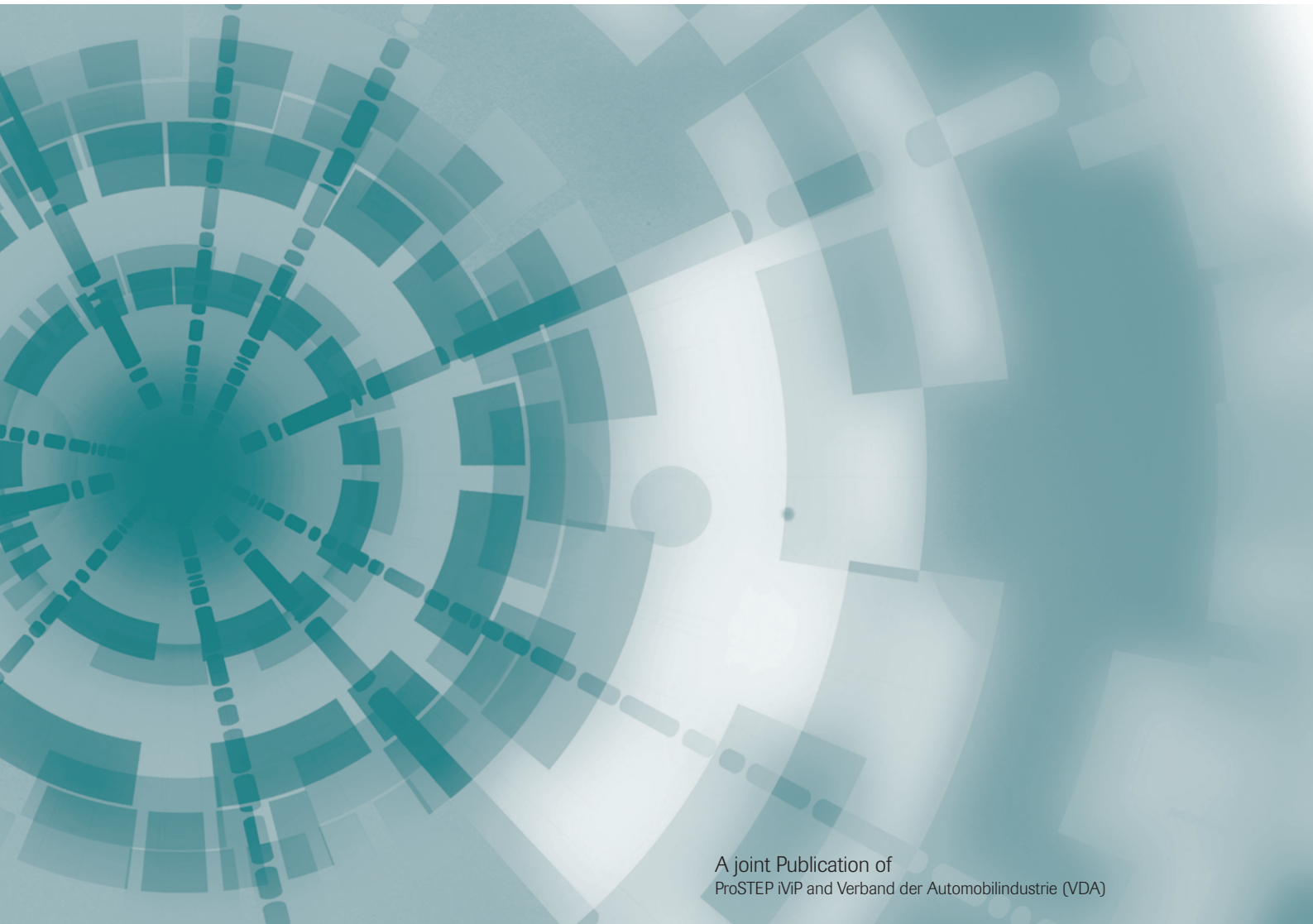
Recommendation for schedule management

Requirements relating to a schedule management tool for the automotive industry
Standardized criterion catalog at detailed concept level
VDA 4959
PSI 10

ProSTEP iViP

VDA | Verband der Automobilindustrie



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List of abbreviations

ANSI	American National Standards Institute
API	Application Programming Interface
APQP	Advanced Product Quality Planning
CCP	Advanced Product Quality Planning
CMMI	Capability Maturity Model Integration
CPM	Critical Path Method / Collaborative Project Management, depending on context
DIN	Deutsches Institut für Normung e.V. (German Standards Institute)
GPM	Deutsche Gesellschaft für Projektmanagement e.V. (German Society for Project Management)
ID	Identifier / Identification
IPMA	International Project Management Association
ISO	International Standardisation Organisation
CW	Calendar Week
MTA	Milestone Trend Analysis
PERT	Program Evaluation and Review Technique
PEP	Product Engineering Process
PMI	Project Management Institute
PMO	Project Management Office
PSP	Project Structure Plan (see also WBS)
Prio.	Priority
RM	Resource Management
RQM	Requirements Management
SLA	Service Level Agreement
SPiCE	Software Process Improvement and Capability Determination (A-SPiCE = Automotive-SPiCE)
SOA	Service Oriented Architecture
SoP	Start of Production
Stat.	Status
SM	Schedule Management
SM tool	Schedule Management tool, ~ system, ~ tool, ~ software or similar
TMS	Transport Management System
VDA	Verband der Automobilindustrie (German Automotive Industry Association)
WBS	Work Breakdown Structure (see also PSP)

Introduction to using the current recommendation

It is really very simple: The automotive industry expects a schedule management tool (SM tool) to provide no more and no less than that which it expects its own products to deliver on behalf of its customers:

- comprehensive, easy-to-use functionality with sophisticated ergonomics that meet the needs of a large number of different users
- a positive overall visual appearance with an attractive, contemporary design
- power and outstanding performance under-the-hood using innovative technologies
- and all of this should be configurable to a very high degree so that customers do not choose a car / a tool but their car / their tool.

Because the automotive industry and its suppliers constitute a strong and important sector within the German economy, countless projects are launched, conducted and successfully concluded in the country every year. Alongside organizational, implementation, IT and many other projects, a huge scope for multiproject activities has emerged in the product development sphere in particular. This is a sector which has for many years been growing increasingly professional, expanding and benefiting from increasing levels of tool-based support. This sustained trend has resulted in the development of a market in which tool suppliers interact with professional purchasers and tool users and are regularly in contact with them concerning the requirements placed on high-performance, forward-looking schedule management tools (SM tools). The aim of the present Recommendation is to facilitate communications between the various parties and to create a common ground that will simplify the conduct of purpose-ful discussions. Neither the experienced project management specialists in the automotive sector nor the consulting and IT specialists employed by the tool suppliers should have to spend more time than necessary in the drafting of product specifications, lists of requirements or interface specifications. They should use this requirements standard as an aid in the design and detailed specification of cus-tomer-specific solutions as well as in the development of innovative systems.

The current Recommendation is *primarily intended for*

- suppliers of schedule management (SM) tools that the automotive industry understands and wants to use
- service suppliers and consulting organizations that act at the interface between tool suppliers and tool users in the project and tool management field and that evaluate, compare, select and implement IT-based solutions.
- the experts and employees of PMOs or central IT service providers that identify recurring pro-cedures during scheduling and schedule management activities in the German automotive in-dustry and want these to be undertaken on a more professional basis with tool support.
- managers of multiple projects, managers of cooperative or strategic networks whose respon-sibilities include the coordination of different planning and control concepts for project scheduling as well as the creation of a uniform working basis.

The present Recommendation was drafted in order to provide guidance to the above-mentioned target groups both within and associated with the automotive industry. It explains the underlying modes of operation within the industry (see section 1) and structures the requirements for interdisciplinary, networked schedule management within the vehicle development field (see section 3).

