A Review on Possible Approaches for Detecting Early Warning Signs in Projects

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ABSTRACT

In this paper, we attempt to provide an overview of the full extent of early warning detection approaches, which are directly or indirectly addressed in the literature. These approaches can aid project managers in taking corrective actions timely enough for preventing failures. The study is based on a review of the current literature within the field of early warning in project management and our own experiences gained from practice. An analysis of the strengths and weaknesses of each approach and their applications in different contexts are also performed. We conclude that the choice of the most effective approach is arguably dependent on the type of project, organizational culture, and the project environment.

KEYWORDS: early warning signs; detection approaches; strengths; weaknesses; project management

INTRODUCTION

Despite the improvements in the utilization of project management tools and techniques in recent years, quite a significant number of projects still fail. An approach to avoiding this is to attempt detecting possible project failures at the early stages of a project in order to take the necessary corrective measures. In retrospect, we are quite often able to point out a number of the most likely factors contributing to the project’s failure, and we can also see a number of signs of this failure. Those signals, with the benefit of hindsight, often appear obvious and it is hardly possible to understand why they were not taken into consideration at the time.

The concept of early warning signs (EWS) is underrepresented in the literature. Apart from a few key works (Ansoff, 1975; Nikander, 2002; Klakegg et al., 2010), which will be discussed further in the literature chapter, not much work has been done on EWS within the project management research literature. We consider this an area that should be looked into more closely; we hope this paper contributes to this area.

The aim of this paper is to create a conceptual understanding of the extent of approaches available for identifying early warning signs. This will be done through reviewing the current literature within the field, looking into studies of industrial practice, and also building upon our own experiences in various forms, both through advising and supervising project management teams and through observations and studies of projects. We extract possible approaches for EWS from the literature and practical experience, and make a thorough discussion of their strengths and weaknesses. The main research questions to be answered in this paper are (1) What approaches exist for detecting early warning signs and how can they be categorized; and (2) What are the strengths and weaknesses of different EWS detection approaches under different circumstances? This approach to the research stems from previous exploratory investigations into the area, strongly indicating that there are obvious gaps in the literature regarding the field of early warning signs.

The work presented here is partly based on review of the literature, again based on a post-positivist view of such studies saying that, on the one hand we aim to be as unbiased and neutral as possible; on the other hand, however, we also acknowledge the influence from our world view on our research.
In the next part of the research, we draw on our heavy involvement in a number of early warning case studies over the last five years. This work has to some extent taken the form of action research, by mainly taking a constructionist stance, which means that the phenomena we observe are interpreted as social constructions not being independent from the people related to them. We should also remark that we acknowledge that our research is well positioned within an objectivist tradition.

It should also be noted that the combination of the two main parts—literature studies and our own experience—has given us opportunities for triangulation (i.e., evaluating to what extent findings from the first is underpinning or confirming the latter or if it is possible to see that they are in any respect conflicting). Based on the results from those two basic parts of our research, we then discuss the findings and draw a set of tentative conclusions.

**The Concept of Early Warning as Presented in the Literature**

The general idea of early warning is a broad concept and applies to almost any area where it is important to obtain indications as early as possible of some development in the future, usually of a negative nature. The concept of early warning in a management context was first discussed by Ansoff in 1975. This was later developed for a project context by Nikander (2002) in his doctoral dissertation. Ansoff stated that strategic surprises, for example, the oil crisis in the early 1970s, do not appear out of the blue: it is possible to predict their occurrence by the aid of signals that are called “weak signals.” A weak signal was defined by him as “. . . imprecise early indications about impending impactful events . . . all that is known (of them) is that some threats and opportunities will undoubtedly arise, but their shape and nature and source are not yet known” (Ansoff & McDonnell, 1990, p. 20). The main idea is thus that even unexpected discontinuities are indicated by some warning signals; there have been some doubts and criticism of this theory, however. For example, Webb (1987) claimed such messages or information about the future could not be obtained and that Ansoff’s work had no earlier foundation to confirm the claims of such weak signals. He believed that these signals only provide weak knowledge of the final threat or opportunity. Ashley (1989) turned the discussion around, saying that such discontinuities are only seen after they have occurred, and possible pre-indicators of their arrival are only identified with the benefit of hindsight. Makridakis and Heáu (1987) stated that the concept of weak signals had remained a purely academic idea, and Åberg (1993) stated that weak signals are usually so vague that they are easily missed. On the other hand, however, several other authors have described the same core idea using slightly different terms; for example, symptoms, early indicators, soft forms of information, and early warnings (Juran, 1995; King, 1987; Mintzberg, 1994). Leidecker and Bruno (1987) and Pinto and Slevin (1988) have also performed some studies that can be regarded as research in support of the existence of weak signals.

Expanding the view beyond management literature, the belief in early warnings seems more profound. Whereas detecting minor behavioral changes in competing industrial enterprises that eventually lead to the introduction of profoundly new technologies can be challenging, identifying physical changes, such as the formation of a low pressure system or an increased concentration of a certain type of algae could be easier. Not surprisingly, there is an abundance of articles, reports, and web pages dedicated to or dealing with early warning signs in many different sectors. In the next section, we will review some of these when looking into specific approaches to the identification of early warning signs.

