard provides a powerful basis for the preservation of quality, because the danger of degeneration of data records is thereby minimized. The benefit which results from the prevention of the degradation of data quality lies in the avoidance of unnecessary replacement of data.

4.1.3 Benefit factor C: Reduction of cost of changes of system

The valuable data must be maintained over a long period. However, the rapid development of information technology drives ever more rapid changes of hardware and often also of software.

Experience has shown that not only software products but even whole companies can emerge in the market place and then disappear without trace. For the costly data to survive such events, system- and producer-independence are very important.

The observance of geographic data standards guarantees that the data can be converted automatically into a new form when a system is changed. Manual reprocessing can be largely avoided.

4.2 Benefits from clear descriptions of data

4.2.1 Benefit factor D: Acceleration of development work

The application of a data standard to the development of data models leads to significant time savings. The precise description of the data and its structure makes discussions more objective and avoids queries and uncertainties.

Time and cost savings in the development of data models and in data exchange are direct benefits. More rapid development also makes the data available for use earlier.

4.2.2 Benefit factor E: Standardization of data supplied

Where a geographic data standard is available, data can be supplied in a clearly defined form. The individual formats and requirements of particular users do not have to be processed individually in each case. Since the user can rely on a clearly defined product, he can be left to adapt the data to his own needs as required.

The benefit in this case falls to the data distribution organization, which has to spend substantially less time on each delivery of data.

4.2.3 Benefit factor F: Reduction of cost of checking

Adherence to a geographic data standard makes it possible to check data descriptions and data records formally and automatically for plausibility and correctness.

An automatic examination of data records takes only a fraction of the time previously needed for checks of this kind. The checks are done systematically and are thus very reliable. This allows the checks needed in other areas to be reduced to a sampling process, resulting in further cost reductions. An additional benefit follows from the hard-to-measure effects of increased confidence.

4.3 Benefits from multiple uses of datasets captured once only

4.3.1 Benefit factor G: Reduction of preparation and processing costs for the individual user

The capture and maintenance of data give rise to the largest expenditure. Maximum savings can thus be achieved if the data only has to be captured once, or has to be updated in one organization. If the data conform to a geographic data standard, they can be made available to multiple users, flexibly and without problems. The cost of capture and updating is then shared between the different users.

The benefits are felt by the data customers through lower charges.

4.3.2 Benefit factor H: Application of the most suitable system for processing, management and use of the data

The requirements for the processing and maintenance of data differ from those for its use. While conditions can be attached to its maintenance, in order to guarantee the continued quality of the data, to follow predefined procedures and to avoid data redundancy, the maximum of flexibility should be allowed in its use.

The creation of products is defined by the needs of the users. It can thus be worthwhile for the data user to employ flexible tools which do not have to obey the cumbersome rules for the preservation of data archives.

This can only be successful if communication about the type, extent, meaning and content of the data available for use, and the exchange of this data between the different systems, is unambiguously regulated.

The provision of customized data which is explicitly defined through the data description within a geographic data standard results in lower processing charges. The possibility of using the most suitable software for the desired application brings rewards both through time savings and through better products.

4.4 Benefits from free and open competition

4.4.1 Benefit factor I: Separation of functions

Through the separation of functions (production, distribution and use of the data), as well as the system-independent organization of the interfaces, effective competition becomes possible.

Within a framework of this kind, the organization responsible for production can concentrate on the capture and updating of the data, while the data owner concentrates on data administration and distribution, leaving the user free to concentrate on its optimal use. This means that all parties can apply the most favorable procedures, best suited to their respective tasks. The interaction of the different functions does however demand the availability of a geographic data standard, so that the data can be made available to each of the processes without problems.

This separation of functions can lead to considerable savings, which eventually reach the taxpayer whether as data owner or data user.

4.4.2 Benefit factor J: Competition in data production

Competition in the field of data production ought not to be distorted directly by the requirements of the data distributors or data users.

For proper and fair competition, it is important for the data to be described as precisely as possible. Only thus can a precisely controlled mechanism for contract awards be set up, together with an equally precise and at least partly automated product acceptance process. For a long time the impossibility of precisely describing and checking incoming data has resulted in substantial losses. Without a precise description of the data there is no possibility of regulating its supply in an effective and contractually binding way.

It must be emphasized that, in this legally and economically important area, there is no substitute for this precise description. Interoperability alone cannot supply a precise basis for contracts. Only the precise definition of objects can serve for this essential part of such a contract.

Clear contractual agreements allow the price advantage which usually results from competition to flow undiminished to the client. In the geographic information field the client is often the public, so the tax-payer profits directly.

4.4.3 Benefit factor K: Competition in data distribution

Competition for data distribution is also becoming ever more topical in view of the developments in public procurement and the trend towards the "new public management". Particularly in the communes, which often have no technical departments for the operation of information systems nor any interest in creating such departments, there is latent interest in the establishment of the most favorable supply arrangements. But even at the canton level it must be increasingly assumed that such services are contracted out. This usually occurs by means of public invitations to tender.

Without precise description of the data, requirements cannot be clearly defined and cooperation with producers and users cannot be regulated.

Conformance to geographic data standards enables the integration of data without costly post-processing. This also benefits the taxpayer directly.

4.4.4 Benefit factor L: Competition in the evaluation of data

The use of the data to carry out the most diverse analyses and generate a wide range of products can also be subjected to competition through the application of geographic data standards. If clear specifications exist for how data are ordered and delivered, the provision of products such as analyses, project plans and studies can be organized through free competition.

This possibility usually leads to lower costs, without the risk of data being lost or duplicated and thereby generating inconsistent data records which must be expensively reworked.

5 Possible geographic data standards

5.1 Overview

By "geographic data standard" we mean a standard or norm in the field of data processing in connection with the description of the earth's surface and the environment and its use for the most diverse purposes.

Since most people readily understand maps and plans, in order to illustrate this, a variety of geographic data standards begin by dealing with graphic representations. Typically this may begin with graphic standards to relate raster or vector data to a geodetic coordinate system. For example, the vectors may be given directly in national coordinates, or the transformation into the national surveying system of the image described in local coordinates may be recorded.

