

Envisioning Risk

A Systematic Framework for Risk Visualization in Risk Management and Communication

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Abstract

Managing and communicating risks have become crucial tasks in today's economy and society. Visualization – through its numerous cognitive and communicative advantages – can play an important role in comprehending and conveying risks. This report thus examines how graphic representations such as maps, charts, diagrams, and visual metaphors, can be applied to risk management by summarizing the current state-of-the-art in a conceptual framework that is illustrated with application examples.

Keywords: risk management, risk communication, risk visualization, knowledge visualization, decision making, risk governance, graphic representations of risk, visual risk communication

Outline:

1. Introduction: The Need for Risk Visualization
2. Current Approaches to Risk Visualization
3. A Conceptual Framework for Risk Visualization
 - 2.1 The Framework in Overview
 - 2.2 Elements of the Framework
4. Examples of Risk Visualization
5. Emerging Guidelines for Risk Visualization
6. Future Research Needs
7. Conclusion

References

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1. Introduction: The Need for Risk Visualization

In a business world that is becoming more complex and faster every day, effective communication between experts and decision makers plays a key role. A recent case study examining the risk management of Goldman Sachs that avoided the subprime troubles explains one of the success factors of this bank as follows: A strong oversight with the firm-wide risk committee meeting weekly, daily risk reports and incorporating all kind of risks into the analysis (Buehler, Freeman, Hulme, 2008). This strong oversight can only be achieved through effective communication between all involved parties. Visualization is one way to support such effective risk-related communication¹. Many forms of business diagrams, mapping techniques or visual metaphors are in use today in many areas of business. Visualization in risk management, however, is still not a frequent topic in organizations, probably because “risk is both very difficult to visualize and extremely challenging to describe” (Horwitz, 2004, p. 83). Exceptions may be the typical *Value-at-Risk diagrams*, *risk maps* to show the impact/likelihood positions of specific business risks or *graphic risk dashboards* to visualize key risk indicators in a simple overview.

In the financial industry, the quantitative aspects of risk management and analysis dominate. Enormous tables, colorful charts and complicated formulas are the common tools in the day-to-day communication between experts and managers about financial risks and their management. Still, it is common that monthly risk reports exceed a hundred pages. Consequently, it may be difficult for decision makers to identify and understand the most relevant risks and to initiate adequate countermeasures. This problem has also been mentioned by UBS’s recent shareholder report on its monumental write-downs caused by the subprime crisis (UBS, 2008, p. 32) as “insufficient attention to idiosyncratic risk factors”. The report points to the importance of *high quality content* in risk reporting, or in the words of the report’s authors (UBS, 2008, p. 39): “The reports did not, however, *communicate an effective message* for a number of reasons, in particular because the reports were *overly complex*, presented outdated data or were not made available to the right audience. The extensive catalogue of risk reports runs against a simple presentation of the risks that needed to be managed and identification of the actions that needed to be taken.” This clearly shows the

¹ A general definition of risk communication is given by the US National Research Council (cited in Koskosas, 2008): “Risk communication is an interactive process of exchange of information and opinion among individuals, groups, and institutions. It involves multiple messages about the nature of risk and other messages, not strictly about risk, that express concerns, opinions, or reactions to risk messages or to legal and institutional arrangements for risk management.”

need for better ways of representing complex risks. There is also other evidence suggesting that (interactive) visualization may often be better suited to communicate risks than mere text or print media (Hahn et al., 2007). Based on the general need for more effective communication between experts and decision makers (Eppler 2007), the generally accepted benefits of visualization (such as swifter, more engaging and memorable communication see Eppler & Platts 2008), and the lessons learned from the recent cases of inadequate reporting about risks, this article explores the *usefulness of visualization for risk management*.² In the next section, we define risk visualization and review current approaches. In subsequent sections, we propose a conceptual framework for risk visualization, give illustrative application examples, and discuss emerging risk visualization guidelines. We also discuss caveats or limitations of this approach and highlight future research needs. In the final part of the article, we summarize our main findings and draw conclusions for risk management and communication.

2. Current Approaches to Risk Visualization

In the context of organizational risk management, risk visualization designates the systematic effort of using (interactive) images to augment the quality of risk communication along the entire risk management cycle. Risk visualization employs charts, conceptual diagrams, visual metaphors, and mapping techniques to improve the understanding and subsequent management of risks in specialist and management teams or stakeholder groups. Risk visualization uses the power of graphics to help experts, decision makers, and laymen to better deal with risks in the areas of management, health, and security.

Taking this *definition of risk visualization*, there is still very little research or documentation on how to visualize risks. Below, we review existing studies that discuss the visualization of risk and describe their application contexts.

Horwitz (Horwitz, 2004) elaborates on risk visualization within *hedge fund risk management*. He describes the main functions of risk visualization in this context as follows: “A key component of understanding risk is ‘risk visualization’.” As useful visualization techniques he highlights *profiling, style drift analysis, attribution/ decomposition, comparison to historical*

² On the importance of (high quality) graphics for effective risk communication see also Hance et al. (1990), p. 83.

*norms and comparison to peers*³. Although Horwitz dedicates a whole chapter of his book “Hedge Fund Risk Fundamentals: Solving the Risk Management and Transparency Challenge” to risk visualization, the resulting visuals are relatively simple quantitative business charts.

A paper by Fey and Prakash (Fey, Prakash, 2001) also focuses on a specific field in finance, the volume visualization within *option pricing of derivatives* to better understand some specific risk factors. However, this article limits visualization to a very narrow application field and also does not provide novel ways of representing risk insightfully.

A typical practitioner article (Capital Market Risk Advisors, no date) describes the need for risk reports to be understandable, comparable and to be aggregated to maximize their value for readers. The article highlights that not only risk data must be reported but also *context information* (e.g. peer group comparisons). Here, the usage of visualization is limited to *spider graphs (radar charts) and distribution diagrams* which are quite common in today’s risk management reports anyhow. Qualitative visualization, such as conceptual diagrams, would provide means of adding context information to such quantitative charts, as we will see in the examples that follow below.

Husdal (Husdal, 2001) discusses the application of visualization techniques (in particular *cartographic methods*) in *natural risk exploration and communication to the public*. He discusses the need for visualization when studying and analyzing phenomena or events that can be considered a risk and informing and raising awareness about such events. He sees visualization as an “excellent tool” because “it stimulates thought and because it can be used to *display uncertainties* and the *variability* of the parameters that influences risk”. On the other hand, he also points out *drawbacks of visualization*, for example when misleading map types are used or sufficient data is not available (regarding these risks of visualization, see Bresciani and Eppler, 2008).

Cutter (Cutter, 2008) consequently lists specific requirements for visualizations that will be used to communicate *natural hazard risks* to a broad variety of stakeholders. Visualizations must be “clear, simple, readily interpretable, and truthfully represent the data upon which they rest.”⁴ While these requirements make sense and can be generalized, the author does not help readers in achieving them (for example by providing applicable guidelines).

³ For descriptions and examples see Horwitz, 2004, p. 85ff.

⁴ Cutter, 2008, p.311.

A vastly different approach to risk visualization is described in a report in which the authors have evaluated three different risk modeling methods in a *software development project* through an experiment (Kontio, et al, 2004). The results of this experiment indicate that more formal and visual methods to identify and document risks in a project situation are adequate if a more *detailed discussion* about risks is needed, but with the caveat of higher costs compared to other methods. This is one of the rare examples where the use of risk visualization has been experimentally evaluated.

As we can see from these examples, the risk visualization field is currently an emergent, explorative and fragmented domain. The field still *lacks systematic approaches* that try to combine the rich area of visualization studies with the needs and requirements of modern risk management. In the next section, we provide a first step towards this consolidation by structuring the risk visualization process into five key questions.

3. A Conceptual Framework for Risk Visualization

3.1 The Framework in Overview

Our aim with the formulation of a conceptual framework for risk visualization is threefold: First, we aim to show the *scope of risk visualization*, that is to say highlight *where* and *when* risk visualization can provide tangible benefits and should be considered as a useful tool by risk managers. Second, we would like to provide a sort of checklist of the *key factors* to consider or take into account when visualizing risks or risk-related information. Third, we would like to show (complementary) ways or *representation formats* to visualize risks in risk management, risk governance and communication, as well as for risk-related decision making. The framework thus answers the questions of *why*, *what*, *for whom*, *when*, and *how* which kinds of risks and risk-related information (the *what*) should be visualized (see Figure 1). It provides useful pointers or possible answers for each one of these questions. The visual shape of the framework is a cycle as the questions need to be addressed one after the other: It is crucial to start with the *why* or main objective of a risk visualization, then look at the contents that should be visualized and for whom and in which situation, before actually choosing a specific representation format. Having implemented or applied a risk visualization, one may detect other useful purposes that can be achieved with the graphic representation and thus the cycle is re-iterated.

