ISGSR 2011 - Vogt, Schuppener, Straub & Bräu (eds) - © 2011 Bundesanstalt für Wasserbau ISBN 978-3-939230-01-4

Knowledge Based Risk Controlling

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ABSTRACT: Safety, reliability and risk analysis and management are the keywords in engineering these days. Yet while technical solutions are in many respects extended by safety margins of 30 to 70% commercial risks are limited to surcharges of the order of 1% forced by the actual market situation. In this respect a proper and sensible management of risk is the key to handle constructional and mechanical questions as well as operational challenges. The presented approach implies modeling the development of knowledge regarding a specific risk, based on both the physical manifestation and the awareness of risk and a representation of the actual project by some explicit parameters like complexity, connectivity and sensibility. Based on these elements the unknown and unforeseeable consequences of a risk given only by probabilities but in case of occurrence ruling out every schedule can be replaced by well defined measures. We expect such an approach of controllability to provide alternative means to handle risks both on constructional as well as on operative tasks even if statistical methods fail. The remaining risk is well defined while the actual hazard is compensated by measures which generate costs but can be kept within affordable and calculable limits.

Keywords: risk evaluation, strategic planning, system complexity and connectivity, risk management

1 INTRODUCTION

All entrepreneurial activity is characterized by handling risk in a proper way. This concerns technical risk issues in the same way as it concerns commercial risk. In both cases all possible needs to be done to avoid certain situations which cause injury to persons or damage to objects. This includes physical impairment as well as financial distress to individuals and companies. In a somewhat more abstract view to such situations all hazard must be avoided to some degree and therefore their variation is only a matter of scaling. Based on this we propose a general approach to deal with the probability of risks and an adequate description of methods to avoid safety hazard.

2 RISK MANAGEMENT

2.1 *Definition of Risk*

In order to define risk according to Zimmermann, Eber et al (2008) for a specific issue we consider a space of states given by the set of all existing variables where a state is defined as a point. Time is also considered one specific variable t. The development of a system is described as a path through the space of states. If all states and interactions are unambiguously defined the development of a system can be predicted with perfect precision for all times and no risk occurs. Yet as in general the development of some variables $r(t)$ is not completely foreseeable and therefore some deviation $\delta(t) = s(t) - r(t)$ from the expected path $s(t)$ occurs defined as risk. Figure 1 indicates an exemplary corridor of states along the time axis representing possible deviation paths $r(t)$ where for clearness the space of states is reduced to two dimensions as the ordinates.

Without losing generality this concept is applicable for the development of circumstances which affect the process of construction like e.g. the environmental temperature as a failure criterion for appropriate pouring concrete activities as well as the unforeseeable detailed properties of rock to be drilled and thus influencing strategies of securing measures.

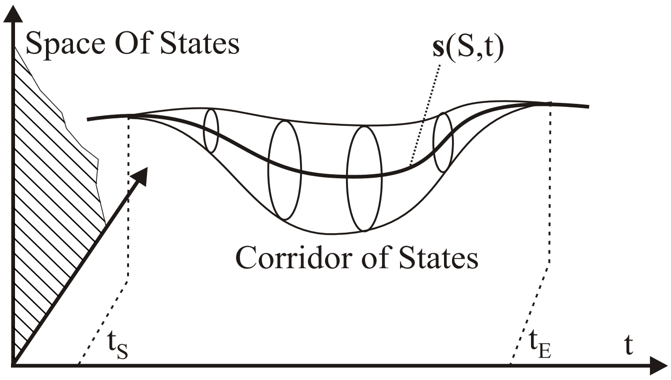

Figure 1. Deviation from an assumed path

Well known models make use of this concept by considering well determined functions of interaction between variables and adding a term representing uncertainty. E.g. the LEN-model represents the interaction of agent and principal regarding their individual interests and the resulting effort on a common project, see e.g. Picot et al (2008), which gives some recommendations about the agreements of the respective contract. In this model the wages are linearly modeled as $s(x) = s_0 + s_1 x$ where the production volume $x = x(a, \vartheta)$ is a function of the effort a and some unknown influencing circumstances ϑ which are only determined by a given distribution. Making use of exponential utility functions for both the participants (Principal: $G(x) = -e^{-\rho(x-s(x))}$ and Agent $H(s,a) = -e^{-r(s-V(a))}$) the resulting constant wages are $s_0 = H_0 - s_1{}^2(1 - \sigma^2 \cdot r/2)$ while the optimal output related wage fraction turns out to be $s_1^{opt} = (1 + 2\sigma^2 \cdot r)^{-1}$. In the end the effort of the agent is optimized as $a_{opt} = s_1 / 2 = (2 + 4\sigma^2 \cdot r)^{-1}$. In such a context, insecurities obviously lead to a perceptible variation of strategies regarding the intended future behaviour in order to minimize risk, represented by the variance σ of the unknown parameter.