However geographic data standards which deal with the data independently of their portrayal are becoming increasingly important. There are two main objectives:

- the exchange of data between different systems;
- the execution of processes on another system.

5.1.1 Exchange of data between different systems

For a long time data exchange has mainly implied rigidly defined formats for a particular purpose. Examples include the national transfer format (NTF) in Great Britain, the ARINC standard for navigation data in aviation and a variety of formats developed in connection with specific electronic data processing programs.

In connection with software products which can be flexibly adapted to different purposes (data base systems, CAD systems or GIS/LIS), different transfer processes have been developed, in which some basic principles are defined, but the format is only defined in terms of the explicit application. This leads to the problem that senders and recipients both use the same transfer process, but the data exchange does not work well because the two parties have different perceptions of the nature of the data.

This problem emerged relatively early in the surveying sector in Switzerland as a result of the federal structure and the mixture of public and private sector activity. Accordingly an exchange mechanism, INTERLIS, was defined, which first of all describes the nature of the data and only secondly derives a transfer format from it (see next section). This was followed in the European standards organization (CEN) with EXPRESS and afterwards in the international standards organization (ISO) with UML. With its common basic principle, XML seems at present to be becoming ever more established as a basic transfer medium (see INTERLIS 2 and ISO). However, in contrast to INTERLIS these standards have not yet reached the point that they can be implemented in practical software applications.

Practical data models must afterwards be defined on the basis of such fundamental mechanisms. In Switzerland the first step was taken with the basic data set of the official cadastral survey. Different areas of application were defined by means of INTERLIS in accordance with the mixed public and private sector environment of the official cadastral survey. In particular the data structures in the SIA standard GEO-405 "geo-information for underground services" are also defined in INTERLIS (see www.sia.ch). It could, however, still be some time before data models are defined which cover the whole field of geographic data and meet practical needs without imposing technical restrictions on any systems involved.

5.1.2 Execution of processes on another system

Instead of merely exchanging data, systems can also be interoperable over a network. One system sends a command to the other, which executes it and returns the appropriate response as a stream of data. This gives rise to similar problems to those of data exchange. Meaningful commands are only possible if the participants have a common perception of the data objects involved. If in addition one wishes to exchange data in this way, this is at present also a question of system capability.

CORBA and OLE/COM have become established as a basis for this. Standardization within the field of geographic information systems is shaped by the Open GIS Consortium, an internationally-managed non-profit organization based in the USA. Much is still in a state of flux, however.

With the solution of data transfer and interoperability, standardization faces new tasks. Thus INTERLIS and ISO are already tackling the question of how the cartographic presentation of maps and plans derived from data can be described in a system-independent way.

5.2 The INTERLIS standard

5.2.1 Reform of the official cadastral survey (RAV)

In 1984 the directors of the project for the reform of the official cadastral survey (RAV) tasked Werner Messmer, canton surveyor of the City of Basel, with the development of a plan for the application of electronic data processing to the future official cadastre. His report [Messmer, 1985] was delivered in February 1985 as one of 25 consultancies running in parallel.

The consultant made the following recommendations on the subject of data exchange:

“for the interfaces (data transfer mechanisms and basic data set) of the official cadastral survey and the development of future systems, standards should be considered on two levels:

- a higher-level, application-orientated *official cadastral surveying interface (Amtliche Vermessungs-schnittstelle - AVS)*, in line with the basic data processing structure of the official cadastre;
- a lower-level graphics-oriented standard interface conforming to ISO7942 (GKS)."

Messmer presented his ideas in the form of Figure 1. Today DXF version 10 or 12 would probably replace GKS.

The project directors approved this recommendation and sought a computer specialist to draw up a proposal for the implementation of the AVS. The search proved difficult but finally Joseph Dorfschmid was identified as ready to perform this task. The proposal went beyond the definition of a format-based interface. Dorfschmid suggested a definition language with which the data could be precisely described. The transfer format would be generated automatically through rules for its derivation, and software tools would enable the automatic checking of data and data descriptions [Dorfschmid, 1996].

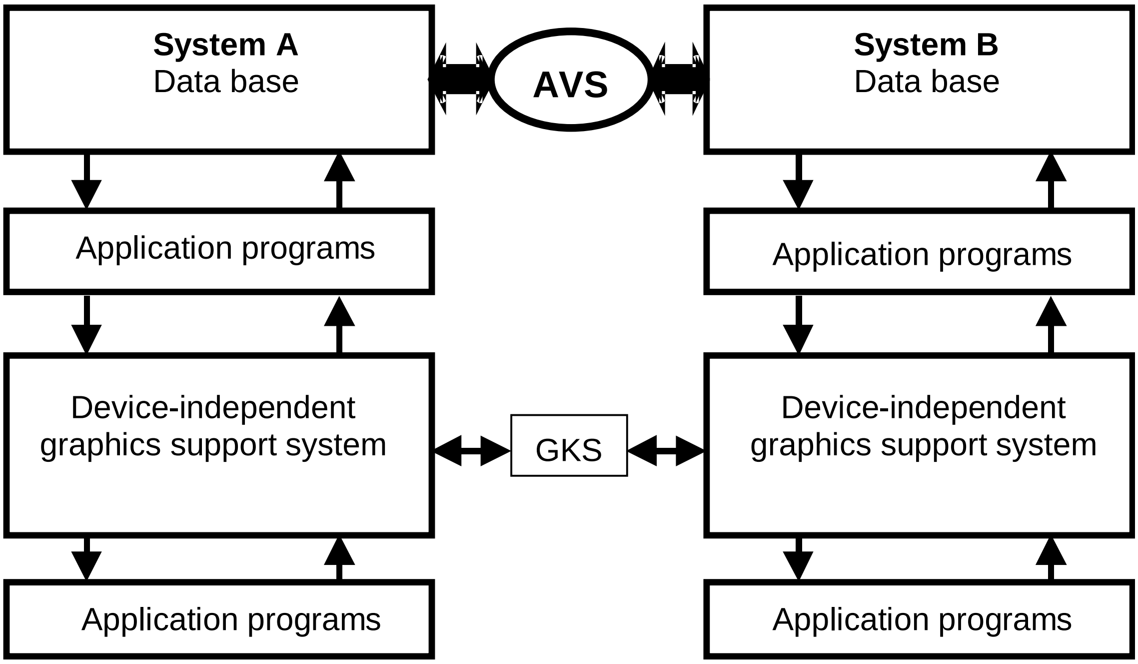

Figure 1: *Data exchange on two "levels" with GKS for graphics and INTERLIS/AVS for digital geographic data [Messmer, 1985].*

This proposal was based on the following:

- precision and flexibility in the data description;
- data archiving in accordance with the principles of data and information security;
- formal checks on data, with a view to eventual automation.