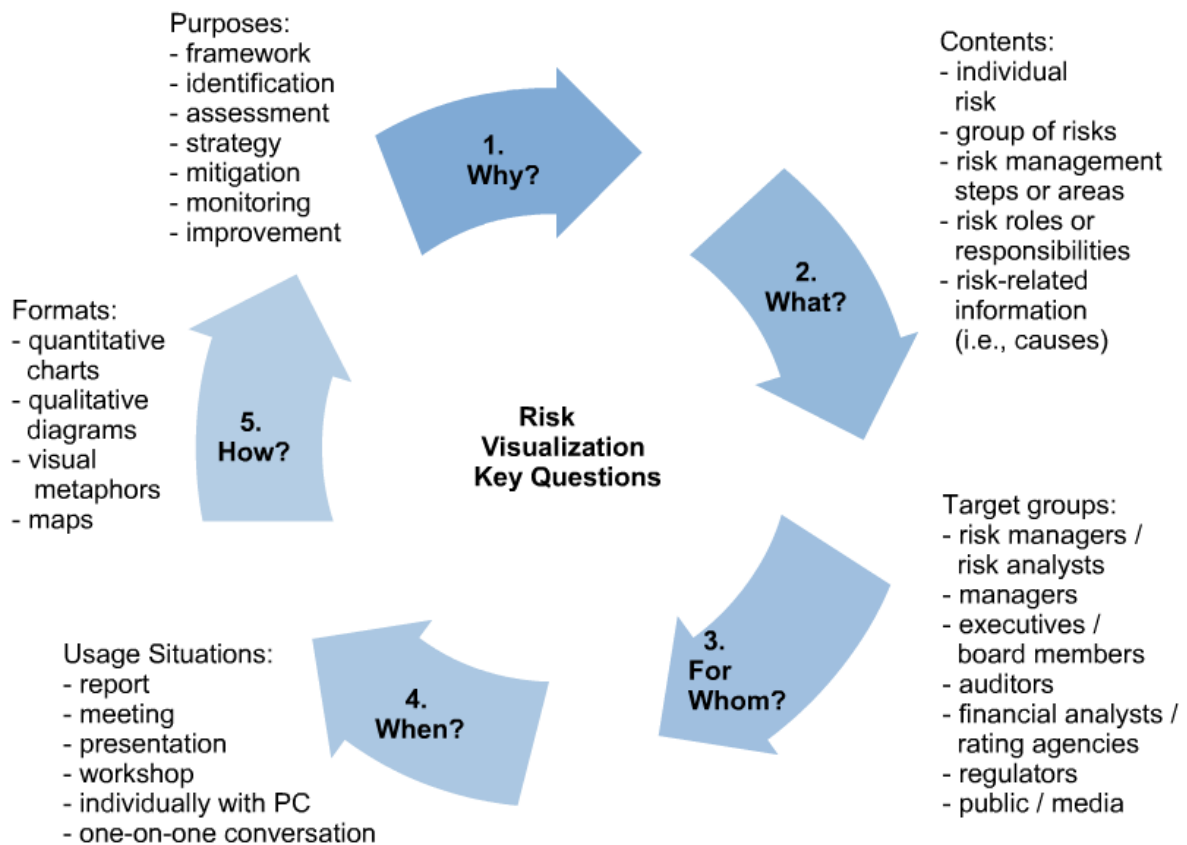


Figure 1: Key questions of the risk visualization framework⁵

In the next section, we will describe the individual items in each of these five dimensions. We will then show – through examples – how the five dimensions can be addressed simultaneously to use risk visualizations in risk management and communication contexts.

3.2 Elements of the Framework

Having shown the rationale and scope of our framework, we will now focus on individual elements within it and elaborate on their use in risk visualization. This will enable us to illustrate how the aforementioned three goals of the framework can be achieved.

Why – The Uses of Risk Visualization

The uses or application opportunities of risk visualization can be structured according to the typical risk management process (see Figure 2). As Figure 2 illustrates, there are seven

⁵ This framework is based on the standard interrogatives and the knowledge visualization framework originally developed by Eppler & Burkhard, 2004.

elements of risk management in which risk visualization can provide value. We discuss these below.

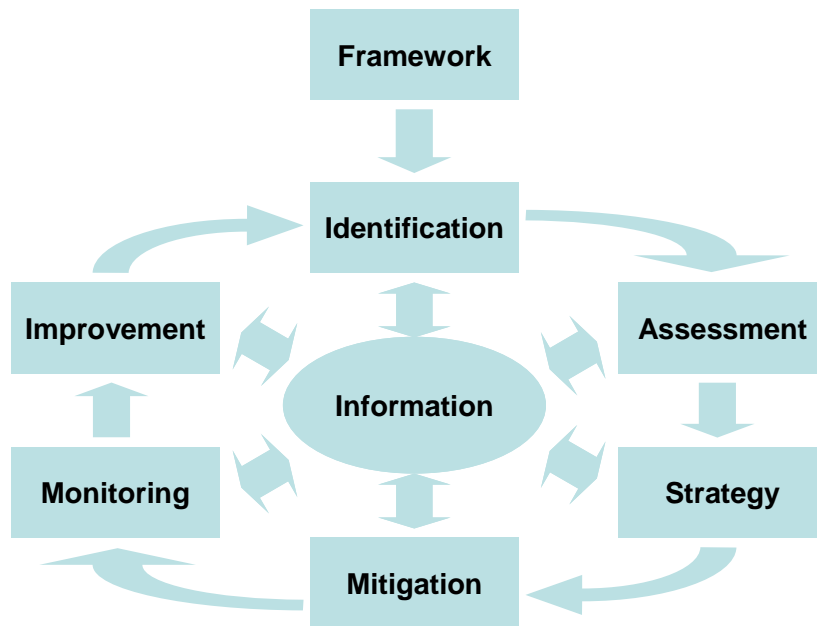


Figure 2: Risk Management Process (Based on: KnowledgeLeader, 2000)

Framework: The risk management framework defines all relevant elements of a risk management approach, including policies and guidelines, limit systems, organizational aspects, methodologies, processes, information needs and reporting structures as well as (IT) systems and data structures. Visualization (risk governance charts, network diagrams etc.) enhances the transparency and the discussion about the company’s risk management capabilities and resources, in particular towards external stakeholders such as investors, rating agencies or regulators. Visualizing the risk management framework of an organization is a simple mechanism to improve its distribution and marketing internally and externally. In addition, visualizing an organization’s risk management approach in a pyramid, cycle or Venn diagram makes the framework a tool that can be directly used in management discussions.⁶ The current state of an organization regarding its risk management capabilities can be visualized (and documented) using a so-called maturity model (see Figure 3).

⁶ On the importance of having a risk management framework see also the comprehensive Review of Canadian Best Practices in Risk Management at http://www.tbs-sct.gc.ca/pubs_pol/dcgpubs/RiskManagement/rm-rcbpl_e.asp.

