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ORIGINAL ARTICLE

Stakeholder identification for a structured release planning approach in the automotive domain

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Abstract
In regulated domains like automotive, release planning is a complex process. This complex process consists of an agreement between product development processes for hardware as well as mechanic systems and approaches for software development. Particularly in automotive, the creation and synchronization of release plans for hardware as well as software is a challenge. Within the whole complex system development, it is challenging to consider the relevant stakeholders in the initial creation of a release plan. Depending on the context that a release plan shall be created for, there are different stakeholders that have to be considered from the beginning. There are numerous publications in the area of release planning, but there is no detailed research that shows which stakeholders have to be addressed in the automotive context. The aim of this work is to identify stakeholders of a release plan as an appropriate approach to create transparency in release planning in the automotive domain. Action research to elaborate relevant stakeholders for release planning was conducted at Dr. Ing. h. c. F. Porsche AG. We present a detailed overview of identified stakeholders as well as their required content and added value regarding two pilot projects. With this contribution, identified stakeholders of release planning from the hardware and software points of view are introduced. We discuss, based on the results, why there are common stakeholders for the two projects and why there are individual stakeholders for each project. With this work, we present a more complete stakeholder identification and a more detailed understanding of their needs.

Keywords Automotive · Release planning · Stakeholder identification · Required content

1 Introduction

A long time ago, vehicles were a purely mechanical matter. Current challenges in the automotive industry are connectivity, artificial intelligence and electric mobile services driven by environmental legislation [1]. Nowadays, such a variety of software necessitates a corresponding planning and coordination effort. State-of-the-art system architecture of vehicles consists of up to 100 electronic control units (ECUs) distributed in the vehicle. However, the trend is toward centralization of functionality in less ECUs [2]. The centralization is a paradigm shift toward a more function-oriented development. Nevertheless, today's vehicles consist of an interaction between mechatronic systems, software and hardware [3]. The new view, the centralization of functions and these interactions, cause serious challenges [4]. Furthermore, such complex development projects have to be considered and planned in a multidisciplinary way. The rising complexity because of the increasing embedded IT in vehicles make a common development more difficult considering all incorporated dependencies.

Release planning is a key activity for effective and efficient product implementation [5]. It describes the selection of an optimal subset of requirements that will be implemented in a particular release [6]. This coordination and control are based on a release plan that is essential for projects achieving the goals assigned to them. A major part of

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release planning is to consolidate complexity such as different stakeholders' and customers' needs, as well as to fulfil boundary conditions given by the company into one release plan. Release planning is necessary because errors made at the beginning of a development are hard to compensate for later during the development process. The creation and update of a common release plan of vehicles that includes all stakeholders is a central and challenging task. This task is the more complex, the more people are involved in the work according to different development processes [5].

The multidisciplinary work mentioned above is conducted in a variety of development processes, ranging from completely traditional, waterfall-like processes to adaptations of agile processes. Combining them in the development of a complete vehicle is necessary, but hard to achieve. In particular, traditional development is milestone-driven, focused on strong safety requirements and complex supplier constellations while agile development methods are applied to the development of control units, software and functions. Hybrid approaches are focused on combining well-structured widespread methods with agile principles [7]. However, reality shows that the synchronization of these approaches does not work successfully [8]. All of these approaches have their own specific release plans that best fit their project characteristics.

Yet, there is no established means in science nor industry resolving these differences in handling release planning in an automotive context. Therefore, there is a lack of synchronization for a coordinated release plan of all involved stakeholders. Although there are release planning approaches that mention stakeholders as a fundamental factor that has to be considered [9], there is no further recommendation and sufficiently detailed consideration. The literature study by Ameller et al. [10] indicates that the 17 selected papers analyzed therein do not go into detail about stakeholders as an essential source of input. The stakeholders are an important part of planning and have a major influence on its creation and usage [11]. Our previous study [12] showed it is not obvious who will be affected and what benefit they expect from a release plan. To support release planning, it is necessary to create transparency regarding the parties involved and the required content. The stakeholders of a release plan, the kind of content as well as the served purpose have to be identified and are an important aspect of a release plan. For this reason, we focus on stakeholders and consider them in detail. In our context, we define release planning stakeholders as an influencing factor on the release plan, delivering something into the plan and receiving something from the plan. We present with this work not only who the stakeholders are, but also what content they need from the release plan and what purpose they serve. These three points form the research questions this paper is based on. We produced the results presented here in cooperation with two pilot projects of one German automotive original equipment manufacturer (OEM) using the research method action research. Furthermore, this paper contributes to the discussion, which stakeholders have to be observed to set up a target-oriented and structured release planning. Together with existing release planning methods, our results can be supported to find the relevant stakeholders for release planning. We present the first empirical evidence of relevant stakeholders of release plans with two pilot projects performed in industry.

The remainder of this paper is structured as follows: Related work is presented in Sect. 2. Section 3 defines the research approach including the research questions and design, the research site and the participants, the data collection and analysis procedure, as well as the data collection instrument. The results are reported in Sect. 4. Similarities and differences of the results as well as a discussion are part of Sect. 5. Section 5 includes learnings and recommendations for other companies. We conclude our work and outline future research in Sect. 6.

2 Background and related work

2.1 Hybrid project environment: soft- and hardware development with corresponding development methods

In the automotive domain, vehicles are developed in a hybrid project environment that often contains two conflicting parts. On the one hand, there is the strategic framework with processes consisting of an idealized and generic description for a product development process [13]. This framework defines different phases of the development process and characterizes the strongly regulated automotive industry. It contains several milestones planned a long time in advance before vehicle projects related to production and distribution start. All the defined and fixed milestones given by the company can be summarized as a time horizon and must be followed. The strategic framework has to be considered at the beginning of the release planning process and restricts the possible levels of flexibility in the development process. On the other hand, there is the operational level where projects are developed with different development methods depending on each project's characteristics. On this operational level, the projects can be developed in an agile, hybrid or traditional way. The results of a large-scale online survey show the current state of practice and show that agile, hybrid and traditional development methods are used in industry [14]. There are different possibilities to do planning, but there is no general approach for structured release planning that brings together different development processes effectively and that serves the strategic framework. Since soft and hardware development is a complex and challenging task

involving many stakeholders [15], there have to be different ways to do planning because of the projects' characteristics. In the automotive industry, there are different development levels, which are characterized by function development at the lowest level over ECU integration up to the vehicle level. Depending on the individual mandatory safety and security level of each software, different characteristics of release plans are required additionally. As a result of the complex specifications and influencing factors, flexibility regarding release planning and consideration of certain stakeholders is decreasing. Nevertheless, all the different ways have to work together well in one vehicle and therefore a general structure for a coordinated release planning is necessary.

New ways to address projects and development processes are possible due to industry 4.0, which offers new possibilities for networking and collaboration [16]. To use these new technologies and to integrate the vehicle seamlessly into the digital urban world, a new type of vehicle electronics network is required. An end-to-end electronic architecture forms the technological basis for implementing future innovations [17]. To consistently apply this system architecture, new high-performance computing platforms are necessary. The goals of future electric/electronic architectures are open and scalable architectures that are sustainable and durable. They are expected to be able to map current megatrends such as autonomous driving and connected cars, as well as future challenges such as swarm intelligence and artificial intelligence [18]. For this reason, ECUs and functions that are currently distributed throughout the vehicle are grouped on one or more computers. This centralizes and maps the complexity and responsibility of several ECUs in one high-performance computing platform (HPCP). An HPCP thus hosts hundreds of different functions, e.g., from the areas of connectivity, driver assistance, energy, and charging, which makes the requirements, planning and control of that HPCP much more complex than current vehicle architectures. We present the identified stakeholders of release plans for such a new HPCP and for one function located on it.

2.2 Release planning approaches

The consideration of release planning combining software and systems engineering is hardly to be found in the literature. Sax et al. [19] conducted a survey on the state and future of automotive software release and configuration management. The outcome of that study faced challenges during release development and management. The focus of this study was on technical trends such as variant management, software updates and multi-domain system design. In their findings, Sax et al. cover both software and hardware aspects. Nevertheless, their results are strongly aimed only at future technical challenges. Müller et al. [20] elaborate fundamental requirements for IT support regarding the release management process. They presented to which extent product data and process management technology meet their identified requirements. Based on their gained experience they formed four categories (IT infrastructure, process control, process enactment support and usability) for IT support. The requirements shown by Müller et al. refer to the automotive context, and they use release management as an example in their work to gain requirements for an IT tool.