**Early Warning Detection Approaches Mentioned Directly in Project Management Literature**

According to Nikander (2002), which is consistent with our own findings, very little existing literature deals explicitly with the early warning in projects and project management; however, the project management literature does include some statements that are possible to interpret as examples of early warnings. For example, Kerzner (1994), Cleland (1994), and Zeitoun and Oberlender (1993) have pointed to this phenomenon in their studies (Nikander, 2002). The approaches we will discuss in this section include risk management, earned value management, and project assessments.

A broad range of the project management literature points to early warning signals through the treatment of risk management as one important part of the field’s toolbox. The body of work on risk management is too large to review here, so it is sufficient to say that various authors have mentioned terms such as “risk symptoms” and the “occurrence of symptoms and issues.” According to Nikander (2002), because early warning refers to a problem that may arise in the future, the relation between the early warning phenomenon and risk management is rather obvious. Kappelman et al. (2007) also link these two concepts by stating that early warning signs provide an indication of evident risks and thereby an assessment of a project’s exposition to future problems and failure.

An example of research done on the link between risk and early warning is the work done by Niwa (1989), outlining an approach based on the use of computer-based expert systems. The concept of risk alarms was introduced and intended to be advance warning of emerging problems.

**Earned value management (EVM)** is mentioned to be another approach that provides triggers or early warning signals (Fleming & Koppelman, 2000).
According to Vanhoucke (2012), the earned value management system relies on a set of metrics that measure and evaluate the general health of a project. Kim et al. (2003) also refer to this approach by stating that EVM is perceived as being a good forecasting or early warning tool that enables project managers to plan and control projects proactively. In addition, there are other authors who have referred to this method without directly using the exact term, but emphasize its usefulness as a tool that enhances proactive problem solving (Anbari, 2003; Brandon & Daniel, 1998; Lipke, Zwikael, Henderson, & Anbari, 2009; Vanhoucke, 2012). Lipke et al. (2009) mention this method as a predicting tool for a project’s final outcome. They claim that it can actually start predicting the outcome as soon as 10% of the project is completed, thereby giving project managers enough time to take timely action in case of negative predictions.

Various project assessments have also been discussed as a way to identify areas that should be addressed by early warning monitoring. Project assessments go by many names, some of which are project reviews, project health checks, benchmarking, post project evaluation, and project audits (Klakegg et al., 2010). Assessments can take place during the project initiation stage and up to the project mandate stage, when the go/no-go decision is made and even post-project completion. There is much literature on the stage gate approach and how it aims to preempt potential problems that make a project non-viable (Cooper et al., 1997; Cooper, 2005; OGC, 2007); however, as Flyvbjerg et al. (2003) caution, overoptimistic assessments of benefits and underestimates of problems and risks can subvert this process as a way of flagging risk that may result in an unsustainable project. As mentioned earlier on, the concept of early warning signs has been underrepresented in the literature. It is not easy to find specific approaches for the detection of early warning signs and responding to them. Looking at the overall picture of what the literature already contains on this topic, we see that the importance of detecting early warning signs is emphasized as a means for avoiding the full impact of problems, but there is still a great deal to be found out on how to detect these signs and how to act upon them. We believe there are many fields in which this topic is alluded to without using the exact term of “early warning.” We therefore investigate further into such fields and try to extract the useful information in order to make a statement on how early warnings can be detected in a systematic way. This will be presented in the following section.

**Overlooked Possible Early Warning Detection Approaches**

The overlooked approaches, which we will review in this section, include stakeholder analysis, brainstorming, maturity measurement, extrapolation from earlier projects, cause and effect analysis, gut feelings, and interface management.

One of the sources that does not directly refer to the early warning concept, although quite related to its identification throughout the project, is *stakeholder analysis*. Every single project is “surrounded” by entities that directly or indirectly participate in or influence the design, execution, and effects of the project. These are commonly termed stakeholders, defined by Project Management Institute as (PMI, 2000, p. 16):

> Individuals and organizations who are actively involved in the project, or whose interests may be positively or negatively affected as a result of project execution or successful project completion.

There are a number of models proposed that outline the process of undertaking a stakeholder analysis, (for example, Cleland, 1986; Karlsen, 2002; Savage et al., 1991) but they have clear similarities, which include activities to identify the project’s existing and presumed future stakeholders; gain a better understanding of their needs and expectations toward the project and its outcomes; and anticipate their strategies and actions. Irrespective of which approach is used, the outcome of a stakeholder analysis will be some level of insight into what stakeholders the project has to relate to and what they expect from the project and how they might react if they don’t achieve this. The issues emerging from such an analysis can clearly be utilized to identify early warning signs.

**Brainstorming**, in particular based on the project team’s knowledge of prior projects and their problems, can also be a source of early warning signs. Although brainstorming in its most basic form is a very simple technique, there are more advanced varieties as well. The technique has its roots in work in advertising as early as 1939 (Osborn, 1953). Rules were defined to aid brainstorming, but there are also doubts about its effectiveness. Stroebe et al. (1992) identified three processes that derailed brainstorming efforts; free riding, evaluation apprehension, and blocking. Issues arising from the brainstorming effort can then feed a process to identify early warning signs.

