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Legal and Technical Aspects of Decisions on Property Boundaries – The Case of Austria

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Abstract. *Legal-technical systems like cadastral systems combine technical and legal aspects. Decisions are an important aspect of a system. Decision-making processes in legal systems have other principles than those in technical systems. The processes may even have different results. In combined legal-technical systems this will cause problems.*

The paper discusses legal and technical aspects of decision making processes. The discussion reflects that the Austrian Supreme Administrative Court (VwGH) in 1983 ruled that a distance of 3.96 m from a building to the boundary of the neighbouring parcel was insufficient if the law demands a distance of 4 m. The context of this ruling includes that the Austrian cadastre records boundary coordinates and stipulates a 15 cm deviation limit as acceptable since 1969. Furthermore, once the coordinates are recorded, the cadastral prescripts do not allow for changes even if later measurements of better quality warrant this. Investigation of the legal and technical approaches suggests that the technical process is capable of improving the quality of continuous data, whereas the legal approach adopted in Austria can only deal with discrete data and prevents gradual improvements. The paper demonstrates the need for further investigations into the issue of determination of property boundaries.

Keywords: *cadastre, decision-making, law.*

1 Introduction

A cadastral system can be a system consisting of separate cadastre and land registration. The separation splits the spatial component, the cadastre, from the legal component, the land registration (Augusta Silva and Stubkjær 2002). Often the cadastre is a public inventory showing the boundaries of pieces of land, whereas the land registration is the process of registering rights on land (Henssen and Williamson 1990). A cadastre is thus a legal-technical system (Kroes, Franssen, van de Poel and Ottens 2004; Ottens 2004) containing technical aspects like the measurement of boundaries and local aspects like adjudication of land rights. If there is a split of land register and cadastre, the cadastre provides identifiers to connect land with persons and analysis of the interaction, which shows that cadastre and land registration form a common, dynamic system (Zevenbergen 2004).

Cadastral systems have been developed during a long period and thus there are different approaches. Bogaerts and Zevenbergen presented a list of alternatives to design cadastral systems (Bogaerts and Zevenbergen 2001). One of the decisions was whether to use general boundaries or fixed boundaries (see also Dale and McLaughlin 1988, p. 29). England uses general boundaries, whereas Austria and other central European countries normally use a system of fixed boundaries. Austria emphasised the idea of fixed boundaries by using coordinates in a national reference frame to secure the boundaries. This changed the status of the technical documentation from being just documentation of reality to being the legally valid proof of the boundary.

Running a cadastral system requires procedures to update the data in the system. These procedures are based on documents and contain a decision point where the data is either rejected or included (Navratil and Frank 2004). In addition, there are a number of decisions necessary to create the document. The subdivision of a parcel requires answering a number of questions. For example, the following questions may arise: Where is the boundary of the parcel? Does the new parcel fulfil all legal requirements for a parcel of this type? Does the result fit the needs of the owner?

Answering the above questions requires different approaches. Determination of the boundary may require evaluation of old documents like textual descriptions, maps, or previous surveys. The result of the evaluation is a boundary description that may then even be subject to discussion between the owners of neighbouring parcels. The restoration of the boundary is mainly a technical process, whereas the discussion is a legal process. The actual decision about the boundary is however legal. This answers the second question in the list, which emerges from a purely legal decision-making process. The answer to the last question can only be answered from the user's perspective. In the following, I will concentrate on the distinction between legal and technical approaches. The examples are taken from the Austrian cadastre but the conclusions can hold for all systems with a similar approach.

The remainder of the paper is organized in 5 sections. Section 2 discusses the technical and legal decision-making processes and shows how these processes work. A practical example in section 3 proves the possibility of different results when using technical or legal decision-making processes. Section 4 discusses the goals of the two decision-making processes. Section 5 then shows the implications for cadastral data. The paper then ends with some conclusions.

2 Decision-Making

Decision-making is choosing between two or more alternative courses of action (Yntema and Torgerson 1961). The process of decision-making then is a set of strategies guiding the decision-making behaviour such that they cover the alternatives (Golledge and Stimson 1997, p. 54).