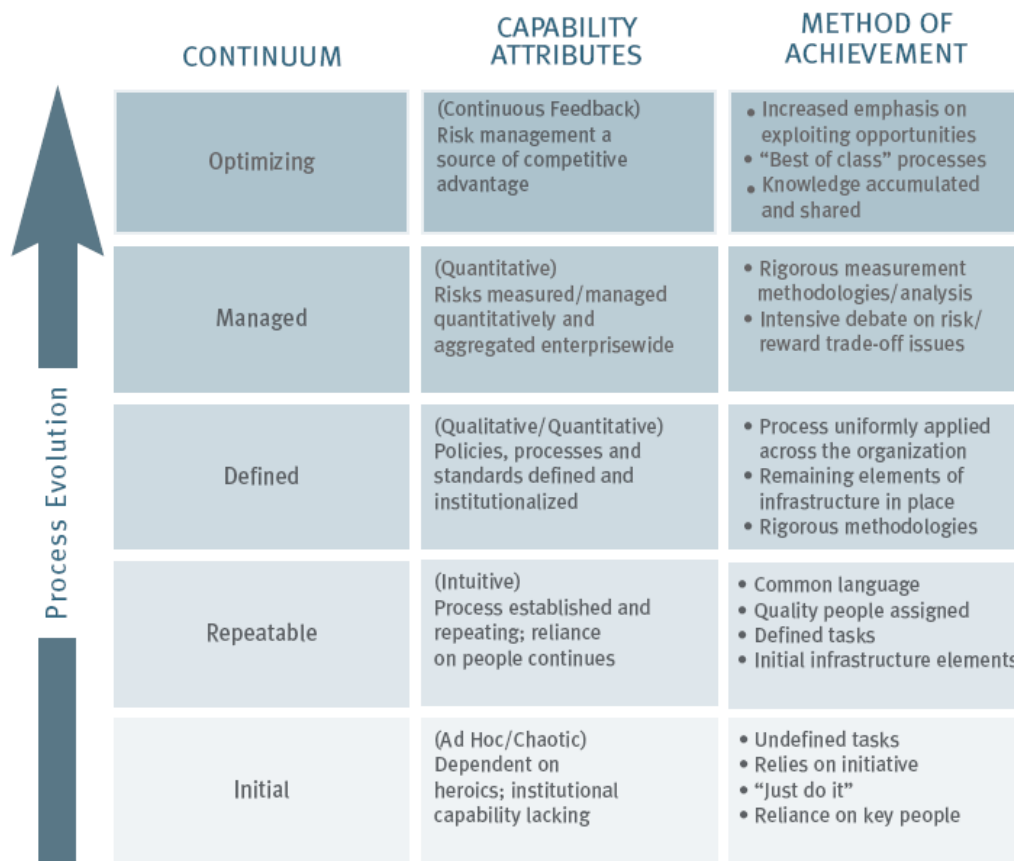


Figure 3: Risk management capability maturity model (Source: Protiviti, 2006)

Identification: Identifying relevant risks is one of the most critical parts in risk management. Graphic representations of risks, for example in a so-called Risk Universe, see Figure 4, help to prevent that one focuses only on the most pressing problems⁷. If such a Risk Universe encompasses all relevant generic risk categories (e.g. strategic, operational, financial, environmental etc.) it's much easier to identify similar risks that threaten the company's future (see also the network diagram case in the example section below).

⁷ However, such a graphic Risk Universe must be complemented by definitions and examples to ensure that it is properly understood.

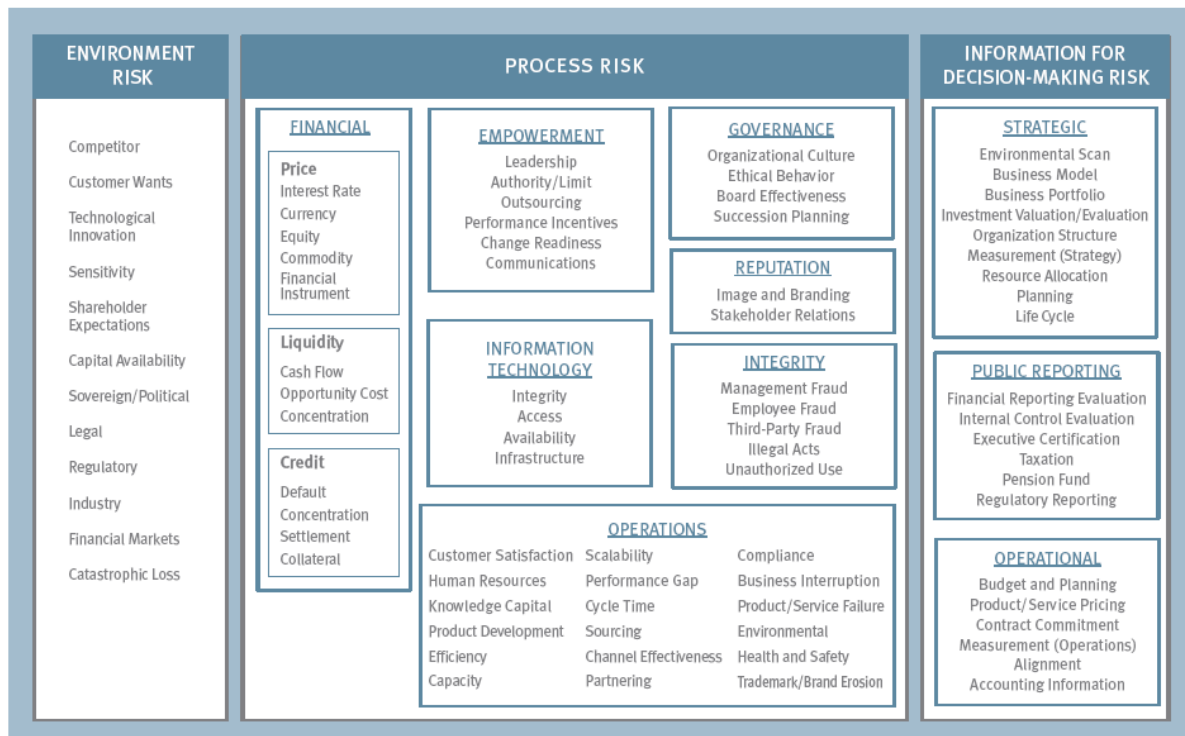


Figure 4: Example of a Risk Universe (Source: Protiviti, 2006)

Assessment: In the assessment phase, the previously identified risks are evaluated regarding their possible impact on an organization and their probability of occurrence. *Risk driver network diagrams* for example help risk analysts and managers to understand the background of a specific risk which enables a more accurate discussion of possible consequences (see Figure 5).

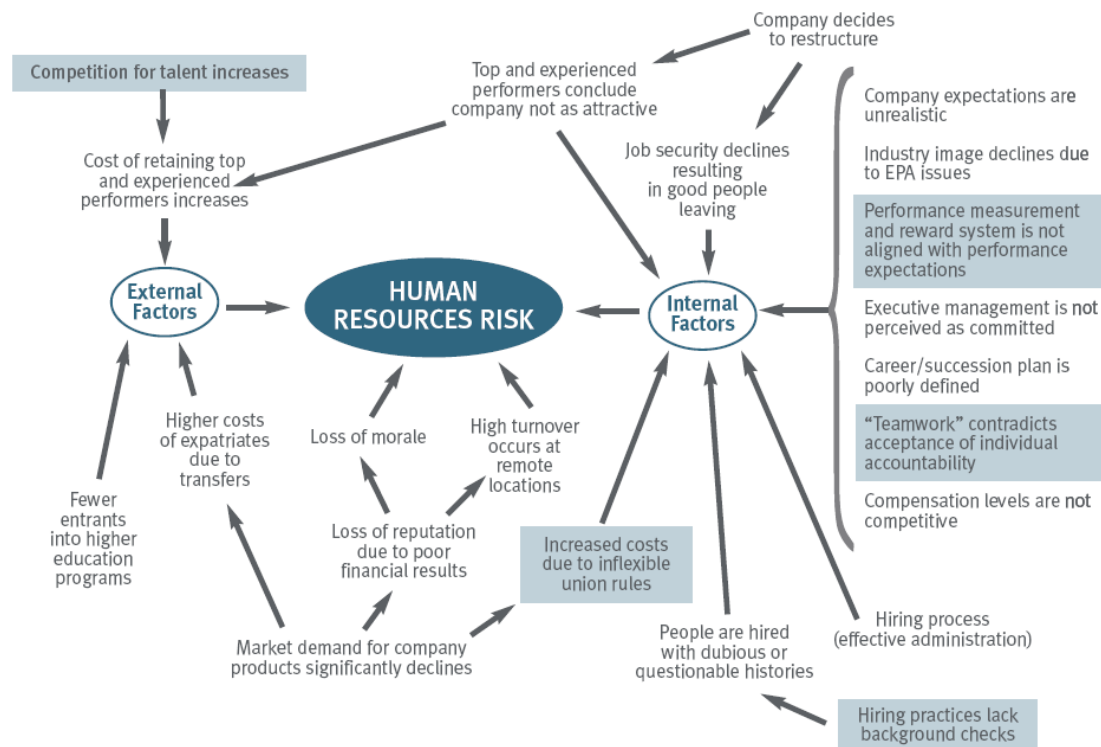


Figure 5: Risk driver network diagram (Source: Protiviti, 2006)

Strategy: If risks are identified and assessed, management has to decide about the allocation of resources to mitigate these risks. Within this discussion, executives have to follow strategic objectives and cannot tackle all risks at the same time. They have to decide on a risk strategy. So-called *risk heat maps* show individual risks on a two dimensional matrix with their relative positions regarding impact and likelihood of occurrence (see

Figure 6). Enhanced with target positions⁸ for these risks, this visually supports the discussion about the relative importance of risks and enables the adequate allocation of resources to mitigate these risks. Another visualization format that can support risk strategy discussions are *roadmap or timeline diagrams* that sequence risk-related activities or initiatives chronologically (see Blackwell et al, 2008).