The proposal fulfilled the brief in a most satisfactory and forward-looking way, and was accepted by the project directors. The detailed work was commissioned, and both INTERLIS, the data description language, and AVS, the data transfer mechanism and the basic dataset of the official cadastral survey in the INTERLIS language, were thus launched.

5.2.2 The legal principles of official cadastral surveying

This decision of the RAV project directors flowed directly into the new legislation on the official cadastral survey. Thus Article 8 of the Regulation on official cadastral surveying (Verordnung über die amtliche Vermessung - VAV, 1992) specifies:

To guarantee the long-term availability of official cadastral survey data and its compatibility with other information systems the Swiss Federal Justice and Police Department is establishing the official cadastral surveying interface (AVS).

It must be remembered that, in its position statement, the Federal Information Technology Office (today the Federal Information Technology and Telecommunications Office) particularly demanded this formulation, as one of the most important requirements in information technology.

Article 42 of the Technical Regulation on official cadastral surveying (Technischen Verordnung über die amtliche Vermessung - TVAV, 1994) specifies:

The official cadastral surveying interface (AVS) is defined by the data description in "INTERLIS" (Appendix A to TVAV) and the description of the corresponding transfer format in accordance with INTERLIS documentation.

In particular the INTERLIS documentation consists of the "INTERLIS" data description language and the INTERLIS compiler.

Thus, beyond possible doubt, this solution was, and is, also legally justified. The solution was not universally accepted by users in Switzerland and did trigger some discussion. However, when about two years later the same concept was used in the course of the standardization efforts of the European standards organization (CEN), which was originally tackling only the format level, it was clear that the decision on the Swiss cadastral project had been along the right lines.

5.2.3 State of the standardization and further development of INTERLIS

Before a solution could be achieved by CEN, the work was absorbed by the International Standards Organization (ISO), which began anew two years later. The data description format generation concept is also being applied by ISO, but it has not yet been possible to finalize an international standard. The current status of the international standard was described by Keller [2000], and Gnägi [1999] compared the standards. Meanwhile INTERLIS has been introduced in Switzerland on a broad front as Swiss standard SN612030 and the experience is proving positive (see www.snv.ch). In the opinion of experts who are working on international standardization, a transition to an international standard should cause no major problems.

Already during the introduction of INTERLIS it was clear that further development would be necessary. Article 45, paragraph 2 also states: *The Swiss federal survey directorate is providing for the further development of the AVS and can call upon expert assistance*. As can be deduced from comments on the AVS, at that time the solution of the problem of incremental updating of data records had to be deferred. Also formalizing the additional requirements of the cantons caused extra difficulty. From the first experiences it emerged that some aspects must be even more precisely described. The separation of data and its representation, which had been consistently demanded throughout the cadastral reform process, also suggested the possibility of being able to describe the graphic representation equally formally.

These shortcomings were remedied by an extended version of the INTERLIS 2 data description language (see www.gis.ethz.ch, www.swisstopo.ch or interlis@lt.admin.ch). With this tool both data and graphic depiction models can be described precisely and unambiguously.

6 Experience in the official cadastral survey

INTERLIS has already been in use for several years in the official cadastral survey, and is still the only geographic data standard available today. It is thus possible to assemble practical experience with INTERLIS from a variety of projects. In this section several examples are discussed, in which the lack of a geographic data standard led to problems, or its availability proved beneficial. Since record keeping in the organizations involved did not take account of the possible benefits of data standards, structured interviews were carried out and losses and benefits were estimated. Thus an attempt was made to assess the overall benefits in accordance with the twelve benefit factors described in Section 4.

The resulting estimates and projections are naturally approximate. For this reason the lower end of the range of expected benefits has been quoted in each case. Thus the projected figures represent the lowest likely values; the actual figures would certainly be higher.

6.1 Data procurement for the AlpTransit project in Schwyz Canton

For the preparation of the necessary documentation for the planning and design of the AlpTransit project (a new transalpine tunnel - Neue Alpentransversale (NEAT)) in the period 1993 to 1995, data procurement in the cantons of Schwyz, Uri, Graubünden, Ticino, Berne and Valais was somewhat rushed. The SBB and the BLS (Swiss railways) needed digital data for the design, which could only be taken to a limited extent from available plans. A data procurement program was therefore drawn up in close collaboration with the Swiss federal survey directorate. The data required by the SBB and the BLS included the information layers (themes) for ground cover, single objects and linear elements and heights to be captured by photogrammetry, in accordance with the new specifications of the official cadastral survey 93 (AV93). This data first served for the project design, but was also to be integrated into the official cadastral survey. AV93 was expected to be able to provide for the completion of the data in accordance with the AV93 data catalog (i.e. the data model of the official cadastral survey, otherwise known as the basic data set) and its ongoing maintenance. The costs of these rapid surveys were charged to the AlpTransit project budget. In agreement with the canton survey offices concerned, the AlpTransit data was passed on to a local registered surveyor to be held in trust, until it was integrated into the official cadastral survey.

In these projects the integration into the official cadastral survey caused particular problems. The lack of a geographic data standard proved especially negative.

The expenditure for data procurement in the Schwyz canton amounted to about 1 million Swiss Francs (SFr.). In the following paragraphs the financial effects in Schwyz are estimated with the aid of the benefit factors outlined above.

6.1.1 Benefit factor A: Avoidance of loss of data

The data which could be supplied by photogrammetry was not standardized or structured. On transfer to the local surveyor who had taken on the data management, the data had to be interpreted and structured. Information and data losses could fortunately be corrected through a semiautomatic process. The cost of this work on the ground cover and single object/linear element layers amounted to 110 000 SFr., or about 10% of the original procurement cost.