The data that early warning is built on should indicate pending problems as far in advance as possible. An approach of possible relevance is that of *maturity measurement*. This is a type of measurement that represents an even earlier warning than events; the maturity of the organization to undertake the project that it has been mandated to do. The key idea is that it might be possible to assess how mature (i.e., how qualified) an organization is to run projects, and thus very early, even before the project starts, determine whether it seems likely that the project will run smoothly or end up in trouble. Andersen and Jessen (2003) discussed the term and pointed to the dictionary definition of maturity; having reached a state of full natural or maximum development. This definition fits products and organizations alike.
A Review on Possible Approaches for Detecting Early Warning Signs in Projects

although it might be argued that organizations never reach a state of full maturity. Maturity models have also been extensively used as an improvement tool, where organizations conduct self-assessments (Ahern et al., 2004). If such maturity assessments reveal areas of lower maturity, it is natural to consider these targets for early warning monitoring.

To extrapolate from earlier projects is a way of using the experience gained, but the validity for the current situation must of course always be ensured first. The project management literature has numerous references to how experience from earlier projects is used in order to identify early warning signs. See, for example, Pinto and Slevin (1988), Kerzner (1987), Pinto and Prescott (1988), and the IMEC study (Miller & Lessard, 2000). A somewhat different approach has been used by Kappelman et al. (2007) and Klakegg et al. (2010), in which experience from earlier projects is used as a basis for discussions with project management experts, in order to get their qualified assessments of the relative importance of the early warning signs.

Another concept that is indirectly related to early warnings in projects is the cause and effect analysis approach. We believe that because this topic focuses on causes and origins of issues, it is closely related to the success and failure factors in projects. Nikander (2002) provided a model indicating that problems, their causes and early warnings are connected through a chain. There are other sources, which although not mentioning the term “early warning” directly, refer to cause and effect analysis and root cause analysis approaches for the identification of risks in advance in order to prevent future problems (Leszak et al., 2000; Ohatka & Fukazawa, 2009; Parker & Skitmore, 2005; Sambasivan & Soon, 2007; Williams et al., 2012).

In addition to the EWS that can be identified through project assessments, another category of signs can be “gut feeling” signs. These signs are described by Nikander and Eloranta (2001) through the statement: “anticipatory feelings are the least easy to detect, identify and interpret, intuitive feeling” (p. 387). Klakegg et al. (2010) make a very simple categorization of EWS, where they are either identified through assessments or they are based on “gut feeling” (Table 1). Such a “gut feeling” will usually be closely related to the tacit knowledge of the recipient of the signals. Whitty (2010) showed the importance of emotions as an expression of knowledge, and also the use of body language as such an expression, and exemplified the importance of reading body language in a project setting in order to read some of the—sometimes even critical—signs about the state/condition of a project.

The last approach we will refer to is interface management, described by Cleland and Morris (1988) as an element that serves as a natural checkpoint for managers in order to monitor performance and thus prevent problems from falling into a snowball process. Calgar and Connolly (2007) defined it as a means for the development of effective communication and information exchange among project participants. The main objective of this process is to facilitate agreements with other stakeholders regarding roles and responsibilities, timing for providing interface information, and identification of critical interfaces early in the project through a structured process. The overall goal for the process is early identification of issues that have the potential to impact cost or schedule. This is done in order to minimize or to remove this impact, and also to promote clear, accurate, timely, and consistent communication with other

| Through Assessments                                      | Based on “Gut Feelings”                                      |
|----------------------------------------------------------|-------------------------------------------------------------|
| The numbers or information missing                       | Lack of culture of openness and good communication between the actors |
| Assessments not performed/documentation not completed    | Strained atmosphere                                         |
| Plans and reports delayed or unclear                     | Evaluating the reality of needs                              |
| Contract obligations not fulfilled                       | Inconsistent arguments about agendas                         |
| Milestones/activity definitions unclear or missing       | Changes in positions over time                               |
| Lack of an implemented governance framework              | Uneasy comments and body language                           |
|                                                          | Stating uncertainty, unwillingness to conclude               |
|                                                          | What kind of information is willing to be shared             |
|                                                          | How questions are asked and answered                         |
|                                                          | Making reservations                                          |
|                                                          | Lack of showing trust in the project organization            |

Table 1: Additional important early warning signs from case studies [Klakegg et al., 2010].
organizations for exchanging interface information. Voss (2012) emphasized the importance of clear interfaces among project participants as a vital part of the project portfolio management process. Findings about interfaces among components or actors can be sources of early warning.

In the next section we will briefly discuss several case studies that the authors have been involved in, with the aim of identifying how early warning signs were detected in these cases, which specific signs were found, and how these signs were used in performing these real-life cases.

### Industrial Experiences on Application of Early Warning Detection Approaches

Through our involvement in case studies performed as part of various research activities, here we present the summary of our findings as examples of implementation of some early warning detection approaches in real-life cases.