⁸ Complementing the residual risk ratings regarding likelihood and impact with target positions (where do we want to have the risk rated in the future) enables decision makers to get an overview on the relative importance of the risks and their improvement potential. In

Figure 6, risk A should be reduced in likelihood and impact. Risk B can only be reduced in impact (e.g. if this point represents the risk of an earthquake, you cannot influence its occurrence, but only limit its impact through investments in recovery mechanisms).

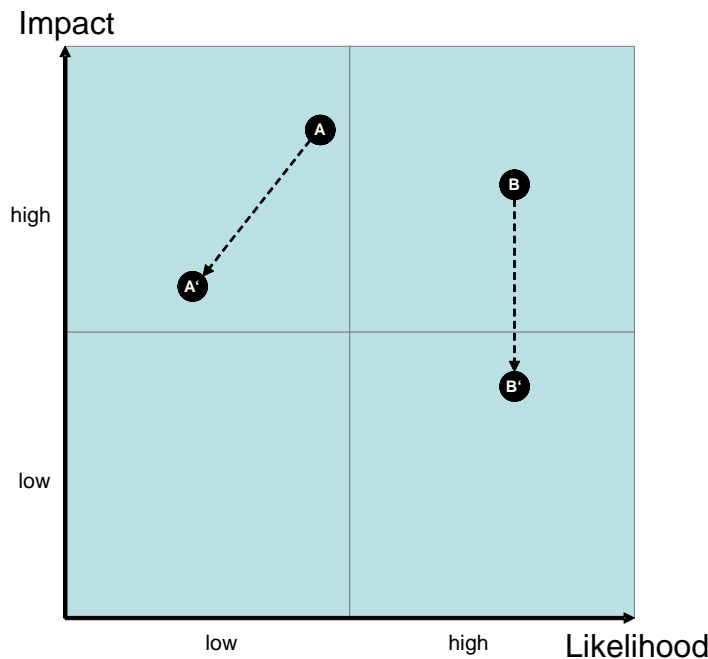


Figure 6: Risk map showing two risks with their residual and target positions (Source: own figure)

Mitigation: Mitigation consists of preventing risks or reducing their impact. Based on a given resource allocation, specific measures are taken to achieve this. Based on *risk driver network diagrams* (see Figure 5) for example, the key factors influencing a risk can be better identified and controlled with specific measures and controls.

Monitoring: Key Risk Indicators (KRI) are often used to track the development of specific risk factors. Diagrams or *dashboards* are preferred means for management to communicate such trends (see the example further below). Large *tables* showing numbers and percentages are often supplemented by graphic elements such as highlighting, informative icons, or color coding.

Improvement: This phase is about learning from other risk management processes to improve the current framework. Graphic *timelines* are one visual way to facilitate learning from risk-related events, in particular by mapping them out in a larger chronological context and looking for recurring patterns (Eppler & Platts 2008). Another feasible mapping technique for this are specific, risk management-related *cause-effect diagrams* or *critical incident diagrams* (see Figure 7) that surface new insights regarding risk relationships. The status of the improvement measures can be mapped on a maturity model again (cf. element ‘Framework’ above).

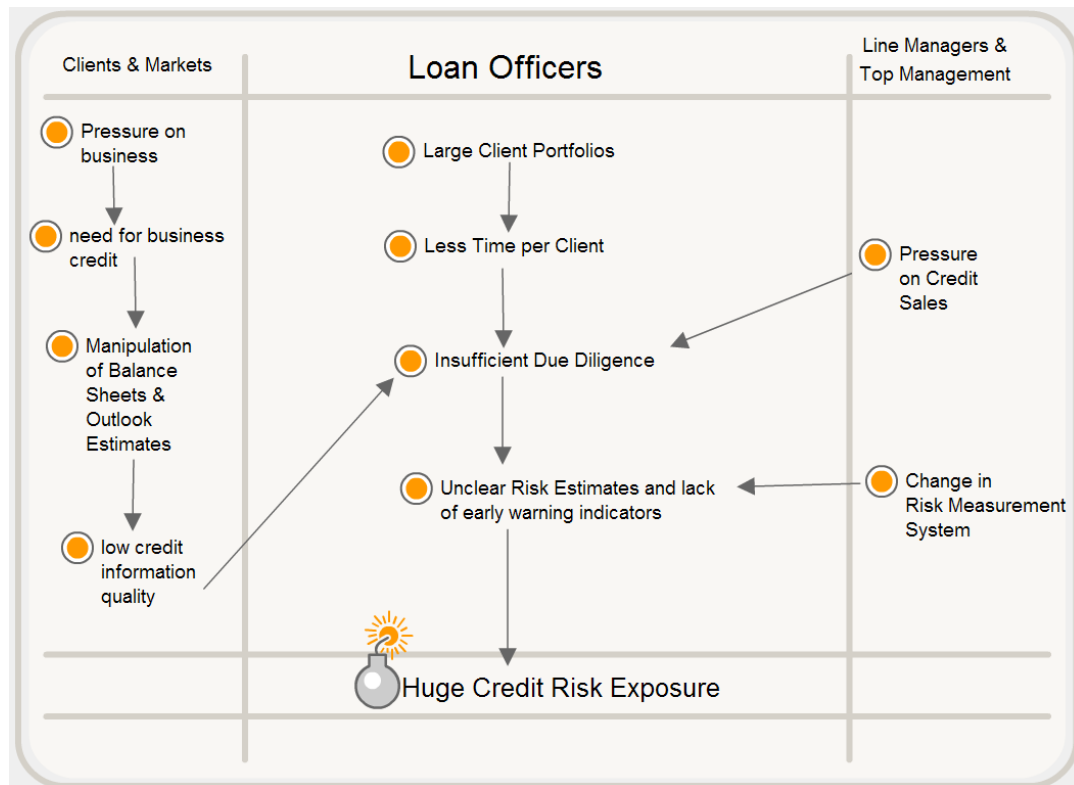


Figure 7: A critical incident or decision discovery diagram surfaces key antecedents of a risk (Source: own figure)

Information: The last element of this risk management process focuses on information and communication about risks and risk management capabilities themselves. Here, all kind of visuals can improve the transparency regarding an organization's threats and opportunities and its capabilities to manage these risks. *Visual metaphors* (see the example further below) can be one feasible format to inform other stakeholder groups about risks in an instructive and memorable way.

What – The Contents of Risk Visualization

Regarding the '*what*' or *contents* that should be depicted in risk visualizations, we can distinguish among the following different content types:

- Visualizing individual risks and their characteristics,
- visualizing a set or group of risks and their relationships
- visualizing the status of the risk management capabilities or how to deal with risks, i.e., risk management processes or domains,

- visualizing risk-related roles and responsibilities (operationally and strategically),
- visualizing other risk-related information such as risk scenarios, antecedents etc.

Depending on the use ('why') of the visualization, risk-related content can be represented differently, for example either highlighting *overall* patterns or revealing pertinent *detail* information. Another useful distinction may be the one between strategic risk information and more operational information that is visualized.

For Whom – Stakeholders of Risk Visualization

Many stakeholder groups are interested in an open and informative communication about risks and risk management systems of an organization. Below, we briefly discuss how the most important ones of those can profit from risk visualization.

The *risk managers* and *risk analysts* of an organization (whether on a group-level or on a business unit-level) want to understand the risks in their area of responsibility to be able to monitor or to control these risks. This stakeholder group typically includes functions such as market risk, credit risk, operational risk, controlling, legal, compliance, quality control and many more. Visualization can help them keeping an overview of their main risks and conduct drill-downs to examine key risks in more detail. Another use of visualization for them is to communicate their risk management approaches to others.

Managers of specific business areas who often also have profit/loss responsibility want to know their risk profile to be able to allocate adequate resources for mitigation measures. In addition to visualizing their risk landscape, they also want to use visualization to understand how their risks are inter-related.

Executives and *Board Members* have to define the organization's strategy with the overall risk profile in mind and have to allocate resources on organization level to mitigate their risks. They need highly aggregated risk information and the possibility for drill-downs.