6.1.2 Benefit factor B: Avoidance of fall-off in data quality

Not applicable.

6.1.3 Benefit factor C: Reduction of cost of changes of system

The transfer from the photogrammetric system to the surveyor’s system can be treated as a system change. Current experience shows that if the data had been available in standardized form, this work could have been completed for less than 5000 SFr., as an error-free automatic transfer would have been possible.

6.1.4 Benefit factor D: Acceleration of development work

Not applicable.

6.1.5 Benefit factor E: Standardization of data supplied

Not applicable.

6.1.6 Benefit factor F: Reduction of cost of checking

An automated check would have been possible only after transformation and cleaning of the data to fit the basic data set. During data acquisition an attempt was made to improve the usefulness of the data by means of staff training and by visual sample checks. Nevertheless a large sum had to be invested again.

6.1.7 Benefit factor G: Reduction of preparation and processing costs for the individual user

Not applicable.

6.1.8 Benefit factor H: Application of the most suitable system for processing, management and use of the data

Not applicable.

6.1.9 Benefit factor I: Separation of functions

Not applicable.

6.1.10 Benefit factor J: Competition in data production

The contracts called for data delivery in accordance with the official cadastral surveying interface (AVS). Unfortunately, the AVS was neither legally binding nor implemented on the systems involved. The contractor could therefore not be compelled to bear the additional costs.

6.1.11 Benefit factor K: Competition in data distribution

Not applicable.

6.1.12 Benefit factor L: Competition in the evaluation of data

The lack of a geographic data standard at the processing stage and for the transfer of the AlpTransit data to the official cadastral survey cost the taxpayer a minimum of 100 000 SFr.

Similar AlpTransit projects took place also in the five cantons of Berne, Graubünden, Valais, Uri and Ticino. These projects covered a variety of areas. Schwyz represented the average. In the various cantons the introduction of the INTERLIS standard had only just begun and the creation of the conditions for successful use of INTERLIS in the Alptransit projects caused a variety of difficulties.

It may therefore be concluded that the economic loss incurred by AlpTransit, which resulted from the absence of a geographic data standard at the data procurement stage and for the integration of the data into the official cadastral survey, amounted to a minimum of 600 000 SFr.

6.2 Nidwalden Canton

The RAV Subito Nidwalden pilot project was carried out between 1990 and 1992. The objective of the project was to take the first step in the reform of the official cadastral survey (RAV), and in particular to test the possibilities of photogrammetry for the rapid collection of data for the ground cover, single object, linear element and height layers in practice (see Subito pilot project documents).

When the pilot project was carried out, the AVS had not yet been finalized. By the end of 1999 the conversion of the land register survey into AV93 was completed. Nidwalden was the first Swiss canton to have full cadastral data coverage. This fully conforms to the INTERLIS standard and can be exchanged without problems and securely archived on a long-term basis.

To safeguard the operation of the land information system (LIS) which had meanwhile been set up on the basis of the official cadastral survey, the canton founded the partly government-owned company, LIS Nidwalden AG. This company operates the information system, under which different system platforms are applied to different sub-tasks. The INTERLIS standard is of paramount importance to LIS Nidwalden AG.

Managing director Fredy Studer was available for interview. The Nidwalden example shows above all that the value of data is dominant in relation to the costs of hardware and software. The following actual costs were incurred [Source: Odermatt, 1993 and Kaufmann, 1995]:

Component	Cost	Proportion
Hardware	SFr. 60 000.-	1
Software	SFr. 240 000.-	4
Data	SFr. 6 500 000.-	>100

Table 1: *Costs for a land information system based on the example of LIS Nidwalden AG.*

Regarding data exchange, the final report on the pilot project stated [Odermatt, 1993]:

> *If different systems are involved [with the transfer], the data format must be selected. At present this must usually be tackled individually depending upon the available interface. The official cadastral survey interface (AVS), which should solve this problem through standardization with the help of a uniform data exchange mechanism, is actually already specified. However, it will still be some time before the software suppliers can offer this interface.*

Meanwhile Nidwalden has experience both of the losses which result from the absence of standards and of the benefits gained if a geographic data standard is available. In conjunction with the benefit factors already discussed, the following estimates can be made.

6.2.1 Benefit factor A: Avoidance of loss of data

Data losses occurred in the transfer of the photogrammetric data into the ground cover layer.

The photogrammetric system was not able to supply structured data. The “spaghetti” data which was delivered did actually contain object codes and could be read into the ground cover layer. However, their individual interpretation and correction was a laborious task. It had always to be expected that these transfers would involve the loss of data, and the data often had to be re-supplied several times. The expenditure for the additional work, which was necessary due to the absence of a data standard, is today estimated as 300 000 SFr.

6.2.2 Benefit factor B: Avoidance of fall-off in data quality

The data were implemented in the form of a provisional data model on a system which had an explicitly defined data model. A loss of data quality could thus be largely avoided. However, the expenditure needed for the introduction of the definitive AV93 model in Nidwalden canton in 1994 gives an indication of the order of magnitude of subsequent rework in case of missing or lost data. In Nidwalden the rework needed to achieve conformance with the AV93 data catalogue cost 250 000 SFr., or about 10 SFr. per hectare.

This figure also demonstrates the importance of the management of the official cadastral survey pushing through an effective geographic data standard.

6.2.3 Benefit factor C: Reduction of cost of changes of system

The integration of externally processed data can be regarded as a change of system. In addition to AV93 data, LIS Nidwalden AG manage further information layers (themes), such as those for regional planning, traffic, and various utilities’ asset registers managed by local government. According to Studer, the lack of official geographic data standards has an especially negative impact on network asset registers for water supply and sewage disposal, as well as on other themes for which no standardized data definition is available. Rework involved in the integration of such data demands the investment of some 5000 to 10 000 SFr. per commune for each theme. LIS Nidwalden AG considers the addition of missing data model descriptions to INTERLIS to be urgently needed.