A study of a selection of eight cases from different industries (both the public and private sectors) with varying degrees of complexity, in three countries, was done in order to investigate the most important early warning signs that were detected by the project teams, the approaches that were implemented for performing this task, and also to assess the level of usefulness of the early warning detection systems. The analysis process of these cases was not very easy due to the different range of projects, which varied in size, complexity, and task uniqueness. According to our findings, the approaches used for detecting these signals were mainly project assessment tools and “gut feelings.”

Many of the experts involved in the case projects pointed out that many early warning signs are of a less measurable nature and thus depend on more “gut feelings.”

In general, the case studies suggested further possibilities for the detection of early warning signs, many of which consisted of soft atmospheric or “feeling” issues, such as introducing the existence of a culture of openness and effective communication among actors, as an aid to detection of early warning signs. In addition, there were suggestions on more reliance on personal “antennas” than on systematic analyses and other assessments.

Table 1 shows some of the main findings from typical “assessment-based” approaches compared with some findings of a more “gut feeling” based type. From the table we can see that by using a formal assessment and looking for indications of issues such as the ones mentioned in the left column of the table, it is rather unlikely to be able to detect the types of indications mentioned in the right column, unless being very much aware of their potential as early warning signs.

For answering the question about how useful the used approaches for detecting early warning signs are, we can conclude from the findings of the case studies that early warning signs may be identified via assessment methods, and in this respect, assessments are considered to be successful, but in the studied cases, this knowledge did not always lead to actions for dealing with them. This can lead to the conclusion that assessments, no matter how successful they are in the identification of relevant issues, can be a waste of time and effort. Some experiences, however, showed that the exercises themselves were most important due to their allowance of crucial questions to be raised early.

In addition, it was revealed that dialogue and organizational culture play key roles in detecting early warning signs, and this confirms the need for “gut feeling” approaches that can detect signals that are not easily covered by formal approaches. Generally, comparing the two approaches, we can conclude that “gut feeling” approaches are limited in the way that there is no awareness as to what to look for, but this is also its strength because there are no preoccupations with looking for specific indicators. This provides the opportunity for detecting any type of early warning sign.

It is part of future plans to perform case studies on other possible approaches for detecting early warning signs and to evaluate their usefulness, strengths, and weaknesses in practice.

### Analysis of Possible Early Warning Detection Approaches

As stated earlier, we have not been able to locate a systematic and coherent documentation of where projects can turn for information that allows identifying issues and potential problems that could be worth tracking, through the use of early warning signs. This section of the paper discusses a wide range of sources for such issues and analyzes them in order to clarify how each approach can be used as an early warning source (the approaches are shown in Figure 1).

Note that the following sources come from both literature studies and experiences we have gained through various industrial case studies; there is no direct link between these sources and the specific cases mentioned in this paper.

The purpose of outlining this spectrum of possible sources is to systematize currently fragmented knowledge. We also hope to inspire academicians as well as practitioners in terms of where projects can look for issues that can be developed into early warning signs. After a few years of close study and contact with the channels mentioned, we have come to realize that projects have an extensive range of tools available when looking for issues that could become future problems. Some of these are obvious; others are more obscure and have gradually emerged as useful sources that can be tapped into. The same way we have sometimes been surprised at the variety of possible early warning sign sources, we hope this overview will expand others’ views as well.

The following section discusses all the various sources we have deemed...
A Review on Possible Approaches for Detecting Early Warning Signs in Projects

Figure 1: Categorization of different early warning sources according to various aspects.
useful to include as separate entities (some of the list entries could be construed as collective terms for a group of similar sources or variants of the same type of source). For each source discussed, an example is given of how early warning could arise through the use of the source (please notice that these examples are not taken directly from real-life cases, but are fictional illustrations of how each source could work).

**Analysis of Sources Directly Mentioned in Literature as Early Warning Detection Approaches**

*Risk analysis* results are probably the most obvious source of them all. Risks identified as part of a risk analysis exercise must be handled in some way by the project, typically by assigning responsibilities within the project team for monitoring the situation and taking action as needed. This monitoring can lead to identification of risks that represent issues for which early warning signs can be developed. For example, if an identified risk is increasing contractor prices, early warning monitoring can consist of periodically reviewing the market conditions. Relevant risk analyses can be undertaken specifically for the project in question by the project owner organization for a larger portfolio; and results from previous projects can also be used, to the extent previous projects are similar to the current one.

*Earned value management* is primarily focused on keeping track of time and cost-related issues in a project. This is done by periodical measurements of project progress over time, both in terms of cost and time, and presenting a comparison between the key parameters of the earned value method: planned value (PV), actual cost (AC), and earned value (EV). By periodically measuring these parameters and assessing the amount of excessive ness, an early warning sign emanates from serious deviations; of course it should be noted that it is a prerequisite to define the limits in advance in order to establish a baseline for comparison.