Internal and *External Auditors* base their audit plans more and more on management's risk considerations supplementing their own, third-party risk assessments. Areas with high residual risks or areas with non-effective controls according to management's view are more

likely to be tested by auditors than others. Visualization may help them both in assessing risks quicker and communicating their assessments to others.

The stakeholder group that risks the most in a business context is the *investor*. The more transparency they have about a company's risk profile the better they can decide whether to invest more or to withdraw their money. Standardized, recurring visual formats of risk representation can lower their screening and monitoring costs.

Financial analysts and *rating agencies* assess the financial health of companies and publish their opinion in the form of buy/sell statements or credit ratings. This stakeholder group also relies very much on effective communication about risks. Some investment research companies have developed their own unique visualizations to depict risks an informative way, in order to communicate their recommendations more effectively (and 'brand' their unique expertise through a proprietary diagram format, see Eppler & Wil, 2001).

Regulators (and the government) have to ensure that all market participants are obeying rules and regulations. Specific risk situations (e.g. large exposures of some banks within the subprime market) may turn out to be big disadvantages for other market participants or the economic stability as a whole. Risk visualization can help regulators detect such risks and communicate them to the public more effectively.

The *public* and the *media* should also be informed (and educated) about certain risks (and its biases in assessing those risks). Examples are exposures to natural hazards or health risks other similar threats that need to be made accessible to the public (taking into account the many psychological biases that exist in risk perception and comparison). Visualization can not only help to gain the public's attention for certain risks (for example through shocking or emotional images), but also instruct them in an efficient way how to deal with these risks adequately.

In general, individuals normally want to understand specific risks, including risk drivers and possible impacts. Within certain groups (e.g. management boards) the focus of risk communication lies on information sharing, sense making, and decision making. Communities like the public not only want to understand specific risks, but also want to gain assurance that their leaders initiate mitigating measures and ensure their safety. Visualization plays a crucial role in all of these endeavors.

When – Risk Visualization Situations

Situations for the visualization of risk can be distinguished by their main *purpose* or their *constraints*. Visualization probably adds the most value when risks need to be better understood to make decisions, to clarify the governance structure to manage and oversee risks, to audit and monitor risks and to document risk-related findings concisely in a risk report (see the why dimension for these aspects). The benefits of visualization for these situations are usually a better overview, new insights into the causes of a risk, and a more concise and clear communication of risk-related information. Nevertheless, the ‘when’ dimension mostly relates to the *actual usage situation* of a risk visualization, or more precisely the available resources or constraints in a given situation (such as the available time, know-how, space, tools etc). The constraints of a particular application context may affect the choice for a certain risk visualization format: In a risk-related discussion over lunch, for example, managers would most likely use the back of a napkin to illustrate risk relations or drivers, whereas in a risk management workshop they would make use of sophisticated graphic modeling software, interactive whiteboards and LCD projectors. Also, a risk management dashboard (see example below) would look very different if it is intended as a print-out, made available to the risk committee members during a meeting, or if each one of managers explores it interactively on his or her personal computer.

How – The Methods of Risk Visualization

The methods of risk visualization are made up of several existing visualization formats that are applied to risk management and communication or used in combination. The main genres of visualization that can be used for risk-related purposes are quantitative or numeric charts, qualitative or conceptual diagrams, geographic or conceptual maps, and visual metaphors. Whereas charts help to present or aggregate quantifiable risk information, diagrams are helpful to clarify more qualitative aspects of risks, such as their interconnectedness. Maps are useful representation formats for risks that are location-dependent, such as tornado or hail risks or other natural hazard risks. Visual metaphors, finally, take concepts known from other domains to make risk-related information more easily accessible to a (typically non-expert) audience. Other useful distinctions regarding feasible risk visualization formats relate to their representation medium, i.e. whether a graphic is static and can be printed in a report, or whether it can be dynamically changed or animated on a computer screen.

4. Examples of Risk Visualization

In this section we present five *diverse* examples of how visualization can support risk management and communication. We have selected these application examples, as they represent a broad spectrum of *typical* challenges in risk management that can be met by applying different formats of visualization systematically. Each example starts with a ‘fingerprint’ preview, containing answers to the five dimensions of our framework. After this, the application context of the risk visualization is explained, and the visualization format is presented together with a screenshot. This is followed by a short section on the resulting benefits and caveats to consider when using the risk visualization.

Example 1: Evaluating risks through data maps

Why:	Risk Analysis
What:	Individual Risk
For Whom:	Executives
When:	Presentation
How:	Maps

Context: For the insurance industry it is pivotal to understand the risks that have been underwritten and the specific environmental factors related to it in order to get an accurate view of loss potentials. Depending on the business model and insurance type this can be extremely complex. In car insurance, for example, hail events are one type of coverage. Based on the historical data of the hailstorms and calculated possibility of future hail events – combined with the number of insured cars in the specific regions – an insurance company can better estimate possible damages and therefore related payments to insured car owners.

Visualization Format: The following Figure 8 illustrates simulated hail events affecting total cars running (Deepen, 2006, p55).

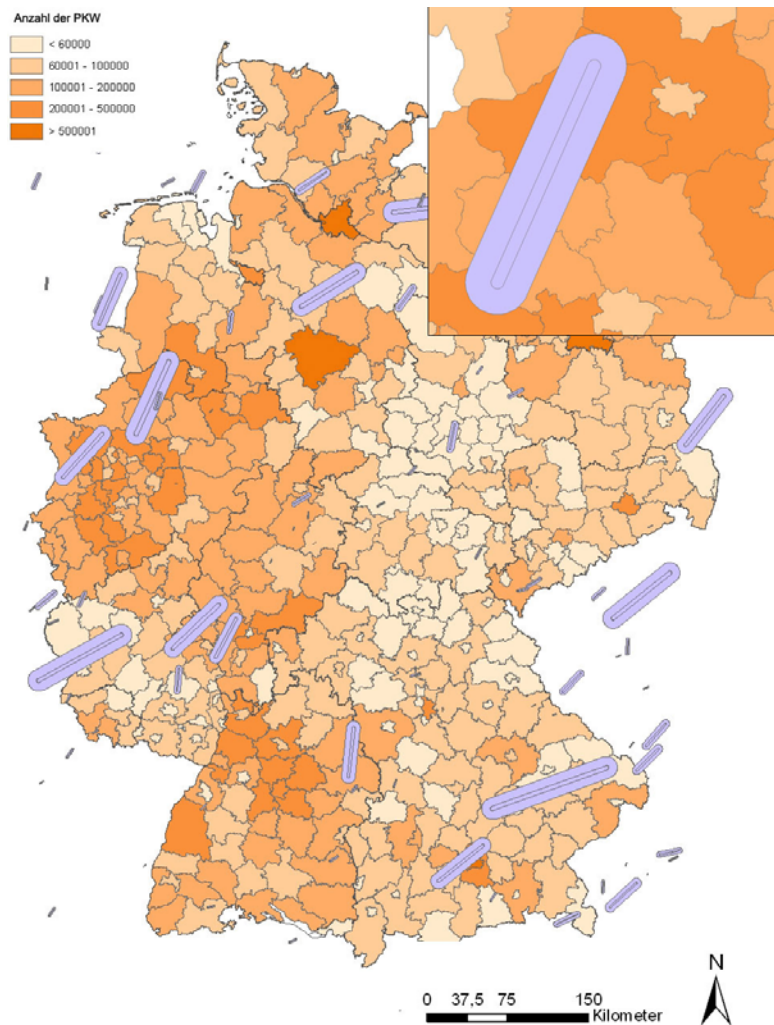


Figure 8: Visualization of one hundred simulated hail events in Germany and number of cars (Source: Deepen, 2006)

Such kinds of visualizations are normally based on a *geographical map* of a region, country or continent. Relevant information is represented by different colors of sub-areas of the map (in this case the darker the shading, the more cars are running in total in this area). A second type of information is highlighted by another visual feature, for example dots, strokes or icons (in our example above the lines with round edges stand for simulated hail storms). Similarly, it is possible to add further data, for example the historical information for vandalism against motor vehicles or accidents.

Benefits: Normally, payments to car owners after hail events are recorded and reported in table format, for example by total payment amount per specific geographical area or city. Relatively higher payments may be highlighted in the table using other font or cell colors. However, using tables for this kind of information does not enable the management of a car insurance company to understand the *reasons* behind the higher payments in certain areas.