In addition, release planning in agile software development projects for both single projects and for scaled projects is discussed in the literature. Heikkilä et al. [21] presented research of release planning in large-scale agile software development organizations. They conducted a longitudinal study and identified a lack of firm empirical evidence of results demonstrating practices for scaling up Scrum regarding release planning. They filled this gap by presenting two results produced within a case company using the Release Iteration Planning method [22]. However, their results focus only on software development in an agile context and did not include the hardware development. Danesh et al. [23] performed a multiple case study to investigate the methods companies use to plan for new software releases. Their results demonstrate that experienced companies prefer improving their existing software products rather than creating a new plan. These results correspond partially with the challenges identified by Marner et al. [12], who have highlighted the problems that exist in both software and hardware development regarding release planning within an OEM.

Heikkilä et al. [24] describe in their case study how release planning is done in a large-scale Scrum development organization. One of the challenges identified in this study was the over commitment caused by external pressure. They even presented benefits such as increased flexibility and decreased development lead-time. Heikkilä et al. [25] used a case study to improve coordination of work of multiple agile development teams. They tested two joint release planning events to set up the case companies' own joint release planning events.

To the best of our knowledge, there is no explicit research on release planning in co-existing traditional and agile way of working in the automotive domain or in a related domain with similar boundary conditions. Few publications deal with agile release planning, but none of them regard the targeted hybrid project environment combining software and hardware engineering. Karvonen et al. [26] analyze both direct and indirect impacts of agile release planning practices within their systematic literature study. In addition, Ameller et al. [10] conducted a literature study to report on software release planning models. Both publications focused only on software engineering.

The results of a systematic review on strategic release planning models [10] show that there are various kinds of mathematical models and simulations that are unusable in

practice [27]. By using these approaches in daily work, the practitioners reported that they are either too simple to generate a benefit or so difficult to use that they cannot reconstruct the structure and procedure [28, 29].

2.3 Release planning approaches addressing influencing factors

The approach EVOLVE [30] and its extensions [31] are a support for decision-making in software release planning. This method combines the strength of genetic algorithms and the flexibility of an iterative solution method. EVOLVE in its original form considers numerous constraints such as software requirements, stakeholders' priorities, prioritization of requirements by stakeholders and effort estimation for all requirements. The extended version EVOLVE II incorporates additionally soft requirements and objectives into their proposed decision-making process. EVOLVE II concentrates with its approach on software release planning considers numerous influencing factors but excludes the hardware development.

Saliu and Ruhe [11] describe ten key technical and non-technical aspects impacting release planning. They refer to the aspects as dimensions. The following selected dimensions particularly affect the automotive industry because these dimensions are what compose the complexity: time horizon, objectives, stakeholder involvement, prioritization mechanism and technological as well as resource constraints. Lindgren et al. [32] used the key aspects of release planning of Saliu and Ruhe [11] and performed a multiple case study in the context of software and system development projects. Furthermore, they considered the state of the practice for release planning in industry. Within their performed work, they validated the defined aspect of Saliu and Ruhe [11] involving industrial companies and proposed one further key aspect (short- and long-term planning). They stress that too little attention is dedicated to the complex topic.

Both Saliu and Ruhe [11] and Lindgren et al. [32] assume the availability of or knowledge about certain constraints, such as functional requirements or stakeholder preferences. Within their work, there is no closer proposal to look at or how to identify which constraints are necessary or important. However, in such a complex environment as the automotive domain with many technical dependencies and fixed milestones, it is not always obvious what kind of constraints are given and what has to be considered. Based on our own experience, we give some additional examples of different constraints especially for the automotive industry below:

- prototype cars and target hardware (on a certain development level the prototype car environment is needed for final testing and calibration)
- climate conditions for testing (many functions depend on climate conditions; that means the seasons have to be taken in account to avoid expensive costs)
- complete vehicle maturity level (the required maturity level of all functions has to be fulfilled on a certain degree)
- safety and security aspects (functions that have to fulfil lots of safety and security aspects need much more time for development and testing in advance)

Extracting out of the analysis results of Ameller et al. [10] within their literature study, it can be stated that there are incomplete input factors processed by the analyzed models within their study. For release planning in the automotive context, further factors (safety and security, practical applicability, and requirements given by the company), have to be included as input in the models. None of the analyzed approaches deal with input factors such as safety and security requirements or a more complex list of fixed requirements given by the company to fit industry needs. Safety and security aspects play a major role within the automotive domain [33]. Another important finding of the analyzed publications of Ameller et al. [10] is the lack of practical relevance. Only one method developed by Heikkilä [25] is related to industry. There is no further validation performed in industrial settings as well as further literature except [11, 32] dealing with aspects a release plan should include. All other evaluated approaches have been generated with academic references.

With this paper, we rely on the input factor *stakeholder involvement* in accordance with Saliu and Ruhe [11] stating that stakeholder consideration is very important to address their needs in the release plan. This key factor is crucial and has a huge influence on the content of a release plan in the automotive industry. For this reason, we focus on relevant stakeholders of release planning and show which information stakeholders provide in the release plan and which information they require from a release plan.

3 Research approach

3.1 Research questions

Stakeholders of all kinds are critical for creating realistic and goal-oriented release plans. Their requirements have a great influence on the development of a release plan and have to be aligned with the defined guidelines of the companies. Therefore, it is important to understand who the stakeholders are and what they require from a release plan.

This paper aims to answer the following research question (RQ 1–3) in Table 1

Table 1 Overview of the research questions

RQ1	Who are the involved stakeholders?
RQ2	What kind of content do the stakeholders require from a release plan?
RQ3	What benefits do stakeholders gain from the information in a release plan?

RQ1: This question aims to identify the involved stakeholders and thus have an impact of a release plan. Specifically, we study the relevant stakeholders of two pilot projects and therefore release plans from two perspectives.

RQ2: After identifying the relevant stakeholders of a release plan, it is necessary to know what kind of content the stakeholders require from a release plan or which information the stakeholder can provide for the plan. That is what we investigate with this question.

RQ3: This question aims to determine what purpose stakeholders are pursuing and why they require information contained in the plan or why they provide information in the release plan.

3.2 Research site and research projects

The results were developed at Dr. Ing. h. c. F. Porsche AG, a manufacturer that builds sports cars for everyday driving. The division EE (Electrical/Electronic) and one further division within Dr. Ing. h. c. F. Porsche AG in Weissach, Germany is responsible for the development process of electronic systems and its integration into the development process of the complete vehicle. For achieving this goal, transparent development processes and hence accurate release planning are essential.

The findings were generated for an HPCP, and one function located on it as pilot projects within the case company. The first project is one of the new system architectures as mentioned in Sect. 2 and follows a traditional development procedure. That HPCP can be regarded as a representative example since it provides a main ECU within the network. The aim of this project is to centralize the number of numerous ECUs in one HPCP, thereby creating installation space by reducing the wiring harness. Overall, the complexity in the vehicle and also in the release planning is reduced. The smaller number of individual ECUs also reduces the individual decentralized release plans. However, the complexity of the release planning of the HPCP increases because the software functions located are much larger than on smaller ECUs. The second project is a function located on this platform and is called predictive thermal management function. The function is one of several functions that are located on an HPCP and is developed in an agile way. The goals of this function are to increase performance, efficiency, and comfort through predictive thermal management by cooling and heating of the battery. The two projects represent the hybrid project environment consisting of traditional and agile development methods. Furthermore, the hardware level is included in the results by the HPCP. In addition, the selected HPCP is a joint group development within the Volkswagen Group and this fact increases the complexity. The Volkswagen AG, Audi AG and the Dr. Ing. h. c. F. Porsche AG participate in the development of the HPCP altogether. Due to its structure, the selected function is also a highly distributed and networked function. For these reasons, the results listed in this work are appropriate. In the following, project 1 representing the HPCP will be called study 1. The same applies to the function called study 2.