A *project assessment* is a somewhat imprecise term by which we mean various types of reviews/audits/status checks the project is subject to, which could reveal issues to be aware of in the future. Examples of such assessments are pre-sanctioning assessments (e.g., based on CII’s PDRI [Project Definition Rating Index]), evaluations or reviews done during execution (e.g., stage-gate assessments, internal or external review board evaluations, etc.), and many other types of evaluations undertaken for different purposes. Common for these is that the primary purpose is not to feed early warning efforts, but they will typically reveal issues that are often relevant to monitor on a more continuous basis. For example, an external project evaluation after year 1 points to conflicting goal interpretations among involved stakeholders, an observation that can be used to focus early warning measurements on goal alignment. It should also be noted that so-called “health-checks” can be construed as one such project assessment, but one that is very closely linked to the concept of early warning.

*Performance measurement* is a common label for various efforts to periodically collect “performance” data about the project, but that are not primarily aimed at early warning purposes. For example, all projects track incurred costs, most projects are mandated by authorities to measure health and safety issues, and schedule monitoring is ingrained in all project management. Such measurements are undertaken as part of project administration and control efforts, but can easily be used as a basis for identifying early warning signs. If periodic measurements indicate construction site safety issues, this is a development that should be analyzed in an early warning light in terms of the future consequences of such issues. It should also be noted that performance measurement is also a specific tool for collecting data required to look for early warning signs.

**Analysis of Sources Indirectly Mentioned in Literature as Early Warning Detection Approaches**

*Stakeholder analysis* insights are a fairly obvious source; most projects undertake more or less formalized and extensive stakeholder analyses that create insights relevant to exploit for early warning issues. Stakeholders can, by definition, influence the project, and how they actually come to influence it depends on how well their needs and expectations toward the project are fulfilled and the strategies they pursue. The stakeholder analyses aim to uncover such needs and expectations and likely behavior of the stakeholders, and can clearly be converted to early warning signs. For example, if an environmentally focused NGO’s assessment of a project and subsequent actions depend on the extent of depletion of natural resources in an area, monitoring the depletion rate can give early indicators of future negative behavior by the stakeholder.

*Brainstorming* based on the project team’s insight is arguably the most frequently used source for early warning signs, where the project team simply builds on its collective insight into the project and its surroundings to come up with possible future problems. Such exercises can be more or less structured, ranging from “lunch break talks” to facilitated brainstorming sessions. The outcome from such brainstorming can also vary considerably, from loosely described “uneasiness,” to well-defined potential problems approaching risk factors resulting from risk analyses. The more structured the brainstorming approach, the more similar to traditional risk analysis sessions such an exercise can be, but the main difference lies in their uses; risk analyses create risk factors that will be further analyzed and handled specifically, whereas potential problem brainstorming serves to give rise to early warning signs directly. For example: a project to build a new hospital identifies the development of new PET-scanning technology as a potential problem if the new

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machines require more power than what the infrastructure under design is dimensioned for. This situation can be kept under control by postponing the design decision and staying in touch with research environments leading the PET-scanning development.

*Maturity assessments*, which could be viewed as a specific subset of project characteristics analysis, focus on assessing the maturity of various aspects of a project and its context. By use of tools, such as CII’s PDRI, the maturity of the project organization, or the “quality” of the project methodologies in use by the project organization are assessed—all of these typically produce “maturity profiles” that show areas of weakness. Such areas of weakness are obvious indications that the project could run into problems relating to the lack of skills or methodologies revealed. Early warning signs can then be based on monitoring the development of these areas as the project progresses and possibly indications that these weaknesses may lead to specific problems. An example illustrates both approaches: a maturity assessment of a project team undertaken early on in the project reveals low levels of maturity for the areas of supplier management and procurement as well as project close-out and handover to operations. The lack of procurement expertise can easily harm the project as it progresses through engineering and into the procurement and construction phases, warranting updated maturity measurements to see whether the team is being strengthened. Close-out and handover are specific events, but represent culminations of a string of preparations and events leading up to them (e.g., preparation of technical documentation, development of operations and maintenance manuals, training of operational personnel, and so forth). Early warning signs can be linked to these activities to ensure satisfactory progress early enough.

*Previous projects*, both inside the organization and in the public domain, are other obvious sources of ideas for problems the project can encounter. Most relevant are typically similar projects, but also seemingly very different projects can have characteristics that coincide with the project in question and offer learning points. The purpose is to tap into knowledge about things that have caused problems in these projects and therefore can indicate relevant issues also in the incumbent project. Such knowledge from other projects can be found in available documentation (e.g., public domain descriptions, lessons learned reports, post mortems, interviews with people who were involved, formal databases, and the experiences of people in the current project who were also parts of relevant past projects). Like the interface approach, this is also a two-stage exercise: first, problems that have occurred in past projects must be found; and second, causes or triggers of the problems must be identified to allow developing early warning signs (thus, knowledge from previous projects can be used as input to a cause-and-effect analysis). For example: a railroad infrastructure project learns from similar past projects that a key supplier of signaling system components has been prone to delivering immature technology, causing delays in getting the total signaling system to work properly. From this knowledge, some causes appear: insufficiently stringent requirements specifications, lack of dialogue with the supplier, certain “maverick” people lead the supplier’s team, and so forth, and these can then be monitored through suitable indicators/observations.

