

The Cadastral System as a Socio-Technical System

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Key words: system approach, cadastral system, socio-technical system, modelling systems, designing systems.

SUMMARY

From an increasing interest in large scale complex systems a research to these systems defining them as being socio-technical is conducted at Delft University of Technology. In this paper the ideas and concepts in this research are explained and used in analysing the cadastral system.

Socio-technical systems consist of social and technical elements and agents. We argue that social elements are of a fundamental different nature than technical elements and, therefore, need to be treated differently. System theories in engineering and in social sciences do not take this distinction sufficiently into account.

The cadastral system is based on the social concept of ownership of real estate. Nevertheless technology plays an essential role in modern cadastral system. Therefore I argue that the cadastral system is a socio-technical system with a social core.

This has far going implications for modelling and designing the cadastral system. The idea of designing seems to vanish completely, while with regard to modelling the dynamic aspects of the social character of the system have great impact. Neither the Cadastre 2014 document nor the (Lemmen et al. 2003) model (both aiming at future cadastral systems) do take sufficient notion of the nature of the cadastral system.

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1. INTRODUCTION

There is an increasing interest in system research. Both in engineering and in social science the importance of understanding the working of large-scale, complex systems in society is acknowledged. Research institutes and academic departments studying them are founded and conferences dedicated to them are organized. Additionally, there is a drive from society seeing itself faced with bigger and more interdependent systems, where failure of one system may cause considerable damage throughout society. Not only technical failure may cause such damage, but also failure due to organizational issues. The robustness of large-scale, complex systems is therefore not only based on sound technical elements, but depends increasingly on social aspects as well. In the light of this increasing importance a research project studying socio-technical systems, as we will call them, has been initiated at Delft University of Technology. Existing systems theories in engineering and the social sciences define systems as composed of elements linked by various relations, without making a distinction between social and technical elements. The Delft research project is based on the idea that the differences between technical and social elements are so fundamental that they should be clearly distinguished.

The research project proceeds by conceptually analyzing several systems that we consider as being in the socio-technical realm, like a civic aviation system or the energy-infrastructure. While most systems engineering is about systems that have technology at their basis, the cadastral system seems to be of a different breed. Since the whole concept of ownership is essentially social, the cadastral system has a social basis instead of a technological one. Due to technological innovation, however, especially the total reliance on GIS data, technology is so deeply involved in the cadastral system that it must be considered a socio-technical system. Therefore, our analysis of socio-technical systems should apply to the cadastral system as well.

In this paper I will introduce the concept of a socio-technical system. I will tell into more detail why I think the cadastral system is a socio-technical system and why it has a social basis. Furthermore I will tell something on implications this has or can have for modelling such a system and in particular give some comments on attempts to do so as well as on consequences this social side has in implementing a model in the real world.

The leading research questions, to the answering of which this papers aims to contribute, are:

- What are socio-technical systems?
- Is the cadastral system a socio-technical system?
- What are implications of being a socio-technical system for designing and modelling the cadastral system?

2. SOCIO-TECHNICAL SYSTEMS

The following table from (Kroes et al. 2004) summarizes a distinction we make between three kinds of systems.

	Without agents	With agents
Without social institutions	1) Landing gear	2) Airplane
With social institutions	-	3) Civic aviation system

Table 1 – Three kinds of engineering systems

The first kind is a system without agents or institutions performing a sub-function in the system. An example is the landing gear of an airplane. A landing gear does not need someone to manually turn the wheel, and, although subject to a great many regulations, it is not dependent on any of these regulations for its functioning. If these regulations suddenly cease to exist, the landing gear is still able to ground the airplane. Next we move up to a more complex type of system: the whole airplane. Here human agents fulfil sub-functions, like piloting the plane. But still an airplane does not need any regulations to function (and presumably airplanes function in the absence of regulations in some countries). If we then move up again to systems of the third kind, for instance, the complete civic aviation system, we see that, apart from human agents, institutional elements now also fulfil sub-functions. They are essential for the system as we know it to function. Without insurance, for instance, no airline company will send its planes in the air (as was the case after 9/11), passengers will stay away, and pilots might refuse to fly. In this kind of system there are many interdependencies of a social kind, which determine the functionality of the system. It is also evident that, for example, a billing system, an air-traffic system with agreed routes, et cetera, are essential to the functioning of the civic aviation system as well.

