Understanding Policy Processes by Engineering Principles of Systems Theory

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ABSTRACT

Socio-technical systems incorporate several dynamic factors that are analyzed by different scientific communities. Political science underlines the non-linearity of the decision-making process while engineering science has made good progress in applying cybernetics to socio-technical systems in various hazard analysis methods. Therefore, this paper incorporates a lens from policy analysis, MSP (multiple streams perspective) with STAMP (systems-theoretic accident modeling and processes) to improve the understanding of the political process within socio-technical systems and its results. The method is then applied to the German road traffic system.

Keywords: Policy Process, Hazard Analysis, Multiple Streams Perspective, Systems Theory, Control Structures, Ambiguity

1. CHALLENGES OF COMPLEX SYSTEMS FOR POLITICS AND SAFETY

Political decisions within a socio-technical system are considered key to sustain a system's safety and to control social components within safety-relevant constraints [1]. Recent research has shown that the application of system dynamic models improves the policy process and the intended impact [2]. Some decades ago, the adaptation of cybernetics to political science led to first models of the policy process, such as "Information Flow in Foreign Policy Decisions" by Karl W. Deutsch [3]. Nevertheless, political systems and policy processes have diversified and become more complex.

Other modern systems have similarly evolved from formerly simple mechanic systems to complex systems with a vast number of components, like hard- and software, personnel, equipment, environment, functions, procedures, and policies [4, 5]. All these disciplines aim to create a safe system behavior, or at least an intended system behavior. Generally, safety can be defined as the absence of undesired events [6], which means it is measurable by its complementary, the accident [7]. In contrast to the development of simple systems to complex socio-technical systems, the so-called classic hazard analyzing methodologies, which were designed to find hazards in the system which cause accidents, have not been developed adequately enough to fulfill the exigencies of todays' systems; especially the influence of policies has mostly been neglected. Methodologies like FMEA (failure mode and effect analysis) or FTA (fault tree analysis) are still based on the assumption that accidents result from chains of events leading to an undesired event. Breaking these chains consequently prevents the accident from occurring. The primary problem lies in the fact that complex systems cannot be understood thoroughly and that safety is an emergent property of the system. Consequently, a better analysis must look for problems in the interaction of system components, rather than breaking event-chains in order to prevent accidents. [5]

There is a range of developments which abet the systems' complexity and strengthen the need for renewed policies and thus analyzing methodologies. Minding the fast pace of technological change while the range of a product's functions is increasing [8] the period of a product's life-cycle is decreasing [9]. Using software within systems generates new kinds of hazards, which do not only stem from mechanical dysfunctions. Nowadays, an incremental amount of information is necessary to control a social-technical system. [10]

> *"The operation of some systems is so complex that it defies the understanding of all but a few experts, and sometimes even they have incomplete information about its potential behavior." [11]*

Unfortunately, the less we know about accidents, the more often personnel are accused as the initiators of accidents. [6] Usually human behavior only is reported if it generates an undesired event. However, oftentimes human operators need to intervene in a system's operative processes if an accident is already inevitable [5]. Ergo, tolerance for simplified accident causation models decreases. The understanding of an accident must be based on the analysis of the system's design and not simply on human failure [12]. Furthermore, public opinion tends to force the institutions applying/issuing the policy to take more responsibility in achieving safety, and increase the control of human behavior to achieve more safety compliance, because "[…] safety exists within a complex environment involving interactions between people, equipment, policies and operating conditions." [1] These trends are viable in the heavy activities within the normative backgrounds and standards. For instance, the safety standards IEC 61508, as well as its derivatives for transportation domains ISO 26262 and IEC 50126 ff., are under continuous development and need to be applied for new safety relevant systems in transportation.

> *"Effectively preventing accidents in complex systems requires using accident models that include that social system as well as the technology." [12]*

Therefore, analyzing complex socio-technical systems requires an approach which is capable of identifying meshed interactions between social and technical controllers. Every sociotechnical system is influenced by society, psychology, economy, and politics. Following the ascendancies on shaping human behavior will be regarded more intensely [5].