*Cause-and-effect analysis and root cause analysis* are well-known techniques from the quality management field and can be applied in an early warning context. The principle idea is that issues that arise from brainstorming are usually undesirable “end states,” but determining early warning signs that indicate progress toward these end states can be difficult. By applying these techniques, one tries to nest backward through cause-and-effect chains to identify triggers that, early on, set in motion chains of events eventually leading to the end states. For early warning, the project can then monitor for the occurrence of these triggers. For example: the project team of a complex technology infrastructure project identifies a loosely defined problem of substandard performance of technical components of the system to be built. Looking for paths that could create this problem, a root cause analysis uncovers a chain of events where substandard performance is caused by a supplier delivering an unsuitable component, due to unclear requirements specifications, caused by poorly defined goals, ultimately triggered by poor understanding of the stakeholder’s needs. Thus, early warning monitoring could focus on the degree to which stakeholder needs have been mapped and understood.

*“Gut feeling*” is not a scientific term, but it seems to be quite prevalent in projects when looking for potential future problems. This is closely linked to brainstorming, where gut feelings and instinctual responses of project team members involved in such exercises represent an important source of brainstorming ideas. As such, gut feeling probably does not deserve labeling as a source of its own, but we find it important to mention that, in many cases, it is the most used “inspirational well” that develops into early warning signs. As mentioned earlier, the results of the case studies done show that many experts involved with case projects believe that many early warning signs are less measurable and depend more on gut feeling approaches. They believe that many early warning signs are only possible to be detected by reliance on personal intuition rather than systematic analyses. These gut feeling ideas can then form the basis for defining early warning signs that can alert project management about a development toward the occurrence of these potential problems. For example: A
et al. (2011) have also observed similar trends, and the project seems unable to resolve them. After an initial growth phase, no new interface issues are identified, and the project appears to be stable. However, the volume of interface issues is increasing at an alarming rate (e.g., the total number of unresolved interface issues). This suggests that several characteristics of the project need to be carefully examined. For example, a project determined to being heavily dependent on the development of new technology should be subjected to close monitoring of innovation progress, whereas a heavily distributed project team could monitor aspects such as extent and quality of communication, goal alignment, and so forth.

External factors are another example of issues that can arise through risk analysis, stakeholder analysis, which we include as a final item, because external factors represent a specific type of issues with a range of sources external to the project. Such issues are typically uncovered through some kind of analysis looking into aspects like the political/regulatory climate surrounding the project, market/financial issues, climate/weather where this is relevant, organizational issues, and so forth. In all cases, triggers of problems originate outside the project, sometimes completely outside its sphere of influence; in other cases, with influence from the project. Keeping a watch for such external factors and problems they could cause is a natural part of an early warning approach. An example of such an external factor is the price development in the contractor market. Cost estimates for a project are based on current prices at the time of estimation, possibly adjusted for projected changes ahead, but significant deviations can occur in the period from estimation until the project is ready to start tendering for bids, thus influencing the costs. Monitoring price levels or, better yet drivers of price levels in the forms of larger projects gearing up for tendering, are a natural response from the project.

Figure 1 represents the EWS sources discussed, and contains a small diagram per source to illustrate the mechanisms at play for each source. We do not claim this list of various sources to be exhaustive, but believe it covers a much broader range than what might be readily apparent from previous publications on the topic. It is also obvious that not all of these sources for early warning signs are “unique” singular items; rather, many of them are similar or interconnected in how they can lead to the identification of early warning signs. The next section of the paper will therefore analyze the various sources to provide a better understanding of their natures, pros and cons, and how they can best be applied and possibly combined.

Analysis of Strengths and Weaknesses of Sources for Identification of Issues

To summarize some main facts regarding the sources for early warning signs, we have compiled Table 2. For each of the EWS sources, a categorization has been done of the types of data used, the data sources that will typically be used, the data availability, and the sources for early warning signs. The next section of the paper will therefore analyze the various sources to provide a better understanding of their natures, pros and cons, and how they can best be applied and possibly combined.

Project characteristics analysis is a rather ambiguous term. By this term we endeavor to point to various assessments that projects are frequently subjected to in order to determine certain characteristics (e.g., degree of complexity, degree of physical distribution, degree of novelty, and so forth). In some cases, there are more specific “tools” available (e.g., team measurement instruments), and for other characteristics sets of indicators have been developed (e.g., project complexity or degree of distribution of a project team). For many factors the assessment is a matter of qualitative discussion. Irrespective of which characteristic the project is analyzed against, for projects that are determined to have certain characteristics, these can be sources of early warning signs. For example, a project determined to being heavily dependent on the development of new technology should be subjected to close monitoring of innovation progress, whereas a heavily distributed project team could monitor aspects such as extent and quality of communication, goal alignment, and so forth.

Figure 1 represents the EWS sources discussed, and contains a small diagram per source to illustrate the mechanisms at play for each source. We do not claim this list of various sources to be exhaustive, but believe it covers a much broader range than what might be readily apparent from previous publications on the topic. It is also obvious that not all of these sources for early warning signs are “unique” singular items; rather, many of them are similar or interconnected in how they can lead to the identification of early warning signs. The next section of the paper will therefore analyze the various sources to provide a better understanding of their natures, pros and cons, and how they can best be applied and possibly combined.