3.3 Research design

To answer the research questions, we selected a two-step research approach and conducted action research proposed by Myers [34] in a series of workshops (Fig. 1). Action research is selected because of a prevailing real particular problem situation to develop new release plans for two industry related projects. The objectives of step one are the definition of relevant stakeholders (RQ1), the identification of expected content for the stakeholders (RQ2) as well as the gained benefit for the stakeholders (RQ3). The evaluation of the results for the two projects were done in step 2.

Step 1: Data collection and analysis procedure

The online survey conducted by Marner et al. [12] revealed the challenges regarding the stakeholders involved in the release planning process. Among other questions within this survey, the participants assessed the extent to which they were aware of the interfaces and relevant stakeholders. The results showed that communication and information problems are prevalent. In particular, insufficiently known stakeholders and counterparts of input and output relationships lead to alignment issues. These identified challenges in release planning of the case study of Marner et al. [12] served as input for step 1.

The initial situation for this work indicates that so far there were both no structured stakeholder mapping and there were no existing release plans for both projects, as they represent new technologies. The results for each RQ are carried out in a cyclical process as demonstrated in Fig. 1. With feedback loops, the researchers planned changes to be introduced in the case projects, took these changes, reflected on them, and evaluated the results. The iterative changes mainly consisted of the following improvements. Firstly, the number of stakeholders identified varied. Stakeholders were added

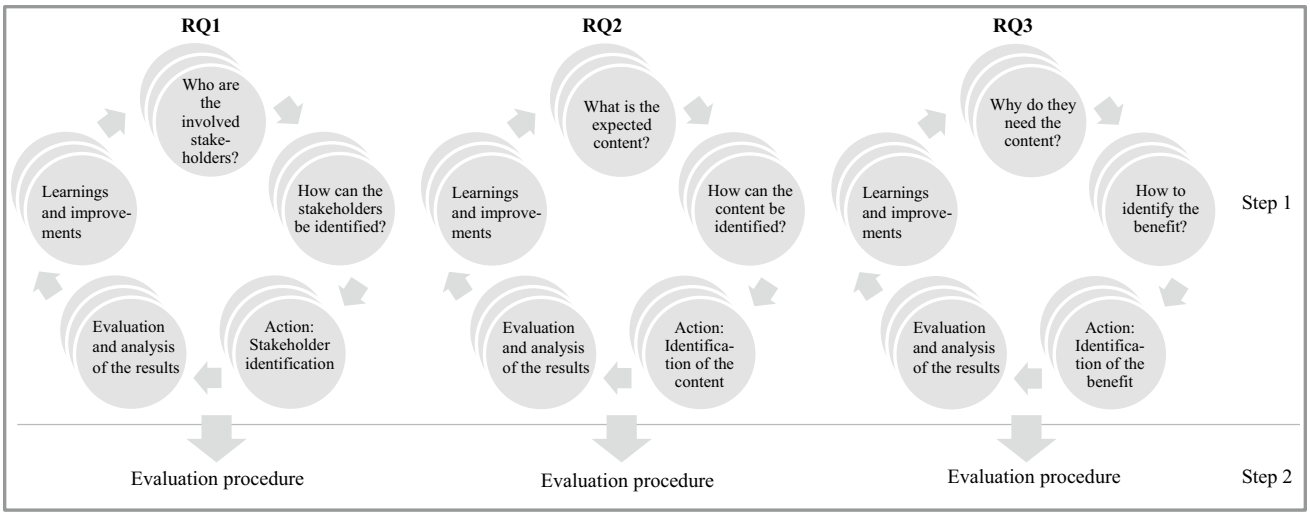

Fig. 1 Used procedure for both research projects

and others removed. Furthermore, the requirements of the stakeholders and thus the input/output interactions of the stakeholders in relation to the release plan changed. We discussed to what extent there was a one-way or/and two-way relationship between the stakeholders and the release plan. Once it emerged that the stakeholder only needed information from the plan and in another iteration, it turned out that this stakeholder also had input into the release plan. An additional improvement was the discussion about the specific content the stakeholders take from the release plan or actively contribute to it. We repeated the cycles several times for each research question. Step 1 lasted from April 2019 until July 2019.

The action research team consisted of researchers and participants who collected the results. The researchers were the same persons for both projects, only the participants differed. The researchers are the three authors. The participants of the action research team of study 1 consist of one HPCP owner, three developers, one tester, one project owner and one representative of the quality department of the HPCP. The action research team of the second project is composed of one function owner, three developers, two testers and one responsible from the quality department. As reference group, two department heads and one integration manager supported us for both projects. Among the participants of the action research team as well as the reference group were stakeholders who are identified as stakeholders in the results. We combined the experience of the authors due to the active involvement of the first author in the automotive software development and the experience of the second and third author regarding software engineering.

The action research team for step one was composed of participants all working at Dr. Ing. h. c. F. Porsche AG. The results were produced in close collaboration between researchers as well as practitioners, and both benefit from the findings. The results for study 1 were created independently of that of study 2.

The action research cycles, started by diagnosing well known still unsolved problems of relevant stakeholders emerging from Marner et al. [12]. After a procedure to answer the problem was found, this was worked out in the respective pilot projects.

The involved stakeholders (RQ1), the required content (RQ2) and pursued purpose (RQ3) regarding the release planning was specified in that way. The results generated were revised after each cycle by the first author. Emerging issues, such as vague phrases, were addressed before further cycles were conducted. The results from each cycle were incorporated into later ones. We used the post-processed results as new inputs for incremental improvement systematically. The results were created iteratively to confirm its design and to draw a more complete picture of the way release planning was done by different participants. This allows for more validated results but gave every participant the chance to provide further qualitative results by sharing their experiences. Table 2 summarizes the changes over the five iterations for the first pilot project. The plus symbol represents results that were added during the iteration, and the minus symbol indicates results that were rejected. As can be seen from Table 2, in the first session we focused on possible stakeholders who are involved in the release planning process in some way. We conducted the first iteration in the form of brainstorming.

In the second iteration, we discussed already identified stakeholders and came to the conclusion that purchasing is not a relevant stakeholder. In this iteration, we also talked about the *content* that stakeholders provide in a release plan and/or take from the plan. For each stakeholder, we

Table 2 Overview of the changes regarding the different iterations of study 1

	Stakeholder	Content	Category	Purpose
1st iteration	+ HPCP quality representative + Department heads + Model series organization + Integration management department + Cross-section department + Project manager + Purchasing	–	–	–
2nd iteration	− Purchasing + Smart mobility department + After sales + Production and logistic department	+ Maturity level + Implemented content for SW and basis SW + Delivery dates for HW, SW and basis SW	–	–
3rd iteration	+ Type approval + Functional safety	+ Planned maturity level + Required maturity level + Functional safety dates + Type approval dates	+ Development + Management + Market	Incomplete first version
4th iteration	–	–	− Market + After sales and market	Improved second version
5th iteration	–	–		final version

considered individually which content they take from the plan and which content they deliver to the plan. We then noticed that similar content is of interest to different stakeholders. In addition, different content was named the same for different stakeholders. Therefore, we asked ourselves to what extent the content could be standardized across the stakeholders. In this iteration, for example, the content *maturity level* was detailed in *required* and *planned maturity level*. For the third iteration, the vehicle development process served as an input to add new results to the already identified stakeholders and their content. We also introduced categories for stakeholders because we noticed that certain stakeholders need the same information from the plan or provide the same information to the plan. In the discussions about content and categories, the first results about *purpose* became visible. In the fourth iteration, we achieved the results shown in Table 2 by specifically questioning the previous categories. The previous category *market* was replaced by the new category *after sales* and *market*. This describes the stakeholders more appropriately. In a final iteration, we looked specifically at the question of the *purpose* the stakeholders need their information for.

The results of the four iterations are shown in Table 3 for study 2. In the first iteration, we brainstormed and identified the stakeholders listed in Table 3. In the second iteration, we asked ourselves whether the agile development team itself should be listed as a stakeholder in the release plan. As a result, the corresponding roles in the agile team were identified as stakeholders and the category "agile team" was introduced. In addition, another stakeholder was added as part of this discussion. In the second iteration, the question about the required content was answered as shown in Table 3.