The psychological definition of social learning postulates that individuals adopt habits of other role models. These habits may be contrary to policies. but legitimated by others. Thus, policies almost never get full compliance and the system drifts into an unsafe state [13]. Dulac also anticipates that social systems continuously shift into an unsafe state, because in some way unsafe states are higher rewarded to the social controllers than safe states [6]. This effect is supported by psychological ascendancies on humans within socio-technical systems. Walter [14] introduces a model, which is based on the Law of Effects by Thorndike [15], that can be used for describing the link between stimulus and response of humans. The model separates humans' behavior into the state of rule-compliant and rule-non-compliant behavior. Non-compliant behavior results in a negative response. If a stimulus results in a negative response, humans switch back to the safety-compliant behavior [14]. Knowledge of this stimulus-response link is crucial because it forces politics to take this into account while creating safety-increasing policies. Furthermore, it strengthens the need for combining interdisciplinary research approaches in order to create a better knowledge about systems and thus develop adequate policies.

In political science numerous concepts and theories exist to explain the process and results of the policy process. These theories deliver conflicting perspectives though. The political sphere is a crucial variable for system-safety since its decisions affect the whole safety environment. In accordance, the cybernetic model describes the interaction between the political system and its environment mainly with the simple but established triad of input, throughput, and output [16, 17]. On the input side demand and support are introduced. Inside the political system, decisions meet certain 'checkpoints' "occupied by gatekeepers" [17] who have a major influence on the system's agenda, and thus its decisions or policies [16]. This perspective corresponds with the textbook approach of the policy cycle that focuses separately on each stage. Input, throughput, and output occur at univocal moments in time involving specific actors and institutions [17].

Multiple streams perspective (MSP) in contrast presumes that the policy process consists of changing constellations of different actors at different moments in time [18]. This assumption draws upon the "garbage can model of organizational choice", which was introduced by Cohen, March, and Olsen [19, 20]. Cohen, March, and Olsen define choice in organizations as a garbage can into which an alternating set of actors discards solutions and problems [18]. Kingdon applies this concept to the policy process and presumes that those constellations emerge under conditions of ambiguity, and with the possibility of political manipulation [20, 21]. Ambiguity describes a "realistic" view of political decision-making. In contrast to traditional theories of economics, political actors are not viewed as rational people that follow stable goals. Accordingly, politicians follow different and even conflicting goals. Changes of incentives and even new information do not lead to predictable changes of political decisions. MSP thereby assumes that the policy processes are shaped by "fluid participation, problematic preferences, and unclear technology" as Robinson and Eller underline by citing Kingdon´s key indicators for ambiguous policy processes [22]. The MSP model of the policy process consists of three rather independent streams which are coupled by a policy entrepreneur during open windows of opportunity [23]. The distribution of all necessary information for policy makers is hampered by systemic conditions which refer to a notion of a very broad spectrum of motifs, ideas, beliefs, and other patterns of thinking that could be connected to the same phenomena [24]. Neither the epistemic and ontological foundation, nor the perception of phenomena as problems or solutions is definite [20, 25]. This affects the whole policy process. Problems and solutions are not determined, and policy outcomes are utterly variable. Therefore, the conversion of different opportunities into decisions within a political system is not predictable [20, 26].

Despite the important role of experts within complex systems [27, 28], the influence of "traditional" policy-making venues persists. In Germany, for example, traffic policy is generally not an issue for party competition, media coverage, or campaigning [29]. Nevertheless, conflicts occur between traffic policy experts of all parties on the one hand and generalists on the other hand [29]. The frictions occurring from this cleavage are enhanced by a lack of cross-linked traffic policy expert networks [30].

Against the background of the increasing challenges within complex sociotechnical systems and the conflicting theories of policy-processes, the following chapter will present interdisciplinary perspectives on systems and thus generate a hybrid methodology for gaining a deeper understanding of policy-processes using cybernetics.

2. POLICY PROCESSES UNDER AMBIGUITY: THE MULTIPLE STREAMS PERSPECTIVE

The political system is capable of affecting system´s safety especially through legislation. It sets framework conditions for engineering, education, enforcement, and the economy. The assumption of ambiguity affects the model of the policy process as rationality cannot be improved by more information and policy choice is hardly predictable.

Zahariadis names three assumptions of the MSP [20]. Firstly the difference between serial and parallel attention, respectively processing: serial attention applies to individuals e.g. policy makers who are only able to regard one issue at a time due to the limits of human cognition and other constraints. Political systems in contrast have the possibility of parallel processing. Secondly time restrictions are an important aspect: issues are non-permanent phenomena. They only remain salient for a certain time until another competing issue raises on the policy agenda. The third assumption focuses on the independence of the streams: The streams within a policy subsystem not only generate different contents but usually do so without considering each other. For example, policy "solutions" might be produced even before an issue floats on top of the problem stream. [20]

The implications for the policy process that result from these assumptions are quite unique. First of all, it is necessary to consider which should be the level of analysis: Should it be the individual with serial attention and processing, or the subsystem with parallel attention and processing? Increasing a system's safety by providing all necessary information might especially be hampered when decisions are made at an individual scale. Secondly, policy makers' shortness of time limits their rationality and problem orientation [26]. Furthermore, data validity might not have an impact on policy output if data and policy makers meet at the wrong time. Thirdly, to improve a system's safety, one needs a deep understanding of how the streams of the policy process are structured.