Maybe the risk managers argue that hail storms in this region are normal, but that does not really improve the knowledge of management. Consequently, using risk maps as described above to complement raw loss amount data enables management to immediately understand the overall risk they are running when enforcing the sale of car insurance in regions with a high hail risk.

Caveats: These maps are very “data intense”, meaning that a lot of raw data must be integrated into complex formulas to create such a visual. Poor data quality or errors in the formulas may lead to wrong maps and inadequate interpretation of the risk situation. Furthermore, if several information types are combined on one map, it may become “overloaded” and difficult to interpret.

Example 2: Ratings risks through interactive visualization

Why:	Risk Assessment
What:	Risk Profile of one risk
For Whom:	Risk managers and analysts
When:	Risk management workshop
How:	Interactive, software-based visual metaphor

Context: Risk assessment is too often considered an individual exercise left to the experience and talent of an individual risk analyst. Risk visualization, however, provides the opportunity to include more know-how in the assessment of a risk and use the risk evaluation process as a group communication and joint risk analysis process. The current application context for such a group-based discussion is the operational risk department of a mid-size universal bank.

Visualization Format: The visualization format that can support such risk assessment discussions is the risk ruler, an interactive graphic template that captures the ratings of a risk analyst team along a pre-established set of relevant risk assessment criteria. First, the team defines or adapts the relevant dimensions of a risk. Then it defines or refines the needed scales (the horizontal sliders) for each dimension. Having done this, the team is ready to jointly assess a specific risk, as in the example of a reputation threat in the screenshot below. The slide ruler is used by a facilitator who projects it with a LCD projector so that it is visible to all participants. The facilitator also leads the discussion and activates participants to share their views and assessments with each other or to voice disagreements over a given ranking.

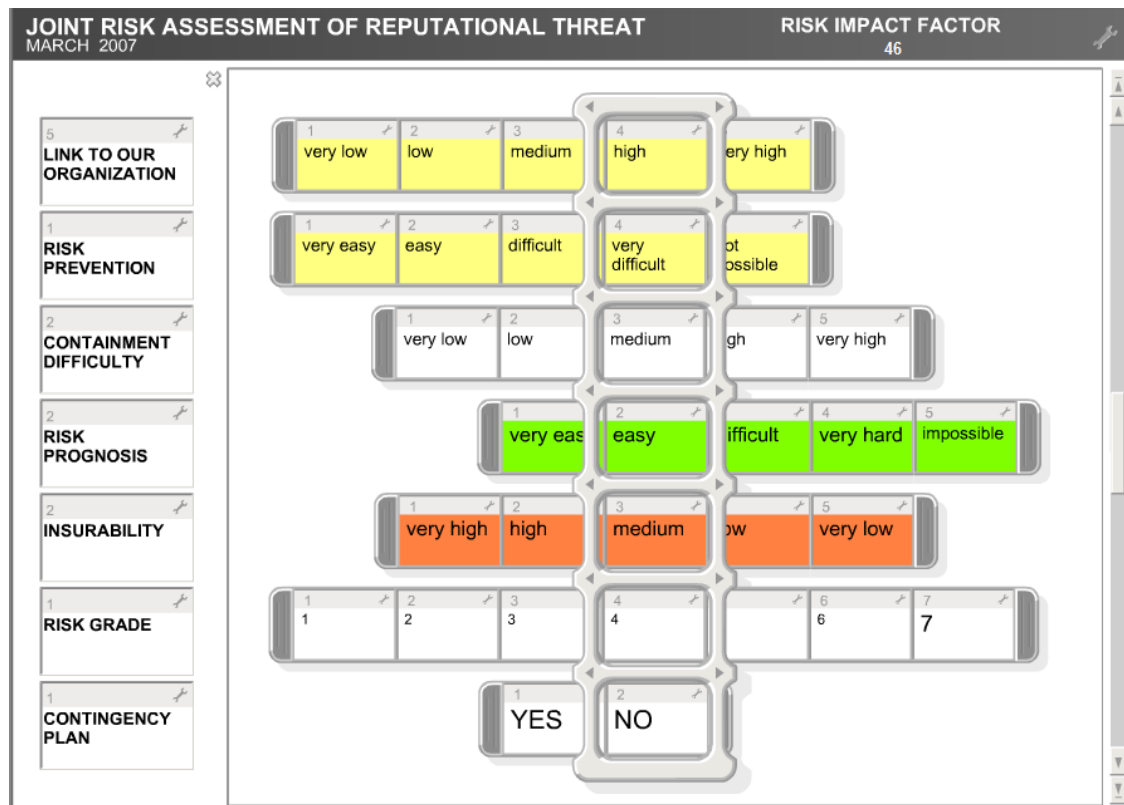


Figure 9: A real-time joint risk assessment and rating

Benefits: Compared to a written risk assessment report, the interactive risk visualization provides a fast way to clarify the relevance and significance of a certain risk for an organization. As changes to the risk assessment can be immediately visualized an entire group of risk analysts and managers can build and document a jointly agreed risk profile. As the graphic template also provides a replay functionality, the modifications made during the discussion can also be captured and reviewed in later meetings.

Caveats: The use of a risk ruler has to be accompanied by careful facilitation in order to avoid documenting a pseudo-consensus on a given risk. Shy participants may otherwise be reluctant to share their insights into a certain risk or fear countering a more senior opinion present in the meeting.

Example 3: Identifying and understanding risks through network diagrams

Why: Risk Analysis
What: Risk-related Information
For Whom: Risk Managers and Executives
When: Workshop and Presentation
How: Qualitative Diagram

Context: The risk management community has developed sophisticated risk evaluation models like the Value-at-Risk (VaR) method, scenario analysis or similar ones. Many of these models and methods are based on the assumption that a risk is known and that the likelihood (or frequency) of occurrence and the possible impact can be estimated. The challenge that still remains, however, is to “think of the unthinkable”, i.e., to identify risks that seem to be highly unlikely to occur but could have a major impact on an organization. These kinds of risks are also referred to as “black swans” (Taleb, 2007).

Using network diagrams to model the core value adding processes and their influencing factors for one’s own business can support the communication regarding all elements and can help to identify opportunities and threats that have not been thought before.

Visualization Format: Gomez and Probst (2002) suggest a specific form of these networks with the main value creating activities as a central “motor” and elements that can be influenced either as strengths and weaknesses or components that cannot be influenced as threats and opportunities. Figure 10 below illustrates such a cause-effect-diagram.

