## 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 can aid project managers in taking corrective actions timely enough for preventing failures. The study is based on a review of 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 application in different contexts is also performed. Authors 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

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1. **Introduction**

Despite the improvements in utilization of project management tools and techniques in the recent years, still quite a significant number of projects 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 failure, and we can also see a number of signs of the failure. Those signals, with the benefit of hindsight, often appear as 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 (see for instance Ansoff (1975), Nikander (2002) and 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 as an area that should be looked into more closely, and we hope this article will contribute to this.

The aim of this article is to create a conceptual understanding of the extent of approaches available for identifying early warning signs. This will be done through reviewing 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 possible strengths and weaknesses of them.

The main research questions to be answered in this article are: 1) Which approaches for detecting early warning signs exist and how can these 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 that is presented here is partly based on review of 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, but on the other hand we also acknowledge the influence from our world view on our research. In the next part of the research, we draw on 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 meaning that the phenomena we observe are interpreted as social constructions not being independent from the people that are 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.

1. **Literature Review on the Concept of Early warning**

The general idea of early warning is a broad concept. It applies to almost any area where it is important to obtain indications as early as possible of some development that in the future will become clearer, usually of a negative nature. In this section we will briefly go through the limited work that has been done in this area and try to develop a path for further investigation.

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 signs 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, page 20). The main idea is thus that even unexpected discontinuities are indicated by some warning signals. But there have been some doubts and criticism of this theory. 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. It is difficult to believe in them; in fact they are uncertain, irrational and not credible. But on the other hand, several other authors have described the same core idea using slightly different terms, for example symptoms, early indicators, soft form of information, and early warnings (Mintzberg, 1994; King, 1987; Juran, 1995). 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 like the formation of a low pressure system or an increased concentration of a certain type of algae could be easier. In Nikander’s words (2002, page 49) “an early warning is an observation, a signal, a message or some other item that is or can be seen as an expression, an indication, a proof, or a sign of the existence of some future or incipient positive or negative issue. It is a signal, omen, or indication of future developments”.

Not surprisingly, there is an abundance of articles, reports, and web pages dedicated to or dealing with early warning in many different sectors. In the next section, we will review some of these when looking into specific approaches to early warning systems.

1. **Literature Review on Early Warning Approaches in Project Management**

According to Nikander (2002), which is consistent with our own findings, very little literature exists that deals explicitly with early warning in projects and project management. But the project management literature, according to Nikander (2002), does include some statements which are possible to interpret as examples of early warnings. For instance, Kerzner (1994), Cleland (1994) and Zeitoun & Oberlender (1993) have pointed to this phenomenon in their studies.

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 like risk symptoms and the occurrence of symptoms and issues. According to Nikander (2002), since 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. (2006) 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, which are meant to be advance warnings of emerging problems. A knowledge transfer system was proposed as a solution to recurring risks in project, a system that would partly collect and store large amounts of experience from relevant projects, analyze risk causes and mechanisms, and establish these risk alarms. The book deals with how such a system could be developed and implemented, but does not elaborate further on the risk alarm approach.

Another large body of literature in the project management field deals with so-called project success factors, or sometimes their inverse, project pitfalls. This topic was also extensively researched by Nikander (2002) who listed a number of key publications on the topic. Important work includes Baker et al., (1983), Pinto and Slevin (1987; 1988), Pinto and Kharbanda (1995), Lewis (1993), Cleland (1994), Harrison (1993), Lim (1987), Keil and Montealegre (2000) and Miller and Lessard (2001). Similarly, on project problems or pitfalls, some relevant material can be found in Nikander and Eloranta (2001) and Nikander (2002), where compilations of typical project problems were presented, while both Kerzner (1994) and Lientz and Rea (1995) discussed cause-and-effect (cause-and-problem) chains in projects.

There is much literature outlining ways to ensure that success factors are promoted or pitfalls avoided. The recommendations range from specific tools like project planning and stakeholder analysis to good advice about communication, leadership, and other soft management skills. Paying attention to these signs, earlier in the project, is believed to increase the probability of successful outcomes. However, still very little seems to focus on the early warning aspect of trying to detect either the absence of success factors or movement toward pitfalls. To the extent that the different empirical studies of successful or failed projects have been able to identify truly generic issues, these should represent a suitable platform for developing early warnings. Thus, it is perhaps a little surprising that little work has been done pursuing this idea.

