Monitoring Risks in Large Software Development Programs
An Experience Report from Ericsson

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Abstract—Identifying and mitigating risks in early phases of software development helps practitioners to avoid unexpected negative outcomes and better use emerging opportunities. Over the past 30 years several risk management approaches have been proposed and sophisticated risk management tools have been developed to facilitate software development risk management activities. In addition to those, scholars in the field have identified and discussed commonly occurring risks and mitigation strategies for in software development. However, as scales of software development products grow, risk management activities are facing new challenges. In large software development programs, which contain several interconnected projects, it is not always straightforward to understand in which projects a risk is identified, in which projects it has high impact, and in which projects it should be mitigated. The communication loop between the projects is long, and therefore risk management activities are far from being optimal. In this paper we propose a method for monitoring risks proactively. The method offers a minimized communication loop between interconnected projects, when conducting risk identification and monitoring activities.

Keywords—risk management; risk assessment; monitoring software project; software program;

I. INTRODUCTION

Risk management in software development projects is a strategic activity, which ensures proactive response to adverse events that can inflict monetary or reputational loss. Boehm [1] was one of the pioneers who proposed a standard lexicon of risk management in software development projects. He also identified the most common risks that occur in software projects, which served practitioners as standard reference for many years [2]. Following Boehm several risk management approaches and tools were proposed. Notably, continuous risk management approach was proposed by Higuera and Haimes [3] and riskit method was proposed by Kontio [4]. This works have been influential for organizing modern risk management activities in software projects, and our case study at Ericsson is not an exception. There are also relatively recent studies whose endeavor was focused on addressing the current challenges of risk management in software development. Examples are [5-7]. These studies investigate risks that are intrinsic to software projects, therefore they bring new insights in software risk management.

Despite a number of methods, experience reports, and tools that are to facilitate software risk management, the problem of scale does not seem to be addressed. When several software projects are incorporated into a large scale software development program, a new challenge of risk management emerges, that is, how to effectively monitor risks of the whole program. The problem is that even though there is good knowledge on how to identify, assess, and mitigate risks, it is not always clear in which projects risks are identified, on which projects they have high impact, and whose responsibility the mitigation planning is. In our experience, we have seen that the same risk can be identified independently in several of the projects in a program context. And since there is long communication loop between the project risk facilitators, multiple mitigation strategies can be planned. The program management, in their turn, can identify the same risk in the program level, and plan their own mitigation strategy. Since all the projects are in the same program, it is usually the case that any identified risk should be mitigated only ones and only by one of the projects, therefore multiple mitigation usually cause unnecessary cost and effort to the program. To avoid the unnecessary efforts we conducted this research in order to solve the presented problem. Research question addressed here is as follows:

How can we proactively monitor risks of software development programs?

To create a method or an approach for the presented problem we conducted a case study research in a large software development program at Ericsson. Unobtrusive measures were used to collect data from the management and particularly from the risk management documentations from the program, in order to understand the organizational
structure, dynamics, and risk management tactics. As a result of this research a method and supporting checklist for program risk monitoring was developed. The method allows to keep track of all program risks proactively, and to eliminate the possibilities of multiple mitigations. Initial evaluation of the method showed that it is simple to use and can be a handy tool for a program risk facilitator. The tool can be used by such organizations which avoid using commercial risk management tools due to high administrative efforts, but rather use simple local checklist-based tools.

II. BACKGROUND

In 2012 Ericsson launched a variety of new mobile money services, which are called Ericsson Money Services. Ericsson Money Services was initially launched and operated in seven European countries: Sweden, UK, France, Germany, Italy, Spain, and Poland. This was the first step by Ericsson in order to expand the service availability to the rest of Europe and also in a word wide range and become a global service in the future. Through Ericsson Money Services Ericsson aims to provide a full suite of convenient, cost-efficient, secure, and instant mobile financial service to consumers globally. Users can sign up and create easily a safe and secure online mobile wallet. They are able to access their money safely from the Ericsson Money Services network through their mobile phones in order to send, receive money from and withdraw cash. All the transactions described above are done through a network that connects the electronic money wallets with different telecom operators and banks across the world. The whole process of money transaction via Ericsson Money Services is done with an SMS message. The user can send a simple text from wherever he/she is located to another person who lives thousands of miles away.