2.2 *Classical Risk Management*

Traditionally risk management focuses on the calculation of risk consequences in units of possible damage or injury to persons times the respective probability of the occurrence of risk. The integral of this product over time gives the overall risk of a specific parameter for the total system. In order to identify all possible risks tools like checklists and risk maps are used as completeness of the list of risks considered is essential to any strategic decision about handling the situation. After that, risks are classified into groups by criteria allowing to treat them accordingly, e.g. “insignificant”, “reasonable”, “fatal”, “existence threatening”.

Some of the identified risks can possibly be transferred to other units or organizations; some can be secured by purchasing appropriate insurances. Sometimes modifying technical methods, designs or schedules allow eliminating risks completely or at least minimizing them. After that risks can be sorted to criteria regarding the probability of occurrence or the possible hazard consequences. On this background finally strategic considerations may lead to specific decisions about the remaining risk which is to be borne or ignored.

2.3 *Surcharges due to Risky Issues*

Since the direction of $\delta(t)$ is not determined further, this approach is capable to handle losses as well as gain. In general symmetry should be expected regarding loss and gain, but for some other reasons, which are not to be discussed here, it is known that the loss side weights much more. This is well understood as chances are gladly accepted while negative risks in many cases need to be avoided absolutely. Yet this property results from characteristics of the mental attitude while scheduling and does not affect the concept presented here.

Risks that cannot be transferred to other organizations need to be covered or ignored. Therefore the conventional method to deal with commercial risks is to add surcharges to calculated costs. The technical pendant to such measure is to add safety margins to parameters responsible for stability.

Therefore the question of the amount of safety i.e. volume of surcharges or safety margins becomes crucial in every respect. In many cases an expedient value can be derived from the mean value of the respective risk resulting in the average gain or loss over a sufficiently high number of trials. Yet average processing requires the solution of at some problems:

At first all statistical estimations are based on high numbers of trials which are given only in very few cases. In most situations only probabilities for the occurrence of single events are derived from the frequency of occurrence of a number of investigated projects. Yet probabilities give absolutely no information about the single event, neither for a specific commercial project nor for the absolute stability of a mechanical situation. Therefore as long as only probabilities are given and not absolute limits or at least limits which are violated with definitely ignorable probability, no statement can be made for a single situation.

Secondly it turns out to be difficult to find a sufficient number of experienced situations to form a valid database for statistical investigations. On some aspects, specifically regarding constructional details there are sets of data available e.g. in steel construction. In some other respects most of the situations available for investigation differ too much to be taken representative which is certainly typical for production processes and supposedly for most of the processes dealing with natural resources like geotechnical.

Thirdly in consequence every surcharge based on average situations is invalid for a specific situation. In case of an occurring risk the maximum hazard is pending instead of a mean hazard even if the probability of occurrence was originally low enough to expect only bearable consequences. On the other hand if the considered risk does not turn up every surcharge becomes obsolete and too large. As a consequence such experience is likely to lead to ignoring risks as the evaluation is based on a subjective background. Any parameter calculated correctly in order to fulfill the determined requirements and increased by a surcharge which meets the real average risk is likely to be abolished in the run-up because no contract and no tender will be accepted on this basis. Yet the personal acceptance of risk and risk hazard is commonly very low, safety is on high priority due to good reasons.

Finally decisions are made due to the theory of decisions not on the “basis of risk” if there are no determined values to rely on but on the “basis of insecurity”. In other words risk calculations are done but the final decision considers only well known facts i.e. crucial limits calculated from the possible results. If such processing fails risks tend to be ignored.