Earned value management (EVM) is mentioned to be another approach which provides triggers or early warning signals (Fleming & Koppelman, 2000). According to Vanhoucke (2012) the earned value management system relies on a set of metrics which 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 an 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 early warning term, but emphasizing its usefulness as a tool which enhances proactive problem solving (Brandon, 1998; Anbari, 2003, Lipke et al., 2009; Vanhoucke, 2010). Lipke et al. (2009) mention this method as a predicting tool for projects’ final outcome. They claim that it can actually start predicting the outcome as soon as 10% of the project is completed and thus give the project managers a good time for taking timely actions in case of negative predictions.

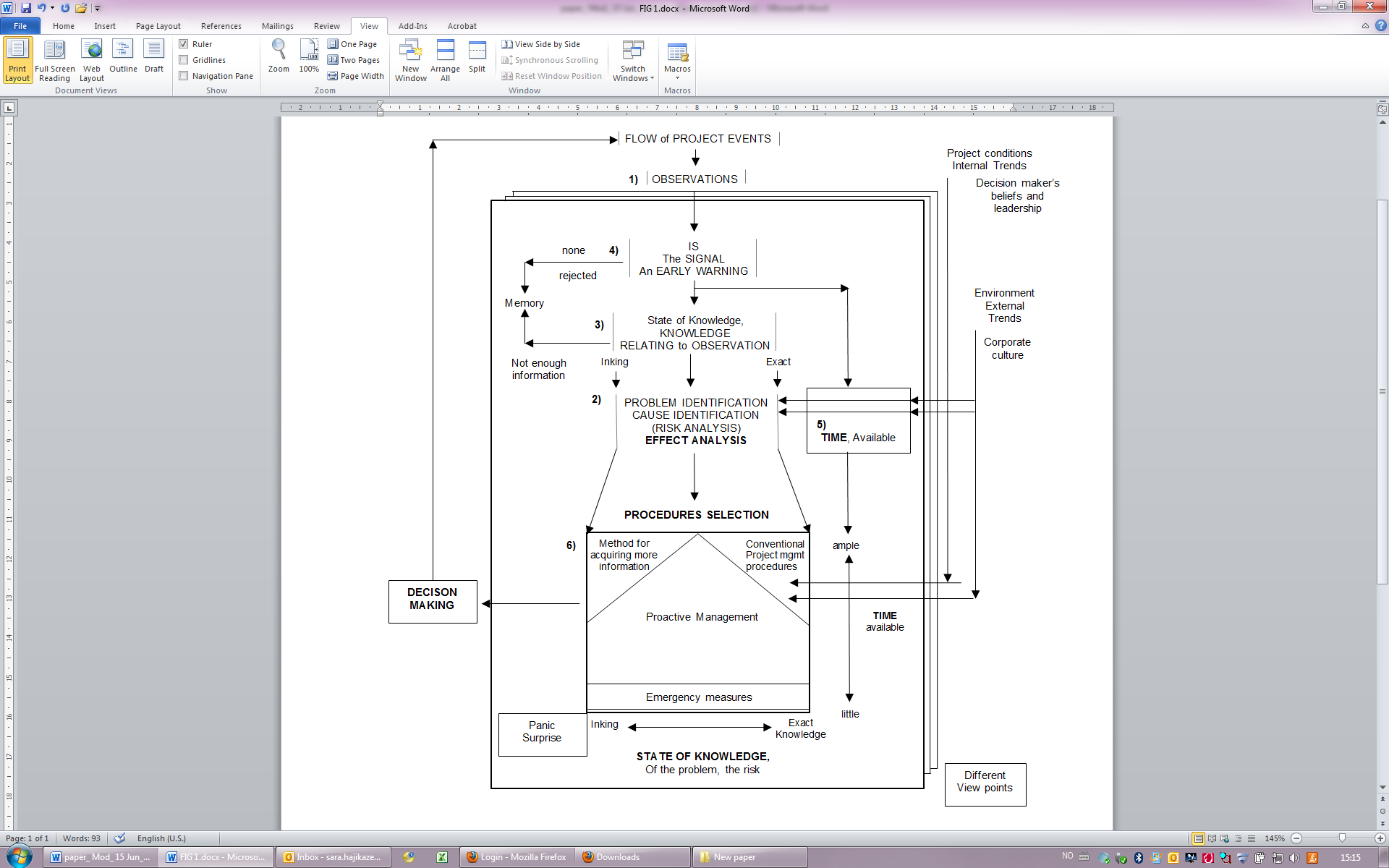
Various project assessments have also been discussed as a way to identify areas that should be addressed by early warning monitoring. Project assessments go by many names, some of which are summarized in Table 1. Assessments can take place during the project initiation stage and up to the project mandate 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 pre-empt potential problems that make a project non-viable (Cooper et al. 1997; Cooper 2005; OGC 2007). However, as Flyvbjerg et al. caution (Flyvbjerg et al. 2002; 2003), 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.