Using a simple scenario here we describe a possible money transaction using Ericsson Money Services in order to provide the reader with an outline of the service operation.

Suppose that Ida, who lives in Sweden, wants to send some money to her friend Jane, who lives in UK. Both the two friends need complete the registration process to the service and provide the required information in order to complete the secure process, using their mobile phones. After, Ida needs to fill her account on her mobile wallet by providing her credit or debit card and bank account. Eventually she can load say 1000 SEK from her bank account to her mobile wallet. Instead of waiting around three days for the transaction via a banking system, she can perform a few clicks on her mobile phone and the money instantly will be transferred to Jane’s mobile wallet together with an SMS confirmation.

Figure 1 visualizes the money transaction described above. In fact such a simple transaction involves many parties in different countries. Ericsson Money Services is involved in a complex relationship with all of these parties, and therefore there are many risks involved in this business. Telecom operators, banking systems, and rules and regulations of different countries create a complex environment with a complex system for money transaction management.
As the reader might notice, the visualization is done for only two countries, two banking systems, and two telecom operators. When the number of parties are increasing, the complexity of the problem is immensely increasing, thus the risks and opportunities are immensely increasing.

III. PROBLEM DESCRIPTION

Ericsson Money Services had a number of large projects implementing different parts of the system. Generally when different projects move towards the same goal, they may have one coordinating center called program. A program is an organizational structure which aims to create a business value and includes several interrelated projects. Ericsson Money Services is such a program. In such organizations risk management is a complicated task due to the complicated relations of the projects inside the organization. For this reason it is sometimes hard to make optimal decisions for the mitigation activities.

In our case, the program and its projects needed to keep track of risks, opportunities, and risk dependencies among projects, so all the risks can be mitigated effectively, and all the opportunities can be used beneficially. The term of dependencies refers to the following two dependencies:

- The dependencies of risks that emerge in different projects running under the same program
- The dependencies of projects due to common risks

Due to dependencies, there were the following problems of risk management in the program and in its projects:

- A risk that emerged in one project, could impact other projects also, however long loops of communication between the projects did not allow risk facilitators to be informed and to manage such risks effectively.
- The same risk could be identified in several of the projects, and due to lack of communication among projects, the risk could be mitigated in multiple places, inflicting unnecessary costs to the program.
- One risk that was identified in one project could be latent in another project. This case was particularly important, when the first project decided to accept the risk, whereas it could have significantly greater impact on the later project.
- Several risks emerged in several projects could be dependent on each other, and mitigation of one of the risks might automatically mitigate the other ones, however, due to long loop of communication between the projects and program effective mitigation might be compromised. The risks could also be depended in a way, that that mitigating one of the risks might increase the other risk. This was could be dependent on the selected mitigation strategy.

There was yet another dimension of complexity that hindered effective risk management in the program. There were external partners, such as telecom operators, and banking systems, with whom risk sharing activities needed to be established. This means that not all risks should be mitigated in the program. The program management, and in some cases even individual projects, needed to negotiate with their partners and decide who shall mitigate a given risk.

Figure 3 illustrates the risk dependencies between Ericsson Money Services Program, the including projects, and the external partners.
Projects have dependencies between themselves, with the program, as one general coordinating center, and with the external partners. The interactions between the partners were weak or none, so the figure does not show connections between the partners.

In the program some of the projects used Waterfall development methodology and other projects used Agile/Lean methodologies. In projects, which were run by Waterfall principles [8], risk identification and mitigation planning was conducted primarily in the beginning of the project and reviewed in every two months. In this projects risk management was a scheduled task. Whereas, projects which were run by Agile principles [9], did not have fixed risk management schedule, but rather conducted integrated risk management. In this projects, risk identification and mitigation planning was a part of project planning, so there was a more frequent attention on risk management.