Legal systems rely on rules and abstract legal concepts, whereas technical systems rely more on mathematics as a tool for modelling. The legal system as a regulated system stands in contrast to the technical system. In this section I show some of the methods of decision-making in a legal and technical system.

2.1 Legal System

Decisions in a legal system are done by humans and then in many countries like Austria without technical assistance. Although databases may help in finding court decisions or texts, the reasoning is done without the help of computers. The reasoning capabilities of humans are limited (Miller 1956). Therefore, reasoning done without additional help should be kept simple and the number of parameters for the decision should ideally be small. The complexity of the legal question can however be great and the question must then be subdivided into small parts with simple reasoning. This does not, however, prohibit the use of material emerging from technical processes. After a car accident, for example, experts may testify on the speed of the vehicles based on physical evidence like the length of the breaking distance as determined by tape measures or photogrammetric evaluation. However, the person making the decision must assess the quality of delivered material and must use it according to legal rules in the decision. Based on the trustworthiness of the expert, the decision-maker may rate this testimony higher than contradicting remarks made by others.

Not all cases of legal decisions are simple from the start. Claim of reparation payments are examples for complex decisions. Legal decision-making requires a strategy to deal with this complexity often shown in the reasons for the court decision and still keep the decisions simple. The strategy is to divide the problem in a series of smaller problems.

Questions in the decision-making process are: Is it the right claimant? Is it the right body? What are the material rules? Each of these questions deals with a different aspect. The first question tests, if the applicants have the right to ask for a decision. A father, for example, may ask for a decision while acting for his child, whereas a stranger may not. There may also be a temporal restriction, i.e., after the limitation period a lawsuit or prosecution cannot be brought into court. The second question tests, if the body is entitled to make the decision. Each body has a specified field of responsibility with a spatial and a factual extent. Decisions outside the field of competence will not be made by the body. The third question tests, which rules are applicable to the case. The specific case is subsumed under a legal category. An action may, for example, be considered as making a contract if specific requirements are met. Subsumption defines the set of rules applicable to the situation. After answering the third question, the decision can be made according to the extracted rules.

Errors in the decisions can be corrected by an appeal, which is a 'proceeding undertaken to reverse a decision by bringing it to a higher authority' (Garner 1996). These higher authorities check the process of decision-making, not the evidence used. The higher authority may, for example, rule that a specific regulation used in the decision-making process is not applicable to the case. However, within some jurisdictions like the Austrian, the higher authority will not look for new evidence on the case.

Legal decisions separate between two problems: the factual and the legal question. The factual question identifies the facts and subsumes the situation as one of the legally defined types. The decision on the factual question is based on evidence presented to the decision-maker. Five different methods to show evidence are used (Hilgendorf 2003, p. 243): witnesses (persons talking about their observations), expert witnesses (surveyors and other experts talking about their observations, measurements, and evaluations), documents with content that can be read out, direct inspection (of objects), and remarks made by the accused.

The result of answering the factual question is a classification for all relevant facts where the classes are used as defined in the legal system. The legal question then uses the words representing these abstract classes and argues within the legal structure only.

The decision-maker is normally restricted to the facts presented to him when dealing with the factual question. The parties present the evidence that supports their position. The decision-maker can only use the evidence presented to him. This is especially important for civil law. He must, for example, accept an agreement between the parties even if it is wrong from an objective position. Typical examples can be compensation payments in cases of liability. Thus decision-making in the legal domain is an example for bounded rationality (Selten 1999).

2.2 Technical System

Data used for decision-making cannot be free of errors if based on observations. These errors emerge from the stochastic nature of the observation process and result in deviations from the 'true' values that would result from deterministic observation processes (Helmert 1872). Technical decision-making strategies take these deviations into account.

The standard method to deal with this kind of problem is statistics. Descriptive statistics allows describing the deviations for samples and theoretical approaches provide models for the distribution of deviations in general. Widely used theoretical models are normal (Gaussian), Student, or χ^2-distribution. Each of these distributions suits special situations.

Test statistics (see for example Koch 2004) establishes a connection between the distributions and statements, which are represented as hypotheses. Theory and application can be found in any text books on statistics (e.g., van der Waerden 1957; Diehl and Kohr 1970; Papoulis 1991).