The third kind of system in this distinction we call socio-technical systems. These systems consist of technical elements (1), and additionally of non-technical elements like agents (2) and social elements (3), including the aforementioned institutions. In our analysis we will use this preliminary distinction between the three kinds of elements and the six relations (i – vi) these elements are involved in to gain more insight in these systems (see Figure 2).

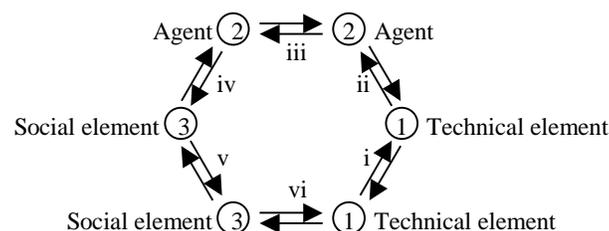


Figure 1 – Elements (1-3) and relations (i-vi) in a socio-technical system

In (Ottens et al. 2004) we characterized these relations as either physical, functional, intentional or normative, where the latter two kinds come into play when socio-technical systems are considered.

Our interest in the cadastral system arises from the peculiar nature of this kind of system. While we originally looked at systems where the social elements come into play due to for example an increase in scale or complexity of the system, by for example moving up in the system hierarchy, this does not seem the case for the cadastral system.

Systems come in different builds. A transportation system for example is about the physical transportation of goods and persons. This necessarily involves physical technology. As discussed in the above case these systems can be ‘stripped’ down to individual objects that can be used for the same means without social elements playing (an important) role. These systems have technology as their basis. When we look to the cadastral system and try to do a similar exercise we end up with a different basis. The cadastral system is based on the notion of ownership of real estate. Ownership is a social concept that can exist without any reference or link to technology. The core of the cadastral system is therefore social and not technical as in the case of for example transportation systems.

From the above it is clear that if we consider both systems to be socio-technical systems, the notion of socio-technical comes to include a wide variety of systems. By applying a concept to a wide variety, there is always the danger that it becomes excessively generalized and is rendered useless. We think, however, that the distinction we made between the different kinds of elements is useful in both kinds of socio-technical systems, since it is not based primarily on either technical or social elements. It focuses mainly on the differences in these elements, and these differences exist in both systems.

In this focus our approach differs from ‘established’ approaches in the fields of engineering and social sciences. In engineering, and more specific system engineering, social elements are to a great extent excluded from the system and agents are modelled from a functional and/or physical perspective. On the opposing side, in the social sciences, intentions are taken into account, but in their interaction with technology the latter is either black-boxed or, for example in the actor-network theory, technical elements are modelled as entities that act just like agents do.

We argue that social elements, technical elements and agents are different in their nature. Social elements are not subject to the laws of nature in the same way as technical elements and physical agents are. Of course, it is not denied that humans are subject to the laws of physics and chemistry, and the design of technology obviously takes this into account concerning the operation of machinery and in safety precautions. The point is that the description, anticipation and understanding of the behaviour of agents and social elements does not refer to the laws of nature but to principles of action and to social rules. This difference in nature between social and technical elements implies a difference in the way they are treated with regard to the modelling and designing of socio-technical systems.

3. AN ANALYSIS OF THE CADASTRAL SYSTEM

I use the notion of cadastral system as used by (Bogaerts 1999; Zevenbergen 2002; Zevenbergen and Bogaerts 2000) as a system that combines both the registration of land ownership and use (the administrative/legal component) and the definition of parcels of land (the spatial component).

A lot of research is already done on the cadastral system. For example the article by (Zaibert and Smith 2003) gives an excellent view on the concept of ownership of real estate. This concept is at the basis of the cadastral system. The system is not merely a tool to help in providing information on who owns what, but, as I will argue, that it is part of the legal framework that is needed to socially enforce ownership. In order to gain a greater understanding of the cadastral system, I will analyze the system using our ideas about socio-technical systems, taking a closer look at the (social) concepts involved and at the role of technical elements in the system.

3.1 Social concepts (or elements)

3.1.1 Real estate

As (Zaibert and Smith 2003) argue, for ownership of real estate to be conceivable it is necessary to socially define what real estate is. This is not the case for the ownership of, for example, a watch. It is simply clear to everyone what the boundaries of a watch are. When it comes to real estate, the situation is more difficult. Here the defining properties are not, or at least not that obviously, related to physical properties. (Zaibert and Smith 2003) point out that exchanging ‘all’ the soil between two real estates does not change the definition of the real estates. They also remark on the other hand that the social choice to use geographical coordinates for defining real estate parcels might run into problems as well since the surface of the earth is not immovable itself.