**Table 1. Summary of the main types of project assessments (Klakegg et al., 2010)**

| Project Assessment Type | Characteristics | Cited authorities |
| --- | --- | --- |
| 1. Project reviews | Often undertaken beforehand through a staged gateway approval approach, also during and after the project as benefits-realization.  The characteristic of this category is that it is anchored in some sort of governance framework or institutional framework/decision making process. Can be formal and mandatory. | See Archer and Ghasemzadeh (1999) OGC (2007), Cooper et al. (1997), and Cooper (2005) |
| 1. Project health-checks | Often implying a more formal assessment, sometimes looking for fraud, often while the project is being undertaken, sometimes at set stages or ad hoc if there are suspicions that particular issues need investigation. Usually checklists and Key Performance Indicator (KPI) performance reports can be used. Other front-end review forms in infrastructure type projects include constructability reviews and value analyses. | See Shafagi and Betts (1997) for health checks. The Construct IT group, University of Salford, health check initiatives from the 1990s and Wateridge (2002) on project health-checks looking at the stakeholders’ view of the project success direction. For constructability, see Griffiths and Sidwell (1997) and McGeorge and Palmer (2002). For value analysis and value engineering, see Champion (2001) and Male et al. (2007). For diagnostics, see Jaafari (2007) |
| 1. Benchmarking | Benchmarking is a systematic comparison of two or more projects, analyzing quantitative aspects of project performance and/or qualitative descriptions. Quantitative data can be cost and time information, PDRI evaluations, etc., while qualitative information can encompass objective formulations, stakeholder assessments, environmental impact descriptions, etc. In the early stages of a project, benchmarking is typically used to compare project proposals competing for scarce resources, in order to determine which is most likely to succeed and give high return on investment. Benchmarking can also be used to obtain realistic estimates, learn how other projects have solved certain problems, or rank projects after completion. | Not very much literature exists; one of the first applications of benchmarking to projects was done in the IMEC project, started in 1995 and documented in Miller and Lessard (2000). Emhjellen (1997) discussed the adaptation of industrial benchmarking to project benchmarking in his PhD thesis, and PDRI is in itself a tool for benchmarking. (CII also runs a benchmarking service.) |
| 1. Post-project evaluations | After the project as a project history | See Kleiner and Roth (1997) Roth and Kleiner (1995) and Schindler and Eppler (2003) for project histories. See Maqsood et al. (2006; 2007) for literature reviews and focus on knowledge chains. |
| 1. Project Audits | A formal assessment looking for accordance between what is done and some regulations, decisions or systems, and sometimes looking for fraud. Often while the project is being undertaken, sometimes at set stages or ad hoc if there are suspicions that particular issues need investigation. Sometimes ex post. In many circles, the word “audit” has a quite specific meaning, sometimes enforcement by law (e.g., the UK National Audit Office). |  |

One reference discussing the link between project assessments and early warning signs in some detail is Klakegg et al. (2010) where it is shown that results from such assessments can be used to determine early warning signs before it is too late, allowing projects to be successful in delivering the expected value for their owners and other stakeholders.

One of the most distinct approaches is the key contribution from the doctoral dissertation of Nikander (2002), whose precursor was also described in Nikander and Eloranta (2001), a decision support model of early warnings, shown in figure 1.



**Figure 1. Nikander's approach to early warning (Nikander,2002)**

In this model, the flow of events in the project forms the main source of information, of which observations are made by persons inside the project organization. Some of these observations can represent an early warning, most observations do not. This is determined through an analysis of the observation and knowledge about the project. For observations deemed to constitute signals of future problems, the rest of the process follows more or less a traditional risk management procedure of analyzing possible effects of the problem and developing different types of responses. The model says very little about how to make the required observations of the flow of project events. However, the model is accompanied by an extensive set of typical early warnings of different problems, derived from empirical and literature studies performed by the authors. This is perhaps the most helpful piece of information to practitioners attempting to implement an early warning system.