- The *problem stream* consists of conditions and information that, under conditions of ambiguity, are neither obvious problems nor do they have public attention [22, 31]. The mechanisms of attention drawing include indicators, feedback, and focusing events. Indicators like the number of deaths on the road or people without health insurance are either periodically published or emerge in single studies. Feedback from former programs highlights the best practices as well as failed policies. Focusing events are able to disrupt the dominant pattern of thinking about a problem and thus the erupting policy process. [20] For instance, multiple vehicle collisions or other unpredictable fatal traffic accidents might shift the actors' perception and increase the contingency of the underlying political system. The conversion of such conditions into problems is a genuine political process. Kingdon alleges that problems have a "perceptual, interpretive element" [31]. In addition, specialized actors draw policy makers´ attention to a limited spectrum of problems [22].

- The *policy stream* represents a "soup of ideas that compete to win acceptance in policy networks" [20]. These ideas might be "solutions" to one or a set of problems [22] but lack an obvious nexus between problem and solution since the streams are independent and problems have an interpretative element. Zahariadis identifies "technical feasibility" and "value acceptability" as "selection criteria" of the policy stream. The selection effects on ideas reach from no change at all to their total disappearance. [20] Robinson and Eller point out that policy selection in MSP is dominated by an elitist set of actors and public opinion is mainly disregarded [22].

- The *politics stream* includes three elements, namely the "national mood, pressure group campaigns, and administrative or legislative turnover" [20]. National mood and pressure group campaigns are important to policy makers since they have to identify which policies are zeitgeisty and will be supported by interest groups. Turnover in administration or legislation change the political conditions in the way that a different set of actors with different beliefs and values might change the value acceptability of some policies. [20] Another important aspect is what Zahariadis defines as "party ideology" [23]. Comparing the privatization of telecommunication authorities in Britain and the non-privatization in France, he operationalizes party ideology as "the perceived degree of party identification with state ownership" [23]. In other words, important policy makers from a party which supports state ownership will most likely seek to prevent privatization.

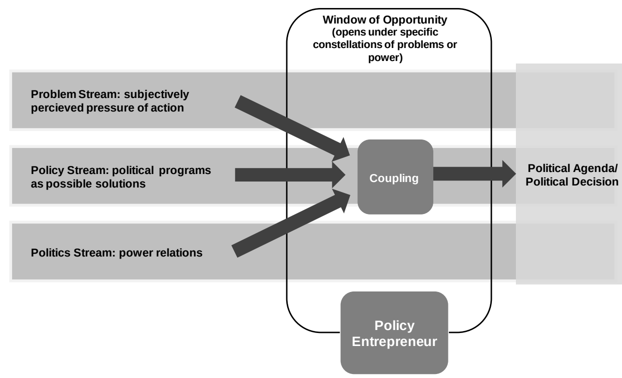

Figure 1. Multiple Streams Perspective according to [29]

Policy Windows or "windows of opportunity" are points in time when "advocates of proposals [are able] to push their pet solutions, or to push attention to their special problems" [31]. Policy windows do only open when each of the independent streams functions complementarily. Firstly, at certain moments in time a phenomenon must be defined as a problem. Secondly, a technically feasible and value acceptable solution has to be at hand, and thirdly, restrictions within the politics stream must not be too intense. Policy windows are only of short duration regardless of whether they have opened from the politics stream e.g. through changes of individual actors or by new problem definitions e.g. shaped by focusing events. [31] Policy windows might be predictable e.g. through elections but can also emerge out of the sudden e.g. epidemics, nuclear or natural disasters [32]. Although those more or less predictable events might provide the opportunity for decisions to be made, MSP assumes another venue for policy change which involves active coupling or joining of the three streams [20, 22, 31]. Individual or corporate actors who are trying to use these windows by coupling of the streams are labeled *policy entrepreneurs*. In order to enforce policy change, policy entrepreneurs try to manipulate policy makers and develop a decision context within which the political framework, problem definition, and their pet solution work complimentary [20, 31]. Zahariadis identifies three factors that have an impact on coupling. Firstly, access through value compatibility is helpful to convert an entrepreneur´s solution into actual policy. Policy entrepreneurs who have general access to policy makers due to similar values are more successful than others. Secondly, the more resources they have to promote their solutions the more successful they tend to be in achieving their goals. Thirdly, policy entrepreneurs who are skilled at using manipulating strategies, e.g. salami tactics, framing or affect priming have greater chances of success. [20] In summary, policy entrepreneurs that couple streams and open policy windows can use anything that either improves the perceived feasibility of a solution that increases the normative acceptance of a policy and/or that lets a problem appear more urgent.