In the third iteration, further required content of the stakeholders was included based on the vehicle development process. Using the categorization introduced in iteration 2, the remaining stakeholders already identified were grouped into two further categories (*technical* and *informative stakeholders*). A first assignment of the purposes was made. In the fourth iteration, no new stakeholders, contents and categories were found. The purpose of the stakeholders was revised and finalized on the basis of a committee overview within the case company. The committee overview contains all relevant committees of a vehicle development project at an OEM as well as their tasks, responsibilities and decision-making authority. In this fourth and last iteration, we finalized the results of the second project.

Step 2: evaluation procedure

In Step two, the results applied in both case projects were analyzed and evaluated with further participants between July and September 2019 with experts from Audi AG. After achieving the results for study 1, four workshops over 60 min were conducted. To these workshops, we invited the experts from Audi AG due to their knowledge and experience in release planning to get further criticism. These workshops were held with project managers of ECUs and further HPCP owners working at Audi AG to align the results of both brands on this complex topic. In these workshops, the generated results were presented and discussed. Together with the participants from Audi AG, the identified stakeholders were discussed and whether these roles also apply to their company. The provided feedback is incorporated into the results presented in this work.

Table 3 Overview of the changes regarding the different iterations of study 2

	Stakeholder	Content	Category	Purpose
1st iteration	+ Management + SW quality representatives + Integration management + Base thermal management + Provider predictive data + Component of coolant circuit + SW supplier + HPCP	–	–	–
2nd iteration	+ Production department representatives + Development team + Product owner	+ Delivery dates for SW and sub functions + Implemented content of SW and sub functions + Planned maturity level of SW and sub functions + Required maturity level of SW and sub functions	+ Agile team	–
3rd iteration	–	+ Top-level management summary + Type approval dates + Functional safety dates	+ Technical stakeholders + Informative stakeholders	Incomplete first version
4th iteration	–	–	–	Improved second version

The validation of the results for study 2 was done in the form of two 60 min meetings with attendance of the corresponding partners from Audi AG, who are responsible for function development on their side. The received feedback was incorporated into the results to achieve improvements by using the knowledge from Audi AG. The feedback received from the discussions concluded that the initial situation, where until now there was no overview of identified stakeholders and their requirements, has been improved with the results presented here. With the methodology implemented, the results were iteratively improved so that first a structure and classification of the stakeholders became apparent and second it became transparent which intention and purpose a stakeholder pursues. The qualitative analysis of the data collected during the workshops was done by a content analysis of the meeting protocols. We followed Mayring's approach of qualitative content analysis [35]. We performed a mixed approach of deductive and inductive coding and encoded the meeting protocols to extract important categories regarding our research goal. During analysis on sentence level, we formed hierarchies of codes and sub-codes. In several iterations, the codes were revised, split or merged. The results of the different meetings are presented in Sect. 4.

3.4 Threats to validity

We used the following four criteria suggested by Wohlin et al. [36] and we refer specifically to action research in accordance with Staron [37].

Construct validity. This validity is related to the design of our study and concerns to the diagnosing phases as well as the planned activities. Based on the study by Marner et al. [12], indicating that stakeholders of a release plan are not immediately apparent, we have ensured a common understanding of the problem or research question at the beginning of each research cycle. In the process, we have incorporated interpretations from each individual and created a common understanding. During the planning of actions, we avoided relying solely on one's individual opinion about the improvements. To report the results, we did it together in common workshops.

Internal validity: Internal validity regarding action research focus on action taking. Because of the close cooperation, which was spread over several cycles and lasted for a certain period, the industrial partners are learning. As a result, their

assessments are no longer as objective as they were at the beginning of the project. We reduce this threat by performing reviews with participants from different departments within the case company and from Audi AG.

External validity: Since action research takes place in a specific context, we have to reflect on the impact of our results. As the results only represent one specific case, it might not be possible to generalize them. However, the fact that the case company has the same framework conditions (regulated domains, complex supplier relationships and high safety requirements) as similar OEMs, others could benefit from the developed approach. Furthermore, the selected projects represent an ECU still in development and a function not yet published.

Conclusion validity: Conclusion validity is reflected among others in the evaluation phase. There is bias concerning drawing conclusion because of the fact the action team is part of taking the action. If you have to judge your own actions, you are simply less objective than judging the results of others. Once we realized that our results revealed no differences, we included other participants when the action team could not find a common consensus. Here, people in the role of technical department heads were particularly suitable because of their specialist knowledge and their ability to look at things from a distance.

4 Results

In this section, we present the results following the research questions (Sect. 3.1). The results will be reported for each of the two research projects. We start with the presentation of the results of study 1, and afterward the results of study 2 will follow. The results are presented graphically in Figs. 2 and 3. The two Figures contain the following graphical representations, as explained at the bottom left in the figures. The symbol displayed with an arrow to the left represents input provided by stakeholders into the plan. Moreover, the symbol displayed with an arrow to the right shows the information that the stakeholders extract from the plan. Commonalities of the two pilot projects due to stakeholders and required information are highlighted in italic. The presented content of both figures is also displayed in italic, even if the stakeholder has not been identified in both release plans. This indicates that the content exists in both plans but is required by different stakeholders. The respective stakeholder and the respective content that is explicitly required for study 1 or study 2 is shown in non-italic.

For a better understanding of the results below, the definition of terms has been made as follows.

Strategic framework

Specification of the OEM representing the time and content requirements; consisting of project-specific milestones, vehicle-specific milestones and release dates.

Implemented content

Description of the content to be developed, what will be implemented in detail at what time (e.g., at different levels possible).

Delivery date

Time at which a certain scope must be delivered in (required maturity level) containing the agreed implemented content.

Required maturity level

Is a predefined maturity level by the OEM that is incorporated in the product development process and has to be achieved by every software and hardware project. These maturity levels are to be fulfilled at certain points in the development process.

Planned maturity level

Is an intended to reach maturity level reported by every hardware and software project. This maturity level is compared to the required maturity level when the milestone within the development process is passed.

These definitions will be used in Sect. 4 but mainly applied in Sect. 5.

4.1 Results of the high-performance computing platform

Figure 2 shows a graphic summary of the results of study 1. The particulars and characteristics of this Fig. 2 will be discussed in more detail in Sect. 5. In the following, we present the results of the research questions by first explaining the identified stakeholders (RQ1), followed by demonstrating the required content of that stakeholder (RQ2), and then providing an answer as to the benefits (RQ3) the stakeholders gain. Before action research has been conducted, the status was that study 1 neither had a release plan nor there was an overview of relevant stakeholders. This can be explained by the new technology of the HPCP and the early stage of the project.