The Recommendation should be used for

- internal enterprise or network evaluations of existing SM tool solutions (section 2.1)
- comparisons between different SM tools or the concepts of different SM tool suppliers (section 2.2)
- the drafting of a product specification for the functional concept underlying an SM tool (section 2.3)

The Recommendation is defined at the level of functional concepts. It presents industry-wide require-ments and is therefore an enterprise-neutral recommendation. Experts and individuals with experience in the field will identify considerable differences in the level of detail devoted to the description of the individual requirements (see section 3). The main aim of the current Recommendation is to

- identify and describe the requirements placed on an SM tool
- justify the requirements wherever necessary in order to reveal the underlying purpose of the requirement or make it possible to look for alternative solutions
- permit the systematic categorization of requirements into groups and categories in order to simplify their use and ensure that a complete listing is achieved more quickly
- define requirements primarily at the level of functional concepts in order to leave sufficient de-sign space available for the development of detailed tool or enterprise-specific variants
- nevertheless include detailed and extremely concrete requirements when these can be uniformly defined in compliance with standards and on a cross-enterprise basis

(see Fig. 1 and section 3)

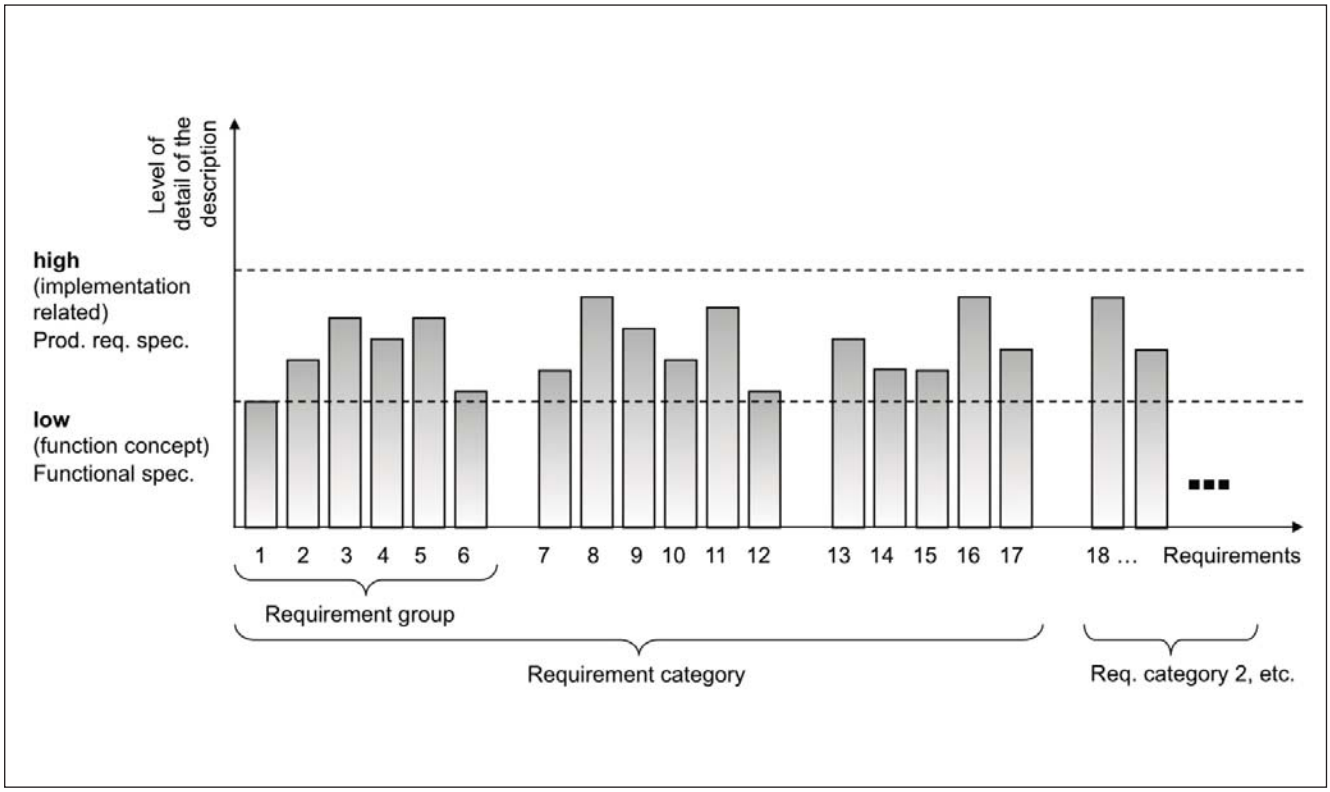

Figure 1: Requirements schema and assurance of a minimum level of accuracy in the description of requirements

The current Recommendation for a requirements catalog is therefore an important basis for discussion between the companies operating in the automotive industry as well as between prescriptors and tool suppliers. It can be quickly and easily tailored to meet individual needs (see section 2). An important step during this process is to prioritize the requirements. These are currently presented in an intuitive, deliberately non-prioritized order.

Extensions are also recommended during this enterprise-specific adaptation, in particular when the development of enterprise-specific detailed solutions (e.g. an interface specification and subsequent implementation) is a critical factor for the successful implementation of the selected SM tool solution.

Based on experiences from applying this Recommendation in their daily businesses, experts and key users from the automotive industry have derived improvements for the definitions of a number of criteria. In dialogue with SM tool vendors, the plausibility and applicability of the requirements catalogue has been confirmed.

In order to facilitate easier alignment of the requirements with company-specific processes, this Recommendation has been extended with a list of schedule management use cases (see section 4) as part of the update for the current version 1.1. In a concise table format, it lists the essential working steps for schedule management. In addition, key criteria from the catalogue have been associated with the use cases.

The current Recommendation is supported by leading associations and federations and in particular by the Verband der Automobilindustrie (German Automotive Industry Association), ProSTEP iViP.

For questions or to make comments, please contact one of the below:

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Experts and experienced individuals representing the leading German automobile manufacturers Audi, BMW, Daimler, Porsche and Volkswagen participated in the study which forms the basis for the current Recommendation.

1. Schedule management

1.1. The significance and development of schedule management

The very large number of different features that characterize projects place an equally wide variety of demands on the software used to plan and control them and handle the accompanying documentation. Yet, despite this, the areas that primarily determine whether a project is successful or not are similar and the most important of these are integrated scheduling, resource planning and budget plan-ning.

The definition of a project "… that is characterized above all by the unique combination of the various conditions, e.g. by a stated objective, temporal, financial, HR-related or other constraints, a project-specific organization etc."[1] clearly indicates the point that is always of supreme importance: professional project management. Project management is the "… sum of the … management techniques and resources required for the initiation, definition, planning, control and conclusion of projects."[2]

In many cases, the novelty, uniqueness and all the characteristics derived from the formal definition above have now given way to a high level of professionalization and, as the frequency of recurrence of applications grows, a widespread standardization. The project network method that was developed in the 1970s was initially characterized by its creative application to each specific project situation and, in the early years, was used as a manual tool due to the lack of suitable IT support. However, standardization soon followed as growing numbers of EDP/IT-based tools became available. And certainly by the time the Stage-Gate® process was developed (see also section 1.2.), the innovation and development process of the 1970s underwent widespread standardization. Reproducible templates were created and the tool-based automation of schedule management soon followed.

Despite the constantly increasing diversity of project management tools, the broad-based compliance with standards exhibited by the majority of tools means that there is considerable similarity between the basic functionalities they provide. The differences tend to be found at the level of the additional functionality(ies), the implementation of interfaces, user-friendliness, the speed of tool development and the service-orientation of the suppliers. Recent years have seen a growing level of detailed optimization of processes and methods in various enterprises and these have resulted in the dissemination of tool-based best practices which, in turn, have been consolidated in typical industry solutions.

Below is a systematic description of the basic requirements and basic variants that will enable consultants and tool suppliers to gain a more fine-grained understanding of the industry requirements and the wishes of large enterprise clusters.

1.2. Schedule management in the automotive industry

Schedule management was one of the first disciplines within the project management field to be addressed in a highly structured and systematic way. It was very rapidly incorporated within the framework of project network methodology and has regularly developed in terms of its professional use since then. It has by now given rise to a very extensive set of methods characterized by a number of variants and industry-specific features. A number of typical characteristics of the automotive and automotive supply industry that, although they apply not only here, are particularly relevant in this context, are presented briefly below.