The 20 themes which have so far had to be integrated into the data records of different communes without a geographic data standard have led to a loss of 50 000 to 200 000 SFr. The data changes continually, so that for externally administered data a new integration process is needed every two years. The cost is of the same order of magnitude each time. Since 1995, the beginning of the further development of the land information system, at least two such updates have taken place. The financial loss has therefore reached 300 000 to 600 000 SFr.

6.2.4 Benefit factor D: Acceleration of development work

The effect of the more rapid development found in the Liechtenstein example (see below) did not take effect from the beginning in Nidwalden, since the INTERLIS geographic data standard was not used systematically. Studer considers however that the savings due to acceleration of development estimated for Liechtenstein should apply equally to Nidwalden. It is advisable thus to carry out development work on the basis of geographic data standards. In the meantime LIS Nidwalden AG have defined all data models in INTERLIS.

6.2.5 Benefit factor E: Standardization of data supplied

LIS Nidwalden AG is responsible for data supply and must be able to deliver data in different formats. Compared with supplying data conforming to the INTERLIS standard, the preparation of data in non-standard formats leads to an average additional expenditure of about 50 SFr. per delivery. Many data customers have systems which cannot handle the INTERLIS standard. Thus about 95% of data supply is still in DXF. Studer considers conversion of such systems to INTERLIS to be urgent because the losses both in time and money terms can no longer be tolerated. The current average of some 300 data deliveries per year result in annual losses of at least 15 000 SFr. and the number of orders for data is steadily increasing.

A transfer of data takes place each night between the data management system of LIS Nidwalden AG and the “Viewer” system of the canton administration. It consists of an automatic data delivery in INTERLIS. This is checked with the INTERLIS test program. This process would not be feasible at all without a geographic data standard. For manual transfers the necessary checks and data cleaning would amount to about 1 to 3 hours work. For a daily transmission without the standard about 200 hours of work per year would thus be required. For an employee who can judge the results of a test program, decide on the necessary cleaning measures and carry them out successfully, costs of 100 SFr. per hour should be allowed. Thus Nidwalden saves 20 000 to 60 000 SFr. per year on this, thanks to INTERLIS.

6.2.6 Benefit factor F: Reduction of cost of checking

From the outset, consideration was given to using the strictly defined data model for data verification. Unfortunately the necessary tools such as the INTERLIS compiler and check programs only became available some time after the pilot project. However they are used intensively and successfully today for data integration and for checking data exchange between different systems. For the daily transfers to the canton viewer system, the necessary checks can be automated, which brings a saving of 15 minutes per transfer. Thus with 220 transfers annually, INTERLIS saves at least 5000 SFr. per year.

6.2.7 Benefit factor G: Reduction of preparation and processing costs for the individual user

With the introduction of the land information system, multiple use of the data was institutionalized. The operating cost of LIS Nidwalden AG can be shared among a very wide variety of users. The capital investment in the Nidwalden cadastre finally amounted to 8.5 million SFr. Thanks to the INTERLIS standard the exploitation of this data is free from problems. It is made available at low cost and it is error-free. Since many users bring in more revenue, the charge for an individual delivery can be reduced.

6.2.8 Benefit factor H: Application of the most suitable system for processing, management and use of the data

In conjunction with LIS Nidwalden AG, the canton planning office was equipped with a viewer system, which enables flexible analyses tailored to individual needs. Thanks to a clearly defined INTERLIS-based data exchange process, this collaboration is free of problems. It is difficult to estimate the direct benefit of the application of the most suitable system. The prices for hardware and software licenses are constantly changing. For each user system 1000 SFr. can certainly be saved on hardware, since lower performance is necessary for large holdings of data. License costs should also be reduced by at least 1000 SFr. per user system, because the software has only to include the functions needed to yield the result. The elimination of data management can also be cited as an indirect benefit, because the viewer has direct access to error-free data.

6.2.9 Benefit factor I: Separation of functions

With the establishment of LIS Nidwalden AG the functions of data processing, management and use were cleanly separated: LIS Nidwalden AG concentrates on data management, data supply and the marketing of geographic products, including sales of data and data products. Those who produce and maintain the data and those who use it are thus not forced to set up expensive procedures for data security or data reconstruction. The equipment can also be better adapted to needs. Thus the private survey offices responsible for update of the widely varying themes, and especially the government departments as data users, take advantage of the possibility of employing the most suitable system for each purpose. This undoubtedly results in a benefit which cannot, however, be quantified at present.

6.2.10 Benefit factor J: Competition in data production

Through the separation of functions described above, the work on the various layers can be submitted to open competition. Much use is made of this opportunity in Nidwalden today. The communes award the work to those firms which they prefer as partners. Unfortunately, up to now invitations to tender have not demanded the use of geographic data standards, so that no conclusive statement of savings can be made. Experience shows, however, that each layer which cannot be supplied in accordance with the INTERLIS standard incurs 5000 to 10 000 SFr. in reprocessing costs. This amount could easily exceed the savings from free competition. Thus without geographic data standards the possible benefits of open competition can again be wasted. With the changes in the public procurement process (the law on tenders) the importance of this aspect will increase enormously.

6.2.11 Benefit factor K: Competition in data distribution

A market in which suppliers of GIS/LIS compete has not yet developed in Nidwalden. In individual communes systems do operate, which were however set up by those responsible for the production of geographic data. Experience shows that unfortunately all projects are delayed, and because of the lack of geographic data standards the delivery of the data to LIS Nidwalden AG takes place years behind schedule. Therefore any possible benefit cannot yet be quantified.

6.2.12 Benefit factor L: Competition in the evaluation of data

Little practical experience of this matter can yet be gathered in Nidwalden. However, according to Studer there is a clear potential benefit, which can only be enjoyed if the data can be made available in conformance with a geographic data standard. Vendors should exploit the flexibility of production afforded by geographic data standards to offer advantageous products conforming to market trends. At the same time it is necessary to begin to view systems in an increasingly function-oriented way, and to move away from the use of multipurpose systems which can do a little of everything but do nothing perfectly.

6.3 Solothurn Canton

In Solothurn canton there has been a clear program since 1995 for the introduction of the AV93 cadastral system. At the same time as this program was adopted, a Solothurn GIS (SOGIS) was also set up. In the following five years, experience, some of it painful, has been gained both of the use of geographic data standards and of their absence. The canton land surveying office made the manager of the GIS center, Mr. Erich Brunner, available for an interview.