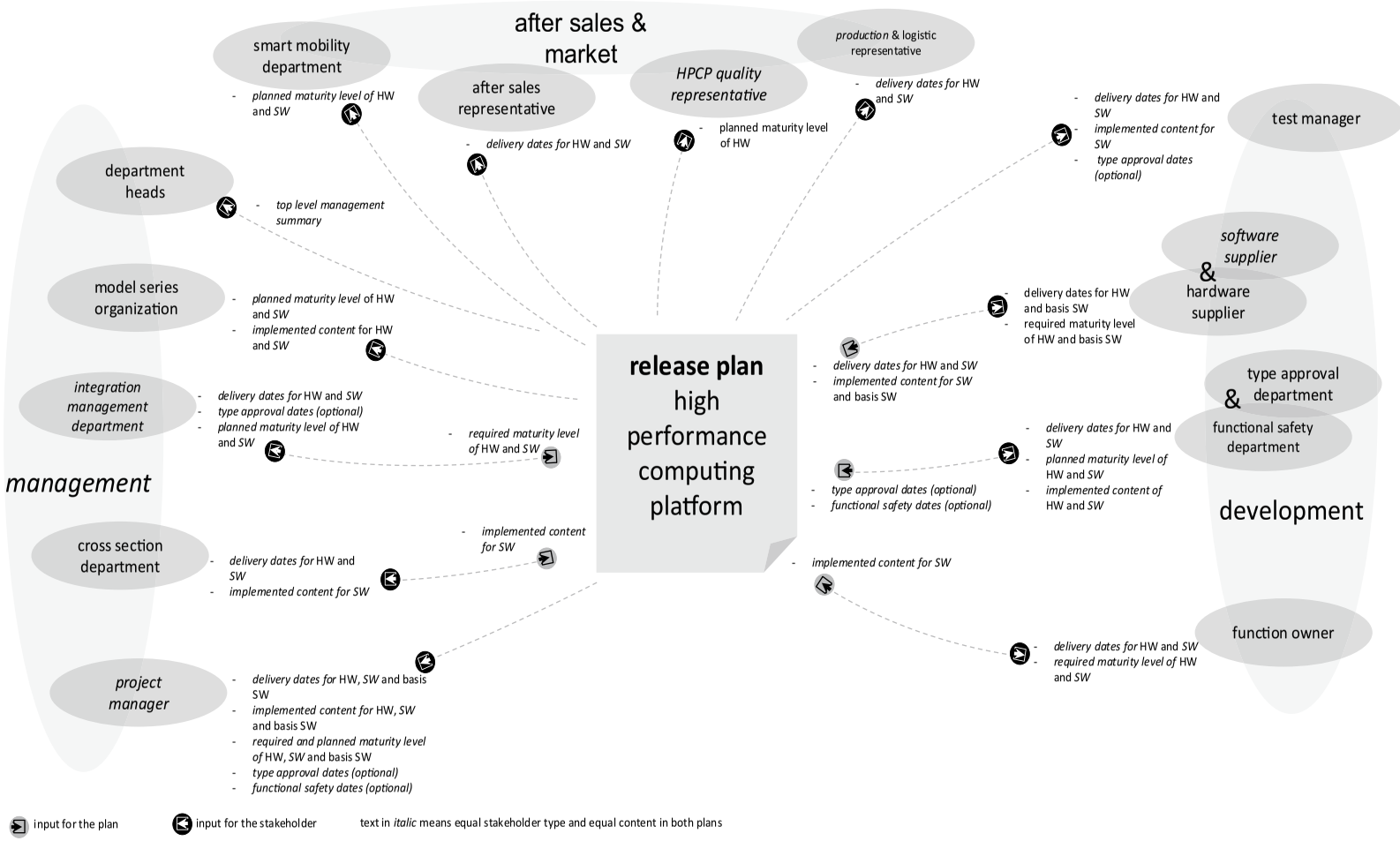

Fig. 2 Overview of the identified stakeholders with the corresponding information flow of study 1

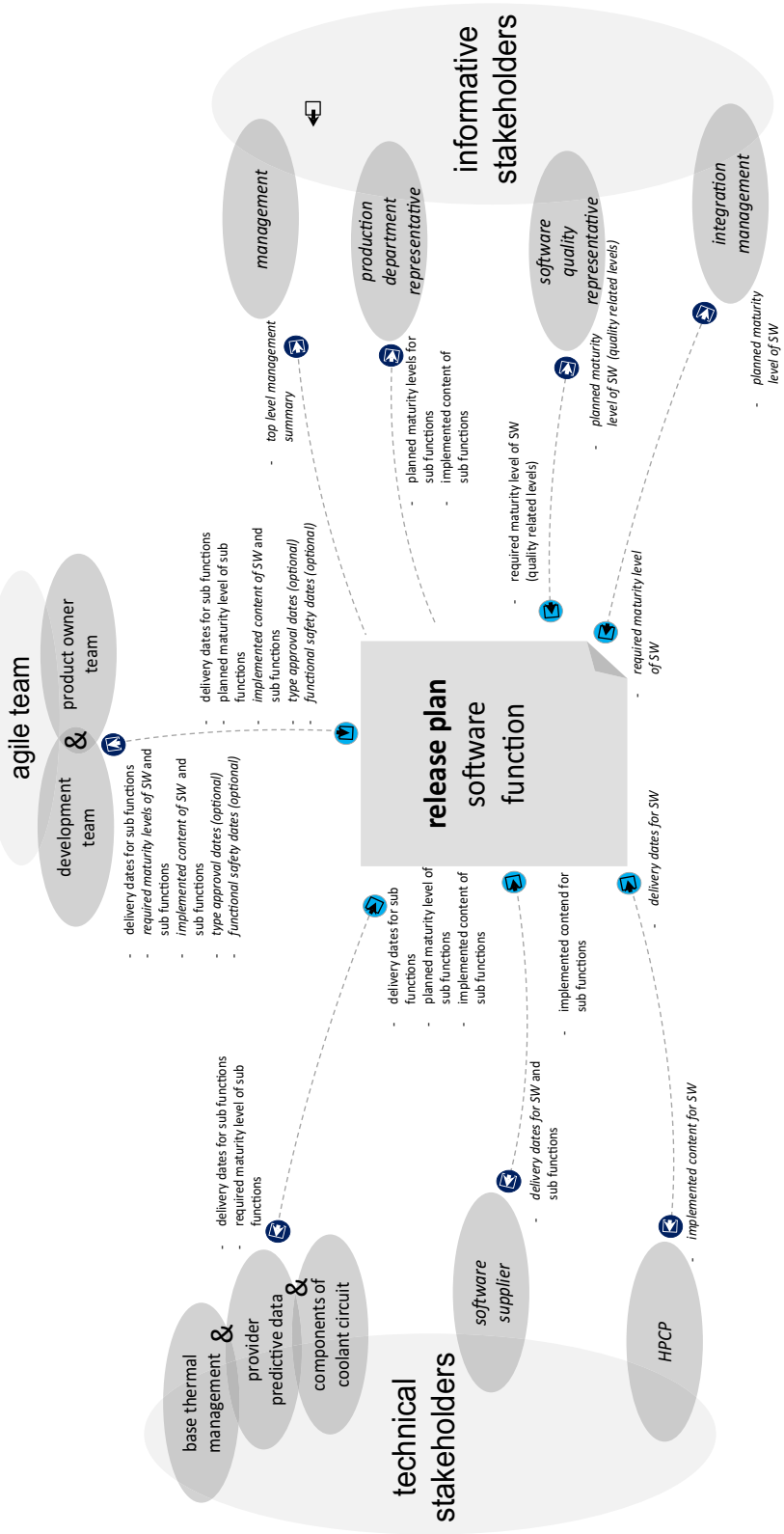

Fig. 3 Overview of the identified stakeholders with the corresponding information flow of the software function

4.1.1 Identified stakeholders

As illustrated in Fig. 2 the stakeholders of study 1 are classified into three categories: management, development and after sales and market. In the following, we give a brief description of each category with the corresponding stakeholders and their role description.

Management

Stakeholders having a management role, bearing responsibility, and having decision-making authority, define the category *management*.

The first identified stakeholder is the *project manager* responsible for one HPCP. The project manager is in charge from the definition phase to the handover of responsibility to production. In addition, this role monitors the component development according to the specifications, the process-safe manufacturing process as well as the planning, tracking and regular reporting of these components. This role description also applies to suppliers of hardware, software or third parties who perform the same tasks for their scope. The companies in which these project managers are employed and especially OEMs have a line organization. The authority to give directives carries out from top to bottom. This also enabled *department heads* and even their superiors to be identified as stakeholders in the *management* category.

The *project manager* is the main stakeholder of this plan because this role requires most information or content. Its task is to consider the development comprehensively, and therefore s/he is the contact person for all further stakeholders. The automotive domain is a strongly regulated domain. The strategic framework with fixed milestones and required maturity levels are given by the development process of a vehicle. The project manager takes this strategic framework as a basis and includes further contents such as delivery dates from suppliers of hardware and of software. Furthermore, the project manager adds points in time to this plan regarding delivery dates. Specific deadlines for the basic software of the HPCP has to be included into the plan as well. The basic software is the software on an ECU that provides the base functions. Functions located on a HPCP are not part of the basic software. Different software version deliveries and required maturity levels of the functions and of the basic software are other elements of the release plan. Additional information such as functional safety dates as well as type approval dates are part of the plan. Type approval is responsible for all kind of technical compliance, communication with authorities and technical guidelines. Functional safety dates represent additional dates that have to be observed additionally if the product to be developed has to operate the Functional Safety [33]. In general, it can be stated that the project manager is a central stakeholder that is essential. All the information this role creates and requires is needed by the other stakeholders.