A standard way to estimate 'true' values is over-determined observation. Each observation is distorted by random deviations. Equations using the observations will therefore show contradictions. Corrections for the observations allow removal of the contradictions. The determination of the corrections requires additional conditions because otherwise any solution would be ambiguous. The assumption of normal distribution for the observations leads to the condition that the square sum of the corrections shall be minimized and, finally, to the method of least squares adjustment (e.g., Helmert 1872; Ghilani and Wolf 2006).

The distribution deviates from the normal distribution if there are not only random errors but also gross errors. This assumption leads to robust methods (Huber 1981; Hampel, Ronchetti, Roussew and Stahel 1986), which have already been applied to geodetic problems (Wicki 1999; Kanani 2000; Wieser and Brunner 2001). These methods use different conditions to resolve the contradictions. The treatment of gross errors in the observations is excluded from the discussion in this paper.

Examples for the use of these methods for statistical testing can be found in the literature. The complexity of the questions ranges from simple to complex. A question leading to a simple decision is for example the question if an earthquake caused a permanent movement of the earth (Sager 1995). The decision to seed a hurricane is an example for a complex question (Howard, Matheson and North 1972).

3 A Practical Example

Twaroch presented a case where the legal approach to making a decision caused a problem (Twaroch 2005). The deviation of a building from the building permit is not a minor deviation if the actual distance falls below the legal minimum distance. A distance of 3.96 m from the boundary of the neighbouring parcel is insufficient if the law demands a distance of 4 m (VwGH 1983). A deviation of 1% of the distance is thus enough to contradict the law and result in serious legal consequences like the demolition of a building.

The problem with this approach is the definition of the objects included. Figure 1 shows a sketch of the situation. The distance between the building and the parcel boundary must be at least 4 m. The question is how the objects are defined. There are two different approaches that can be used: The real world objects (e.g., the fence and the outside wall of the building) define the objects and provide the reference for the distance measurement, or the objects registered in the cadastre are used if existing. Then real world objects are used only if the objects are not yet registered.

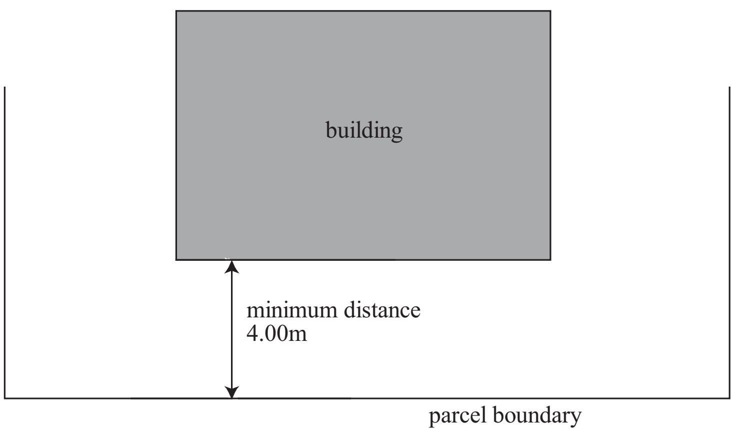

Figure 1. *Schematic figure of the building-distance problem.*

The determination of the distance is simple if existing objects are used as end points. A tape measure for a distance of 4 m is possible with a standard deviation of 1 or 2 cm. However, the relation between the measured distance and the distance defined in the laws is unclear. Since there is no constraint to build the fence on the boundary, there may be a deviation between fence and boundary. Thus the measured distance could be incomparable to the distance defined in the law.

The use of registered objects separates the problem of boundary definition from the distance measurement. As soon as there are coordinates for the boundary and the corners of the building, the Hesse normal form (e.g., Reinhardt and Soeder 1991) can be used to determine the boundary:

$$d = \begin{pmatrix} \frac{\Delta y_{12}}{s_{12}} \\ -\frac{\Delta x_{12}}{s_{12}} \end{pmatrix} \cdot \begin{pmatrix} \Delta x_{1P} \\ \Delta y_{1P} \end{pmatrix} \tag{1}$$

Let us assume the following situation: The minimum distance between a point of a newly created building and the front boundary of a parcel shall be tested. The boundary line is defined by the points 1 and 2 with coordinates from the cadastral database as listed in Table 1. The coordinates are the result of a previous survey. The building is not part of the cadastral dataset because it was constructed after the survey. The coordinate system is assumed to be a plane, rectangular system.