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 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 that there are many fields where this topic is pointed 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 be able to make a statement on how early warnings can be detected in a systematic way. The specific topics we will look into are stakeholder analysis, brainstorming, maturity measurement, cause and effect analysis, interface analysis, extrapolation from previous projects, and gut feelings.

1. **Literature Review on Overlooked Possible Early Warning Approaches**

One of the sources that does not directly refer to the early warning concept, although being quite related to its identification throughout the project, is stakeholder analysis. Any project will in some way or other have an impact on its surroundings; otherwise there would not be much point in carrying out the project in the first place. 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 PMI as (PMI, 2000, page 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, (see for example Savage et al., 1991; Cleland, 1986; Karlsen, 2002) but they have clear similarities and include activities to identify the project’s existing and presumed future stakeholders, classify the identified stakeholders according to some criteria, delve deeper into each stakeholder to 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 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. Diehl and Stroebe (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 long 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 product and organizations alike, although it might be argued that organizations never reach a state of full maturity. Maturity measurement has over time become quite common and several different maturity models have been proposed, including for project management. The idea is that through assessing the fundamental skills of an actor, the quality of the actor's work and contributions in specific projects could be predicted. Later, the model has 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 naturally to consider these targets for early warning monitoring.

To extrapolate from earlier projects is a way of utilizing 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 utilized in order to identify early warning signs. See for instance 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), where 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 since this topic focuses on causes and origins of issues, it is closely related to success and failure factors in projects. Nikander (2002) argued about the common causes of failure of projects and their effects on the project success. He concluded that project problems and their causes are at least to some extent parts of the same factor group even though they can be interpreted differently when observed from different points of view or at different times. In addition he provided a model indicating that problems, their causes and early warnings are connected through a chain. This phenomenon is claimed to be similar to the one observed in project risk management results. 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 identification of risks in advance in order to prevent future problems (Leszak et al., 2000; Parker & Skitmore, 2005; Sambasivan & Soon, 2007; Ohatka & Fukazawa, 2009; Williams et al., 2012).

In addition to the EWS that can be identified through project assessments, another category of signs can be denoted "gut feeling" signs. These signs are by Nikander and Eloranta (2001) described through the statement: "anticipatory feelings are the least easy to detect, identify and interpret, intuitive feeling" (page 387). Klakegg et al. (2010) are making a very simple categorization of EWS, where they are either identified through assessments or they are based on "gut feeling" (see also 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/conditions of a project.

The last approach we will refer to is interface management, described by Cleland and Morris (1988) as an element which serves as a natural check point for managers in order to monitor the performance and thus prevent problems from falling into a snowball process. Calgar and Connolly (2007) defined it as a means for 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 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 a source 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.

1. **Industrial Experiences on Application of Early Warning Detection Approaches**

Having been involved in case studies performed as part of various pieces of research, we will here 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 public and private sectors) with different 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 which 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 having a different range of projects according to their size, complexity and task uniqueness. It is clear that the most important early warning signs identified in the early stages and during project execution are shown in table 2).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 feeling” approaches.

In general the case studies suggested further possibilities for 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. Also there were suggestions on more reliance on personal antennas than on systematic analyses and other assessments.

Table 2 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 type of indications mentioned in the right column, unless being very much aware of their potential as early warning signs.

**Table 2. Additional important early warning signs from case studies, sorted according to the way they are expected to be detected (Klakegg et al., 2010)**

|  |  |
| --- | --- |
| Through assessments | Based on “gut feelings” |
| * The numbers or information missing * Assessments not performed / documentation not completed * Plans and reports delayed or unclear * Contract obligations not fulfilled * Milestones / activity definitions unclear or missing * Lack of an implemented governance framework | * Lack of culture of openness and good communication between the actors * Strained atmosphere * Evaluating the reality of needs * Inconsistent arguments about agendas * Changes in positions over time * 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 |

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 identification of relevant issues, can be a waste of time and effort. However some experiences showed that the exercises themselves were most important due to their allowance of crucial questions to be raised early.

In addition it was found that dialogue and organizational culture play a key role 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 the strength of it since it is not preoccupied 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 evaluate their usefulness, strengths and weaknesses in practice.