An organizational special feature at the case company is the so-called *'Model Series Organization'* [38]. A *model series* has the corporate responsibility for its vehicle scopes as well as platform scopes of all co-users. It is therefore responsible for the cross-departmental compliance with all specifications regarding technology, deadlines, costs and quality. It includes the cost targets for purchased parts (direct material costs and investments), the development costs and the target achievement of the production parameters. The end customer's requirements are included in the release plan through the model series. The required maturity levels are defined by the model series. For this reason, the model series organization is an identified stakeholder of the release plan and is interested in specific content of that plan.

From a planning and decision-making point of view, the *integration management department* plays an important role in the vehicle release process. It ensures the integration of functions into a vehicle by tracking and evaluating the corresponding maturity level. It also contains the interface between development and model series. Integration management is also involved in the definition of maturity levels.

The next identified stakeholder is a technical connection between project manager and integration management. The *cross-section department* specifies general requirements for ECU development. For example, this contains requirements for the used bus technology like Ethernet or requirements for diagnosis.

Development

The second category, *development*, represents stakeholders who are involved technically with the HPCP. This category includes the development and testing level.

In the HPCP, there are numerous functions. Such functions are the *function owners'* responsibilities. A function is the smallest unit delivered to a HPCP. Such a function includes the entire effect chain from the sensors and actuators to multiple HPCP domains, across the entire network. The effect chain ranges from electronics to display or backend functions. Each function is integrated into the overall software of an HPCP. For each function, there is a responsible person. Therefore, the function owners are involved stakeholders of the release plan.

The functional safety department and the *type approval department* have great impact on an HPCP. Functional safety [33] refer to risk reduction due to malfunctions of electronic/mechatronic systems. Type approval deals with obtaining the required operating permits for the market launch and registration of customer vehicles in sales markets. This area is responsible for all kind of technical compliance, communication with authorities and technical guidelines. Contents

that are subject to *functional safety department* require delivery dates for hardware and software. That strongly relates to the ISO 26262 [33]. Functional safety and type approval influence the creation and implementation of the plan regarding fixed milestones and testing. For this reason, these departments have to be considered as stakeholders.

Vehicle testing is assigned to this category. It serves to ensure durability, functionality, reliability, and quality throughout the entire product development process as well as during the first months of the current series. The fulfillment of customer- and market-specific requirements is checked with different standardized or demand-adapted test methods. The *test manager* as an identified stakeholder is responsible for the preparation and execution of the test activities.

The *hardware supplier* is another important stakeholder and develops the necessary hardware for an HPCP. This supplier is responsible for hardware development, integration of (all) software, product validation (testing) and production of the computing platform. In coordination with the hardware supplier, the project manager also specifies the delivery dates for hardware.

The *software supplier* is responsible for developing the basic software, containing the operating system, hardware near drivers and system functions such as standard diagnostics. This stakeholder ensures the basis functionality of HPCP and provides attributes such as diagnostic capability and networking. Both the hardware and the software supplier work closely with the project manager to ensure the most efficient development. In addition, this supplier is further in charge of the integration of software functions for function demonstration. In collaboration with the project manager, the delivery dates for the basic software are also agreed and included in the release plan.

After sales and market

The third category, *after sales and market*, includes stakeholders that are not permanently involved in research and development, but contains key aspects in the vehicles value chain.

The *smart mobility department* is concerned with the alignment and operationalization of the product and portfolio strategy for connected car services, including lifecycle management. This department as an identified stakeholder handles the creation and planning of connect services.

The area *after sales representative* is responsible for servicing the customer vehicles in the worldwide OEM workshops and thus represents the most important point of contact after purchasing the vehicle.

The *HPCP quality representative* is responsible for controlling all quality issues within the model series for the development process and series support. This department with *HPCP quality representative* for each model series ensures the requirements in the development process of electronic/electrical components, as well as defining and implementing the quality objectives in the vehicle specifications.

The department *production and logistic representative* for a special model series includes the series production of all vehicles. Even in this department, there are representatives who ensure that their model series meet the requirements regarding production and logistics. The high quality and punctual completion of the vehicles across all trades is closely connected with the planning and control of the production and logistics processes.

Following the action research cycles, it was revealed that purchasing is not a stakeholder in the plan of an HPCP. This is related to the fact that purchasing is active before the development phase.

4.1.2 Content needed

The relevant content for the identified stakeholders of study 1 is illustrated in Fig. 2 based on the structure of the defined three categories. This section discusses the contents of each category only briefly, as the results for research question 2 arise from Fig. 2.

The category *management* needs management summaries, including reports with traffic light status and the planned maturity levels of hardware and software. Projects can be evaluated efficiently and easily according to its status with the traffic light control.

The stakeholders of the category *development* need detailed information from the plan as the delivery dates of hardware, software and basic software as well as required maturity levels of hardware, software and basic software.

The stakeholders of the category *after sales and market* require general information of the strategic framework and specific project milestones as well as delivery dates for hardware and software.

4.1.3 Benefit and purpose of the information

Three stakeholders in the category development (function owner, hardware supplier and software supplier) are key stakeholders who both require some information from the plan and provide information to the plan. This group uses the information for its respective development, whether it is hardware, software, and basic software. Without these stakeholders, the development of study 1 cannot be applied and implemented in a target-oriented way.

The information contained in the release plan is used for the four stakeholders of the category management: project manager, model series organization, integration management and cross-section department. This group needs the defined information for project tracking, costs monitoring, content overview and different deadlines. Every stakeholder that

requires a status report in form of traffic lights deploys the report for tracking and an escalation instrument regarding the HPCP.

In close exchange with study 1 the development and the cross-section department use the information for planning test activities (e.g., for network tests and tests for interfaces) and for target comparison regarding production relevant content.

The after sales department uses its information to establish an after sales strategy. The information requested will also be reused for the organization and planning of the spare parts warehouse.

Several stakeholders need the different type approval dates. Function owners adjust their planning to these dates. With the given information, they are informed when they are no longer allowed to change anything in the development. The integration management takes on a superordinate role regarding these deadlines. The integration managers look at the technical departments and sensitize them to the dates. On the one hand, the department for type approvals and functional safety coordinates with the development department to announce the dates. On the other hand, they obtain information from the development department when they intend to implement their functions.

The required maturity levels are a key input for overall vehicle planning. These levels are indicative to develop high-quality software as well as hardware, and therefore important for almost all stakeholders involved in this release plan.

In the area of production, the contents of the release plan are used to fulfil the project specifications related to plan logistics. Furthermore, the information is needed for the synchronization of the testing equipment.

4.2 Results of the function: predictive thermal management

4.2.1 Identified stakeholders

The identified stakeholders involved in the release planning process of study 2 are grouped into three categories: agile team, technical stakeholders and non-technical stakeholders as presented in Fig. 3. As already mentioned for study 2, in the initial situation for the second project there was no release plan and also no list of stakeholders to be considered.

Agile team

The *agile team* itself forms the first category. The agile team is composed of the *product owner team* and the *development team*. The function owner is the first representative of the *agile team,* and this role is part of the *development team*. Within the project, the function owner is assigned the task of the central contact person. For this reason, the role of the function owner is described in detail. The tasks of the function owner consist of the transfer of the delivery dates regarding the HPCP as well as the transfer of the agreed delivery dates of the software supplier into the release plan. For this reason, the release plan is an important base consisting of predefined dates and corresponding content for development as well as the application done by the software supplier. All milestones related to test activities are a significant part of the plan and must therefore be reflected in the plan, which also belongs to its task. Further additional dates result from the detailed implemented content of the software and sub functions concerning the upcoming release and has to be done by the function owner. In that case, the function itself is divided into several sub-functions, providing a more detailed level of description.

The members of the agile team and their corresponding role descriptions are also interpreted and performed at Dr. Ing. h.c. F. Porsche AG as described in [39]. For this reason, we will not discuss these role descriptions in more detail and will not look into them.