3.1.2 Ownership

Next to the problem of clarifying what real estate is, there is also the question about what ownership is. The expression “possession is nine-tenth of ownership” might work for a watch but is problematic for real estate. It is easier to capture that I own the watch or t-shirt I wear or the car I drive than that I own the land I walk on or cultivate or the place I work or even live. Of course more forms of use of immovable and movable objects exist: you can also lease a car, rent a house or probably even rent a watch. Another interesting point that can be made about ownership is that because it is a purely social term, it can also be declared not to exist (by for example a new political regime).

3.1.3 Owner

Not only real estate and ownership are socially defined, but also the notion of an owner is. Of course people are not socially defined, but legal bodies are. In most systems real estate can be owned by companies or organizations as well as by real people. Although it is perhaps an extreme example, it can socially be defined that a tree be appointed as the owner of the piece of land it stands on. In fact, certain rights and restrictions on land use are motivated by the presence of rare plants and animals on the land. This is currently conceived as restricting the rights of the human or corporate owner, and the layered model covering all rights and restrictions on land, proposed in the Cadastre 2014 (Kaufmann and Steudler 1998) document, conforms to this. However, developments in environmental ethics and animal rights might change this.

3.2 Legal framework and dynamic aspects

So what is needed for a system about ownership of real estate is a sound social definition of what real estate is and what owners are, and a stable concept of ownership itself. All this has to be embedded in a sound legal framework. This legal framework does not only include the laws that state *what* ownership and real estate are and *who* (or what) can be an owner, but also *how* someone can own.

A question would now arise about the position of the cadastral system relative to this legal framework. Can the cadastral system be seen as existing and functioning separate from the legal framework or is it perhaps part of this framework.

It seems to me that the cadastral system itself is part of the legal framework. Disputes about property will not be resolved on the legal concepts of real estate and ownership, but also or probably even more on information from the cadastral system. If I would argue that I own a parcel of land, I would refer to the cadastral system. Also when for example some claims unrightfully usufruct on my parcel (because three generation of land-owners ago this usufruct was cancelled) I need to defend my case by referring to the cadastral system.

This is because we are dealing here with social concepts. As argued before, we cannot go back to social laws to analyze the dispute, which could be seen as a malfunctioning of the system. In principle we can trace back a malfunctioning in a technical system to the laws of nature and the physical make-up of the system, though this can prove quite complicated in practice. However, even though ownership, owner and real estate are socially defined through the law, exceptions can be and are made as long as they are in the 'spirit' of the law, or the law can be changed. This while the laws of nature that apply to physical (technical) objects do not allow exceptions, nor can we change them as we see fit.

The above relates to the how question in the legal framework. Not only should the framework contain social definitions of what and who, but also on how, on procedures to register what and who and the precise relation between what and who. This implies a dynamic nature of the cadastral system. Both (Zevenbergen 2002) and (Molen 2002) argue that the cadastral system must be seen as a dynamic system rather than just a static one. Changes are usually seen as changes concerning the owner (for example a new owner), the parcel (it can be split up or change from rural tot urban land), or the character of the relation (different rights or restrictions can apply). Because of the social character of the system however, changes can also be of a more fundamental type. The kind of owner can change, as can the kind of real estate as is argued before. Since these concepts are socially defined, a material object or even an abstract entity may become eligible for ownership, and the real estate can, instead of being linked to specific coordinates on the surface of the earth, be linked to the position of the sun or the moon. These examples are of course exaggerated. It would not be practical to model a system to be able to cope with such penetrating changes. It seems to me, however, that it is important to recognize this social and therefore fluid nature of the system, since similar changes can also be of a less rigorous form, such that you would want your system to be able to incorporate them. For example (Mattson 2003) mentioned an 'Everymans's Right' on certain real estate. It is also not inconceivable that new kinds of relation will come in existence, for example rights and restrictions regarding environmental issues, as mentioned before.

3.3 Technical elements

In the analysis so far I have discussed every aspect of the system as being social. Does this not imply that the cadastral system is a social system instead of a socio-technical system? If not, then where do the technical elements come into the system and what is their role? Are they not better seen as standing apart from the cadastral system, merely supporting it? I will argue that this is not the case. Technical elements are this deeply integrated in the system that they cannot be seen as separate.