Experience has shown that what is particularly important when it comes to choosing the right methods and tools is less the presence of specific concrete functionalities but rather the ability to reflect this sector-specific mode of operation. The planning philosophy, type and scope of networking between the development partners and the support for the methods of operation adopted by highly interdiscipli-nary teams are crucial for the successful use of selected methods and tools. In addition, it is important to note that the companies active in the German industry are extremely successful at the international level, i.e. they develop world-class products based on world-class methods which they operate on a distributed, highly networked basis worldwide.

1.2.1. Phases and the use of milestones

Modern vehicle development is organized into phases, i.e. in artificially specified time slots in which activities with different contents and different objectives are bundled together. These phase models generally represent a logical application of the Stage-Gate® methodology developed by Edget/Cooper, with third-generation Stage-Gate® processes now being used at every point in the model. They are characterized by the six fundamental F´s:

- Flexibility — Flexibility in application
- Fuzzy Gates — Lack of clear separation between the individual phases
- Fluidity — Gradual transitions between phases with activities being carried over
- Focus — Transition from multiproject management to portfolio management
- Facilitation — Facility management in processes, use of process managers
- Forever Green — Frontloading and risk management or logical discontinuation of the activity

[1] DIN 69901-5

[2] DIN 69901-5

All automotive companies subdivide these phases into a preliminary or preparatory phase, the main/product development phase and the follow-up phase (see Abb. 2) which, for example, forms part of the development project but takes place after start of production. While this philosophy is generally uniformly adopted within the OEMs, at the immediately underlying levels of detail, although identical planning methods are used, the boundaries between the phases and the contents of the phases are extremely different.

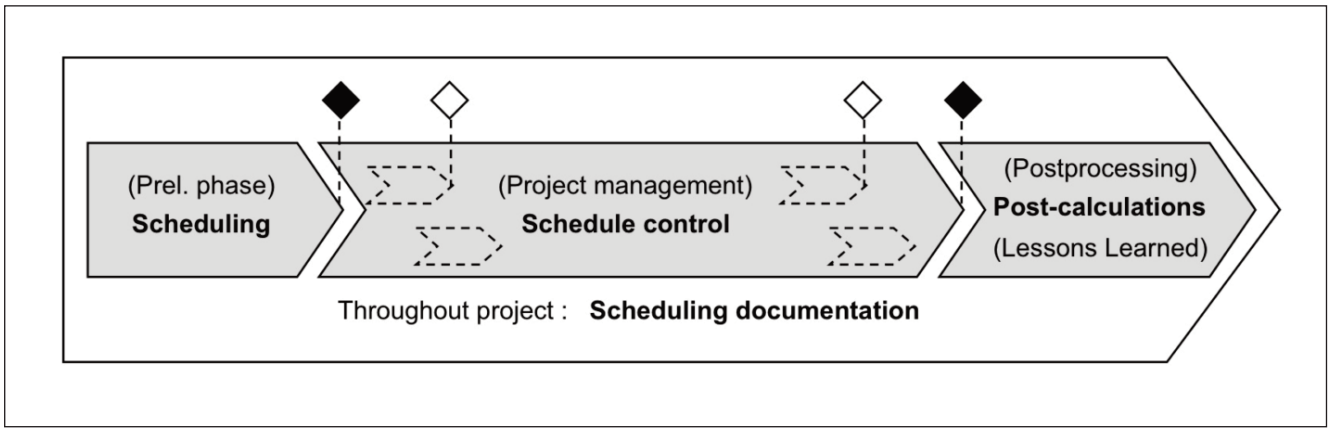


Figure 2: Temporal components, simplified representation of typical project phases

What consequences does this have for schedule management and the requirements placed on SM tools?

- The different phases call for different levels of planning detail, and different project participants – perhaps playing different roles and equipped with different rights – must be able to access the project. During the preliminary phase, changes to planning occur much more frequently and are implemented much more quickly and the documentation is therefore more pragmatic than in later project phases in which automatic mechanisms, unavoidable dependencies etc. tend to lead the many different participants who are now involved in the project to perform comprehensive planning, documentation and version management activities. At the same time, early phases do not have the strict, fixed character of the tightly scheduled product development activities but are instead characterized by an attempt at product innovation coupled with the strategic market positioning of the product. That is to say that at this point, the link to the enterprise's strategic planning tools including the resulting access and authorizations concept plays a much more important role than after the start of the focused, standardized product development process when the 'secrets' may not be secret any longer and a much larger project team has access to the data and information.

- What is required is simply the ability to plan on the basis of phases that can be defined as required. It must be possible to map different (and as many as necessary) project phases separated by milestones, design these differently and administer them. At the same time, of course, the processing of bulk data should be a quick and easy matter that makes it possible to redesign all the phases with little administrative effort.

- At the highest level of abstraction, the aim is to gain a rapid overview of the project, its status, the most important scheduling information and the most critical synchronization points. The target group for which such representations are destined frequently consists of individuals who them-selves have no direct project responsibility (program managers, departmental managers etc.). This means that very high demands are placed on the graphical preparation and ease of compre-hension of the core messages (which may need to be fully up-to-date).

1.2.2. Functional networking along the tool chain

The planning and control of scheduling is no longer a standalone function. Schedule management is only one aspect of project management which is highly networked at the functional level and which has to be replicated in this form in a tool-based environment.

The results of scheduling can be and often are usefully linked to and re-used in other areas. It must, for example, be possible to assign resources, and subsequently also budgets, directly to work packages for which schedules have been defined. Work operations are account assignment elements, i.e. planning elements and containers for times, work activities and costs, and are therefore a central design element in integrated schedule, capacity and budget planning. Scheduling and resource management must form a functional whole. (see Abb. 3, center)

The results of project planning can be viewed from a scheduling perspective (e.g. project network or Gantt chart), a resource-oriented perspective (e.g. resource loadings) or a budgetary perspective (e.g. cost, expenditure and work activity planning) depending on the required information. Each of these views addresses a different target group and covers different requirements in terms of information. It is not only the project members in interdisciplinary teams who need different views of this information. Other parties who are external to the project, such as company management, the customer, or central departments, may also have concrete questions. The different types of depiction usually require different access rights to the stored data and possibly also the right to extend the level of detail, add to, or consolidate the data. (see Abb. 3, right)

The projects involved in vehicle development are very frequently re-used or further used, not only in vehicle modules and components during product development but also in standardized process models, in typical recurrent sequences of operations, or in logical sequences of

development steps which always occur in the same or similar form. As a result, the modeling of the Product Engineering Pro-cess (PEP) is a step that must be dealt with at an early stage within an SM tool in order to instantiate the same or similar product-specific project processes as often as may be required. It must therefore be possible

- to derive a project-specific schedule from a process template or from a standard process (see Abb. 3, left),
- reconfigure it from individual process modules, or
- construct it on the basis of a legacy development project which is configured as necessary to adapt it to the current requirements and circumstances.