The multiple streams perspective helps analyzing policy processes on the qualitative level, but it lacks capabilities in quantifying policy processes. Hence, the aim of this research is to combine the multiple streams perspective with cybernetics-based hazard analyzing methodology and thus quantify policy processes to certain amount.

3. SYSTEMS-THEORETIC ACCIDENT MODEL AND PROCESS

Various systems-theory-based hazard analyzing methodologies are known. Beside SoTeRiA (Socio-technical risk analysis) [33] and CREAM (cognitive reliability and error analyzing methodology) [34], STAMP (Systems-theoretic accident model and processes) [12] is the state of the art in modern hazard analyzing methodologies.

> *"[STAMP] is a new approach to hazard analysis that enables model-based simulation and analysis of risk throughout the system life cycle, including complex human decision-making, software errors, system accidents (versus component failure accidents), and organizational risk factors." [35]*

The approach is far more advanced than introduced within this contribution. STAMP provides a cybernetic modeling language for so-called safety control structures, which can also be used to model the relations and interactions between policy makers and policy entrepreneurs within a system. These safety control structures can be seen as the means of description of STAMP. The basis of any control structure is a simple control loop (see fig. 2). Every control component, human-based or technological-based, has various actuators to control a process and sensors to receive feedbacks.

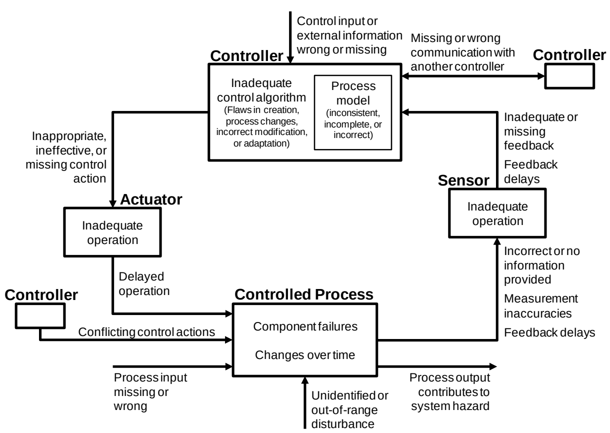

Figure 2. Generic Control Loop within Systems [5]

The controlled process can be measured by sensors which deliver their information to the automated controller. Within socio-technical systems most interactions between human and technical control components are cascaded control loops – one output of a controller is the input of another controller. The controlled process, also named operative process, transforms inputs into process outputs influenced by disturbances. The automated controller adheres to a model of the process and a model of the interfaces. In order to conduct the adequate control actions, the automated controller controls the controlled process by actuators [5].

At the center of the STAMP analysis is the safety control structure. It represents all relevant control components involved in a safety-relevant process. The control structure models the in- and outputs of each control component, and generates virtual containers. These functional relationships of in- and outputs can be quantified by empiric data of systems. By doing so, the static control structure can be translated into a simulateable system dynamics model. System dynamics is an approach developed by Forrester to understand nonlinear system behavior. The approach has been used by the club of Rome initially, but finds broad acceptance throughout industry and research. By translating every control component of the safety control structure of the sociotechnical system, it is possible to create so-called virtual containers with in- and outputs to other system components. These virtual containers can be modeled in a system dynamics model and afterwards be quantified.

The concept of control structures will be used to model the interactions between policy makers and entrepreneurs with the goal to gain a deeper understanding of the influences on the multiple streams and the processes themselves.