1. **Discussion and Analysis**

As stated earlier, we have been unable to locate a systematic and coherent documentation of where projects can turn for information that allows identifying issues and potential problems that could be worthwhile tracking through the use of early warning signs. This section of the paper discusses a wide range of sources for such issues and analyzes these in terms of the nature of each source as well as strengths and weaknesses of each.

1. **Sources for Identification of Issues that Warrant Early Warning Monitoring**

Under this heading, we aim to present the broadest possible spectrum of sources for early warning signs. These sources originate through two primary channels:

* Literature that deals with early warning and related topics, as presented in the literature review section of the paper.
* Case data from industrial projects where we have been involved as researchers/advisors in the process of implementing early warning measurements.

The purpose of outlining this spectrum of possible sources is to systematize currently fragmented knowledge. But 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 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). Table 3 presents all the approaches that we will describe in detail in the subsequent sections.

**Table 3. Categorization of early warning sources directly and indirectly addresses in the literature**

|  |  |
| --- | --- |
| Sources Directly Mentioned in Literature as Early Warning Detection Approaches | Sources Indirectly Mentioned in Literature as Early Warning Detection Approaches |
| Risk analysis | Stakeholder analysis |
| Earned value management | Analysis of brainstorming data |
| Project review assessments | Maturity assessments |
| Performance measurement data | Analysis of previous projects |
|  | Cause – and – effect analysis |
|  | Gut feeling |
|  | Interface analysis |
|  | Analysis of project characteristics |
|  | External factors |

* + 1. **Sources Directly Mentioned in Literature as Early Warning Detection Approaches**

First, 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 obviously be linked to early warning efforts, and risks identified represent issues for which early warning signs can be developed, as illustrated in Figure 2. 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 utilized, to the extent previous projects are similar to the current one.

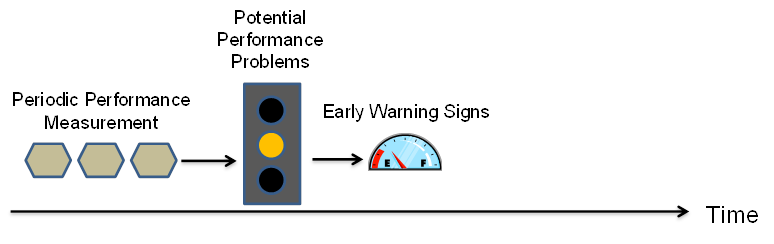


Figure 2. Risk analysis as source for early warning signs

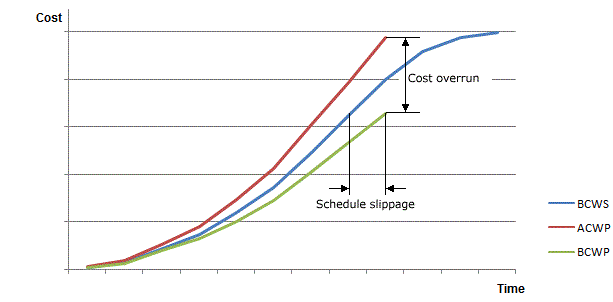
Earned value management is mainly focused on keeping track of time and cost-related issues in a project. This is done by periodical measurements of project progress over time, both in terms of cost and time, and presenting a comparison between the key parameters of the earned value method; planned value (PV), actual cost (AC) and earned value (EV). By periodically measuring these parameters and assessing the amount of exceedance, 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. This procedure is illustrated in figure 3.

Early Warning Signs

Time



Periodic Measurement of Thresholds



Exceedance of Limits

Figure 3. Earned value management as source for early warning

Project assessments is a somewhat imprecise term by which we mean various types of reviews/audits/status checks the project is subjected to, and that 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, as portrayed in Figure 4. 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.



Figure 4. Project review assessment as source for early warning signs

Performance measurement is a common label for various efforts to periodically collect “performance” data about the project, but which 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, as shown in Figure 5. If periodic measurements indicate construction site safety issues, this a development that should be analyzed in an early warning light in terms of 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.



Figure 5. Performance measurement data as source for early warning signs

* + 1. **Sources Indirectly Mentioned in Literature as Early Warning Detection Approaches**

Stakeholder analysis insights are fairly obvious sources; 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, as shown in Figure 6. 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.