There was also risk management activity on program level, which was conducted by the program risk facilitator. This was the only risk management activity where all risk facilitators from the other projects participated. In this meeting the participants presented risks of their projects and tried to decide who and how the risks should be mitigated. If a risk was project-specific, without affecting other projects, then the project was assigned for risk mitigation. However, if a risk was identified in several of the projects, or if several projects became dependent due to a risk or a mitigation plan, then they needed to discuss further and understand who and how the risk shall be mitigated.

Since every project had its own risk management activities and schedule, often risk management activities were carried out before the program risk management session. Asynchronous timing of risk management activities created a situation where it was not possible to conduct risk management activities of all projects at the same time. In the experience of Ericsson Money Services there were occasions when the same risk was mitigated in different projects with different mitigation strategies, being unaware of each other’s activities. More often risks identified in one of the projects had impact on some of the other projects, but the other projects were informed quite late. This situation delayed the necessary mitigation activities for the program. Therefore there was a need for more proactive way of dealing with risk identification and communication, so the communication loop between the projects and the program could be minimized.

IV. RESEARCH METHOD

Unobtrusive measures was applied to conduct this study [10]. The choice of method was mainly due to two factors:

- The program had rich documentations in which we could find everything related to how the projects are organized, how risks are managed in projects, who the participants are, etc.
- The program was very large and different projects and partners were located in different geographical areas, which hindered as to apply more interactive research methodologies such as case study or action research

Through these documentations we acquired all the information that was necessary when designing a method for program risk management: Particularly we learned the following items:

- Organizational structure
- Vision and missions
- Schedule of managerial activities
- Deliverables of projects
- Similarities and differences of projects
- Risk management activities in the context of managerial activities
- Risk identification techniques
- Risk Assessment methods
- Risk Mitigation planning
- Risk monitoring activities
- Historical risks and conducted mitigation
- The degree to which individual projects could take own decisions in the program
- The degree to which projects must comply with the program management
- Meetings and negotiations with partnering organizations

Despite the fact that unobtrusive measures were used for the research, we also had active collaboration with the Ericsson Money Services program manager. The program manager was the person who initiated the research with the authors of this paper, and he was the main stakeholder for the research results. Since the program manager had both high interest in the research results and mandate to get the necessary information we needed, we could access any data that was necessary for facilitating the design of the intended method. The program manager was also the risk facilitator on the program level, so he knew how exactly the risk management activities are carried out in the program.

In about four months of time we read all the documentations and understood the program operations in Ericsson Money Services. Accordingly we delineated several prototypes of methods that could be applied for effective program risk management. Afterwards, we presented the alternatives to the program manager to get feedback on the practical issues that risk facilitators could encounter when using the methods.

About three months we had biweekly meetings with the program manager to present the current state of the newly created method and get feedback. After the third month we developed a method and supporting tool for program risk
management. In the next two sections we present the method and the supporting tool correspondingly.

V. PROGRAM RISK MONITORING

In this section we present a method and practicalities for program risk monitoring. The method relies on an online Microsoft Excel-based checklist which is presented in Section VI.

In all projects and in the program risk facilitators used the same locally developed risk management tools, called MiniRisk. The tool was a Microsoft Excel-based tool, where all the risks were registered and mitigation strategies were planned. Every project had their own copy of the tool, thus registered risks from project to project were different.

Risk identification, assessment, and mitigation activities were done based on the principles described by Lichtenberg [11]. This means that Ericsson had well-established approach on how to identify risks, assess the monetary loss due to risks, and mitigate risks. Hence, when we introduced our method for proactive risk monitoring, we had already considered that the organization has a well-established risk management strategy.