3 REDUCING RISK BY ACTIVITIES

3.1 *Understanding Risk Management*

Rarely formulated but widely used and in detail proposed by Zimmermann, Eber et al. (2008) is a very basic understanding of managing risks. The fundamental concept is the replacement of probabilities leading to insecure high efforts by specific activities which reduce the risk definitely to bearable remaining values but require the use of resources and acceptance of additional costs. In contrast to surcharges which will only in average cases cover the risk consequences i.e. are not applicable for unique situations, such activities are affordable constants leaving no unbearable risks.

3.2 *Risk in Construction Management*

Such measures are well known and widely used in construction management as well as in designing constructional details.

Figure 2 visualizes the development of secureness of the construction costs for a infrastructure project. Without making use of any activities no effort is spent on risk management and the expected costs are not obtainable. A first estimation of costs in early phases of a project where only very few valid information is available relies on known parameters like cost per m^2 usable area or net volume. These processes provide some good estimation, accurate enough to enable an investor to decide about terminating or continuing the project. The gain of accuracy is low at this stage but the spent effort is also limited. The resulting distribution of possible cost is symmetrical because the representation of the building by comparable projects includes incompleteness as well as overestimation. During the process of contracting the risk needs to be minimized further. This is done by detailed investigation of activities regarding scheduled methods, duration and costs which again yields a very narrow distribution of possible costs but also requires additional effort raising the total sum. Further activities alike which we call explicitly "risk management" replace insecure parameters by secure activities accepting their additions costs. E.g. risky activities due to their explicit dependence on open parameters like weather conditions are modified by choosing a different method of production which is not affected by such situations but more expensive or disadvantageous in some other respect, yet acceptable. If done correctly we expect the distribution to become asymmetric due to the actively integrated limitation of insecureness at the top end. After all, the result is expected to match the predictions on the basis of successful risk management.

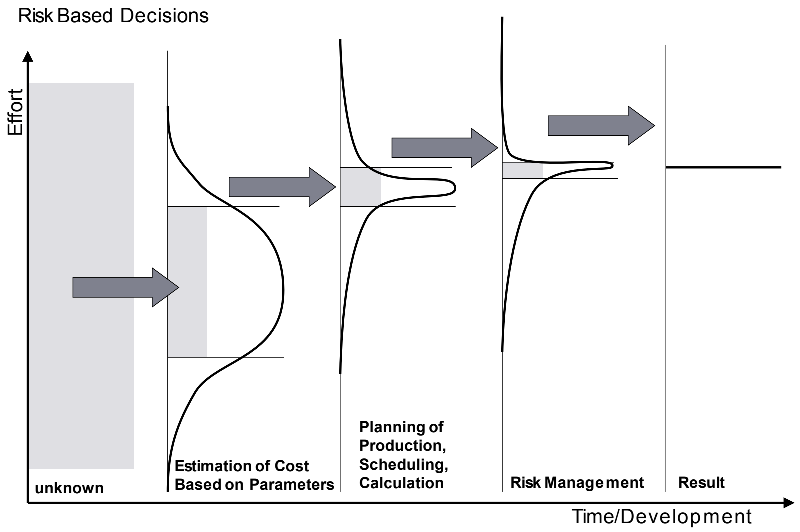

Figure 2. Development of Risk in Steps of Risk Management

3.3 *Risk in Mechanical Engineering*

Regarding constructional details the same procedure is well known: If the stability of a specific system is given only by a distribution of probabilities the respective dimensions are chosen to reduce the remaining risk to an acceptable measure:

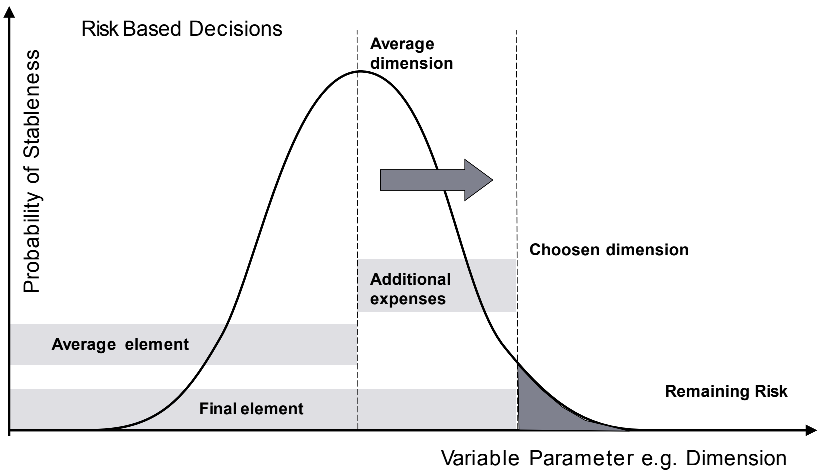

Figure 3. Development of Risk Regarding the Design of a Constructional Element

An element determined by the average stability will fail e.g. with a probability of 50%. Since a construction system usually comprises a set of elements where the failure of a single one or of very few elements already jeopardized the total system such proceeding is in no way acceptable. In this case it is of no great help that the other half of the elements is more stable than assumed due to the statistical distribution. The solution is to increase relevant dimensions, adopt additional expenses in order to reduce the risk of failure to an acceptably low remaining risk in accordance to the overall requirements.

3.4 *Insurance Risk Management*

Processes of insurance business are generally based on the same methods: A single individual is subjected to a particular risk, e.g. health risk or the risk of a car accident. The probability is fairly low but the possible hazard can be tremendous which leads to an unbearable situation. The average risk is taken to be acceptable but any expenses are superfluous if the risk does not occur. Yet if the risk occurs the consequences exceed every acceptable limit. In the view of the concerned individual a measure is required to limit the risk that is the expenses but cover the possible "worst case" consequences.

A large amount of individuals allows for a different point of view. The integral over all risks needs to be covered and is the sum of all risks or equivalently the average risk times the number of individuals. Therefore in this case an average risk is applicable due to the large amount of comparable situations and the existence of a mechanism to couple the individual situations.

Let an insecure value x_i e.g. the expected cost to cover a specific event be described by a distribution of probability $P_i(x)$ and the risk R_i be given by the variance $R_i \sim \sigma_i^2$. For a single individual respectively a single risk issue the squared risk is just $\sigma_i^2 = \int dx_i \left(x_i - x_{m,i}\right)^2 P_i(x_i)$. The cumulated risk of two events of equal distribution is given by the convolution $P_2(x) = \int dx' P_1(x') P_1(x_i - x')$. Continued to higher number j of cumulated situations we find a sequence of convolutions: $P_j(x)$. The solution can be obtained by means of simulation but can be for a basic example shown on the distribution according to A. K. Erlang. The Erlang distribution describes the additive accumulation of a number of elements which are equally given by originally exponential distributions. The resulting distribution is in dependence of the number of elements z and the mean value x_m:

$$P(x) = \frac{z}{x_m\left(z-1\right)!} x^{(z-1)} \exp\left(-\frac{zx}{x_m}\right) \quad (1)$$

The standard deviation is easily derived as $\sigma^2 = x^2 / z$ and develops to zero with the rise of the number of elements. Therefore in order to level down risk to a ratio of only 10% of the mean value at least a number of $z = x^2 / \sigma^2 = \left(0{,}1\right)^2 = 100$ is required. Other distributions show different characteristics but the tendency is equivalent. The fact that mean values cannot be applied on single issues is trivial but this estimation allows to predict a minimum number of elements to be cumulated in order make use of averages. Figure 4 shows the development of risk reduction due to the accumulation of issues.