4. CREATING A HYBRID METHODOLOGY USING STAMP AND MSP

In order to generate a hybrid model by integrating STAMP and MSP, one must get a basic understanding of how systems are designed and where the basic problems of operating processes are located:

Systems are generally designed by a system's designer with a certain mental model of the system itself. Within this hybrid methodology the system's designer is the policy maker, e.g. the legislative authority. The designer develops the original design specifications of a sociotechnical system, which is the basis for the manufacturers to translate the designer's mental model into an actual system. The mental model of the designer represents the ideality of a system; however, the actual system is then implemented in reality. Manufacturing and constructions variances generate discrepancies between the designer's mental model and the actual system. The policies are created on the designer's mental model, thus it is possible that the developed policies do not fit the requirements of the actual systems because they differ significantly from the mental model of the designer. Furthermore, the operators create their own mental model of the system which is based primarily on the operating instructions (policies) and the experience with the actual system. The system's operators, according to MSP, are the policy entrepreneurs, who are trying to influence the policy makers (designer) to achieve their own goals. The mental model of the operator is also differing from the designer's model and furthermore does not fit the requirement to understand the whole actual system, but only a few aspects in which the operator is involved. Thus, the operator cannot foresee what consequences the individual control actions may generate at another place in the system. A single decision may be safety-compliant in one context of the system's operation, but hazardous in another (figure 3).

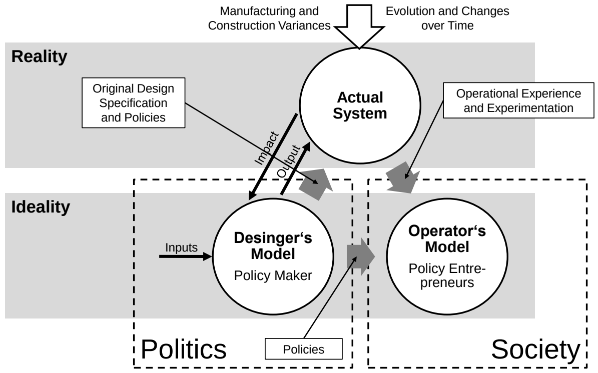

Figure 3. Principles of hybrid methodology, according to [5]

MSP highlights the difficulties of policy making under conditions of ambiguity. In policy processes, information is neither “value-neutral” nor an unused instrument for manipulation [20]. One principle of STAMP is trying to make all relevant information to each control component accessible. Thus the individual mental models of the system can be updated continuously. Policy entrepreneurs are a crucial analytical figure within MSP and drivers for policy change. The combination of STAMP and MSP helps to understand policy maker’s decision patterns and illuminate the consequences of policy processes for system safety on the basis of a control structure representing all relevant policy makers (system designing control components) and entrepreneurs (system operating control components).

In addition to the challenge of an anticipation of consequences of a policy due to complexity and differences between ideality and reality, policy entrepreneurs might push a single pet policy which might actually obstruct a system´s safety. This is also due to the inadequate mental models by the policy entrepreneurs.

After creating a control structure including all relevant policy makers and entrepreneurs, the next step is to identify relevant variables which can be used to develop a system dynamics model of the political system. Making use of system dynamics in analyzing policy processes offers a significant improvement due to the following three aspects:

- Firstly, system dynamics is based on the feedback approach, modeling the effects of variables on themselves.
- Secondly, using control structures aggregates the relevant variables to a minimum and focuses on the main ascendancies.
- Thirdly, the research field of system dynamics provides a large number of simulation tools.

By analyzing policy processes, the formerly qualitative analysis can be upgraded to a quantitative analysis and hence become more profound.

4.1 Generic Control Structure of Policy Processes

Policy maker act like automated controllers since focusing events or feedback as well as national mood meets their value based “sensors” and their decisions are comparable to the actuators. The policy entrepreneur’s influence may lack a predictable “if-then” function. Nevertheless, their more or less successful attempts to frame information and manipulate have an influence on the policy maker´s sensors and their decisions, see for instance figure 4.

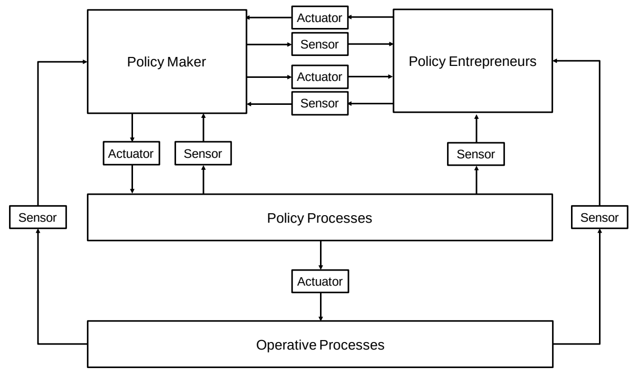

Figure 4. Cascaded Control Loops of Policy Processes in a Control Structure

Although they do have sensory capabilities, they do not have direct actuators to influence the policy processes. Both policy maker and policy entrepreneurs do have sensors to measure certain aspects from the operative processes. Within this model, the operative process represents the safety-relevant aspects about the complex system, which are supposed to be manipulated through policies. This model includes the aspect that policy entrepreneurs can influence policy makers. The model is at a very generic level; therefore it can be applied to individual policy processes within various environments, e.g. automobile industries. The streams are intentionally not integrated in the basic control structure because this model is supposed to explain at a very simple level how the control components are influencing the processes by their sensors and actuators.
The next step is now to adapt the generic model of policy makers and entrepreneurs into more specific showcases and highlight the influence by the policy streams. The elaborated model then can be used for quantification.