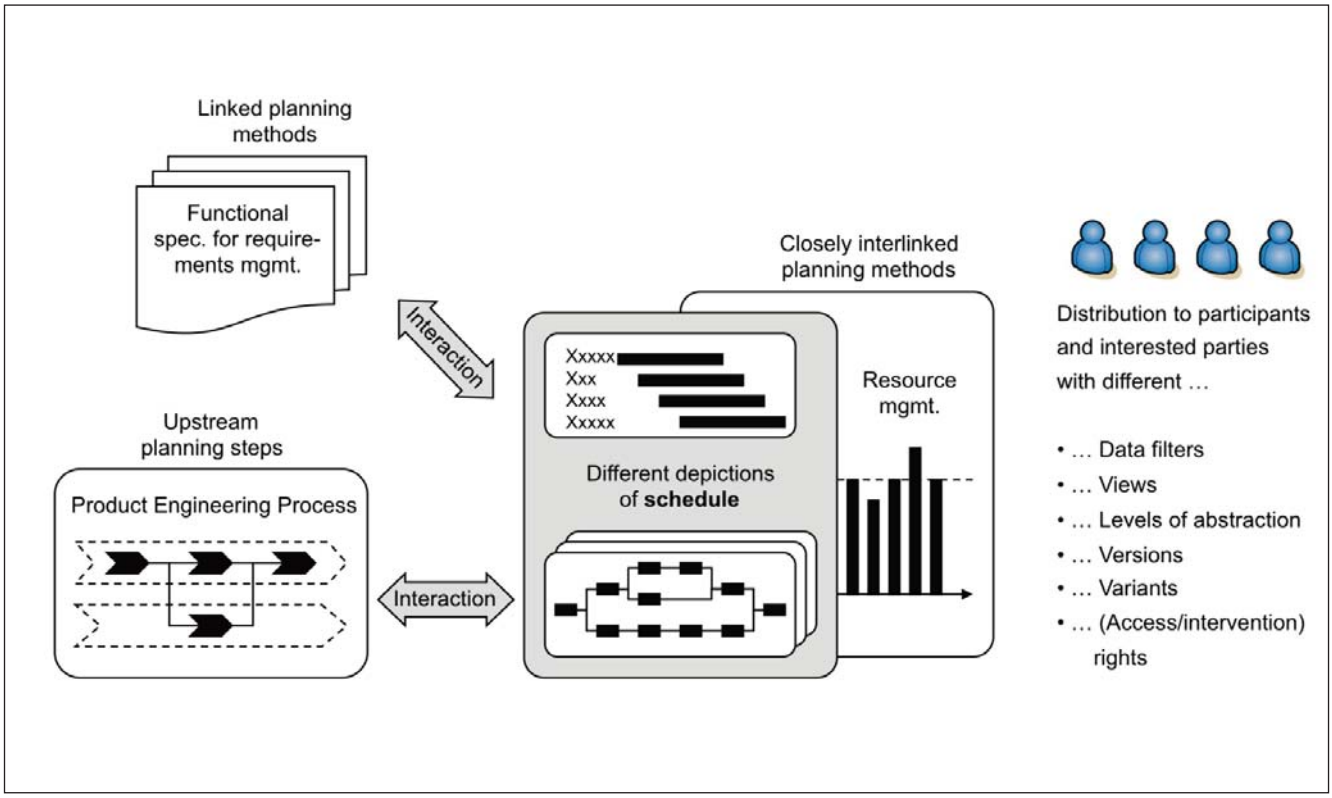


Figure 3: Integration component, simplified representation of functional networking

In the future, links to other data and documents will become of increasing importance to teams and therefore also for SM tools and are already being encouraged today in many areas through accompanying standards. Process reference and maturity level models (e.g. in accordance with VDA, SPiCE or CMMI) demand not only detailed planning and comprehensive documentation but, and in particular, near end-to-end traceability, i.e. the ability to trace the creation and further processing of data, information and requirements easily and unambiguously. What function blocks or subsystems of the product that is to be developed are created in which of the subproject plans responsible for project implementation? What individual functionalities are implemented or tested using which activities in the schedule? The goal-oriented nature of any project management plan/schedule should be demonstrated by a clear connection between project activities and product properties, i.e. the concrete (customer) requirements. In the future, a two-way tool-based connection between schedule management and requirements engineering will be the preferred solution (see Abb. 3) and is only one example of the linkage between schedule management data and the data and information derived from the other project management disciplines.

What consequences does this have for schedule management and the requirements placed on an SM tool?

☞ In most cases, any project schedule is a process instance of a general PEP. This is constructed and maintained in a process modeling and display environment and must be customized via interfaces in the SM tool.

☞ To meet the need for methodological consistency along the various dimensions that converge on central schedule management, the schedule is available in various forms: as a standardized project network, in user-friendly display forms such as Gantt charts etc.

☞ Scheduling an operating step in a project in the SM tool means planning its conduct and therefore implies dependence on the availability of the necessary resources. Schedule management is therefore inseparably linked to resource management.

☞ Every operating step in the project should create value, i.e. it should contribute either directly or indirectly to product creation. Based on tool-assisted requirements management, the product requirements must be assigned to project activities either directly or in groups.

1.2.3. Organizational networking throughout the supply chain

Another important aspect alongside the linking of function units within the tool chain consists of the linking of all the project team members, participants and other affected parties within the supply chain. A close-meshed communication network develops between the team members and, in particular, between the core team members of the project group (see Abb. 4, top left). An SM tool must indicate these information, communication and, possibly also, escalation paths, actively support them and, in exceptional cases, also render their use mandatory. The criteria by which the efficiency of tool-based communication is assessed here include, for example, the accuracy, completeness, uniqueness, timely delivery etc. of the communication channels. Many different types of tool support are conceivable here, such as, for example, not only a flexibly implemented authorizations and roles concept but also, and primarily, predefined ranges of values, the use of mandatory and optional data fields, automatic system notifications etc. (see Abb. 4, left).

At the same time, internal enterprise communication and reporting paths are increasingly having to accommodate parties that are external to the company. Strategic sponsorships and/or partnerships are being set up both within and across groups of companies. Standard modules and components as well as entire vehicle assemblies are jointly developed or jointly used. The large number of product interfaces that this makes necessary results in a similar number of interfaces during the product development (and subsequent utilization) phase. As the pressure of foreign competition grows and given the continuing tendency for corporate consolidation within the industry, the number of axes of communication that have to be mapped during collaborative relations will probably increase rather than decline. (see Abb. 4)

It is also necessary to consider the customer-supplier relations along the supply chain. Due to the continuing low development and manufacturing depth as well as to the continuous increase in product complexity, it can be assumed that the requirement for coordination will tend to grow and that crossenterprise communication will become increasingly intense. This collaboration planning is evolving in similar ways between TIER 1 and TIER 2, partly also directly between the OEM and selected TIER 2 suppliers, but also between TIER 1 and TIER 2 suppliers operating on the same level in order to harmonize production interfaces directly and take account of these appropriately during project planning. (see Abb. 4). AutoSAR and comparable development standards are, on the one hand, making possible and, on the other, making this collaboration within the development network unavoidable and strengthening this trend.