Table 1. *Coordinates from the cadastral database.*

	y	x
1	115.79	751.50
2	132.77	627.63

In the real world a fence marks the boundary. A survey of the building and the fence results in slightly different coordinates for the corner points of the fence, which should coincide with points 1 and 2. Thus the new points are identified as 1' and 2'. The additional point P' represents the point of the building. A tape measure between fence and building produces a value of 3.99 m.

Table 2. *Coordinates from the field survey.*

	y	x
1'	115.85	751.55
2'	132.80	627.67
P'	125.45	651.84

The problem is how to decide if the building is located too close to the boundary. Equation (1) gives a distance of 3.96 m for the points 1, 2, and P', which is less than 4 m. The distance of point P' from the boundary defined by 1' and 2', however, is 4.01 m, which would be sufficient. How would a legal and a technical system come to an answer for the question if the building is too close to the boundary?

3.1 The legal solution

In a legal decision-making process the solution is simple. The object cannot be inspected directly if the decision-making process will – like in Austria – only take place in a courtroom and with no possibilities to have view on the land. Thus the decision-maker will ask an expert. The expert must investigate the situation and express the fact so that it can be understood with common knowledge. The question is thus how the expert must act to come to his knowledge.

The boundary in the Austrian cadastre is defined by the coordinates of the boundary points. Determination of the boundary thus must check the boundary marks using coordinates or distance measures. The decree for surveying specifies a limit for the deviation to determine if the boundary mark is unchanged or not. Figure 2 shows the steps for this test (Twaroch 2006).

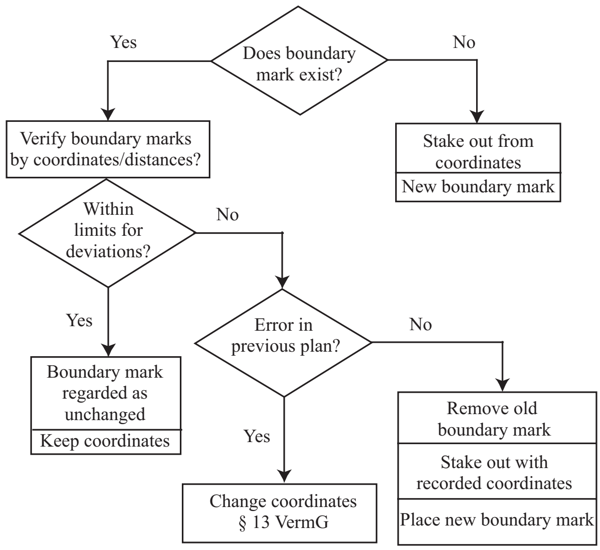

Figure 1. *Verification of boundary marks (translated from Twaroch 2006).*

Boundary marks may be stones or marks made from steel or plastic. In this case it is usually simple to determine if the mark is unchanged. However, the boundaries may also be represented by corners or buildings or fences. This raises some questions. Does the boundary change if a replaced fence is in a slightly different location? Is it allowed to add insulation to the walls of a building without violating or changing the boundary? The answer to such questions lies in the limits for deviations. The decree for surveying (Austrian Ministry for Economic Affairs 1994) states that points are treated as unchanged if the difference between the cadastral coordinates and the results of the new survey does not exceed 15 cm. At the time of the decision of the Austrian Highest Administrative Court the sitiation was even worse since the limit was 20 cm (Austrian Ministry for Construction and Technology 1976). However, I will use the limit of 15 cm to show that even this limit causes problems.

The first step in the legal process is the decision if the points 1’ and 2’ mark the boundary. As soon as the correspondence of these points in reality with the points in the cadastral database is fixed, both can be used for the decision. Two different approaches seem to be appropriate to observe the distance and both are legally valid. A tape can be used to measure the distance in reality or the distance can be computed from the coordinates.