First of all I will go back to the definition of real estate. Boundaries of real estate are defined by coordinates. This is possible because of technology. This technology is not only used in defining real estate parcels, but also in processes of change like splitting up parcels or in disputes. If the cadastral system only stores these coordinates, and if all technology to locate these coordinates fails, then the information in this database can no longer be used to solve disputes. Hence the concept of real estate will become unclear and the cadastral system will fail.

The ongoing development of technology not only made the transition possible from a map-based to a database-based cadastre, but will also make a 3-dimensional cadastre possible. A shift to a 3-dimensional cadastre will bring a vast amount of new legal issues, which a cadastral system has to deal with, but on the other hand also helps in avoiding awkward legal arrangements (Mattson 2003). As said above, the surface of the earth is not immovable, but buildings are even more subject to move. Coordinates can be determined very accurately relating to (the surface or centre of) the earth while big buildings might shift just due to the inclination of the soil or whole areas might incline because of the extraction of natural resources (like gas). If a building would shift enough I could end up living in the real estate space of my below neighbour. It is clear from this example that a change towards a 3-dimensional cadastre is not a question of technology alone; it will have legal implications as well.

Secondly the database itself is part of the cadastral system. If all information is stored in the database and in the database alone, legal claims are made upon what the database provides. Because of the changes towards the integration of the cadastre and land administration system and the size and complexity of the system the database is not only a tool for the storage of information but becomes an essential element. Choices in modelling the future cadastre are based upon possibilities that arise from the use of ICT.

3.4 The cadastral system as a socio-technical system

I argued that the cadastral system is a socio-technical system where both social elements and technical elements play a role and are even strongly integrated. Furthermore I argued that the core of the cadastral system is social. The examples of systems I used in the previous chapter (airplane systems, transportation systems) have technology at their core. This makes the cadastral a different breed of socio-technical systems. The social side is much more important; upon abolishment of the social concept of ownership, the cadastral system would cease to exist. The interesting questions now are what this 'being a socio-technical system' means for modelling and designing the cadastral system and if the social basis has special implications.

4. IMPLICATIONS FOR DESIGNING AND MODELLING

In the following statement by Brian Mar¹, taken from an introductory presentation on systems engineering, the way traditional (systems) engineering deals with the outside, social, world is clearly indicated. This quote emphasizes the importance of and interest in understanding socio-technical systems with a view to modelling and designing them.

At the moment the capability to deal with the outside world is non-existent. Therefore it is usually treated as constraints. There are only a very few people who deal with it, try to improve the world for the benefit of their system. Usually system engineers use risk analysis and design the system so it can deal with these risks. In the future there might be new capabilities, for example, to talk better with the people who design the rest of the world and integrate them in the system design process, or to do something else than risk analysis to handle the outside system. Risk analysis is one way, but hopefully we'll find a new better way to deal with it.

In this section I will discuss the implications of the aspects of the cadastral system that came up in the previous section for the task of modelling and designing them.

4.1 Designing

Since social elements are of such a different breed from technical elements, it is not clear whether the same notion of designing (as engineers use the term) would apply to both. It is even questionable whether a notion of designing is relevant at all with regard to social elements. This is emphasized by (Kaufmann and Steudler 2004). The statements that involve technology, like the switch to IT infrastructures, are on 'schedule' or only slightly behind, but the statements of the Cadastre 2014 document that require the most far going changes in social elements are the ones that are most behind 'schedule'. For example, the inclusion of public rights and restrictions in the system requires a much deeper institutional change. The existing social institutions dealing with public rights on land might not have the same goals as the cadastre and the land registration institutions. To gain more insight in these changes more research needs to be done on social systems. Useful leads on this particular subject might be a multi-actor approach (as taught at the faculty of TPM, Delft University of Technology), which includes for example stake-holder analysis and process design and management (Bruijn et al. 2002). However, the multi-actor approach states explicitly that the solution of the problem has to emerge from the process and cannot be set beforehand. It will be negotiated during the process among the different stake-holders involved. In working towards a standardized cadastral system this is not a very satisfactory thought, since every country might negotiate a completely different system.

This, however, is not reason enough to abandon this idea. Because of the highly social nature of the cadastral system and the many stakeholders involved this might just turn out the way it works. What can be given are arguments in this negotiation process, so a well made model of the cadastral system could be of great value. I doubt, however, whether this process of change will be achieved by 2014.