Figure 6. Stakeholder analysis as source for early warning signs

Brainstorming based on the project team’s insight is arguably the most frequently used source for early warning signs, where (parts of) the project team simply build 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 usages; 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. Irrespective of the process and specification level of the outcome, the factors identified can in the next turn be subjected to monitoring for signs that they are about to materialize and bring about serious problems, illustrated in Figure 7. An example; a project to build a new hospital identifies the development of new PET-scanning technology as a potential problem if the new 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.



Figure 7. Analysis of brainstorming data as source for early warning signs

Maturity assessments, which could be viewed a specific subset of project characteristics analysis, focuses on assessing the maturity of various aspects of a project and its context, e.g., the “maturity” of a project proposal (using for example CII’s PDRI tool), the maturity of the project organization, or the “quality” (or existence) of the project methodologies in use by the project organization. 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 either the development of these areas as the project progresses and/or, possibly even more useful, indications that these weaknesses are in the progress of leading to specific problems, see Figure 8. 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, etc. Early warning signs can be linked to these activities to ensure satisfactory progress early enough.



Figure 8. Maturity assessments as source for early warning signs

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 (in terms of goals/what to deliver, range of stakeholders involved, technology, political setting, etc.) but also seemingly very different projects can have characteristics that coincide with the project in question and offer learning points. No matter how close such other projects are, 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, etc., interviews with people who were involved, formal databases, and the experience of people in the current project who were also part of relevant past projects. Like the interface approach, this is also a two-stage exercise; first problems that have occurred in past projects (or started to occur but been thwarted) must be found, second causes/triggers of the problems must be identified to allow developing early warning signs, as shown in Figure 9 (thus, knowledge from previous projects can be used as input to a cause-and-effect analysis). An 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 dialog with the supplier, certain "maverick" people lead the supplier's team, etc., and these can then be monitored through suitable indicators/observations.



Figure 9. Analysis of previous projects as source for early warning signs

Cause-and-effect analysis and root cause analysis are well-known techniques from the quality management field that 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, as pictured in Figure 10. An 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 stakeholder needs. Thus, early warning monitoring could focus on the degree to which stakeholder needs have been mapped and understood.



Figure 10. Cause-and-effect analysis as source for early warning signs

"Gut feeling" is not a scientific term, but it seems to be quite prevalent in projects looking for potential future problems. This is closely linked to brainstorming, more specifically in that gut feeling and instinctual responses of project team members involved in such brainstorming exercises represent an important, deliberate or not, source of brainstorming ideas. As such, gut feeling does probably 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 antennas rather than systematic analyses. Being gut feelings, i.e., "irrational" assumptions or fears rather than risks stemming from a structured analysis process, such factors can often be easy to overlook, even if there are many examples of cases where such warnings have gone unheeded and created massive problems. Nevertheless, 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, as portrayed in Figure 11. An example; a geologist on a project team has doubts, albeit unfounded in terms of evidence, that the rock conditions of a tunnel site might be difficult. The hesitation is caused by long experience and conditions of similar sites encountered in the past. Extreme reactions on the part of the project can be extremes of either canceling the whole project or moving the location of the tunnel on one hand, on the other hand simply ignoring the input. A better approach would be to implement a procedure for doing more extensive geological investigations ahead of the tunnel progress to allow detection and handling of difficult conditions.



Figure 11. Gut feeling as source for early warning signs

Interface analysis is an approach that builds on the fact that many project problems appear in the “white space” at interfaces between technical systems, disciplines of people, actors, etc. Being aware of such interface “hot spots” can therefore represent a potentially powerful source of early warning signs. Extracting such signs can be done in many different ways; from less structured reviews of technical, human, contractual, etc. types of interfaces that can be foreseen and trying to anticipate which of these can cause future problems (again an approach that in principle seems similar to risk analysis) to applying more specific analysis techniques such as FMEA (Failure Modes and Effects Analysis) and related variants, fault trees, etc. Having identified potentially problematic interfaces, early warning signs with predictive power to identify when these develop into real problems must be found and monitored, as illustrated in Figure 12. This latter task can often be more difficult than finding interface hot spots, and some projects settle for monitoring the volume of unresolved interface issues as an early warning sign itself, rather than developing specific early warning signs for each of them. The thinking behind this approach is that several trends could be alarming, e.g., the total volume of interface issues increases and the project seems unable to resolve them or after an initial growth face, no new interface issues are identified, a possible sign that people underreport and issues remain hidden.