The idea of the tape measure is simple. The measurements of the boundaries proved that the boundary is correctly marked in reality. Thus the fence is located correctly and can be used to determine the distance between building and boundary. Problems may only occur if measuring the distance is difficult due to vegetation or height difference.

The computation from coordinates eliminates the problems of the tape measures. Vegetation has been dealt with during the survey of the scene. Formula (1) provides the distance.

In the example both methods result in the decision that the distance is too small. The tape measure is exactly 3.99 m and the computation results in 3.96 m. However, the distance must be at least 4.00 m and thus the distance is not large enough.

The expert now has knowledge about the case. In the courtroom the judge will ask him to give his opinion according to best practice. However, the question may influence the answer. In our example the questions may be: What is the distance between building and fence? Is the distance smaller than 4 m?

Although the questions seem to be similar, the answer may be completely different. The first question asks for a number, which the judge then may use to make his decision. This leads to a legal decision. The judge will argue that 3.96 m or even 3.99 m are less than 4 m and thus the distance is too small. This happened in the case discussed by Twaroch. The second question, however, asks the expert to express his opinion on the reliability and to judge (from a technical perspective) the relation between the distance in reality and a value defined by the law. As a result the technician must make a decision and thus the decision is performed in a technical way. This leads to a completely different point of view.

3.2 The technical solution

Technical experts have several possibilities to determine the distance and compare it against a required distance of 4 m. These methods may or may not use the coordinates from the cadastral database once the identity of the points is checked. All methods, however, take the quality of the observation into consideration. The methods create an estimation of the result together with a description of its quality. A statistical test then provides a binary result to the question.

A first approach uses the coordinates from the cadastral database to define the boundary. The Austrian decree for surveying stipulates an accuracy of 15 cm for the parcel boundary points (Austrian Ministry for Economic Affairs 1994). This leads to a standard deviation of 10 cm for the coordinates of the boundary points if defining the accuracy of points as $\sigma_P^2 = \sigma_x^2 + \sigma_y^2$ and assuming uncorrelated coordinates. The first order Taylor method (Heuvelink 1998) then returns a standard deviation of 12.8 cm for the distance between the boundary defined by the points 1 and 2 and the point P'. Is it statistically valid to say that 3.96 m with a standard deviation of 12.8 cm is less than 4 m? The distribution for the distance results in a probability of only 62% that the value is less than 4 m. A statistical test of the hypothesis that the expectation value of the distance exceeds 4 m cannot be rejected when using a significance level of 95%. The assumption that the 15 cm stated in the decree is the standard deviation may be wrong. This value could also be seen as an absolute limit for the deviation from the real point. Statistically, this can be seen as three times the value of the standard deviation. In this case 99% of all observations would then comply with the limit. The standard deviation for the distance between the coordinates of the real point and the observed coordinates would then be 5 cm, which leads to a standard deviation for the single coordinate of 3.5 cm. However, the above hypothesis that the distance exceeds 4 m is still accepted. It is also possible to determine the necessary distance value or standard deviation to get the opposite result. The distance must be less than 3.79 m to reject the hypothesis with the given standard deviation. Rejection of the hypothesis for a distance of 3.96 m would require a standard deviation of 2 cm for the distance, which is only possible if the standard deviation of the coordinates is less than 1.6 cm. This is achievable with modern surveying equipment but unrealistic for old cadastral datasets.

The limited quality of the coordinates can be used to plead for not using the coordinates from the cadastral database. Modern surveys have a higher local precision than the cadastral dataset, which evolved over a long time and must fit the results in a national reference frame. Thus the use of the survey results provides results with higher precision for local questions. The problem with this solution, however, is checking the identity of the points. The use of coordinates shall guarantee that the boundaries of parcels remain unchanged. Each resurvey will produce different coordinates due to the stochastic nature of the observation process. A simple comparison is insufficient to check the identity of points in different surveys. Deformation analysis (Niemeier 1985) checks the identity of points in two surveys and uses a statistical measure to decide on the congruency.