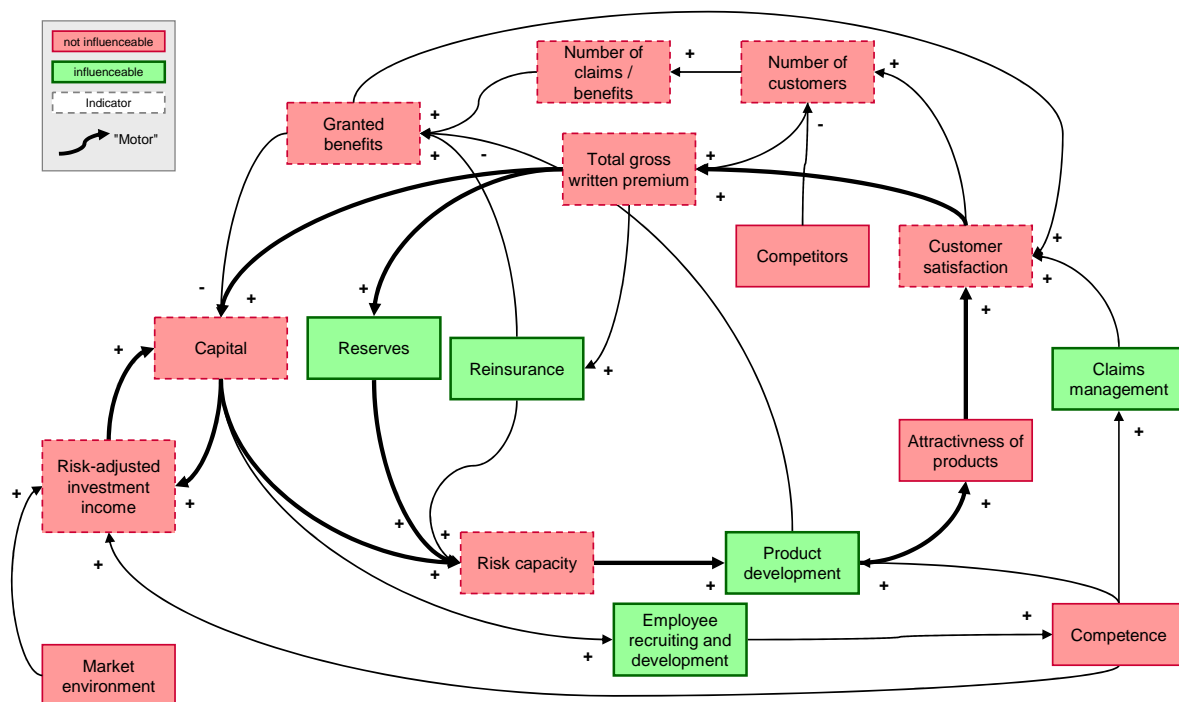


Figure 10: Illustrative cause-effect-diagram for an insurance company

This example explains the main elements and inter-relationships for an insurance company. The bold arrows are the main motor for value creation. Plus signs (+) indicate a positive correlation, minus signs (-) a negative one. Elements like “Number of customers”, “Number of claims/benefits”, “Total gross written premiums”, “Capital”, “Market environment” etc. cannot be influenced directly and therefore represent threats (i.e. risks) and/or opportunities. For example, the insurance company cannot change the number of customers directly. It has to develop attractive products or increase customer satisfaction by establishing a fair claims management process. Then – maybe – the number of customer will increase. However, a sharp decrease in the number of customers is a major risk for an insurance company. If this network is detailed on a more fine-grained level, even more risk and chances may be identified.

Benefits: Thinking in networks is a great way to create a framework for the business situation in a complex environment. By integrating different internal value-added processes and external factors into one single diagram, a good overview on many relevant business elements can be developed. The correlations of causes and events can be identified and analyzed. So far unknown areas can be further discussed. Last but not least, business goals and strategies can be tested against these networks to identify additional risks and opportunities.

Caveats: Networks are complex models for complex business and market situations. Therefore, the creation of such a diagram requires some level of experience. One of the most important points is the careful definition of the systems borders to avoid any complications with factors that are not relevant. It may also be difficult to integrate the time factor into network diagrams (for example by distinguishing short-term and long-term effects through normal or dotted lines). Finally, if such a network is created in a team, it must be ensured that all members can follow the various steps and a common understanding is achieved.

Example 4: Communicating risks through visual metaphors

Why:	Risk communication / reporting
What:	Group of risks
For Whom:	Members of an industry association
When:	Report
How:	Visual metaphor / map

Context: An industry association in the food area has commissioned a report to identify and describe the various risks that it is or will face in the future and how these risks are perceived by the larger public. In order to make the lengthy report more concise and understandable,

by relating what is already known by the audience to unfamiliar information that is new and they are *remembered* better than text or diagrams, especially if the metaphor is unusual, but still fitting. As visual metaphors never perfectly fit the target domain, they also trigger sense making and discussions about the risks and the shortcomings of the chosen metaphor. In this way they help to clarify risk understandings in groups by sparking lively debates.

Caveats: The two greatest dangers in applying visual metaphors to risk communication are picking a metaphor that does not fit the topic or picking a metaphor that is not easily understood by the target group. A visual metaphor should thus fit the risk it is explaining in a manner that is accessible to the target group, because it already understands the metaphor.

Example 5: Monitoring risks through quantitative chart dashboards

Why:	Risk Communication & Reporting
What:	Group of Risks
For Whom:	Manager and Executives
When:	Report or Online Monitoring
How:	Quantitative Charts

Context: Within the risk management process, large volumes of data are typically generated, calculated and analyzed. This information (together with insights and recommendations) is usually presented by risk managers to executives. Other forms of presentation include (interactive) dashboards that try to give a quick overview on the current risk situation, i.e. showing a comparison of the status or level of risk metrics against pre-defined thresholds. Dashboards get their data from databases that are fed by primary systems (e.g. management information systems, accounting systems, etc.). They can be customized by the user and the user can also drill down to deeper detail levels.

Visualization Format: The typical risk dashboard combines gauges, various forms of diagrams and tables with a few key figures to visualize the risk situation (see Figure 12). Most dashboards allow for ad-hoc view changes, zoom-ins (drill downs) or animations (for example to show historic developments).

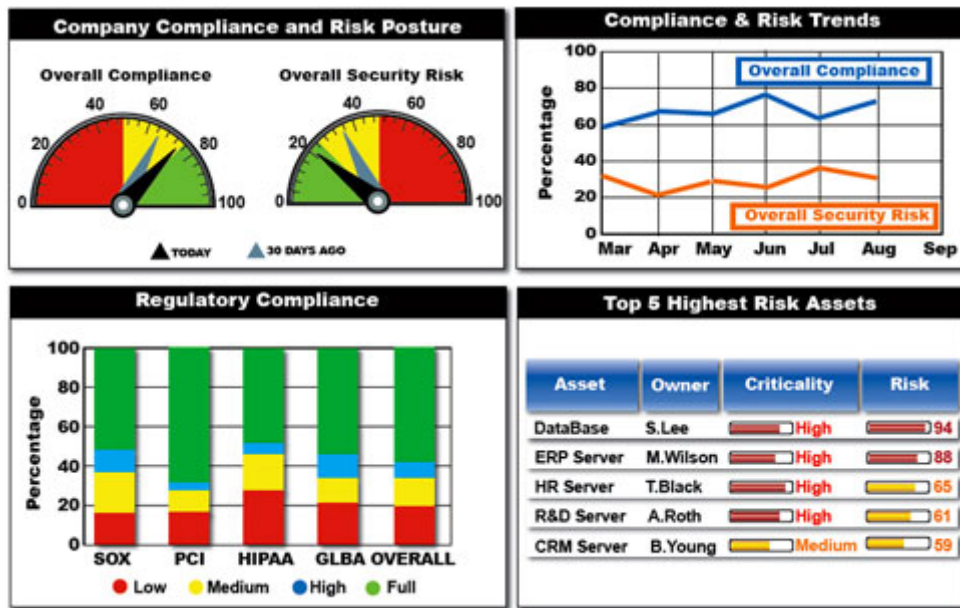


Figure 12: Example of a compliance dashboard (Source: Agilience)

More sophisticated dashboards use different kind of colors and forms to indicate risks or changes of risk-relevant factors (see Figure 13).

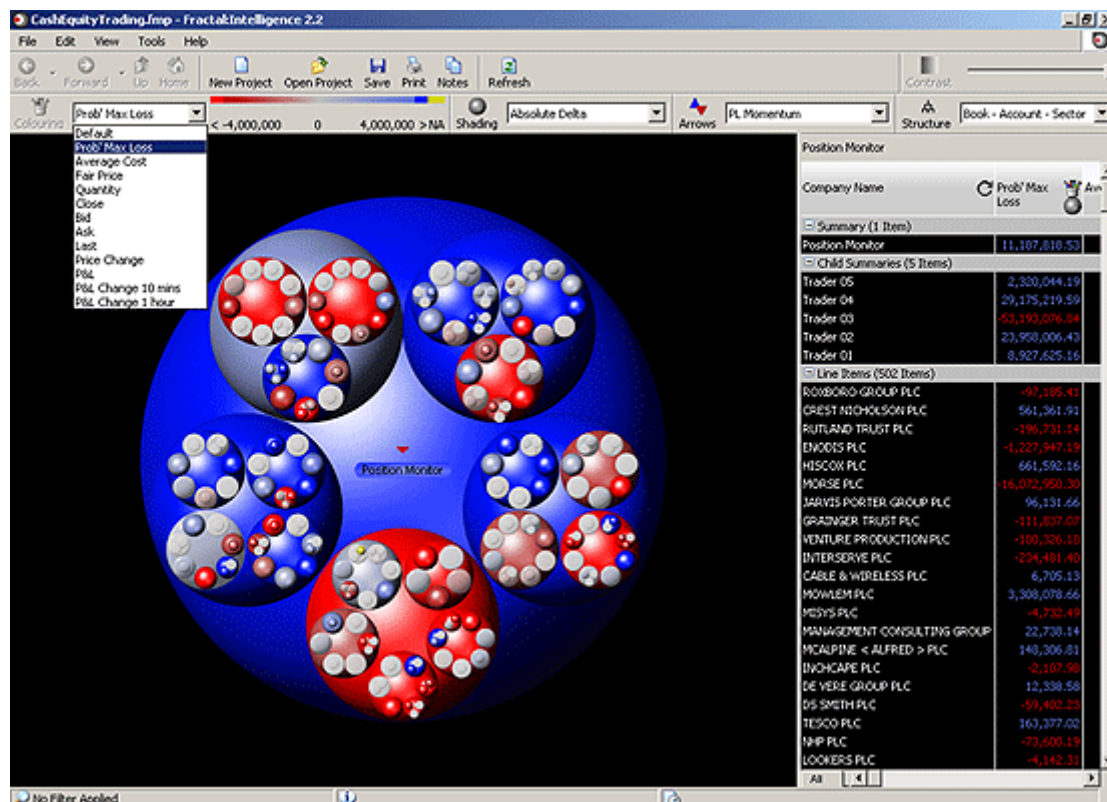


Figure 13: A risk dashboard used by hedge fund traders to show the probable maximum loss in a specific fund (Source: Liezrowice, 2007)

Benefits: The main advantage that risk dashboards provide is an easier overview for monitoring purposes. In addition they can be used to quickly signal worrisome indicators to

decision makers and enable drill-down exploration. The design phase of a risk dashboard can act as a catalyst to engage managers in discussions about meaningful risk indicators and how they should be interpreted. The intuitive interface, finally, may make risk dashboards even accessible to non-experts and help them understand the critical areas of risk monitoring better.