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A Review on Possible Approaches for Detecting Early Warning Signs in Projects

| EWS Source                  | Type of Data | Type of Analysis                      | Focus/Type of Issues                           | Data Sources                                                                 | Project Phase                                      |
|-----------------------------|--------------|---------------------------------------|------------------------------------------------|------------------------------------------------------------------------------|---------------------------------------------------|
| Risk analysis               | Hard and soft, qualitative and quantitative analyses | Structured process blending; qualitative and quantitative analyses | Significant external/ internal, strategic/operational threats | The project team, contextual data, previous projects | All phases, at decision gates/other milestones |
| Stakeholder analysis       | Hard and soft, qualitative analysis                  | Structured process of qualitative analysis | Potential external and internal stakeholder issues | The project team, contextual data, stakeholders, previous projects | All phases, but front-end/early phase bias |
| Project assessments         | Hard and soft, qualitative and quantitative analyses | Snapshot analysis of project status          | Internal and external problems               | Internal and external project data                                      | All phases                                         |
| Performance measurement    | Hard and soft, qualitative and quantitative analyses | Continuous analysis of project performance | Trends indicating internal and external problems | Internal and external project data                                      | All phases                                         |
| Brainstorming from team insight | Soft, qualitative analysis                          | Creative exercise                          | Potential internal and external problems     | Individual participant judgment, previous projects                        | All phases, but front-end/early phase bias |
| Cause-and-effect/root cause risk analysis | Hard and soft, qualitative and quantitative analyses, qualitative bias | Structured process, applying different analysis tools, often combined with creative insights | Sources of internal and external problems | Any source of data about the problem being analyzed | All phases                                         |
| Interface analysis          | Hard and soft, qualitative and quantitative analyses | Identification and resolution of non-clarified interfaces | Avoidance of problems at non-clarified interfaces | Project team knowledge, project documentation | All phases                                         |
| Extrapolation from previous projects | Hard and soft, qualitative and quantitative analyses | Creative exercise                          | External and internal problems encountered in previous projects | Risk analyses, project documentation, close-out reports, interviews, experience | Front-end/early phase |
| Project characteristics     | Hard and soft, qualitative and quantitative analyses | Classification of characteristics, benchmarking with baseline/other projects | Identification of singular characteristics and specific requirements stemming from these | Project documentation, project team knowledge | Front-end/early phase |
| Maturity assessment         | Soft, qualitative and quantitative analyses         | Questionnaire-based measurement of the maturity of the project and/or project organization | Identification of weaknesses in the project and/or project organization | Individual project team member assessments | All phases, but front-end/early phase bias |
| Earned value management     | Hard and soft, quantitative analysis                 | Calculation of earned value                | Shortcomings in value creation                | Resource consumption data, assessment of task completion                  | Project execution                                  |
### Table 2: Categorization of different early warning sources according to various aspects.

| EWS Source       | Type of Dataa | Type of Analysis | Focus/Type of Issues                                                                 | Data Sources                                                                 | Project Phase |
|------------------|---------------|------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------|---------------|
| "Gut feeling"    | Soft, qualitative analysis | Creative exercise | Potential internal and external problems                                             | Individual participant judgment, previous projects                          | All phases    |
| External factors | Hard and soft, qualitative and quantitative analyses | Identification and analysis of external factors | External factors that could negatively influence the project | Contextual data | All phases    |

*a"Hard issue" or "formal dimension" refers to technical managerial aspects, which consist of formal integrative mechanisms through tools and techniques, and "soft issue" or "social dimension" refers to the dynamics and complexities of the human side of the project [Mustaffa & Bowles, 2005].

| EWS Source       | Strengths                                                                 | Weaknesses                                                                                                                                                                                                 | Predictive Power Dependent on                                                                 |
|------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| Risk analysis    | Easy to perform the underlying analysis because it is a structured method; everyone can contribute; generally little need for collecting additional data | Quality of the analysis outcome dependent on the selection and insights of the participants; propensity to focus on concrete; often technical risks and overlook less tangible issues; danger of not updating the analysis to capture dynamics of risk issues | Type of project where technical/immediate risks are of importance for project success        |
| Stakeholder analysis | Easy to perform the underlying analysis because it is a structured method; encourages the project to consider broader issues | Quality of the analysis outcome dependent on the selection and insights of the participants, easy to overlook stakeholders not encountered in previous projects or downplay the importance of some stakeholders, danger of not updating the analysis to capture dynamics of stakeholders | Whether the analysis identified the right stakeholders and their future behavior and the complexity of the stakeholder situation |
| Project assessments | Wide selection of project assessment tools available, which covers many aspects and gives longitudinal insight if repeated at certain intervals | Give only one snapshot assessment if performed only once, usually a need for collecting additional data, requires knowledge about the method. The results not always lead to actions for dealing with the identified early warning signals (according to case study results) | The choice of assessment method and the frequency of analysis |
| Performance measurement | Provides continuously updated data that encourage frequent analysis; continuous data allows keeping track of developments, puts focus on issues covered by measurements | Often a need for collecting extensive amounts of data; for some issues not easy to find relevant data, risk of overlooking issues not covered by the measurements (black swans) | The choice of performance indicators |