In Solothurn canton most of the estimates of benefit had to be made on the basis of additional expenditure resulting from the absence of a standard, because, although INTERLIS was in fact available, its implementation was delayed.

6.3.1 Benefit factor A: Avoidance of loss of data

In the data loss category the costs relate to the integration of survey data into SOGIS. At present in Solothurn about 50 tasks are running at the same time. Since the data could not up to now be supplied correctly in INTERLIS, delivery delays have ensued, which in turn has meant delay in reaping the benefits.

After formal checking by an INTERLIS test program, all of the 50 tasks have had to be sent back 2 to 4 times for extra work. An inspection, including receipt of the data, the execution of the necessary tests, the documentation of errors and the return of the data, takes up at least half a day. The appropriate rework and correction of the data, so as to conform to the required standard and no longer show incorrect elements, takes about 1 to 3 days.

As a minimum, the loss resulting from the cleaning for these 50 tasks involves an additional expenditure of two days per cleaning cycle. At a rate of 1000 SFr. per day the financial loss is at least 100 000 SFr.

6.3.2 Benefit factor B: Avoidance of fall-off in data quality

Also in the Solothurn canton, data which had been generated in the Langendorf pilot project in accordance with a provisional data definition had to be converted into the definitive form. Since no standard was available at that time and because a variety of modifications were necessary, an extensive clean-up of the entire dataset had to be carried out. This work cost at least 30 000 SFr. or over 150 SFr. per hectare. It must also be acknowledged that substantial damage ensues, if the quality of the data cannot be maintained at a high level. According to Brunner, full adherence to the requirements of the INTERLIS working standard should therefore be implemented quickly, which means that the federation, in contrast to today, should lay down a uniform national definition without options for variants. The absence of a uniform federal cadastral interface makes this work, and the achievement of the standards at the canton level, substantially more difficult.

6.3.3 Benefit factor C: Reduction of cost of changes of system

The undefined transfer between two private survey offices provides an example of the costs which can arise with a change of system if no standard is available. The transfer involved the handing over of a task to the surveyor responsible for revision. Both surveyors were using the same system. No geographic data standard was yet available. The costs of the various efforts to bring the data into the target system without errors finally amounted to 40 000 SFr. The majority of this expenditure can be attributed to the absence of a clear agreement about the data.

6.3.4 Benefit factor D: Acceleration of development work

The development of SOGIS was handled pragmatically. Within a short time various datasets which were important for the planning process based on a structure plan were put together. A precise data description using a system-independent geographic data standard was not made at that time, which, because of the lack of an important element of the documentation, became awkward when personnel changes took place. Brunner is convinced that the data models must be described subsequently in INTERLIS.

6.3.5 Benefit factor E: Standardization of data supplied

In Solothurn canton the supply of official cadastral survey data to third parties is delegated to survey firms. But even with relatively few sales being made by the GIS center, the absence of the INTERLIS standard also increases the cost to data customers, as additional measures must be taken in order to achieve a correct data delivery. Extra costs are estimated to be 25 to 50 SFr. per delivery.

6.3.6 Benefit factor F: Reduction of cost of checking

The cost of checks on delivered data has been drastically reduced since INTERLIS became available to the suppliers. Previously a meaningful check was practically impossible because the dataset had to be checked down to the last detail. With correct datasets the automatic check now takes only a fraction of the time. With incorrect data the expenditure shifts from the GIS center onto the contractors who are responsible for the correction of the datasets. The order of magnitude of the costs for the return of datasets has already been recorded under the heading of loss of data.

6.3.7 Benefit factor G: Reduction of preparation and processing costs for the individual user

As it still takes a long time for datasets to be delivered free of errors, the benefit to further users is delayed. It is therefore still difficult to quantify the benefit of the repeated use of same data. On the basis of his experience Brunner is convinced that the application of a geographic data standard is a prerequisite for multiple uses of data. Without safe data exchange it is impossible for the different interested parties to use the data efficiently.

6.3.8 Benefit factor H: Application of the most suitable system for processing, management and use of the data

Within SOGIS at least two systems are in use. Savings through the use of the most suitable system for a given task cannot yet be fully realized, since the precise description of much of the data being used is missing. Therefore no actual figures can be given.

6.3.9 Benefit factor I: Separation of functions

Again in this area no actual figures can be quoted. The separation of functions and their distribution between the systems were in fact brought about through the introduction of SOGIS. However, for cooperation to run optimally, various further procedures must be set up.

6.3.10 Benefit factor J: Competition in data production

In Solothurn canton, competition was introduced into the official cadastral survey as soon as the new legal basis came into force. Tendering for survey work led, as in other cantons, to prices which now stand at about 50% of former rates.

Unfortunately the more favourable prices were again at least partly offset by the expenditure incurred in the delivery of definitive survey results, because no standard for geographic data supply was available. Only one out of 30 jobs was supplied correctly in INTERLIS and could be transferred into SOGIS within days after submission. All other jobs have so far been delayed by between six months and seven years. A large part of these delays are due to the absence of INTERLIS. A quantitative estimate of the losses (in Swiss Francs) which have resulted from the data not being available has not been possible. The financial loss could however amount to several thousand Swiss Francs.

6.3.11 Benefit factor K: Competition in data distribution

Competition in the distribution of GIS/LIS has not yet developed in Solothurn. SOGIS exists at the canton level, while at the commune level the conditions for competition are not yet in place.

6.3.12 Benefit factor L: Competition in the evaluation of data

In this area too, no competition seems yet to have emerged.

6.4 Principality of Liechtenstein

Since 1995 a nationwide land information system, LIS/GIS FL, has been set up in the Principality of Liechtenstein. Besides the data of the official cadastral survey, LIS/GIS FL already holds data on regional development planning, environmental protection and the prevention of water pollution, disaster precautions, agriculture and civil defense. LIS/GIS FL already contains 160 information layers (themes) and further information is continually being added.

From the beginning LIS/GIS FL was based consistently on INTERLIS, as the only working geographic data standard available. It was considered that, should the need arise, it would be easier to change to a new more advanced standard if data was already standardized. This judgment has proved to be correct up to now, because the development work on international standardization has still unfortunately yielded no working standard. And no GIS can be operated merely with good ideas if they are not functional.