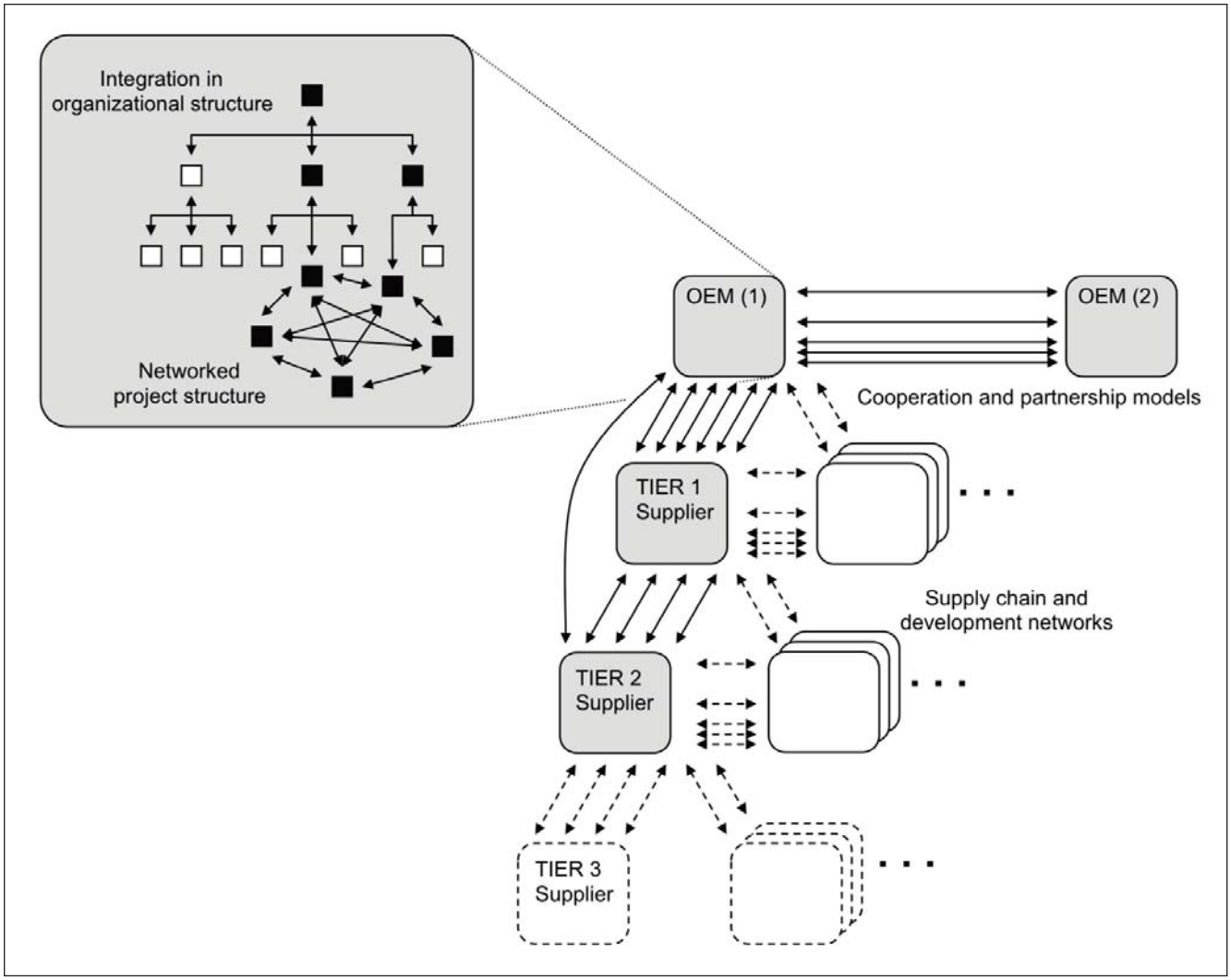


Figure 4: Networking component, simplified representation of links within and between organizations

What consequences does this have for schedule management and the requirements placed on an SM tool?

- ☞ Within the enterprise, the project teams are integrated in communication structures and reporting channels which have to be mapped, in the SM tool, not just for the core team but for the entire project team including stakeholders and the various parties involved in the reporting paths.

- ☞ As the hierarchical level of the parties involved rises (customer, program or portfolio manager through to company management), the background data must be increasingly consolidated. The aggregated depictions must be presented in an easily comprehensible way (generally in tabular or graphical form). It must be possible to scale the increasing access rights and decreasing intervention rights of the program and portfolio managers in an easy way.

- ☞ SM tools must provide suitable support for the increasing requirement for cross-enterprise coordination. The core questions that must be addressed and answered by developers, each in their own way, are to what extent and at what level of detail. What are required here are performance, creativity and flexibility during implementation.

- ☞ There are countless reasons – both objective and subjective – why development partners should grant one another as much access as necessary, but as little access as possible, to their own planning documents. Here it is necessary to combine a suitable roles and authorizations concept, on the one hand, with an appropriate systematic encryption mechanism for the full or partial transmission of the data, on the other. (Data and know-how protection!)

1.2.4. Networking within the project from SoP through to component level

The complexity of products demands the coordination of several tens or hundreds of organization units with different competence profiles. This means that when suppliers and sub-suppliers are included, several thousand individuals are involved in the project and its subprojects. The tens of thousands of planned operations are not pooled in an operations list but are instead made available at the location where the information is needed in accordance with the project structure, i.e. on the basis of the organizational and spatial distribution of the project participants. This results in countless schedules at various levels of detail which all have to be combined in a way that makes it possible to pursue and, where possible, achieve a common goal.

At the highest level of abstraction, a master schedule (phase plan with main milestones) is created that indicates the development process through to SoP, i.e. the start of production of the vehicle. The phase plan and main milestones are orientation and, most importantly, synchronization points for all the further measures that have to be planned. Any postponements have correspondingly far-reaching consequences for the entire project as well as for a large number of work operations and project participants.

Further development processes that are subject to domain-specific responsibilities are derived from the milestones. Typical areas of intersection take the form of the domains of development and design engineering (of mechanical parts including BOMs etc.), electrical and electronics (functional draft and circuit design for electronic components, software programming etc.), sampling (A, B, C and possibly other samples in order to validate the function), production-related activities (in particular, preparation for quality-assured series production) as well as other areas such as logistics, purchasing, sales, marketing, quality assurance etc. Domains that accompany large portions of the overall development process are considered first.

The development processes and subprocesses are then described in increasing levels of detail and assigned to concrete project teams, subproject teams or areas. Scheduling specifications are defined as cascaded top-down planning requirements and are then reported from the bottom up when they are either achieved or not achieved. This results in networked schedules which – sometimes on the same and sometimes on different levels of detail – all contribute to the attainment of the overall goal/compliance with the overall schedule (see Abb. 5).

At the final planning level, the planning elements generally have no time period, i.e. operations (together with their start and end) are reduced to completion dates and are used for coordination with component suppliers.

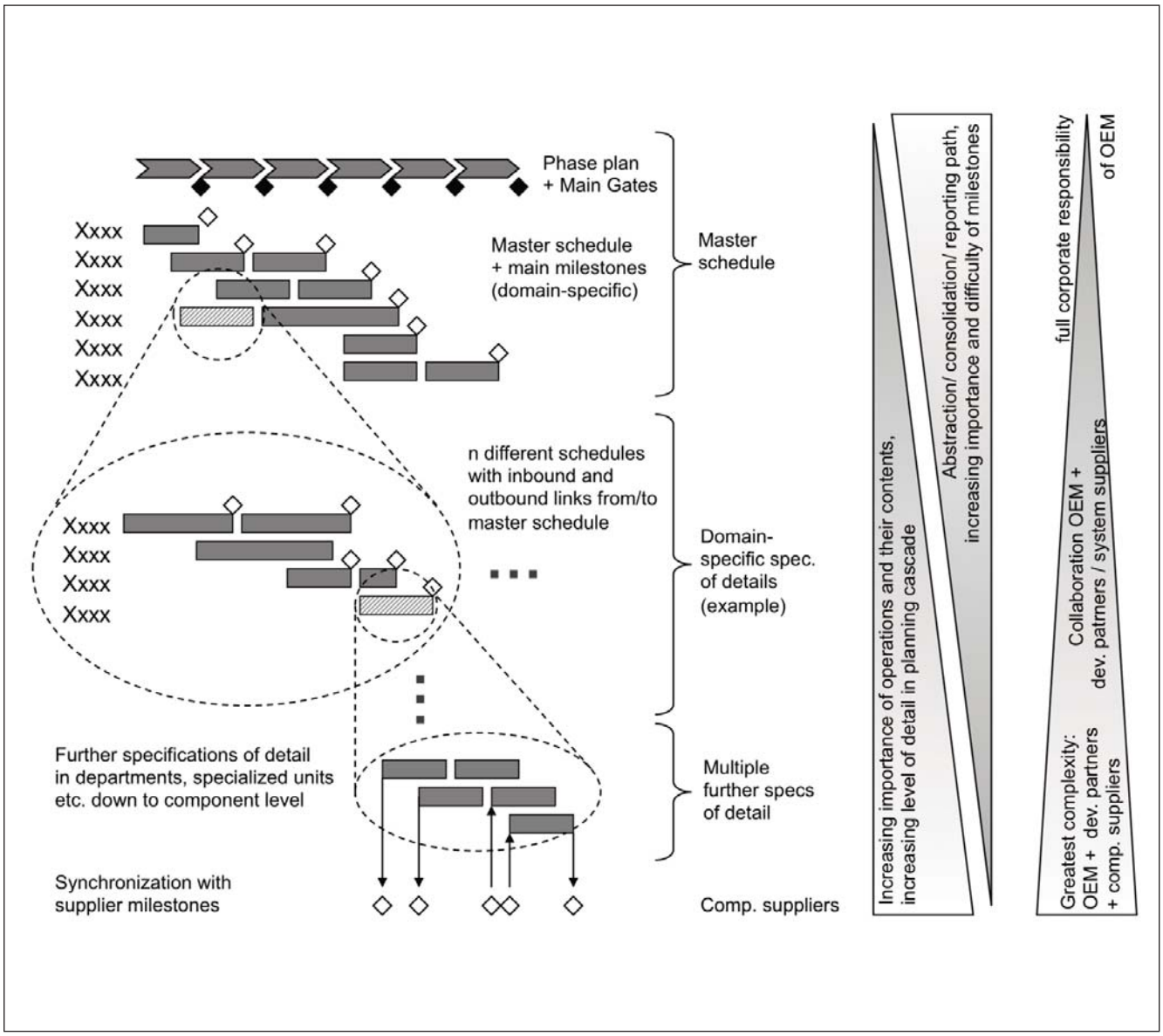


Figure 5: Hierarchically networked schedules

What consequences does this have for schedule management and the requirements placed on an SM tool?