(Continued on next page)
A Review on Possible Approaches for Detecting Early Warning Signs in Projects

Table 3: (Continued)

| EWS Source                          | Strengths                                                                 | Weaknesses                                                                 | Predictive Power Dependent on                                                                 |
|-------------------------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| Brainstorming from team insight     | Easy to perform because it is a "simple" analysis; no limitation on issues that could come up; everyone can contribute and generally little need for collecting additional data | Based solely on previous experience, risk of overlooking issues outside the contributors’ mindsets, danger that some people can dominate the exercise | The team's experience                                                                          |
| Cause-and-effect/root cause analysis| Looks for early triggers of undesired events or developments, uncovers relationships between triggers leading up to events | More complicated analysis because it requires creative backtracking from undesired event, relies on different analysis methods; typically a need for collecting additional data | The identification of undesired developments/events and the interpretation of the connections along the chain of cause-and-effect |
| Interface analysis                  | Looks for issues in the "white space" of the project that might otherwise go unidentified | Provides only a first indication of potential issues, but gives no method for monitoring these issues | People looking for interface issues and transparency about the project, the complexity of the project |
| Extrapolation from previous projects| Relevant source of issues in cases of similar projects, sources for this knowledge often found internally in the organization | Danger of indiscriminately applying findings from previous projects, often relies on tacit knowledge | Similarity of projects and their conditions                                                       |
| Extrapolation from previous projects| Relevant source of issues in cases of similar projects, sources for this knowledge often found internally in the organization | Danger of indiscriminately applying findings from previous projects, often relies on tacit knowledge | Similarity of projects and their conditions                                                       |
| Project characteristics             | Counters the tendency to assume that all projects face the same issues; provides a basis for benchmarking against relevant other projects | Specific analysis method or checklist does not exist | The accuracy of the characteristics profile developed                                               |
| Maturity assessment                 | Analyzes underlying factors influencing project success, focuses on issues not covered by any of the other sources | Doubts about the accuracy of the measurements, relies on subjective assessments by individuals; must collect large amounts of data | The accuracy of the measurements and the correlation between maturity profile and project success |
| Earned value management             | Easy to generate frequent measurements; uses partly objective data        | Uses partly subjective assessments of completion, targets only the issues of cost and performed work | The accuracy of the subjective assessment of completion                                            |
| "Gut feeling"                      | Independent of analysis methods with a specific focus; can capture issues otherwise overlooked; detects issues that are not easily covered by formal approaches; not preoccupied with looking for specific indicators (according to case study results) | Can be difficult to prove validity of issues; no awareness as to what to look for (according to case study results) | The experience and background of people involved; the persuasive power of the person identifying an issue and the openness of the rest of the team |
| External factors                    | Looks at the whole context of the project, could capture issues otherwise overlooked | Focuses on issues that can be difficult to predict the developments of, if only analysis undertaken; risks overlooking internal factors | The correlation between the external factors and project success                                    |

Table 3: Strengths and weaknesses of different early warning sources.
First of all, we must once again remind the reader about the obvious fact that projects are very different, and that the singular conditions must be analyzed in every single case. The conditions and settings may differ so much that there are in fact no single and definitive favorites or one most promising source for identifying early warning signs. Nonetheless, we would like to point to some of those sources, which we believe are quite promising. Performance measurement seems to offer some quite promising toolsets that, when wisely applied, may prove to be useful as sources for EWS. Also, we consider that maturity assessments may offer potentially valuable indicators of possible weak areas for the project. We also believe that by analyzing suitable project characteristics, we can have a simple early sign of possible project challenges. It should be emphasized that this will most likely have to be used in combination with other EWS.

Conclusions
In this paper, we have explored to which degree there exist various possible approaches for identifying early warning signs in projects, many of which are not mentioned directly as an early warning source in the literature. The choice of the right approach is of course very much dependent on the project itself, the project organization, and the project context. We have endeavored to categorize the various early warning identification approaches. This has been done based on the type of data that can be gathered by implementing the specific approach, the type of analysis required, the focus point, the source of data, and finally, the particular phase in which the approach can be used as an early warning source. The results show that each approach has its own strengths and weaknesses. The choice of approach in a given project will be up to the discretion of the project management team, in order to exploit as many early warning signs as possible and timely enough to be able to take preventive actions. The choice of the most effective approach is for sure dependent on the type of project, organizational culture, and the project environment.

We have also briefly described our findings from several case studies on the use of early warning detection approaches which we have been involved in. Our findings are based on practical experiences from the implementation of various methods in real life cases.

We would like to move our future research forward as follows:

• Trying to test as many approaches as possible in different cases in order to reach a concrete statement on the level of usefulness of each approach and its strengths and weaknesses in practice. We would like to do this through introducing the possible early warning approaches in various case projects or having project managers put them to use and reporting their experiences.

• Having identified the possible early warning identification approaches, we would like to show how various sources can be combined to gain the most advantages with the least effort.

• Gathering this information we would like to evaluate how the implementation of an early warning system contributes to overall project performance and its success.

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