A. A method for program risk monitoring

In order follow the here presented method we have created an online Microsoft Excel-based risk checklist. The checklist itself is presented in the next section in detail. However, the reader should know that the herein described method refers to the checklist. The following steps were introduced for effective monitoring of program risks:

Establishing a private risk management schedule

In every project the project risk facilitator establishes a project risk management workshop (depending on the project development methodology the frequency of risk management workshops in each project can differ).

Independent assessment of risks

The project risk facilitator, with the other participants, conducts risk identification and assessment in the project context. The mitigation activity, cost and later activities must not be specified yet.

Report to program level

In the program level, a dedicated online risk monitoring checklist should be created, which should be managed by the program risk facilitator. The checklist should be accessible for all project risk facilitators. All risks and the assessment results from all projects should be input in the dedicated checklist by project risk facilitators, so all risk facilitators can see all the risks in the program and in all the projects.

Reviewing Risks and Marking Dependencies

Every risk facilitator visits the online checklist in every two weeks and reviews the list of risks reported by others. During the review the risk facilitators find out such risks that have high impact on their project or are dependent with any other risks in their project. Then the risk facilitators fill in the following information in the online checklist:

- The level of impact of dependent risks on their own project
- Dependent risks with own project risks

Registering the necessary information in the online checklist

The program risk facilitator calls for a meeting for the risk management activity on the program level. During the meeting, all the risks that have either dependence with other risks or affect several projects are selected and analyzed. Then the participants assess the losses for each of the risks and agree which project is responsible for mitigating each of the risks.

During this meeting the program risk facilitator fills out the following information in the online checklist for each of the selected risk:

- Responsible project for mitigation
- Estimated loss (usually monetary estimates)
- Estimated mitigation cost
- Dependent risks if there are any
- Status of mitigation

After the session it should be clear which projects are affected by a given risk, how much the estimated losses are per project, which project is responsible for mitigating the given risk, and how much the mitigation cost is. The method also assumes that the program risk facilitator can call for a risk management session if there is necessity for it due to newly identified risks, which create project dependencies. Since all risks are input into the online checklist just in time of their identification, there might be necessity of urgent meetings with several of the project risk facilitators. This means that program risks can be monitored proactively, because risk related information is organized and information exchange between the projects is online.

B. Practicalities

We shall notice that the first two steps are standard steps that were already conducted regularly at Ericsson. The latter three steps are specified by us, the authors, for monitoring program risks. We shall also notice that the program risk facilitator already had program risk management sessions, where all the risk facilitators from the projects participated. This means that in our method we do not require an additional meeting or activity. In brief, the method offers an online program risk monitoring checklist, which we present in the next section. The method also requires that all identified risks should be input in the online checklist, so every participant can know the identified risks before the risk management session on the program level.

During the program risk management sessions the participants make decision on which risks that must be mitigated on program level and which ones that must be mitigated in the projects.
Since both the projects and the program management had the mandate to negotiate with the external partners which risks should be mitigated by partners, such risks were assigned to partners in the online checklist.

Figure 4 gives an overview of program risk monitoring. It illustrates how every project and the program reports the identified risks to the online risk checklist. The dialog box above the checklist shows the necessary information to be filed in the checklist.

After filling in all the necessary information in the online checklist, the project and program risk facilitators complete their risk management activities in their projects/program. In the next meeting they inform the other participants about how they have completed the agreed assignments.

Here we do not specify how to calculate the correlation of dependent risks. Neither the risk facilitators had a method for doing so. This information was filled in relying on the participants’ experience. If the participants agreed that there is a significant dependence between the risks, then they marked it.

Risk management sessions were the most frequent in projects running under Agile methodologies. Here the sessions were held on a biweekly basis. For this reason all risk facilitators were recommended to check the online checklist on a biweekly basis so any newly identified risk could be accessible for everyone.