☞ The correspondences and dependencies between the content of the schedules must be reflected in many different interconnections and a logically traceable overall structure. The overall structure is pyramid-shaped and hierarchical.

Time periods are cascaded at multiple levels: phases, core activities, operations etc. Milestones are cascaded in quality gates, milestones for which reporting is mandatory, significant subgoals etc.

☞ The links must have different properties. Scheduling specifications (top-down) must act differently from scheduling reports (bottom-up). An engine that is not made available on time must, for example, result in the indication of the threat of an SoP delay for the vehicle, whereas a missing standard part costing a few cents should not be automatically included in the reporting path through to the master schedule even in the event of a considerable delay.

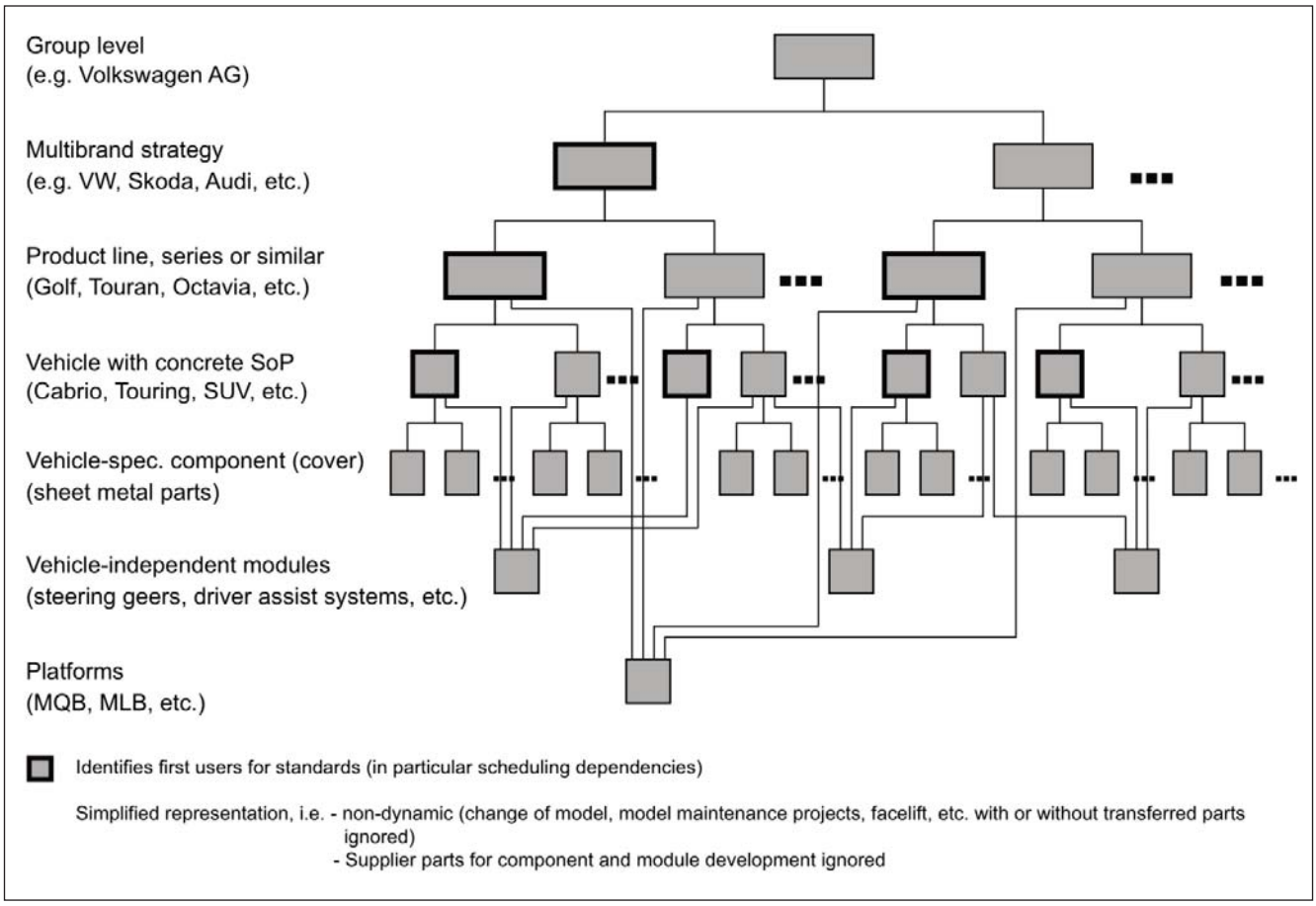
☞ The linkage between the dates specified in the schedules is dependent on the planning stages or level of detail, the product structure of the vehicle that is to be developed and on the team struc-ture of the project group – not, however, on enterprise boundaries. I.e. it must be possible to dis-play scheduling information from various schedules (possibly also at different levels of detail) in a single schedules and, if necessary, allow this to take immediate effect there. If the communication partners come from different corporate divisions or even from different enterprises then know-how protection and planning competencies must be ensured on both sides.

1.2.5. Mapping the product structure to the development network

The development network and the resulting interdependency of countless schedules are characterized not only by customer-supplier relations throughout the value chain but also by different development and production levels. At practically every development level there is a conscious search for synergisms while, at the same time, the characteristics that make each product different are defined. Thus, in the same way as the Audi A4 and A6, the BMW 3 Series and 5 Series must differ on numerous performance parameters while different sales prices must be justified by the different benefits offered to the customer (marketing view). At the same time different vehicles must possess the greatest pos-sible number of common parts in order to keep overall development times and manufacturing costs down.

Since most of today's automotive manufacturers bring together several different vehicles, and indeed a number of different brand names within one and the same group, figures for Volkswagen, provided by way of example, will serve to illustrate the extent of the resulting complexity. According to the VW Group's own figures, the 12 brands that it manufactures currently comprise more than 220 different models (including 40 new start-ups in 2012) which are produced using only 16 engines and 22 gear assemblies. This broad-based customer offering is only possible because more than 870 important standard components are used and products and services from more than 36,000 suppliers are inte-grated.[3]

[3] auto motor sport 16/2012 P. 15



Schedules throughout the product structure; simplified example presentation of the networking of schedules

This lends a further dimension to the hierarchical depiction in Abb. 5 in which the time component is not yet taken into account. Standard parts, modules and components are developed separately and integrated in several different vehicles. They therefore possess technical interfaces with one another during manufacture and organizational interfaces during development.

What consequences does this have for schedule management and the requirements placed on an SM tool?

☞ Schedules are not just constructed hierarchically on a vehicle-specific basis but are also highly networked at a cross-vehicle level. There are numerous scheduling dependencies which do not obey any uniform logic and which must be mapped in the form of links.

☞ Completion deadlines (SoPs) are usually fixed and form the starting point for any backward scheduling. The SoPs for different vehicles, on the one hand, and various cross-vehicle modules, on the other, are also dependent on one another, with the result that scheduling has to be continuously harmonized within the multiproject landscape.