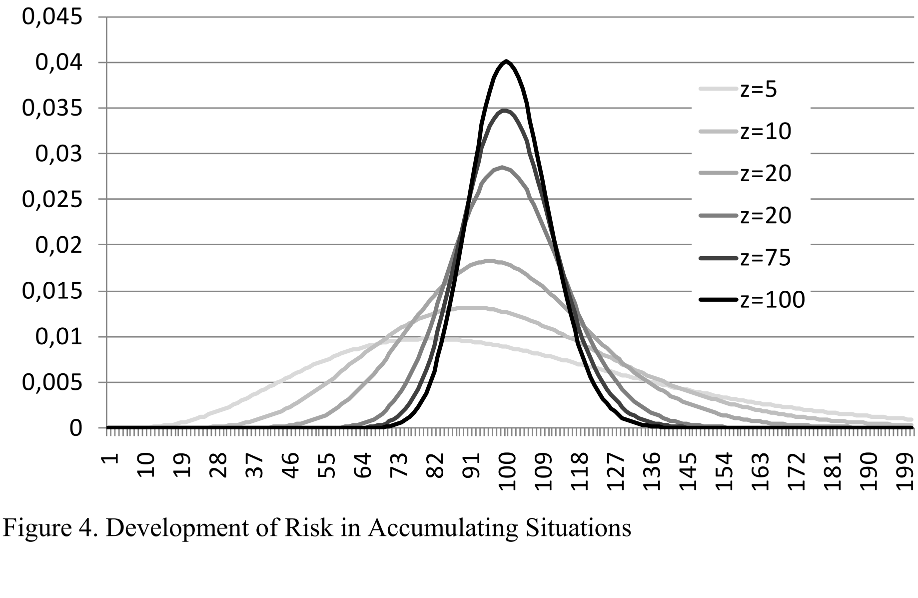

Figure 4. Development of Risk in Accumulating Situations

Thus insuring a risk – if possible – follows the same principle of implementing means to limit the risk taking into account the necessary expenses.

The remaining risk comprises two major elements. At first there is generally a remaining probability of risk consequences to exceed the insured hazard as for example the rare possibility of an extreme springtide. Secondly the risk of something unwanted to happen and causing unlimited hazard is converted to the limited risk of having spent limited effort to means which are probably not required.

4 RISK IN COMPLEX SYSTEMS

Considering risk and risk consequences becomes more difficult if complex systems comprising several parameters underlying different distributions of uncertainty are considered. Within systems not only the number of risky issues causes uncertainty but also their interaction introducing matters of risk propagation.

4.1 *Decomposition of Systems*

Derived from the theory of systems the uncertainty of a complex system can be reduced by decomposing to a number of subsystems. This concept is based on the assumption that on each separation process all interactions between the remaining subsystems are fully understood and can be formulated. Furthermore a system modeled as a graph comprises nodes and edges. Broken down to the finest possible resolution nodes and edges are most simple and contain only one variable or interaction. On this background the "volume" of nodes and edges can be rated equally valued regarding their contribution to the total system. Thus, the number n of separated subsystems implies a number $m = n(n-1)/2$ of fully understood relationships where not existing interactions are also taken as determinedly understood.

If a parameter of the total system can be estimated to an accuracy of ε we expect every subsystem to be estimated to the same degree ε. Yet the arrangement of the separated system comprises n insecure elements and a number of m secured interactions leading to a total insecurity of

$$\varepsilon_n = n \cdot \varepsilon / (n+m) = \frac{2 \cdot \varepsilon}{1+n} \quad (2)$$

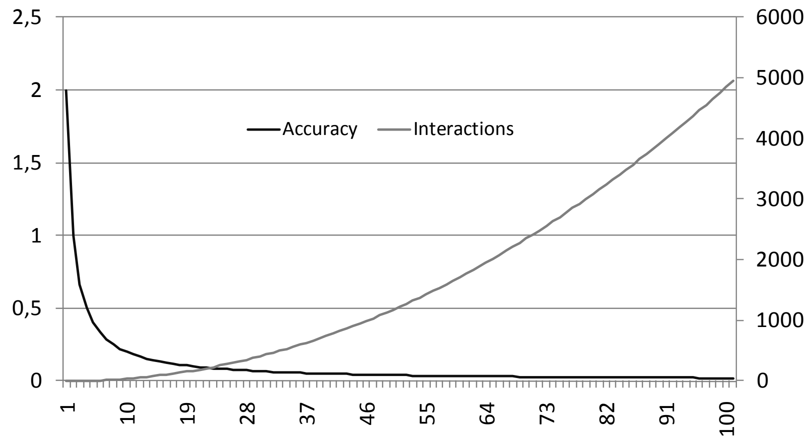

Figure 4. Reduction of Insecureness by the Introduction of Subsystems

The limit of such decomposing is given by the consideration of the validity of perfect knowledge of interactions. Since the number of relationships is increasing to the power of two the problem of identifying and really understanding every single interaction rises as well.

Nevertheless we can derive from such consideration that if the interactions are described well the overall risk decreases to dealing with single risks. Therefore we need to identify the network of interaction and the propagation of risk within the network.

4.2 *Impact of the Structure of Networks*

Networks of interaction can be modeled making use of graphs. Subsystems and their respective interaction are represented by nodes and edges where the presumption of causality of all interrelations requires the graph to be directed.