We did not manage to do a rigorous evaluation of the method, since there was reorganization in Ericsson Money Services and our stakeholder moved to another geographical location. However, as much as we could present the method to him, and as long as he could use the method in the time of being our stakeholder, which was approximately two months, we got positive feedback. The overall impression was that the method and supporting tool have several important concepts for proactive monitoring of risks, such as what information should be shared in the checklist, and what activities should be carried out during the program risk management session. However, the participants might decide by themselves, how often too meet, how often to share information, etc.

VI. TOOL SUPPORT FOR PROGRAM RISK MONITORING

In this section we present the online Microsoft Excel-based checklist (tool), which we created for program risk management. The tool is primarily designed for program risk facilitators and serves for managing risks of interrelated projects. The tool should be used when the risk identification in projects and in the program is already carried out.

Figure 5 presents a snapshot of the tool. The first column shows the numbering of risks – R1, R2, etc. In the second column the risk description should be input. This is done by all the risk facilitators from each of the project and from the program, so during the program risk management session all the risks are in the tool already. There are no actual risk descriptions in Figure 5, because they are regarded as sensitive information for Ericsson Money Services and cannot be presented here. The columns p1 through p9 show project one through project nine. The last column is specified for any external partnering organization.
The rows that contain the risk numbers and descriptions are called main rows. Under every main row, there are five subordinate rows, belonging to the main rows. The subordinate rows are collapsible, so they can be opened or hidden if necessary. In the figure, the collapsible rows for R1 and R2 are opened, and for R3, R4, and R5 are hidden. The five collapsible rows indicate the following five items:

- Mitigation responsible – This indicates the responsible project for conducting mitigation of the given risk. A green tick is put for the responsible project.
- Estimated loss – This specifies the estimated loss for the given project. The column named “total” automatically calculates the sum of all estimated losses or mitigation costs.
- Active mitigation cost – This specifies the estimated mitigation cost for the given project. The column named “total” automatically calculates the sum of all estimated losses or mitigation costs.
- Correlated with R(j) – indicates any risk that is dependent with the current risk in the given project
- Status – shows the status of risk mitigation. Status can have three values: inception, in progress, and closed.

All the values that should be filled in for the projects (program) are also to be filled in for the “partner” field, besides the two values for the column of “total”. The total loss or mitigation cost is not counted involving the partners.

<table>
<thead>
<tr>
<th>description</th>
<th>Item</th>
<th>Total</th>
<th>Program</th>
<th>p1</th>
<th>p2</th>
<th>p3</th>
<th>p4</th>
<th>p5</th>
<th>p6</th>
<th>p7</th>
<th>p8</th>
<th>p9</th>
<th>Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Description of risk</td>
<td>Impact</td>
<td>moderate</td>
<td>low</td>
<td>high</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>high</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mitigation responsible</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Estimated loss</td>
<td>9000</td>
<td>7000</td>
<td>2000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
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<tr>
<td>active mitigation cost</td>
<td>1400</td>
<td>1000</td>
<td>100</td>
<td>300</td>
<td>-</td>
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<td>Correlated with R(j)</td>
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<tr>
<td>R2</td>
<td>Description of risk</td>
<td>Impact</td>
<td>high</td>
<td>high</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Correlated with R(j)</td>
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<tr>
<td>R3</td>
<td>Description of risk</td>
<td>Impact</td>
<td>moderate</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>high</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>R4</td>
<td>Description of risk</td>
<td>Impact</td>
<td>high</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>moderate</td>
<td>-</td>
<td>moderate</td>
<td>-</td>
<td>high</td>
</tr>
<tr>
<td>R5</td>
<td>Description of risk</td>
<td>Impact</td>
<td>moderate</td>
<td>moderate</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>moderate</td>
<td>-</td>
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</tr>
</tbody>
</table>

Figure 5 A Snapshot of the online excel-based checklist for program risk management

Next to “risk description” an “impact” item is specified. This item is to be specified by all project managers before the program risk management session. The “impact” can have three categorical values – high, moderate, and low.

Since the tool is accessible to all the project managers, they input any identified risk any time. This allows all risk facilitators to be informed about any risk in the program as fast as a risk is found in any of the projects. During the program risk management session, all risks are identified, but not all losses are estimated. Such risks that affect several projects might be estimated in the program risk management session.