1.3. Schedule management tools

Schedule management is a discipline which can, in general terms, be subdivided into scheduling (pro-spective) and schedule control (during the project lifetime) and which, overall, forms one aspect of project management. There are many suppliers of project management tools, operating at both the national and international levels, that focus on different issues and requirements either due to the nature of their customer base or for historical reasons. It is therefore all but impossible to compare two SM tools or identify the best product in a group of SM tools without having at least a rough idea of the requirements placed on the tool and its subsequent application scenarios. The current recommendation provides a systematic description of the requirements placed on schedule management within the context of project management.

SM tools do not usually take the form of pure schedule management tools but are instead project management tools with an integrated schedule management capability. Functionalities relating to other areas must therefore also be considered and evaluated in order to make sure that the final decision is justified at all levels (see section 1.2.2.). To do this, it is possible either to consider the functionality in other areas of project management or to assess the professional implementation and flexibility of the interfaces to these areas.

The typical function blocks found in project management software products are indicated in Abb. 7. These are typical in that they illustrate the basic functions provided by project management software and therefore include the aspects relating to scheduling management. Depending on the use that is to be made of the tool and the specific content and, consequently, the methodological focus of the project work, other function blocks may be integrated in the form of, for example, quality management, requirements or change management etc.

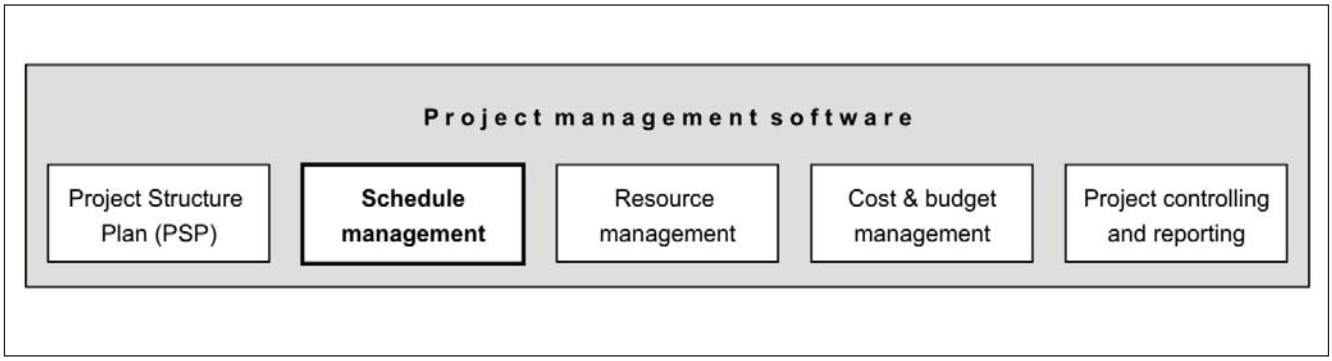


Figure 7: Typical function blocks found in project management tools (according to Mey11, p. 19)

This digression is important given that, in the recent past, increasing numbers of calendar management systems have undergone such a high level of further development that they already provide much of the functionality required for scheduling management and are difficult to distinguish from schedule management systems. Schedule/calendar management systems exist for individuals, as group calendars as well as for the planning and administration of entire resource pools, e.g. meeting rooms or machine pools for the planning of machine utilization etc. If, due to the absence of additional, linked functional units in the environment provided by the tool, it is not immediately and unambiguously identifiable whether the product is a schedule management tool or calendar management system then it is necessary to define the core operational element within the tool. The core element in a calendar management system is usually the calendar, whereas in the schedule management world, it is the project structure plan or operations list.

If we look in further detail at Abb. 7 then it is possible to identify thematic areas and further topics which result in concrete requirements for a project management tool. Within this context, numerous requirements ranging from ease-of-use to fail-proof operation cannot be assigned to any individual functional unit such as scheduling or resource planning but can now be considered as general, selfevident tool requirements that are indispensable whenever large numbers of users are all working on a complex issue. The requirements placed on a project management tool are systematically categorized as follows and can, to a large extent, be transferred to the field of schedule management.

Tab. 1: 1: Functional requirements placed on project management software [according to Mey11, p. 41 ff.]

Idea Generation / Lead Mgmt.	Creativity Techniques	Ideal / Project Classification[1]	Lead Mgmt.	Project Status/ Project Process Mgmt.[2]			
Idea Evaluation	Estimation of Effort	Resources Needs Specification[3]	Risk Estimation	Profitability Analysis	Project Budgeting	Offer Mgmt.	
Portfolio Planning	Organisational Budgeting	Project Assessment[4]	Project Portfolio Optimization[5]	Project Portfolio Configuration[6]			
Program Planning	Project Templates[7]	Resource Master Data	Resource Assignment workflow	Resource Allocation[8]			
Project Planning	WBS Planning[9]	Scope / Product Planning	Network Planning[10]	Scheduling[11]	Resource Leveling	Risk Planning	Cost Planning
Project Controlling	Change Request Mgmt.	(Travel) Expense Mgmt.	Time Sheet[12]	Cost Controlling	Meeting Support		
Program Controlling	Status Reporting[14]	Deviation Analysis / Earned Value	Quality Controlling	Versioning[15]	Milestone Controlling[16]		
Portfolio Controlling	Performance Measurement	Dashbord[17]	Organisational Budget Controlling				
Program Termination	Knowledge Portal	Competence Database / Yellow Pages	Project Archiving[18]	Searching[19]			
Project Termination	Invoicing	Document Mgmt.[20]	Supplier Mgmt.[21]	Claim Mgmt.			
Administration / Configuration	Workflow Mgmt.[22]	Access Control[23]	Report Development[24]	Form Development[25]	User defined Data structures[26]	MS Project Interface[27]	Application programming Interface[28]

1 Projects can be classified on the basis of internally selected criteria. This classification forms the basis for subsequent sorting, filtering and search functions.

2 A lifecycle is defined for every project. This is strictly process-oriented and is supported by standards within the SM tool. The project status acts as a classification feature.

3 Resources, resource types and groups can be stored and described in the SM tool.

4 Project management specialists (e.g. from PMO) have the possibility to subject projects and/or programs to an assessment. The basis for this is the definition of assessment criteria, their weighting and (possibly area-specific) evaluation.

5 In order to optimize the project portfolio, it is necessary to identify negative discordant elements. To enhance the focus on problem cases, a variety of performance indicators make it possible to compare the projects with one another.

6 *Portfolio and program managers* are responsible for a large group of projects. The SM tool also provides them with support during their planning and control activities. They can customize and apply assessments for the overall portfolio and recognize the impact of their own activities on corporate divisions and the overall system.

7 In enterprises with large project portfolios, standardized procedures that support the re-use and further use of proven approaches and forms of documentation have become established. These templates (e.g. project master data, checklists, PEP, review protocols etc.) can be mapped in the SM tool.

8 Every scheduled operation can be allocated a resource. Since all operations have to be sched-uled as a function of resource availability, it is necessary to identify clear resource conflicts and overloads even without performing detailed resource planning.

9 It is possible to store a project structure plan, i.e. a hierarchical structure of phases/work packages/tasks/operations. Every operation in an operation list can be managed individually. The overall structure makes the assignment of the individual elements to the corresponding project content clear and forms the basis for the consolidation rules.

10 Operations or summary operations can be arranged into a content-related sequence. The resulting project network makes it clear which activities have to be performed either simultaneously or sequentially.

11 Work operations are scheduled, i.e. on the basis of a sequence of contents or a chronological order. A number of standard methods are provided for this (Gantt chart, PERT, CRM etc.). => Since this represents the core element of scheduling (operation list inc. suitable display forms, e.g. as Gantt chart), it is important to ensure that a large number of different functions are availa-ble, that the tool is intuitive to use and that information is displayed clearly and conveniently.