There are two different types of movement, which can be detected with deformation analysis and both types may be important in the cadastral case. Relative movement describes movement of one point of the boundary in relation to the other points. This happens if a fence is renewed and one of the rods moves out of position. Absolute movement means that the whole parcel moves in relation to a reference frame, in general the national framework. Reasons for absolute movement can be landslides or plate tectonics. Absolute movement may create problems if the movement remains undetected while staking out the points for the building. Then the position of the fence and the position of the building would not fit together in the cadastral data since they use a different reference frame. The stability and quality of the reference frame is thus crucial for the determination of the absolute movement.

Let us assume that a deformation analysis leads to the conclusion that the boundary is unchanged. This allows using the coordinates from the survey to compute the distance. The result is 4.01 m, which provides strong evidence that the distance exceeds 4 m.

Generally, the technical decision-making process uses as much information as possible. Values are not treated as absolutely correct. Distribution parameters are taken into account when making the decision. Additional data may change the outcome of a technical decision-making process. Technical decisions can be redone and often additional observations are used to verify the outcome of a technical decision-making process. However, this is not possible, if the outcome of the technical decision-making process receives a similar status as the outcome of a legal decision making process. In this case the technicians must learn to argue and understand law because this is the only way to communicate with legal experts.

4 Simplification vs. Optimization

The example showed that the legal and the technical realm use different strategies for making decisions. A difference between the legal and the technical realm are the persons involved in the decision-making process. In legal decisions the involved persons may be legal experts (e.g., a judge or a lawyer) or lay people (e.g., the jury). Thus the strategy must be simple enough to be handled by common knowledge. This is not true for technical decision-making processes. Persons without experience in mathematics and the field of application will not be able to understand and verify a technical decision. A main design principle of the legal decision-making process is thus the simplicity of the steps necessary to come to a decision.

Legal decisions shall settle disputes. The case is presented to an unbiased person and this person makes a decision. The decision cannot be changed unless for very specific reasons, which are: The process of making the decision was performed incorrectly. New evidence suggests that the decision was wrong.

A decision becomes legally binding if the involved parties do not appeal due to one of these reasons. The number of possibilities to appeal is limited in order to finalize the process. Pure dislike of a legal decision is no reason to change the decision. Thus everyone can rely on a decision because after it became legally binding it does not change. The decision holds even if it is wrong according to an external decision criterion, e.g., ethics. Let us assume a court must decide a claim to family allowance. The decision is correct if the requirements defined in the legal system are met and the claim for is confirmed. An ethical discussion, however, may conclude that only needy families should receive family allowance. This leads to the necessity to defining ‘needy’ in the given context. However, such discussions do not influence the decisions themselves; they only influence the legitimacy of the legal rules, which form the basis for the legal decisions or the way the decision-makers use available room for decisions.

The result of the legal decision-making process thus has the following properties:

(1) The process is fast. The process consists of a series of simple decisions, which can be made quickly. This is possible because all objects used after deciding the factual question are free of random errors. The social fact that two persons created a binding contract, for example, has no variation. The contract is either valid or not. Adjustment of the validity similar to adjustment of observations is not possible. The only possible kind of error is a gross error, e.g., one signature is a fake. In this case the contract itself becomes invalid. The process of making the decision is also finalized due to the limited numbers of steps of appeal against the decision.

(2) The result of the process is final. After the decision is made it cannot be changed again. A building permit, for example, is the result of such a legal decision. The permit is valid for two years in Austria. Basis for the decision are the rules defined by spatial planning. Within the validity period the decision cannot be changed even if the foundation changes. Only the detection of new evidence may be an exception to this rule. This could be the case if bribes were paid. However, there must be enough evidence to show that the decision must be changed.

The goal of a technical decision-making process is the optimization of the result. An arbitrary mathematical expression defines the criterion used to determine the optimum. This expression may include statistical, economical, or other measures like logical consistency and even combinations of such measures. Statistical methods, for example, often optimize the estimation variance. Different decision-makers may use different criterions and may then come to different results.

Influential for legal decision-making may be the duty of proof. In case of dispute the court may ask one of the parties to prove the validity of the claim. In general this will be the party where the claim seems to be less plausible. This can cause a problem if neither claim is easy to prove. Then the decision of the court on the plausibility influences the outcome of the decision-making process. In contrast to a technical decision, the less plausible claim may be ignored completely in a legal decision. In a technical decision the weight may be reduced but the observation will still have some influence.