VII. Validity Threats

We observed the use of the method and the checklist nearly two months. This period of time seems to be short for obtaining conclusive insights on whether the method significantly increased the effectiveness of program risk management. Due to this fact the internal validity of the method is not rigorously investigated. After two months of observation Ericsson Money Services program changed its geographical location making it hard for us to conduct a longitudinal evaluation study. Thus far, the most important feedback we got on the method, is from our stakeholder. And as long as he found it useful and used with his colleagues, we
believe the method outperforms the old ways of working significantly. The concept of effectiveness in our case is a sophisticated concept, and therefore is difficult to measure as one variable.

The method by no means can purport to be a generalized method for program risk management. As the reader might have noticed, there were many organization-specific ways of working in the program, thus the method was designed particularly for Ericsson Money Services. This is a substantial external validity threat for the method, if the reader is going to use it “as it is described” in this paper. That said, we must notice that several concepts in the method can be generalized for large software development programs. For example, monitoring common risks across several projects and dependent risks using shared tool can be useful for any large software development program. Particularly, in this paper we have shown practical steps to be carried out for monitoring dependencies of risks, therefore we believe the paper can be valuable for program risk facilitators.

VIII. RELATED WORK
There is a plethora risk management methods and textbook to help risk management in organizations. Example are [12], [13], and [14]. These textbooks have meticulous explanations of how risks should be identified, what methods can be applied for risk exposure estimation, how to select alternative mitigation activities, how to control the status of risks etc. However, when it comes to a risk management problem that is due to organizational complexity, the problem rather has to do with practicalities. Our case was not an exception. Ericsson Money Services decided not to use commercially available tools because they cause additional costs and require substantial administrative effort to use. If any large software development program decides to use commercially available tools than there are choices there, such as GRC Cloud, JCAD CORE, or A1 Tracker [15]. However, if an organization has chosen to use light-weight local checklist tools to reduce administrative costs or increase the flexibility of managerial activities, than risk management methods should be embedded in the checklist by the risk management professionals in the organization. By the way, using commercial tools does not ensure that here presented problem of program risk management will be solved by default.

In literature we can find studies that see automation as key to solve risk management problems emerged by the complexity of large software programs. An example is the study by Avdoshin and Pesotskaya [16]. Barki, et al. [17] propose a risk management checklist that is specialized particularly for software development projects. They develop the checklist based on exploring 120 real life software projects. Görski and Miler [18] present a study similar to ours, where they propose a risk management method and simple tool support for large software development projects. Among risk identification and assessment functionalities proposed in the tool, the authors also create fields where the risks can be reviewed. The review process helped to understand whether the risk is relevant for different parts of software product. Dhlamini, et al. [19] propose a model for intelligent risk management in large software programs. The model promises to facilitate risk management across several projects in a software development program. To conclude this section, we should mention that a review of tools and techniques for software project risk management can be found in a study reported by Rabbi, et al. [20].

IX. CONCLUSIONS
Risk management is a pivotal activity for large software development organizations that empowers practitioners to identify and mitigate risks in an organized manner, so the organization does not suffer severe losses. The more proactively risks are identified and monitored, the earlier they can be mitigated and controlled. In large software development programs, where several projects are jointly working towards creating a common value, it is hard to coordinate risk identification and monitoring activities. The communication loop between the projects can be long, hindering projects being informed about the interrelated risks across the projects. This creates an unpleasant situation, where the same risk can be mitigated in several of the projects, causing unnecessary costs to the whole program. Moreover, risks identified in one of the projects can be relevant but not identified in other projects. In this situation the program needs an effective risk monitoring method, by which all risks across the projects can be identified and monitored proactively. In this paper we presented such a method developed for a large software development program at Ericsson. The method intends to minimize the communication of newly identified risks so no ineffective risk mitigation activity will be carried out.

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