4.2 Multiple Streams in Hierarchical Safety Control Structure

The basic control structure from Fig.4 will be extended into the multiple streams perspective. Fig. 5 shows the extended version of the control structure. The sensors of the policy maker and policy entrepreneurs are now represented by the streams. The streams are in this control structure represented as independent control components of the system. Each stream is connected to different other control components.

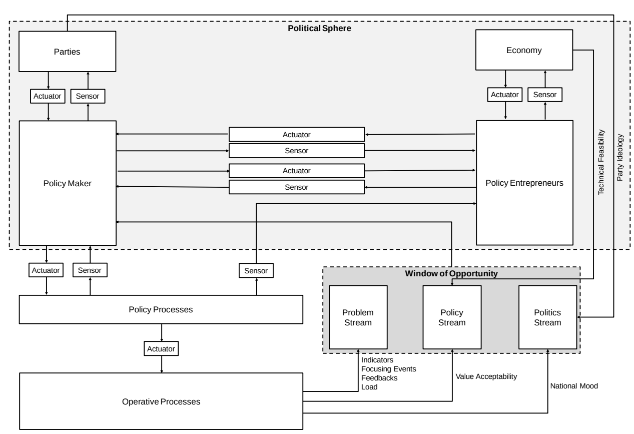

Figure 5. Control Structure of Policy Processes with integrated Multiple Streams

For instance, the policy stream is sourced with information by the operative process as well as the party ideology by the parties. Over the relations between the control components information can be transferred, more than exemplified within this structure. These information flows are non-physical. This means that the basic structure must be adapted to certain policy processes. After creating a control structure including all relevant policy makers and entrepreneurs, the next step is to identify relevant variables which can be used to develop a system dynamics model of the political system. Making use of system dynamics in analyzing policy processes offers a significant improvement due to the following three aspects:

1. System dynamics is based on the feedback approach, modeling the effects of variables on themselves.
2. Using control structures aggregates the relevant variables to a minimum and focuses on the main ascendancies.
3. The research field of system dynamics provides open-source simulation tools.

When the relevant control components involved in the policy process are identified, the next step in the policy analysis is to quantify formerly qualitative characteristics. Hereafter, a short example of how this can be done by system dynamics will be introduced. When changing the speed limit, policy entrepreneurs and policy makers must undertake different assumptions regarding how a policy change may affect safety-relevant characteristics. Policy makers and their parties could mainly be interested in vote-seeking, office-seeking, or policy-seeking [36]. Vote-seeking means that a political actor is aspiring a high number of votes and political esteem [36]. Our approach focuses on vote-seeking since "vote-maximization is an efficient strategy for office- and policy-seeking parties" [37]. This qualitative property can be quantified by defining its characteristics, their quantities, and finally their values. Table 1 exemplifies how this can be done.

Table 1. Quantification of Vote-Seeking

Property	Characteristic	Quantity
Vote-Seeking	Accidents	Number / Time
	Car Sales	Number / Time
	Medical Costs	EUR / Time
	Speed Limit	Km/h
	Voter	Number / time
	...	...

In this case, the crucial characteristic is the number of accidents caused by a change of speed limits. Therefore, the purpose of the quantitative model is to predict how this characteristic is affected by a policy. Fig. 6 shows the feedback model of how the different characteristics are changing the vote-seeking. In this case it can be defined that the policy makers are represented by the variable "vote-seeking", as shown in the figure, and the policy entrepreneurs are represented by the variable "car sales". The policy process in this example is modeled by the actual speed limit and the variable of attractiveness of policy. Furthermore, the operative process is represented by the actual number of accidents and their severity. The model is kept at a very simple level to illustrate the basic principle of the modeling approach. The shown model assumes that the policy makers are influenced by automotive industry (in this case the policy entrepreneurs). They are interested in increasing the number of car sales. At this point it is important to mention that the number of accidents may actually increase the number of sales. This strengthens the idea that not all involved parties are having the same goals in changing a policy. While the policy maker may want to lower the number of accidents, the policy entrepreneurs may have an actual interest in increasing the number of accidents to boost sales.