Any assumed propagation of risks $\delta Q > 0$ would definitively lead to infinite results if the existence of loops was not ruled out. Therefore we assume risk interaction diagrams to be network plans according to the definition of the theory of graphs, comprising one source, one sink and no loops. Such graphs can be sorted by ranks and a maximum number Γ of ranks can be determined. Furthermore the average number of sources for a closing node can be measured as the parameter ς of interoperability while the average number of sinks to a source node is measured as the parameter ξ of impact. Finally we describe the number of elements per rank through the parameter of parallel operations p. On this background the number of nodes affected can be estimated to $\Omega \simeq \Gamma \cdot p$

With no doubt the complete elimination of loops is not possible. Yet including loops obstructs any approach to analytical investigations. Therefore recursion is taken into account in a different way "spread" all over the otherwise well determined network and modeled as the parameter of recursion β, defined later.

5 RISK INTERACTION

Factors of success are defined as a set of production factors which are directly interfaced to the success of a project, easily to be measured and controlled and give a well established tool to control the progress of a project to success while the actual success cannot be measured and controlled directly and in advance.

The same structure can be made use of by defining factors of risk which can be measured and controlled in advance or during the progress of the project or system. This allows controlling the overall risk as long as the singular risk issues are identified in time and their interaction to the total risk is understood.

Such proceeding requires identifying factors of risk first, then defining their scheduled progression and finally monitoring them continuously. In order not only to observe deviations but to control those methods need to be found which allow acting upon these factors and closing the feedback loop. Only then a system can be kept within the designed corridor of states and occurring risks can be managed in a way that eliminates terms of probability.

5.1 *Composition of Risk in a Network*

In order to model risk issues as a number of ς risk factors the corridor of states requires a definition for each factor. Let every factor F_i contribute f_i to the production or development of a value Q during the process time t. Then we define the rate

$$\frac{\partial Q}{\partial t} = \prod f_i \qquad (3)$$

If all the factors are at the scheduled level the rate of production/development is on schedule and the production/development time as well as the desired quality or result will be on schedule too. Any deviation δf_i contributes to the overall development:

$$\frac{\partial Q}{\partial t} = \prod f_i = \prod (f_i + \delta f_i) = (f_1 + \delta f_1)(f_2 + \delta f_2)(f_3 + \delta f_3)\ldots \approx f_1 f_2 f_3 \ldots + \delta f_1 f_2 f_3 \ldots + higher\_orders$$

$$\frac{\partial Q}{\partial t} \approx F_0 + \sum \frac{\delta f_i F_0}{f_i} = F_0 \left(1 + \sum \frac{\delta f_i}{f_i}\right) = F_0 \left(1 + \sum \delta f_{R,i}\right) = F_0 (1 + \Delta), \qquad (4)$$

where $F_0 = \prod f_i$ is the scheduled rate and $\delta f_{R,i} = \delta f_i / f_i$ is the relative deviation of the risk factors. Furthermore the cumulated deviation is $\Delta = \sum \delta f_{R,i}$. If the parallel factors can be assumed to be independent of each other Δ is of the order $\sqrt{\zeta}$ otherwise and valid in most cases of the order ζ.

Normalizing the developing process to an average time of a step and to a standard production $F_0 = 1$ the risk propagation per step is estimated to $\delta Q \approx \Delta(\zeta)$ and the cumulated risk of a linear risk chain of length Γ comes to be $\delta Q_\Gamma \approx \Gamma \Delta(\zeta)$

5.2 *Risk Propagation in a Network*

The linear approach to the propagation of a risk is in most cases not applicable due to the complex structure of interacting factors. Yet the number of interactions is in general not as large as the theoretical limit given above and can therefore be reduced if the description of systems structure is known or can be derived. The following concept is taken from an approach estimating consequences of breaking up a system to subsystems. In the considered situation the volume to be dispersed is equivalent to the risk $\delta Q \approx \Delta(\zeta)$ of which we evaluate the consequences.

Let a system of volume $V(= \delta Q \approx \Delta(\zeta))$ influence and therefore be distributed on a number of Ω branches (sub nodes) using a tree structure. The volume of the subnodes is V / Ω if the risk is divided on the branches otherwise as assumed here fully transmitted. Furthermore let any insecurity induced by a separation be given by the linear equation $T=\eta V+C$ as a fraction η of the respective volume and a constant value c due to the fact of the separation. Then the insecurity of the connecting node is $T_1=\eta\cdot V+c$ while the insecurity of the new subnodes is $T_2=\Omega\cdot(V\cdot\eta+c)$.