Technical decisions are often checked for correctness in a stable environment, the real world. Let us assume we want to construct a bridge. The criterion to determine a satisfying result will probably incorporate material expenses and work time. The most important factor, however, is the durability of the construction. A bridge that collapses after a week will not be useful if the intended use was longer than that. Even before the mathematical formulation of the law of gravity technicians were able to build bridges. Since some of these bridges still exist, they were built in accordance with physics, even if some of the applicable physical laws were unknown. The knowledge of how to build bridges, in general called best known practice, has improved with advance in physics. This allows constructions with smaller safety margins but the system against which the construction is finally checked remains unchanged. The legal system is more flexible. It can and will be changed whenever new requirements emerge. Legal decisions are therefore checked for correctness in a more flexible system.

In general technical systems are not completely known. Legal decisions are made based on the presented evidence. Misinterpretation of evidence may go undetected and then does not invalidate the decision. Once the decision is made it will hold and legal security is established. The check against reality for technical decisions requires capturing all necessary parameters. Misinterpretation of a parameter may lead to wrong decisions and, e.g., if building a bridge, accidents. This risk usually leads to extensive observations. The decision if the climate changes, for example, uses weather data for the longest time period possible to provide a reliable result.

The advantage of the technical decision-making process is thus the ability to cope with vast amounts of data. The mathematical treatment allows elimination of errors in the observations. Gross errors can be detected by robust methods whereas the inevitable random errors are eliminated by strategies to solve over-determined equation systems. This is, however, also a disadvantage of the technical decision-making process. Since random errors may possibly be influential, observations are performed repeatedly to eliminate these errors. This requires time and increases the response time for the system. The detection of soil movement, for example, requires observations at two different points in time. The period must be long enough that the movement is detectable although masked by random deviations.

It becomes evident that both kinds of making decisions have benefits and drawbacks. An important consideration in making law is to find rules which the judge can apply equitably. The results of the application are then defined as correct and are not questioned any more within the limited scope of this decision. This is possible due to the ignorance of random deviations in the observations since in Austria they are assumed to be irrelevant for answering the question. Additionally, the questions must be kept simple. The technical decision-making process does not have these drawbacks. However, the time to answer the question may be much longer and the result may be reconsidered. The Leaning Tower of Pisa, for example, is assumed to be stable at the moment. However, new measurements may contradict this hypothesis leading to new observations and possibly a change of the decision.

5 Implications for Cadastral Data

The last section showed differences between legal and technical decision-making processes. A cadastral system contains both aspects, legal and technical ones. In Austria the determination of coordinates is a technical process with legal effects. Legal decisions are then based on the contents of the cadastre. Both types of decisions take place. The different properties of the decision-making processes will have an effect on the system and there are situations where one type of decision is better suited than the other. The system may even become difficult to manage if the wrong type of decision-making process is selected.

The land register connects land to persons by using rights (Zevenbergen 2004). The elements used in that process are identifiers for pieces of land and persons and documents providing evidence for the right. All these elements are legally constructed (Searle 1995). The definition of the identifiers, for example, is settled in the regulations of a country and may differ between countries. The same is valid for the documents, which may provide evidence for a right only in connection with specific procedure and within a specific country. The processes within the land register deal with these legally constructed elements like person, right, parcel, etc., and the decisions are based on these elements only. The decision-making process is thus of legal type.

The cadastre in dual systems (with land register and cadastre) normally provides geographical reference for the pieces of land. Observation of the boundary of the pieces of land provides positions for these boundaries. These positions, as results of an observation process, are subject to random deviations if measured. A technical system can deal with these deviations and minimize them as soon as there are enough observations. The optimal solution to determine the position of the boundaries is – from a technical perspective – a measurement-based system (Buyong, Kuhn and Frank 1991). Such a system stores measurements and nowadays often computes coordinates only if they are necessary, e.g., for drawing maps. The advantage of such a system is that new measurements can be added. The local quality of the dataset will improve if the quality of the added observations exceeds the quality of the dataset in the area. Since observations will be added for the whole area covered by the cadastre, the quality of the cadastre will also improve gradually.