Figure 12. Interface analysis as source for early warning signs

Project characteristics analysis is a very little precise term, but here we think of various analyses/assessments that projects are frequently subjected to in order to determine certain characteristics of them, e.g., degree of complexity, degree of physical distribution, degree of novelty, etc. In some cases, there are more specific "tools" available (e.g., team measurement instruments), for other characteristics sets of indicators have been developed (e.g., project complexity or degree of distribution of a project team), and 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, as shown in Figure 13. For example, a project determined to being heavily dependent on the development of new technology should be subjected to close monitoring of innovation progress while a heavily distributed project team could monitor aspects like extent and quality of communication, goal alignment, etc.



Figure 13. Analysis of project characteristics as source for early warning signs

External factors are yet another example of issues that could come up through risk analysis, stakeholder, analysis, etc., but we include this as a final item since 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, etc. Common for all are that the triggers of problems for the project originate outside the project, sometimes completely outside its sphere of influence, in other cases the project has some possibility to influence them. In any case, keeping a watch for such external factors and problems they could cause is a natural part of an early warning approach, as shown in Figure 14. 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 till 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 form of larger projects gearing up for tendering, are a natural response from the project.



Figure 14. External factors as source for early warning signs

We do not claim this list of various sources to be exhaustive, but believe it to cover 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 interlinked 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 nature, pros and cons, and how they can best be applied and possibly combined.

**4.2 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 4. For each of the EWS sources, a categorization has been done of the type of data that is used, the data sources that will typically be utilized, and what kind of analysis that is performed. Furthermore, the table gives a classification of the kind of issues that are focused on in the process, and it shows in which project phase that each of the EWS sources will typically be useful. The information in the table is all given on a very broad and general basis, and should therefore be used with great care and a good portion of critical judgment in any specific situation.

**Table 4. Categorization of different early warning sources according to various aspects**

| EWS Source | Type of Data [[2]](#footnote-2) | Type of Analysis | Focus/Type of Issues | Data Sources | Project Phase |
| --- | --- | --- | --- | --- | --- |
| Risk analysis | Hard and soft, qualitative and quantitative | 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 | Structured process of qualitative analyses | 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 | Snapshot analysis of project status | Internal and external problems | Internal and external project data | All phases |
| Performance measurement | Hard and soft, qualitative and quantitative | Continuous analysis of project performance | Trends indicating internal and external problems | Internal and external project data | All phases |
| Brainstorming from team insight | Soft, qualitative | 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 analysis | Hard and soft, qualitative and quantitative, 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 | 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 | 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 | 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 | 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 | Calculation of earned value | Shortcomings in value creation | Resource consumption data, assessment of task completion | Project execution |
| “Gut feeling” | Soft, qualitative | Creative exercise | Potential internal and external problems | Individual participant judgment, previous projects | All phases |
| External factors | Hard and soft, qualitative and quantitative | Identification and analysis of external factors | External factors that could negatively influence the project | Contextual data | All phases |

In the next table, we have summarized the most typical/common strengths and weaknesses for each of the EWS sources. The table also pinpoints the most important factors that the predictive power of each of them will depend on.

**Table 5. Strengths and weaknesses of different early warning sources**

| EWS Source | Strengths | Weaknesses | Predictive power dependent on |
| --- | --- | --- | --- |
| Risk analysis | Easy to perform the underlying analysis since 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 since 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 that covers many aspects, give 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 encourages frequent analysis, continuous data allows keeping track of developments, puts focus on issues covered by measurements | Often 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 |
| Brainstorming from team insight | Easy to perform since it is a “simple” analysis, no limitation on issues that could come up, everyone can contribute, generally little need for collecting additional data | Based solely on previous experience, risk of overlooking issues outside the contributors’ mindset, 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 since 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 |
| 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 |

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. However, we would like to point to some of those sources that we believe are quite promising. Performance measurement seems to offer some quite promising toolsets that when case 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.

1. **Conclusions**

In this article, we have explored to which degree there exists 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, in order to exploit as many early warning signs as possible 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 that we have been involved in. Our findings are based on practical experiences from implementation of various methods in real life cases.

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

* Try to test as many as possible approaches in different cases in order to reach to 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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1. Correspondence will be directed only to the first author listed. [↑](#footnote-ref-1)
2. “Hard issue” or “formal dimension “refers to technical managerial aspects which consists of formal integrative mechanisms through tools and techniques and “soft issue” or “social dimension” refers to the dynamics and complexities of human side of the project (Mustafa and Bowels, 2005) [↑](#footnote-ref-2)