The affected subnodes are possibly interacting to some degree. This ranges from no interaction at all (i.e. $w=0$) through the case of each node interacting with two next neighbors ($w=2$) to systems where each node is actively connected to every other node ($w=\Omega(\Omega-1)$). The complexity parameter $\alpha\in[0..1]$ allows modeling the variety of situations: $w=\Omega(\Omega^{\alpha}-1)$. The increase of insecureness due to the additional interactions of the subnodes is accordingly $T_3=\Omega(\Omega^{\alpha}-1)\cdot(\eta\cdot V+c)$. The parameter α is understood as the ratio of the dimension of the space of states to the theoretically maximum dimension and for not too small values compatible to the definition of the degree of information according to Shannon (1948).

Finally each interaction of two subnodes is likely to cause the further need of adaption of adjacent nodes. Therefore the degree of transmitting insecureness from one node to another including the case of looped interaction needs to be modeled. The effective number of interactions can be formulated as $W=w\cdot\beta^0+w\cdot\beta^1+w\cdot\beta^2+\ldots$ if the recursion parameter $\beta\in[0..1]$ represents the ratio of propagation. Since this is a geometric series we obtain $W=w\sum^{\infty}\beta^i=w(\beta^{\infty}-1)/(\beta-1)=w/(\beta-1)$ and the additional insecureness is $T_3=\Omega(\Omega^{\alpha}-1)(\eta V+c)\sum_{i=0}\beta^i=\Omega(\Omega^{\alpha}-1)(\eta V+c)/(1-\beta)$.

5.3 *Development of a risk issue*

All together we model the development of risk as $T=\mu\eta V+\nu c$ where $\mu=\Omega(\Omega^{\alpha}-1)/(1-\beta)+\Omega+1$ and $\nu=\Omega(\Omega^{\alpha}-1)/(1-\beta)+\Omega+1$. The considered volume is given by $V=\delta Q\approx\Delta(\zeta)$. For sufficiently large Ω the linear terms as well as the constant terms are not significant. The factors are reduced to $\mu\simeq\Omega(\Omega^{\alpha}-1)/(1-\beta)$ and $\nu\simeq\Omega(\Omega^{\alpha}-1)/(1-\beta)$.

Thus the development of a risk issue throughout a complex system is characterized by

$$T\simeq\eta\Omega(\Omega^{\alpha}-1)\Delta(\zeta)/(1-\beta)+c\cdot\Omega(\Omega^{\alpha}-1)/(1-\beta) \quad (5)$$

The second term is not dependant of the actual risk and therefore mirrors the generally acquired risk resulting from the fact that structures exist and cause multiple interrelations. This only leads to the nevertheless most important recommendation to keep structures clean and small.

In contrast to this the first term mirrors the development of a specific risk through a given structure. The character of the volume term is dominated by the parameter of complexity, the factor of recursion and the number of subnodes. Since the risk to be transferred is estimated in the chapter before, the ratio η can be assumed to be unity. In particular any development runs with the rise Ω to the power of α.

The parameter of complexity α is spread over all the structure. Therefore it is advisable to define the development by introducing ranks r. Since α is the ratio of existing interactions to possible interactions the expression $\alpha\cdot r/\Gamma$ equals the share of complexity for one step in the sequence of ranks. With this we obtain as a coarse estimation (where the $-\Omega V$ term compensates for the neglected linear term if β is small):

$$T\simeq\Omega(\Omega^{\alpha r/\Gamma}-1)\Delta(\zeta)/(1-\beta)\simeq\Omega^{1+\alpha r/\Gamma}\Delta(\zeta)/(1-\beta) \quad (6)$$

Thus the factor of risk propagation for the progression of one increment of ranks can be estimated to

$$\omega\simeq\frac{\Omega^{1+\alpha(r+1)/\Gamma}\Delta(\zeta)/(1-\beta)}{\Omega^{1+\alpha r/\Gamma}\Delta(\zeta)/(1-\beta)}=\frac{\Omega^{\alpha(r+1)/\Gamma}}{\Omega^{\alpha r/\Gamma}}=\frac{\Omega^{\alpha r/\Gamma}\Omega^{\alpha/\Gamma}}{\Omega^{\alpha r/\Gamma}}=\Omega^{\alpha/\Gamma} \quad (7)$$