Technical stakeholders (functional interfaces)

The second category called *technical stakeholders* consists of stakeholders having functional interfaces and therefore have an impact on the release plan. This includes functions that either deliver input data or receive data from study 2. The required and planned maturity levels of all these functions are dependent on each other and raise the common coordination effort. In addition, the technical stakeholders having direct impact on the software itself are located in this group. The first role within this category are the *providers of predictive data* for study 2. There are various basis services that process raw data from different sources, combine these predictions and make it available as preprocessed prediction data for different user functions, where study 2 is one of them. Each of these basis services aims at the prediction of special use cases. Therefore, many of these services have to be taken in account. Depending on whether the service is located on the same as study 2 or on different HPCPs or even on the backend, this has a major impact on the release planning activities and raises the complexity.

The *base thermal management function* is another stakeholder that acts as a backup function study 2 when there are no predictive data available. The base thermal management function provides sensor data, controls the actuators and serves as a monitoring and diagnostic device for the actuators and sensors of the coolant and refrigerant circuits. The base thermal management transforms the output of study 2 to control the actuators. Furthermore, the maturity level of study 2 is highly dependent on the base thermal management. For this reason, a regular and tight coordination is essential.

The *HPCP* abd at the same time study 1 is the corresponding hardware platform study 1 is located. The HPCP is responsible for the whole integration process between software and hardware level. That includes the build process of all software functions located on this platform. Especially functional changes that include new interfaces must be incorporated right from the start; otherwise, the lead times will be too long. There is a close exchange between the function and the *HPCP* ensuring the integration of the software on the hardware without difficulty. In addition, the exchange includes an agreement on technical data such as the required resource reserve (RAM, ROM, CPU etc.) of the software that have to be considered in the release plan.

The *components of the coolant circuit* include all devices that need to be cooled or heated by the thermal management system. These devices have a great need for the maturity level planning to be coordinated and known at an early stage, as the proper use of the devices depends largely on the thermal management system. Conversely, the sensor data of the devices are a prerequisite for study 2. Due to this interdependence, it is necessary to determine very precisely when the corresponding maturity levels are reached for both sides.

The *software supplier* defines the build process and due to that specifies the period, how much lead time has to be planned until delivery to the HPCP. Furthermore, when drawing up the release plan, the available resources at the supplier must be kept in mind. The software supplier receives the required maturity levels from the OEM and has to adopt his build process to these given milestones.

Informative stakeholders (no functional interfaces)

A group that has no functional interfaces but is of a purely informative nature characterizes the last category of the identified stakeholders for the pilot function.

The first stakeholder within this category is *the management*. Among others, their tasks include decision-making authority and budget responsibility. Furthermore, it is the responsibility of the management to maintain the software conformity and for this reason, they are interested in a comparison of target and actual maturity levels. The main focus is the monitoring whether the function remains on schedule. However, they are also the stakeholders of all kinds of conflicts that have not yet been solved and have the task of resolving the conflict at their level.

The *production department representative* contributes to release planning with its own processe**s**, in which the sourcing process should be incorporated, as milestones arise retroactively. This area is interested in ensuring that the functions relevant to production have the necessary degree of maturity.

Following the workshops, it was revealed that purchasing is not a stakeholder in the plan of a software function. This is related to the fact that purchasing is only active before the development phase.

The *software quality representative* specifies quality related requirements that have to be considered and addressed in planning. In addition, this group monitors specific quality related milestones. Another task is the execution of software supplier audits. The results of such audits have to be integrated into the release plan as well.

The *integration management* is the last stakeholder within that category and is responsible for transferring the required milestones defined by the OEM to a completely specific vehicle project. This stakeholder specifies the required maturity levels and conducts a comparison of target and actual status of the developed software. If any deviations between planned and required maturity levels occur, this stakeholder can cause an escalation in order not to endanger the development process.

Table 4 Overview of different and common stakeholders of both projects

Common stakeholder	Stakeholders of study 1	Stakeholders of study 2
Project manager	Logistic department representative	Base thermal management
Integration management	Hardware supplier	Software supplier
Quality representative	Test manager (is included in development team of the software function)	Components of coolant circuit
Management	Cross-section department	Provider predictive data
Production department representative	Function owner	HPCP
Respective software suppliers	Department heads	Agile team
	Smart mobility department	
	After sales representative	
	Type approval department	
	Functional safety department	
	Model series organization	

4.2.2 Content needed

The results regarding the relevant content of the identified stakeholders for study 2 are presented in Fig. 3. Each category is briefly described below.

The stakeholders of the first category *agile team* demand for all information the plan offers. The function owner as one representative of the agile team is assigned the task to gather all the necessary information and to transfer this information to the release plan.

The *technical stakeholders (functional interfaces)* necessitate boundary conditions for the implementation of the scopes to be developed. These conditions include as well as the given milestones by the OEM and time dates when the software has to be released defined by the delivery dates of the HPCP.

The *informative stakeholders (no functional interfaces)* require information contained in the plan due to top-level management summary that is prepared for management purposes. These stakeholders are interested in a status report of the project and need no detailed or specific content.

4.2.3 Benefit and purpose of the information

In the following, we present why the identified stakeholders need the information from the corresponding release plan.

RQ1.3. What benefits do stakeholders gain from the information in a release plan?

In summary, it can be stated that all the contained information of both release plans can be used as an input for the involved stakeholders. The input extracted differs in the way it is used by stakeholders. On the one hand, the input is purely informative and on the other hand, it provides basis information for the further development process. Stakeholders from the category *informative stakeholder* need input from the release plan for purely informative reasons. Other stakeholders, on the other hand, need information from the plan to fulfil their tasks or for further activities. The benefit and purpose of the implied content can be summarized because the stakeholders gain similar additional value. The results of study 1 are discussed first, followed by the findings of study 2.

Similar to study 1, certain stakeholder groups pursue common purposes with the information provided within the release plan. The *technical stakeholders* have to generate their own planning and for that, they need delivery dates, required and planned maturity levels and implemented content of the sub functions from the release plan. Using this information given in the plan, they prepare content to be implemented in its function and its sub functions. The *technical stakeholders* and the function owner coordinate their individual plans to achieve the agreed targets of different

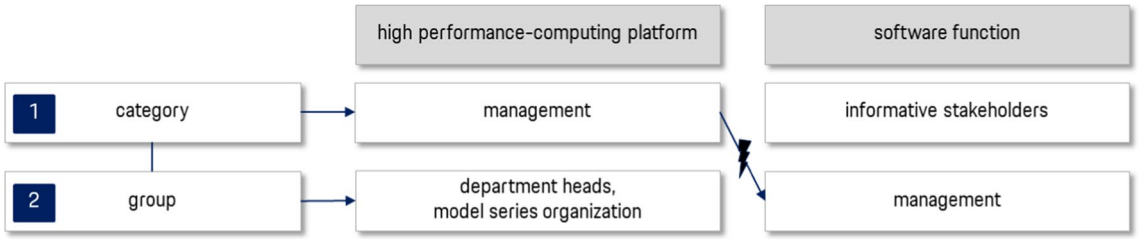

Fig. 4 Different classification of stakeholders

Table 5 Overview of similarities and differences regarding the content of both projects

Common contents	Contents of study 1	Contents of study 2
Delivery dates for SW	Delivery dates for HW	Delivery dates for sub functions
	Delivery dates for basis SW	
Planned maturity level of SW	Planned maturity level of HW	Planned maturity level of sub functions
	Planned maturity level of basis SW	
Required maturity level of SW	Required maturity level of HW	Required maturity level of sub functions
	Required maturity level of basis SW	
Implemented content for SW	Implemented content for HW	Implemented content for sub functions
	Implemented content for basis SW	
Top-level management summary		
Type approval dates		
Functional safety dates		

delivery dates as well as the maturity levels. These stakeholders also create a detailed plan of the implemented content of sub functions to synchronize technical interfaces.

The *agile team* including the function owner is both responsible for the plan itself and for the development of the implemented content, as well as the required and planned maturity levels. For this reason, they need all the information provided by the plan. All the information contained in the plan comes together in the agile team to monitor, plan, prioritize and report on the entire software development process.

The category *informative stakeholder* consisting of *management*, *production department representative*, *software quality representatives* and *integration management* need different information from the plan, but they pursue the same purpose as the *HPCP* with the information received. The *informative stakeholders* only demand information that is not processed in other plans, but to monitor the progress of the corresponding software development project. They have no responsibility for their own software, but rather have coordinating and monitoring tasks to perform. These stakeholders do not only pursue particular software, but also have an overall focus on several software functions and consider the project to be developed holistically.