For the estimation of the potential benefits Mr. Heinz Ritter and Mr. Norbert Frick of the surveying section were available to help us. This department looks after the task of technical coordination for LIS/GIS FL.

6.4.1 Benefit factor A: Avoidance of loss of data

In Liechtenstein the official cadastral survey, which was originally conceived as the land registry system, also in fact forms the basis of the land information system. In view of the size of the country it was decided from the outset to do without a separate GIS.

A first task was to establish the data model for the official cadastral survey explicitly in INTERLIS. Some digital cadastral survey data was already available, but these datasets proved to vary randomly in character and content. It was necessary to modify the existing datasets so as to conform to the new data description. The cost of these amendments, which can be equated to the corrections needed to deal with lost data, amounted to an average of 10 000 SFr. per commune.

6.4.2 Benefit factor B: Avoidance of fall-off in data quality

Because the data was available in standardized form early on, no further degradation in quality occurred. The gain from this is estimated to be 5000 to 10 000 SFr. per commune per year.

6.4.3 Benefit factor C: Reduction of cost of changes of system

Because the available data were in a clearly defined structure, the costs for the conversion of existing datasets into the new model are limited to 2000 SFr. per task. The equivalent process, shown earlier as costing 5000 to 10 000 SFr., would imply a benefit amounting to 3000 to 7000 SFr. per task.

6.4.4 Benefit factor D: Acceleration of development work

During the ongoing development of LIS/GIS FL, the use of INTERLIS for the precise definition of the data and outputs proved to be very efficient. New themes are defined consistently in INTERLIS and also discussed in INTERLIS with the representatives of the specialist areas. The definition and implementation of new layers can thus be done extremely economically. It gives rise to costs of 20 000 to 40 000 SFr. depending on complexity, while the time from conception to implementation of new themes amounts to 2 to 4 months. The ensuing data preparation is carried out purposefully and without the usual discussions and modifications. A comparison with other similar projects from the personnel and organization office shows that the time for planning and implementation is seldom less than a year and the costs are around 100 000 SFr. The benefit from the application of a geographic data standard to design work on a new theme can thus be calculated as 60 000 to 80 000 SFr. per layer. Savings during data preparation are difficult to quantify, since no reports on relevant costs are available. However, over the whole country they may amount to tens of thousands of Swiss Francs.

6.4.5 Benefit factor E: Standardization of data supplied

Liechtenstein also encountered the problem of the adaptation of the data supplied to individual customer wishes. For simple plan extracts from the official cadastral survey, this leads to additional expenditure by the data supply office of at least 25 SFr. per extract. In addition a further 25 SFr. must be added to cover checks and adjustments by the recipient of the data. For larger purchases the extra costs become even greater, because the cost of checking rises with larger volumes of data. Each delivery of data outside the INTERLIS standard thus gives rise to additional expenditure of about 50 SFr. For 1000 data sales per year this corresponds to a loss to the economy of at least 50 000 SFr.

The fee charging regulations of the country allow for investment costs relating to the data for each theme. The processing charge is calculated in accordance with the actual cost. One example of the cost of a relatively large data sale is the supply to the national police force of data for land cover, single objects, names and building addresses over all 11 communes in the country. The investment cost amounted to 2 200 SFr. and the handling charge for the data delivery in accordance with the standard, with all preparation and processing work, cost 750 SFr. The INTERLIS data could be integrated into the operations control system of the police force, without problems or further costs.

In order to lower the costs in the data supply office, a converter is used which can receive INTERLIS data and convert it to DXF. This converter is issued to the purchasers of data. Thus the cost of conversion is shifted to the recipient. According to Ritter and Frick, it would be better if INTERLIS also ultimately became available within the private survey firms' own systems.

6.4.6 Benefit factor F: Reduction of cost of checking

Since work with INTERLIS is consistent, the checking of the data thus produced is equally simple. Data for the official cadastral survey is checked automatically through the survey directorate system. It has not so far been necessary to reject a job, which can be equated with savings of 5000 to 10 000 SFr. per job.

For checking data outside the official cadastral survey, INTERLIS test programs are intended to be used by the GIS/LIS coordination department.

6.4.7 Benefit factor G: Reduction of preparation and processing costs for the individual user

As already indicated above, multiple use of the data is taking off. Different government offices and communes are connected to the GIS/LIS by means of query stations. They benefit especially from the availability of data belonging to other departments and from the unambiguous description of all data in the GIS/LIS. They are assured that the data always has the defined meaning and can rely on always having access to current information on other themes.

Anyone who uses a system outside the GIS/LIS probably already possesses data defined most favorably for his requirements. Not a single case is known of data being procured on an individual basis. Procurement of alternative data is expensive, even if the cheapest procedures are used. It can be assumed that the expenditure by the police force would have increased by a factor of ten to twenty, if they had procured the data independently of LIS/GIS FL. Simple scanning would have cost at least 32 000 to 64 000 SFr. instead of 3200 SFr.

6.4.8 Benefit factor H: Application of the most suitable system for processing, management and use of the data

The police force with its operations control system again provides a typical example of the possibility of the application of an optimized system. Thanks to being able to rely on the availability of error-free basic data, the most suitable solution for the task of operations control could be chosen. The basic data can be updated at any time as required and without excessive costs. This is made technically possible through the application of the INTERLIS standard and is made bearable financially through the setting of reasonable charges.

A further example is land use planning, which is supported by the basic data. Unfortunately the benefit is again reduced, because the organization responsible does not operate a system with a geographic data standard, and with this quantity of data substantial costs mount up for data conversion.

6.4.9 Benefit factor I: Separation of functions

The separation of functions is a topic which is currently being tackled. Quantified statements cannot yet be made.

6.4.10 Benefit factor J: Competition in data production

In view of the limited size of the Liechtenstein market, competition is not highly developed. However membership of the European Economic Area (EEA) is leading to an increased tendency to international tendering, although no experience is yet available in this field.

6.4.11 Benefit factor K: Competition in data distribution

The same applies as to benefit factor J "Competition in data production" above.