Caveats: As with all forms of visualization, a risk dashboard is only as good as the underlying data and the logic of their aggregation. If the gauges and charts compiled in a dashboard are based on wrong, outdated, inaccurate or wrongly aggregated data, then the salient information presented to executives can actually do more harm than good. In addition, the dashboard may give the executives the false illusion of being fully informed about all possible risks, even if the dashboard only captures a fraction of the existing risks.

5. Emerging Guidelines for Risk Visualization

From the benefits and caveats discussed in the examples in the previous sections, and from existing guidelines on visualization from the information design literature, we can derive a set of simple guidelines that managers or risk analysts can follow when attempting to visualize risks.⁹ These guidelines relate to the proper context of risk visualization (when to apply graphic representations), and the correct or user-friendly visual rendering of risks (how to visualize risks). In the following table we have assembled such guidelines and give an example for each one's application.

Risk Visualization Guideline	Illustrative Application of the Guideline
<p>When to use (or not to use) visualization in risk management and communication</p> <p><i>Don't precipitate the use of risk visualizations.</i> Visualizations reify thoughts or opinions: Once something has been represented in an image, it is difficult to view it in another way. Thus carefully <i>time</i> the use of a graphic risk representation, as simple risk conversations can be more flexible than fixing them to an image too quickly.</p>	<p>In a risk management workshop, you might want to wait showing a risk overview or ranking chart or matrix, and first collect individual opinions and ratings and capture them on a flip chart. Otherwise new ideas or different opinions might get lost, as a picture can have a high persuasive power.</p>
<p><i>Consider the application context and its constraints.</i> It is not always possible to make productive use of visualizations in risk management contexts because of <i>lacking time, tools, or space</i>. Thus, consider the time, resource and know-how constraints in a given</p>	<p>A risk report made available to shareholders should try to avoid ambiguity; hence text may be the primary means of communication and images should always be accompanied by explanatory text sections.</p>

⁹ For further guidelines and interactive overviews on visualization methods, see: www.visual-literacy.org

Risk Visualization Guideline	Illustrative Application of the Guideline
<p>situation and whether your audience would react positively to visualization or not. Visualizations may also detract attention from a presenter in a verbal communication setting. In addition, in <i>inter-cultural</i> risk committees the use of visuals may cause confusion because of differing expectations and conventions.</p>	<p>Risk metaphors might be suitable to inform laymen, while actual calculations and text may be more informative to experts.</p>
<p>How to use (or not to use) visualization in risk management and communication</p> <p><i>Make sure that the risk visualization respects the basic rules of visualization and perception.</i></p> <p>In designing visualizations, you need to respect the basic gestalt laws of visual perception and the conventions of graphic design, namely:</p> <ul style="list-style-type: none"> - Items that are bigger should conceptually be more important or significant (as they attract more attention). - Items that are more centrally placed in a graphic are perceived to be more important than those at the periphery of a diagram. - Items that are placed closed to one another are perceived to be similar or to be part of one group. - Visualize the same things with the same symbols and colors and different things differently. Use a consistent representation style. - Don't overload a diagram. Eliminate unnecessary elements whenever possible. - Time is usually mapped from left to right. - Provide a clear informative title for each diagram or map that indicates the so-what or key message it contains. 	<p>Make sure that primary risk information is clearly distinguished from secondary, less important information (i.e., through size, coloring, or position)</p> <p>Make sure that the key elements of your risk management framework are centrally positioned and larger in font.</p> <p>Different kinds of risks should be depicted using different symbols as shown in the food risk example in the previous section.</p> <p>When showing risk developments over time, make sure it is mapped from left to right.</p>
<p><i>Avoid decorative visualization without added benefit.</i></p> <p>You should always check whether your risk visualizations add value, for example by making a risk easier to understand or assess, by communicating risk-related information quicker or by being more memorable than text alone. You should also try to avoid unessential elements in a visualization, such as shading, borders, too many colors, animation effects, etc.</p>	<p>Shading or fancy 3D effects often make quantitative risk charts more difficult to understand. Try to reduce unessential elements.</p>
<p><i>Think visualizing, not visualization.</i></p> <p>The power of visualization lies in its potential to surface implicit assumptions, capture different perspectives, and reveal new insights. This is especially true if visualization is used interactively by a group of managers and risk analysts. The process of creating and modifying a risk visualization is as important (if not more) as the final result.</p>	<p>In a risk-committee meeting, present your qualitative risk visualizations as preliminary work-in-progress that invites changes and modifications, rather than as a polished final product that requires great efforts to be modified according to the inputs from committee members. In this way, your visualization can be improved through the knowledge of other participants.</p>
<p><i>Pre-test the risk visualization.</i></p> <p>Have somebody who was not involved in the creation of the visualization give you spontaneous feedback on its comprehensibility</p>	<p>Before using a risk visualization in a report or presentation show it to a colleague and consider his/her points of criticism or possible areas of misunderstanding the graphic.</p>

Table 1: Guidelines to consider when evaluating or applying risk visualization

We have called this fourth section of our reports “emerging” guidelines as the set of rules contained in Table 1 is neither definitive nor comprehensive. There is still a lack of sufficient experience to come up with a definitive guide to risk visualization do’s and don’ts. This and other research needs are discussed in the next section.

6. Future Research Needs

Risk visualization is clearly still in a stage where there are a few proven applications and various experimental solutions that still need further refinements. A primary research need is thus to *evaluate* existing solutions and compare them to one another, including conducting user studies, in order to establish clear best practices in risk visualization. In this endeavor, research from cognitive psychologists, information visualization researchers, decision support experts, and risk communication specialists will be instrumental to assure that new graphic representations of risk-related information provide optimal communication and decision support.

A related research need consists of finding optimal ways to actually use such new risk representation formats and tools, or in other words how to embed them in facilitation contexts that allow the visualization to provide the optimal benefit (for this issue see also Eppler & Platts 2008). In this context, one should also study how different depictions of the same risk affect the interpretation of that risk by risk analysts and managers. Yet another fruitful research area is the adequate *depiction of uncertainty* related to risk. We still do not know how to make the uncertainties that enter risk judgments visible to executives so that they can base their risk-related decisions also on the level of confidence of their risk analysts¹⁰. There is a clear need for the development of new formats to visualize this crucial factor of risk assessment (see also Cutter, 2008, for this issue).

¹⁰ One solution for this challenge may be to use a risk map for a single risk with different assessment points indicating different executives’ ratings of the same risk, or graphically superimposing risk ruler profiles and thus highlighting different opinions visually.

7. Conclusion

In the introduction of this article we have outlined the need for better communication through visualization in risk management and pointed to the surprising fact that there is not a lot of literature or research available on the topic. A conceptual framework incorporating the purposes (why?), the contents (what?), the target groups (for whom?), the situations (when?) and the formats (how?) allows to systematically discuss existing forms of visualization in risk management and to explore new solutions.

Although we can derive simple guidelines from the examples that we have described in this article and from generic visualization guidelines that can be followed when attempting to visualize risks, there is still need for more research in this field.

Executives and risk managers, however, should already start today to improve their communication about risks and risk management practices to ensure that they discuss not only the details of specific risks, but also gain a holistic view of the risk profile of their whole organization. The adequate application of visualization techniques can be one important – but not the only – step to improve the effectiveness of their risk-related communication.

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