5 Comparison and discussion of the results

Identifying all stakeholders is an essential influencing factor for release planning, as they provide information as an input factor for the planning and require information from the developed plan. Stakeholders strongly depend on the use case, as the results in Sect. 4 have already shown. Although both projects come from the same project context, different stakeholders are needed for release planning of study 1 and study 2 at working level for software development. Nevertheless, there are differences besides some common categories of stakeholders. Due to content, even there are several common information which both projects require.

5.1 Similarities and differences of the identified stakeholders

First, we want to take a closer look at the similarities and differences concerning the identified stakeholders (RQ1). The results in Fig. 2 show that not even half of the stakeholders are marked in italic, implying that the release plan of study 1 requires other stakeholders than study 2. The only shared stakeholders of the two release plans are the six stakeholders, as shown in Table 4.

A possible reason for the few common stakeholders of the plans is the granularity of the planning and the considered planning level of the projects. The release plan of study 1 maps software and hardware contents to a higher level of abstraction and thus includes the software located on the ECU.

Furthermore, Table 4 demonstrates that from a functional perspective, fewer stakeholders have been defined. One possible reason for the lower number of stakeholders is that certain stakeholders (for example, hardware supplier and logistic department representative) are simply not relevant for release planning from a software planning view. However, the technical interfaces (base thermal management, provider predictive data and components of coolant circuit) are an essential stakeholder for study 2 and do not appear in the release plan of study 1. Due to the more detailed planning level, information related to sub functions are even only part of this plan. The stakeholder test manager is not mentioned separately in the plan of the software function, as he is assigned to the development team.

Another reason for the difference in the number of stakeholders is that different categories were formed for the group formation of stakeholders. For example, from a HPCP point of view, a separate category was dedicated to the stakeholder *management*, whereas from a software point of view, *management* belongs to the category *informative stakeholder*. This different classification of stakeholders is summarized in Fig. 4.

The identification of stakeholders was executed independently of each other in different research cycles, and thus each project has formed its own categories and groups.

5.2 Similarities and differences regarding the contents

In addition, Fig. 2 includes commonalities regarding the contents of the respective plans (RQ2). The italic marked contents are already much more frequent. The strategic framework is not explicitly listed in the graphic as content, as it applies to all stakeholders. Table 5 summarizes the similarities and differences regarding the content of the release plans.

Hard constraints such as the required maturity levels (hardware, software and basis software) given by the company, functional safety dates and type approval dates if necessary are valid for both views. The precise difference regarding the maturity levels (required and planned) results from the particular project-specific adaptation to the project. Contents about the hardware and basis software are also only part of the plan of the HPCP and therefore displayed in non-italic.

Both figures demonstrate that only the non-italic marked stakeholders and contents are different and only occur in the respective planning. In summary, the two release plans share

similarities and differences, although the release plans focus on different perspectives.

Regarding RQ3, the pursued purpose why a stakeholder needs information from the plan or provides information to the plan, there are no significant differences. Among the identified stakeholders, from either HPCP's and function's point of view, there are stakeholders who need information for strictly informative purposes or there are stakeholders who need the information for further developing the project.

In summary, the comparison of the two plans showed that the release plans of the projects have more in common than the plans differ. At the beginning of the initial situation, there was no structured overview of stakeholders in a release plan, and thus the number of stakeholders and their requirements was not apparent. The complex input and output dependencies as well as the diversity of stakeholders were initially not transparent. We have created transparency with the results shown here.

5.3 Learnings and recommendations

We conclude this Sect. 5 by learnings and recommendations for other companies. Stakeholders will vary in number and role description depending on the company. One of the lessons learned by the results for us is that the number of stakeholders was higher than initially expected. We were astonished to see how many people require release planning. One possible reason for the high number of different stakeholders is the complex development environment, with numerous project participants and all kinds of supplier relationships. However, an analysis of the stakeholders is essential for target-oriented release planning if companies want to develop their products effectively and efficiently. By identifying the relevant stakeholders, it is evident who needs something and at what time. This is a valuable guidance for the creation of a release plan, as it allows the OEM's specifications as well as the required legal compliance to be better served. It is displayed preventively, and the different stakeholders will not be surprised negatively during the development process. The identification of stakeholders to be considered in release planning allows interfaces to be identified and highlights where dependencies arise. This was a helpful insight for us, as hardware and software development in the automotive industry is a complex process in itself and needs any possible support.

We argue that researchers should pay more attention to stakeholders as an influencing factor to release planning and the researchers are supposed to include this factor in their release planning approaches and not simply consider it as given. Practitioners are advised to be more aware of stakeholder requirements. As the results were collected based on two specific projects, the results are not only based on theory but also have a high practical relevance. Real and concrete stakeholders were identified, which could help other companies to identify their stakeholders.

The results were developed at a German OEM and validated by participants from Audi AG and participants who provide expertise from other companies. During the validation procedure, we asked ourselves whether the results could be applied to other domains besides automotive. We reminded ourselves what characterizes the automotive industry: highly regulated, many regulations and standards, as well as complex supplier constellations. The results were presented from the perspective of an HPCP and a function located on it. We came to the conclusion that the identified stakeholders are also applicable in related domains such as the rail industry and aircraft construction, as they have similar characteristics to the automotive industry. The results are sufficient to identify stakeholders in other OEMs. It might be that the stakeholders in other companies do not have the same name as in the results presented here, but still the requirements for the release plan are similar. But for a deeper validation, an extension of the results with other companies is necessary.

Both projects are developed using different development methods, as explained in Sect. 3.2. Study 1 is developed in a traditional way and study 2 follows an agile development method. During the analysis sessions, we discussed whether it has an impact on the results whether study 1 or study 2 is developed in an agile or traditional way. We came to the conclusion that the stakeholders can be identified independently. The development method used has no effect on the identification of stakeholders. As the name "development method" implies, the method used affects the development team. It depends much more on the perspective from which the stakeholders are viewed. Should stakeholders be considered for a hardware project or for a straight software project? It may be that the stakeholders are called differently, but the role description and the required content should be represented independently of the method. In the software function, for example, there is the agile team as a stakeholder consisting of the development team and the product owner. If study 2 were developed traditionally, the stakeholder could simply be called the development team. It is only important that the role and associated activities of the development team are represented. We also discussed the scenario of whether there would be an impact on the stakeholders if study 1 were developed using agile methods. Again, we concluded that this would have no impact on the identified stakeholders. If study 1 was to be developed agilely, this would only have an impact on the development team. However, the remaining stakeholders are the same and have to be addressed.

6 Conclusion and future work

Release planning in a hybrid project environment is increasingly challenging, even with new technologies as the HPCP. The different release plans from all involved stakeholders have to be synchronized with co-existing traditional development approaches in the automotive domain. Different stakeholders of two release plans were identified to bring transparency into release planning. In addition, we described the stakeholders who are involved in these release plans and who each have an interest in extracting certain content from it. We outlined the description of this certain content and showed what purpose it serves related to the respective stakeholder. With the presented stakeholders of two release plans, we provide a recommendation for practitioners which stakeholders could be considered due to release planning in the automotive domain. Additionally, we compared the results of both projects and showed the differences and commonalities. The comparison indicated that the two plans have much more in common in relation to the involved stakeholders and the required content of the stakeholder. A possible reason for this might be the complex and non-transparent processes as well as the supplier constellations.

In future, we will enlarge the results of the two release plans with a more detailed description of dependencies between the stakeholders. Another issue will be the different classification of the stakeholders, and it will be analyzed whether a consistent categorization is possible. We will add synchronization points to define what kind of content has to be released regarding the strategic framework. Furthermore, we will have a closer look at the results if there is a more structured and general procedure possible identifying the stakeholder. For further validation of the stakeholders, we will conduct more workshops with participants from other OEMs or even companies from other regulated domains that are developing complex systems in a hybrid project environment and similar hard constraints. We have demonstrated an in-depth investigation of two real industry projects considering required stakeholders of a release plan. With the presented examples, we hope to offer support for other OEMs or similar companies that have to struggle with finding the required stakeholders.

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