6.4.12 Benefit factor L: Competition in the evaluation of data

In this area experience is also for the most part lacking.

7 Tentative projections

7.1 Principles

With the figures based on the experience reported above, two cautious forecasts for the future are made. Firstly, an attempt is made to determine the order of magnitude of the financial loss incurred in past years due to the non-application of the INTERLIS standard in the official cadastral survey. Secondly, an estimate is made of the annual losses incurred due to jobs not being delivered correctly or with unsatisfactory data quality, and due to the supply of data which does not conform to geographic data standards.

These projections cannot claim a priori correctness in detail. Since however all of the calculations use minimum values based on experience, they should indicate the lower limits of the economic benefit or damage. This should make the need to extend geographic data standardization beyond the official cadastral survey sufficiently clear.

7.2 Losses incurred to date

The compilation in Table 2, of the figures based on experience in the projects examined, extrapolated over the whole of Switzerland for the last four to five years, shows that a considerable economic loss has been incurred.

Project / Benefit factor	AlpTransit Schwyz canton	Nidwalden	Solothurn	Principality of Liechtenstein
A	110 000.--	300 000.--	100 000.--	110 000.--
B	-	250 000.--	30 000.--	55 000.--
C	-	300 000.--	40 000.--	35 000.--
D	-	-	-	60 000.--
E	-	75 000.-- (5 yrs.)	50 000.-- (5 yrs.)	150 000.-- (3 yrs.)
F	-	-	-	25 000.-- (5 tasks.)
G	-	-	-	-
H	-	-	-	-
I	-	-	-	-
J	-	-	-	-
K	-	-	-	-
L	-	-	-	-

Project total	110 000.--	925 000.--	220 000.--	435 000.--
Per km^2	3225.--	3190.--	3180.--	3200.--

Table 2: *Estimate of economic losses incurred to date (in SFr.)*

It may be assumed that the projected total for Switzerland represents a lower limit. The projections for the four case studies can be summarized as follows:

– Average loss in Swiss Francs by area : 3200 SFr. per km2;
– Area in AV93 to date: 2500 km2;
– Minimum loss in Swiss Francs since introduction of AV93: 8 000 000 SFr.

7.3 Minimum expected annual losses without geographic data standards

Table 3 shows a projection for the three following benefit factors:

– Incorrectly submitted tasks (Benefit factor A);
– Rework of tasks not qualitatively complete (Benefit factor B);
– Lack of a geographic data standard for data exchange between customer and supplier. (Benefit factor E).

The table shows that for these three reasons alone the official cadastral survey incurs financial losses of approximately *two million Swiss Francs per year* at least. The actual damage is surely greater and the unquantified possible savings in the official cadastral survey could amount to many times as much.

With the increasing availability of digital geographic data outside the official cadastral survey, the potential savings also multiply, as shown by the various examples.

Benefit / loss factor	**Units (Basis of estimate)**	**Costs per unit SFr. lower value**	**Costs per unit SFr. upper value**	**Number of units All of CH (Estimate)**	**Total cost All of CH in SFr. lower value**	**Total cost All of CH in SFr. upper value**
Tasks not correctly delivered *Benefit factor A*	10 jobs per canton per year (26 cantons)	2000.--	4000.--	260	520 000.--	1 040 000.--
Tasks with unsatisfactory data quality *Benefit factor B*	Rework needed for half the annually processed area (ha)	10.--	20.--	150 000	1 500 000.--	3 000 000.--
Lack of geographic data standard for data supply *Benefit factor E*	Receipts: 250 survey offices; 50 other suppliers at 75 data deliveries each per year	50.--	100.--	2250	112 500.--	225 000.--
Expected annual loss					**2 132 500.--**	**4 265 000.--**

Table 3: *Projection of expected annual losses without geographic data standards*

7.4 Conclusions

It can be said with total justification that the consistent application of a working standard for geographic data, such as is available in Switzerland with INTERLIS, would put a stop to this economic wastage and would mean financial savings of millions every year. This statement can in all probability also be applied to other countries.

It is urgently necessary that the bodies responsible for geographic data and for its maintenance, the producers of geographic information systems (GIS/LIS) and the GIS consultants should take seriously the introduction of functioning geographic data standards and the imposition of statutory requirements for their use.

Ideas on this topic have been developed since the end of the 1980s. For the moment there are, however, no immediate prospects of alternative standards emerging, which nevertheless could be realized as simply as INTERLIS. However until these perhaps better solutions finally work, at least the Swiss taxpayer should be freed from unnecessary burdens. This calls for the consistent application of geographic data standards in the form of the Swiss INTERLIS standard, and the coordinated production of further geographic data in the future, supported by clear data descriptions.

The success which the official cadastral survey was able to achieve through the introduction of the AVS cadastral survey interface should now lead to its adoption in further areas of geographic data. With the extended "version 2" of INTERLIS, the technical requirements are already in place. And because INTERLIS is freely available, nothing stands in the way of an internationalization of this geographic data standard.

References

Dorfschmid, Joseph [1996], Expertise über eine Vermessungsschnittstelle, im Auftrag der Projektleitung RAV. Eidgenössische Vermessungsdirektion, Bundesamt für Landestopographie, CH-3084 Wabern.

Gnägi, Hans Ruedi [1999], Nationale und internationale Standards im Vergleich. In: Proceedings zum Fortbildungsseminar Geoinformationssysteme, März 1999, TU München.

Kaufmann, Jürg [1995], Kanton Nidwalden, Projekt LIS, Grundsätze zur Realisierung.

Keller, Stefan F. [2000], Trends in der Normung und Standardisierung im Geoinformationsmarkt 1999. In: INFO V+D Nr.1 / April 2000, Eidgenössische Vermessungsdirektion, Bundesamt für Landestopographie, CH-3084 Wabern. Seiten 15-16.

Messmer, Werner [1985], Expertise über die Anwendung der EDV in der amtlichen Vermessung, im Auftrag der Projektleitung RAV. Eidgenössische Vermessungsdirektion, Bundesamt für Landestopographie, CH-3084 Wabern.

Odermatt, Paul et al. [1993], RAV-Subito-Pilotprojekt Nidwalden 1989-1992.