¹ Brian Mar is a Systems Engineering Fellow, one of the founders of the International Council on Systems Engineering, and Emeritus Boeing Professor of Systems Engineering at the University of Washington.

4.2 Modelling

The foregoing comments on designing put the modelling of the system and environmental conditions in a different light. It no longer functions as a basis for designing but as an argument in negotiation. Nevertheless, since the cadastral system is not purely social, but involves technology as well, some parts can probably be designed straightforward from a model.

4.2.1 Boundaries of the system

A recurring question in system modelling, which is closely related to the dynamic aspects, is the question where to draw the boundaries of the system to be modelled. As Mar mentioned, engineers now usually leave out the social aspects, but, as I argued, this is impossible in the case of the cadastral system. The question of boundaries is closely related to the part about dynamicity. It would be useful to make the system adaptable to certain changes, but a system that can handle all possible changes is probably not feasible, or would be useless because of its complexity. A dramatic change in the concept of ownership, as for example has happened in the Soviet-Union, is not a change that is useful to take into account; it would render the system useless. Certain social aspects, like for example the definitions of real estate, ownership and owner are probably best placed outside the system to be modelled, but when designing the system they have to be taken into account. They will probably need adjustment due to choices made in modelling, so they should be dealt with in a more than contextual matter.

4.2.2 Elements and relations

In the previous chapter I described several elements and relations in the system. In modelling I think it is essential to recognize and state the nature of the elements. This will help in gaining more insight in the system and aid in designing the system. By putting emphasis on relations not only within the system to be modelled, but also across the chosen boundaries, dependencies can be found that might cross boundaries in a bidirectional way. The definition of ownership can for example be seen as contextual, yet it is of utmost importance for the functioning of the system. Nevertheless this is not necessarily reason enough to include it in the system to be modelled. In designing however some work might be done to assure a sound definition of ownership suitable to the cadastral system.

4.2.3 Procedures

Not yet clearly defined in our model of socio-technical systems are processes (or in the more formal sense procedures). With regard to the dynamicity and costs related to these dynamic aspects, procedures play an important role. As was mentioned and done at the COST Action G9 workshop in Riga (October 14.-16. 2004, <http://costg9.plan.aau.dk/>) researching the procedures involved in real estate transactions seems an intelligible way to gain more transparency and insight in costs. The sixth statement of the Cadastre 2014 document and one of the aims of Cost Action G9 are about gaining transparency in the costs involved in real estate transactions in order to make the system cost recovering and make systems in different countries better comparable. It seems not likely that the change towards a digital cadastre will

considerably change the amount of costs involved. Legal procedures are still needed to assure the legal validity of the system and will not change because of the change to a digital system. On the other hand costs of retrieving information (for non-legal purposes) might decrease considerably. Neither Cadastre 2014 nor the (Lemmen et al. 2003) model (both aiming at future cadastral systems) deal explicitly with procedures.

5. CONCLUDING REMARKS AND SOME DISCUSSION

In modelling the cadastral system social elements are very important, because of their nature they need to be modelled differently from technical elements. One has to take into account that the definition of the element to be modelled is social and therefore can change; a certain possibility of change needs to be incorporated in the model.

Because of this fluid nature of social elements it is important to think about what degree of change you want to incorporate in your model. You need to think about where and on what grounds you want to draw the boundaries of your system to be modelled.

Because of the social nature of the cadastral system designing is not as straightforward as with technical systems. In social sciences research is done to social systems and knowledge regarding these systems might be used in shaping the socio-technical cadastral system.

The distinction we make between social and technical elements seems very useful in analyzing the cadastral system. Problematic issues in modelling and designing can be identified beforehand.

Neither Cadastre 2014 nor the (Lemmen et al. 2003) model do take sufficient notion of the socio-technical nature of the cadastral system.

In our research we look at boundaries in a more general manner, if for example the boundaries can be drawn based on the aim or the function of the system. When socio-technical systems are considered it seems, however, unlikely that one aim or function exists. This is especially the case when multiple actors are involved. It would be interesting to see whether such an approach would be useful in the case of the cadastral system. (Zevenbergen 2002) used such an approach in studying the cadastral system. Another interesting research might be aiming at finding an ontology of procedures. This might prove very difficult, since they are all social themselves, based on different social concepts of ownership of real estate. Also the question whether a social knowledge exists and can be used in the shaping of socio-technical systems is something that would be interesting to research.

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BIOGRAPHICAL NOTES

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