The mathematical model behind system dynamics are differential equations, therefore it is necessary to quantify all qualitative dimensions and model their mathematical relations.

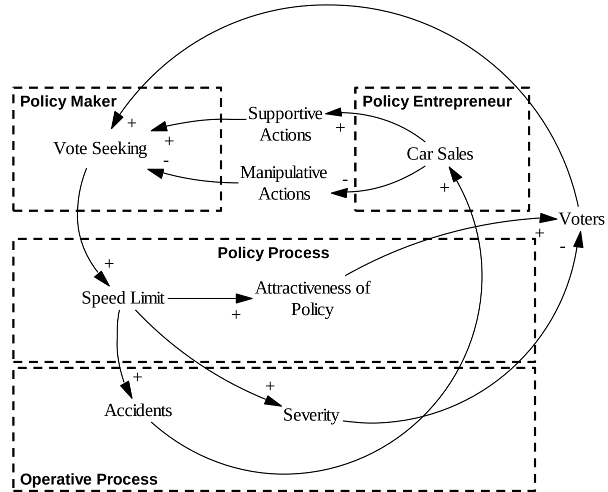

Figure 6. System Dynamics Model of Speed Limit Influences

5. PERCEPTIONS FOR POLICY PROCESSES ANALYZING THE GERMAN TRAFFIC SYSTEM

After describing the hybrid methodology, the next section will show selected results by applying STAMP and MSP to German traffic safety. The interdisciplinary ascendancies of the legislative authorities by the various players within the political system can be illustrated by the STAMP-MSP-analysis. The results of STAMP are based on expert interviews.

Analyzing the German traffic system one can identify 11 operative control components, e.g. the individual driver, and 18 system designing control components including the legislative authorities. Within the analysis, the legislative authority is represented by the German political system and the European Union. The legislative authority is located on the highest level within the policy giving institutions. Located directly under the legislative authority are the public institutions, like the BMVBS (Bundesministerium für Verkehr-, Bau- und Stadtentwicklung), KBA (Kraftfahrbundesamt) and the BAST (Bundesanstalt für Straßenwesen). The institutions take responsibilities for servicing the infrastructure, creating engineering standards, performing research for increasing traffic safety, prosecuting traffic offenders, etc. On the one hand, the legislative authority supplies the public institutions with personnel and monetary resources. On the other hand, the legislative authority receives information about the status within the traffic system from the public institutions. The basis of any policy is defined by the German Basic Law (Grundgesetz), which also serves as the foundation for the control component engineering standards. Any kind of traffic related policy must be created in accordance to the Basic Law. Minding the policy process under ambiguity, one can see within the control structure (see figure 7) that the processes are exposed to various influences. Moreover, the insurance companies, private and professional, execute an influence on the legislative authority. These ascendancies may hinder the policy processes in their effectiveness. For instance, the automobile industry does have an interest in bringing new innovations to the market, which may be hampered by regulatory hurdles.

In addition, the legislative authorities are shaped by society. Minding the multiple streams perspective, different influences steer the focus of politics toward certain areas of interest. This is hard to model due to the numerous aspects having an impact on the attention of politics. Furthermore, in Germany, the different federal states do have different policies defining the rules of traffic. Therefore, the local influences do also shape policies and have an influence on the policy-processes.