Legal processes in Austria cannot deal with random deviations as described above. Decisions can only be redone if a gross error is found. Figure 2 showed the conditions needed to establish (within Austrian jurisdiction) that the coordinates of an existing point are assumed to be correct. The coordinates are only changed if an error in a previous subdivision plan is detected. Such an error is a gross error. Otherwise deviations are treated by legislation as misplacement of the boundary mark. The reason for this is that the coordinates in Austria are legally binding and must therefore be seen as the result of a legal decision-making process. However, the coordinates in a cadastral database are subject to random deviations. The assumption is that they result from a legal decision-making process and cannot be reconsidered. This conflicts with the technical necessity to verify past decisions.

The original cadastral system in Austria was strictly separated into a legal and a technical system even if the technical system in reality also is a type of legal system. The cadastre provided the technical foundation of the right and the land register added the aspects of private law. The figures produced by the cadastre were used by public law processes like land taxation as parameters to calculate taxes. In the private law sector, however, the figures were listed but were not part of the trust system of the land register. Whereas the identification of the land owner is assumed to be true, the size of the parcel is only an annotation.

The current system of legally binding coordinates weakens this separation as legislation is not developed to handle measurement deviations. A legal guarantee system is put on top of a technical system and the results of a technical decision-making process are the fixed legal truth. This collides with the nature of the observation process and tolerance measures for resurveys must hide this design flaw. A result of the fixed coordinates is thus that new measurements must be squeezed into an inflexible frame of boundary points fixed by coordinates. Measurements of high quality must therefore be distorted to fit measurements that may have been performed decades ago with much less quality. The increased measurement quality will be lost for the overall quality of the cadastral dataset.

6 Conclusions

In reality legal and technical systems are connected in cadastral systems. In the article this system has been separated to show the problems that can evolve, especially in a "rigid" legal system as the Austrian.

The paper discussed a simple question: Why is the result of the legal decision-making process in Austria different from the result of the technical process? As soon as this question is answered, further problems emerge. In a legal-technical system it should always be clear which method to use. People working in the cadastre (geodetic surveyors in many countries) must be trained to understand and cope with the problems arising from the different kinds of decision bodies. There should be few cases where the outcome is unpredictable because it is unclear how to connect different processes to be used to make a decision since such a case can diminish the trust in the whole system.

Each type of decision-making process has benefits and disadvantages. Legal decision-making processes try to use chains of simple decisions. Each of these decisions is a logical step to a complex legal decision. Unfortunately, this can lead to a result that is not optimal in a mathematical sense, i.e., such that a specific value becomes a minimum or maximum. The major advantage of a technical decision-making process is the possibility to optimize a large, complex system. This may, however, become a disadvantage since even small changes may influence the decision in a technical system.

The difference in the result suggests further that legal decision-making processes cannot gradually improve the quality of the data by using additional data. Legal decision-making processes can only remove gross errors whereas technical decision-making processes can deal with random deviations and thus can improve the quality of data sets. This distinction must have effects on the design of legal rules as well as the design of cadastral coordinate systems. The Austrian cadastral system is an example for a cadastral system where the boundary is defined by coordinates and the coordinates are protected by law. This in a way rigid design has created some problems that can be explained based on the distinction between legal and technical decision-making processes. Although many of the practical problems have been solved, e.g., by weakening the legal protection of the coordinates, the flaw of the Austrian solution shows that legal and technical decision-making processes should be better mixed. Unfortunately, the effects may not be visible immediately. In Austria it was the improvement of measurement technology over the decades that caused tensions.

The conclusion for lawyers in Austria is that they must learn to identify results of technical decision making processes. They should ask for technical advice and compare the legal rules with technical possibilities. This could, in the future, avoid situations where the results between legal and technical decision-making processes contradict.

The conclusion for surveyors in Austria is that they must learn to argue and understand law. The coordinate decision is a legal fact in the end of the definition process. Surveyors must then be capable of defending their decision in a legal dispute. Surveyors in Austria would become technicians without decision power if this does not happen and the demand for such technicians is questionable.

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