In considering Ω as the number of affected i.e. subsequent nodes in a structure we assume a node where risk propagation via different paths is counted only once and transferred only as one risk issue. As this is not valid in many cases we need to replace Ω by the number of affected nodes even if they are partly identical which leads to the use of $\widetilde{\Omega}=\xi^{\Gamma}$. Herewith we obtain:

$$T \simeq \xi^{\Gamma+\alpha r} \Delta(\zeta)/(1-\beta) \text{ and } \omega \simeq \xi^{\alpha} \tag{8}$$

Obviously the recursion factor only scales the propagation of risk but does not influence the character of propagation. On very simple models $\alpha = 0$ we obtain constant propagation as expected; i.e. every single risk issue is simply transferred to the final result. Yet as complexity rises to e.g. $\alpha = 0.1$ and structures expand to e.g. only 5 subsequent sink nodes per source we obtain clearly more than a factor of unity for every step of development which leads to exponential rise of effect.

6 CONTROLLING RISK

From the previously derived results we find clearly that there is no way to reduce risk by only reducing probabilities or risk hazard because of the complex structures of risk propagation which increase any value however small it is to unacceptably large consequences. From this we conclude the establishment of methods capable to control a risk during the time t in order to lead Q back to its originally intended value.

Preconditioned the risk to develop like $T \simeq \xi^{\Gamma+\alpha r} \Delta(\zeta)/(1-\beta)$, some recommendations can be derived: Measurement of the respective variables needs to be taken every interval or step r_0 and the deviation needs to be evaluated. Immediately, appropriate activities must be initiated to correct the situation. The power of correction λ following the same characteristics as the deviation itself is closely related to the accepted deviation value, the point of time/step/rank when the activity is started and the point of time (=step/rank) r_0 when the situation is expected to be completely returned to the initial state. Then the development of the deviation during steps r_d is to be compensated during the next γr_d steps. Thus we find: $\xi^{\Gamma+\alpha\gamma r_d} \Delta(\zeta)/(1-\beta) = \lambda \xi^{\Gamma+(\gamma-1)\alpha r_d} \Delta(\zeta)/(1-\beta)$ which solves easily to $\xi^{\alpha\gamma r_d} = \lambda \xi^{(\gamma-1)\alpha r_d}$ and thus a power of correction

$$\lambda = \xi^{\alpha\gamma r_d} / \xi^{(\gamma-1)\alpha r_d} = 1/\xi^{-\alpha r_d} = \xi^{\alpha r_d} \tag{9}$$

which allows to control deviation independent of steps/ranks.

The absolute deviation in this case is determined by the development of the risk issue at $r = r_d$ i.e.: $T \simeq \xi^{\Gamma+\alpha r_d} \Delta(\zeta)/(1-\beta)$, where we find evidence to the recommendation to initiate controlling mechanisms as soon as possible in order to keep the needed force of correction low as well as the deviation from the originally determined corridor of tolerated states.

7 CONCLUSION

In this paper we propose and introduce a fundamental description of dealing with risks, also pointing out possible measures to handle risk consequences even on projects where respective surcharges are limited to only minor values. The approach is based on the fact that the considered universe in a unique construction project in technical as well as in commercial respect is in general much too small to rely on any statistical result. We propose to make use of a well understood development of knowledge regarding the risk, based on both the physical manifestation and the awareness of risk which can be easily modeled as a function of the skills, education and structure of organization of the project team. The second factor of the model is a representation of the actual project by some explicit parameters like complexity, connectivity interoperability and impact which can be extracted from the project description in very early stages of the execution and are independent of scales. Such parameters allow modeling the controllability of the considered risk or as an alternative the risk consequences. Future investigation aims at deriving the parameters of interaction directly from non fictional interaction diagrams and normalizing them to scale free situations.

Based on these elements we propose to replace the unknown and unforeseeable consequences of a risk given only by probabilities but in case of occurrence ruling out every schedule by well defined measures. Such can be developed on the background of the derived controllability and valuated by parameters of efficiency and costs.

We expect such an approach to provide alternative means to handle risks both on constructional as well as on operative tasks even if statistical methods fail. The remaining risk is well defined while the actual hazard is compensated by measures which generate costs but can be kept within affordable and calculable limits.

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