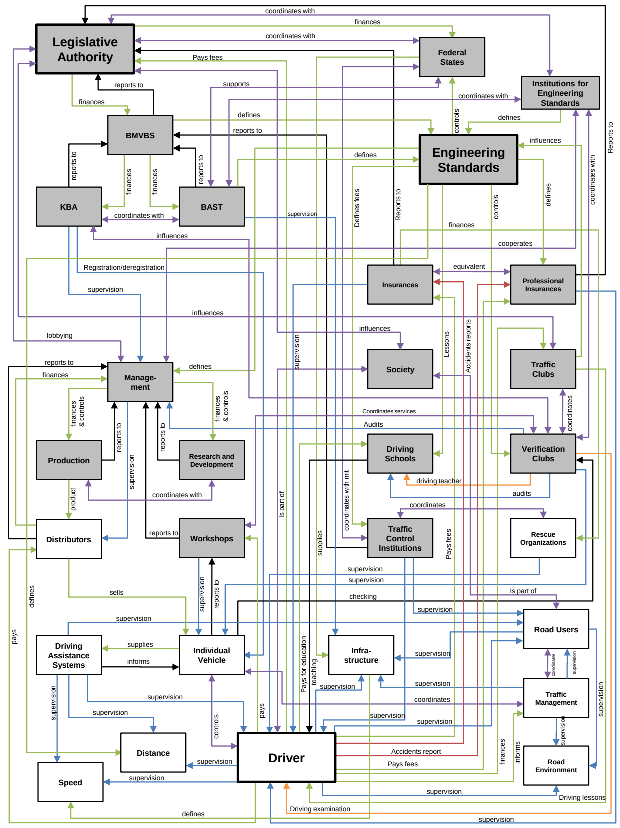

Figure 7. Control structure of the German traffic system, according to [38]

A crucial part during the hazard analysis by STAMP is identifying missing safety constraints within the control structure. Focusing on the political aspects of the German traffic system, one can see that it is mandatory to adhere to the policies issued by the EU. Herein lays a hazard, because the policies of the EU may have a negative impact on the traffic system due to local and/or cultural aspects. Other aspects, like the driver education, are also hazardous. For instance, it is possible to keep the driver's license for decades without any driving experience. There are only mandatory educational provisions when a driver first decides to actively enter traffic, but no follow-up tests assuring the driver's capabilities.

Another aspect analyzing the control structure is that according to the number of control-relations within the system's structure, the legislative authority is inferior to automobile managements. Even though the legislative authority is strongly connected to other control components within the traffic system, it has just 11 relations to other components. However, automobile managements have 13 relations within the traffic system, which are enabling them to perform more control actions influencing traffic safety (see figure 8).

The inferiority of the legislative authorities exemplifies that the political system is hampered, and thus unable to issue the optimal policies for the traffic system. At the same time, it also shows how interconnected the control loops are, and how they are affecting safety and policy-processes within socio-technical systems. Furthermore, the multiple streams can be visualized by analyzing the meshed relations of the different control components.

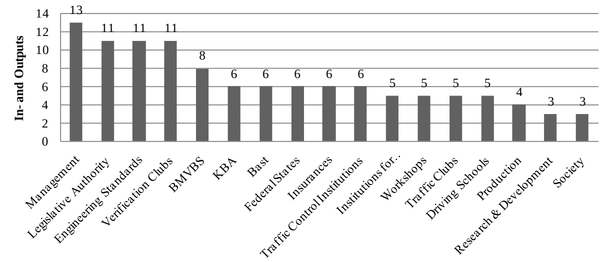

Figure 8. In- and outputs of system designing control components, according to [38]

6. CONCLUSION

Instead of considering accidents as the result of event-chains, STAMP defines an accident as an inadequate implementation of safety constraints within the system's structure. The causal factors of accidents lie within the differing mental models about the system's structure and behavior of the system's controllers.
Policies and system safety are interwoven. Despite unquestionable merits, traditional models in engineering and political science are note capable of analyzing the challenges deriving from the complexity of systems as well as policy processes. Nevertheless, the adaption of cybernetics to political science was fruitful at the time. Therefore, we combined a modern hazard analyzing methodology (STAMP) with a recent perspective in policy analysis.
Our results show that MSP is capable of analyzing policy processes under conditions of ambiguity. Actors involved in ambiguous processes have problematic preferences; their mental models might be influenced by a broad variety of ideas and other cognitions referring to the same phenomenon in a system. Moreover, policy entrepreneurs might push a pet policy that impairs a system´s safety. The Multiple Streams Perspective helps to understand those ambiguous policy processes. Nevertheless, the MSP is not able to quantify policies in order to get a holistic view on system safety.
The newly developed Cybernetic-oriented Modeling of Policy Processes (COMPP) exemplifies that ambiguous policy processes can be integrated in hierarchical safety control structures. Although human behavior generally lacks a predictable "if-then" function, policy makers and policy entrepreneurs can be conceptualized as automated or human controllers, respectively, within a generic control loop. Both of them have sensors to measure specific parts of the operative processes. However, neither of them has direct actuators to influence the policy process. Within a hierarchical Safety Control Structure the problem-, policy- and politics stream can be understood as independent control components of the system. Each stream is connected to different other control components.
Thus, our results support our notion that formerly qualitative models of policy analysis can be quantified by combining them with hazard analyzing methodologies. Further research should attempt to apply our model to different case studies and system dynamics modeling in order to identify strengths and weaknesses of our hybrid methodology.

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