12 The scheduling of operations makes it possible to compare resource-specific operations in order to obtain guideline values and in this way gain a simple insight into the work schedule for each individual person/resource (including information on the associated work level).

14 A status report provides information about the scheduling situation and is supported by relevant statistics and data (adherence to schedules, departures from schedules, etc.). It is the primary source of information prior to the introduction of suitable control measures taken in good time to ensure that schedules are complied with.

15 Projects or programs can be versioned. Versions are identified in a suitable way and can be viewed at any time. Versions are frozen, i.e. they can no longer be edited or changed. They can, however, be compared with one another.

16 Milestones are tracked separately, in particular when they are moved or accomplished. The pre-ferred method here is MTA or Milestone Trend Analysis.

17 The most important information – a suitable mix of project master data and current figures – is made available in a *dashboard*.

18 Concluded and canceled projects are archived. Although it is no longer possible to make changes to the project data of archived projects, they are protected against manipulation and can be called up and viewed at any time.

19 Tool-assisted search functions simplify navigation in a selected body of data (in a screen, in a table or similar) or in the entire SM tool (search parameters at database level).

20 Data and information whose contents are only of indirect relevance for schedule management are collated in separate documents that are saved either in or, using an appropriate method, outside of the schedule management tool and linked to the corresponding operations or milestones.

21 The organizational and structural aspect of supplier management is mapped via interfaces between the user's own activity and the activities of partners and supplier. Delivery dates for prod-ucts and services, as well as synchronization points for the control of joint activities, are fixed in the schedule and assigned to the supplier. The coordination of contents is supported by means of cross-enterprise data exchange.

22 Fixed sequences of operations within the project as well as procedures that can be planned un-ambiguously and that are executed step-by-step are operationalized in the form of *workflows*.

23 Project groups consisting of a number of different individuals demand multi-user systems. Appropriate access control must be ensured and include a rights and roles concept encompassing a large number of different levels.

24 Alongside the provision of standard reports, the system also permits the compilation of custom reports. These are either modular or can be customized via parameter settings so that they can be used even without programming knowledge.

25 In the same way as custom reports, it is also possible to design input and output forms. Enterprise and area-specific requirements determine what functionality is visible and/or available for use.

26 As part of enterprise-specific customization, it is frequent not only for new functionalities to be implemented in the user interface but also for data fields to be extended or databases to be con-siderably enriched. To make this possible, the SM tool contains a flexibly extensible database structure.

27 Microsoft products and the associated look & feel have established themselves in many areas as a defacto standard. In the project management field, this also apples to the MS Project data format. Although it does not permit convenient cross-enterprise operation, links to individual workstations or small groups are of enormous relevance in practice. It must be possible to import and export MS Project-compatible data formats without difficulty.

28 The SM tool provides an API (Application Programming Interface). This can be used to design electronic data interfaces to other systems. (Requirements concerning interfaces to time recording systems or relating to collaboration with other SM tools are frequently formulated).

Like almost all segments of the IT and EDPO world, the project management software market is extremely fast-moving. New programs are launched on the market several times a year or, if apps are included, almost every day. Well-known tool suppliers are constantly further developing their tools with the result that it is not infrequent for new versions to be released every year. With each new release, the scope of the functionality is extended, stability is increased and the technology improved. Older systems are disappearing from the market at the same rate. Service support for obsolete systems that are still in use is withdrawn, suppliers are taken over by their competitors or are squeezed out of the market. Consequently any supply-side evaluation of the market becomes obsolete and therefore loses some of its validity after a period of only 6-12 months.

On the demand side, it is also necessary to check whether, and for how long, previously formulated requirements remain relevant. Projects change and therefore so, too, can the entire project portfolio. Enterprise reorganizations or restructurings lead to changing constraints which have to be reflected in the tool world. The development of new planning and control methods as well as the further development of existing methods is also adding to the requirements placed on IT tools. It can be assumed, for example, that the significance of offline clients will continue to fall because today's users can use wire-less technology to go online almost anywhere. In contrast, networking requirements will grow both in terms of cross-enterprise collaboration and networking between disciplines, e.g. between scheduling, resource planning and budget planning. Here, too, despite the long-term relevance of the requirement for basic functionality, the validity -that is to say, the correctness, completeness and current relevance - of the entire requirements catalog must checked approximately every 6-12 months.

Summary of section 1: The top 3 demands for schedule management in the automotive industry

The German automotive sector is home to so many large and complex players that any schedule management tool naturally faces a very great number of sometimes contradictory requirements. Over the years, procedural models, working methods and tools have become established in which innovative project and multiproject management methods are now being integrated, thus increasing the complexity and speed of change in the field of schedule management itself. These developments make it possible to identify three fundamental areas in which a successful SM tool must excel.

1. A tool supplier/schedule management tool must excel in the way it *deals with complexity*. This applies to the cross-project and cross-enterprise network of schedules, the multiplicity of operations and levels into which any individual project is broken down, as well as the consolidation of the many different requirements of the interdisciplinary project participants who occupy different hierarchical levels and are located at different locations around the globe.

   The challenge lies in the balancing act that is required between extreme flexibility and maximum configurability of the system, on the one hand, and the need to ensure minimum maintenance effort on the part of project managers and administrators on the other.

2. A tool supplier/schedule management tool must excel in providing *industry-specific solutions*. At the same time, the supplier's specialist expertise and methodological know-how must extend the customer's capabilities and make it possible to respond to demands for the tool-based incorporation of practical working modes through improved methods and the exploitation of synergisms.

   The challenge lies in finding a balance between an unwavering customer focus and the fulfillment of individual customer needs, on the one hand, and the capacity to establish guidelines in terms of the processes, methods and tools involved in schedule management, on the other.

3. A tool supplier/schedule management tool makes consistent use of *standardized data ex-change formats* for project plans, or at least for schedules. If this precept is adhered to then users of different SM tools can work on the same project. Information can be passed on across different media within the IT deployment schema without loss of data or the need for redundant input. On archiving, the functionalities of the different tools are retained in full.

   The challenge lies in striking a balance between a tool tailored to meet specific requirements in the user front-end, on the one hand, while simultaneously using standard technologies and standard data formats in the back-end in order to ensure the compatibility of communications with the tool and enterprise environment.

2. How to use the criterion catalog

There are numerous possibilities for using the criterion catalog in the context of tool-assisted schedule management. While these are based primarily on the user's needs, they also take account of situation-specific constraints. Thus, for example, it is possible to access the entire criterion catalog or simply use parts of it.

Typical, proven and also recommended application scenarios are as follows:

1. Use of the internal evaluation of an existing tool-based solution in the schedule management field (see section 2.1.)
2. Use for the system application of a benchmark to permit the evaluation and comparison of ex-isting solutions or proposed solutions (see section 2.2.)
3. Use to minimize the initial internal effort involved in the drafting of a product specification with-in the context of requests for proposals for tool-based schedule management (see section 2.3.)

The core components of a criterion catalog (see section 3) are first and foremost structured in the form of a table which is presented as a structured, unweighted list of requirements (see Tab. 2). Columns 1 and 2, Prio. (= Priority) and Stat. (= Status) have been left empty. If this criterion catalog is used in operation then it can serve directly as a template. The defined priorities or statuses for the individual criteria can then be entered directly for each concrete use case. The fourth, and most important, col-umn of the table lists the criteria relating to a tool-based schedule management solution, while column 3 provides an ID to permit unambiguous identification. This means that no confusion can arise during cross-enterprise communications or if translations of the catalog are used.

In the example below, the priorities and statuses are already entered to indicate how to use the catalog.

Tab. 2: Example of the tabular presentation of the criterion catalog

Prio.	*Stat.*	ID	Requirement
		x-x-x	. . .
3	*2*	2-2-13	It is possible to choose between different relationships (normal sequence, start sequence, end sequence, jumps within sequences). These relationships can be changed at any time and as often as required.
3	*3*	2-3-1	Different display forms can be chosen for the schedule, such as … **x** … bar chart with time axis/Gantt chart ☐ … Event node project network
		x-x-x	. . .

2.1. Internal evaluation

The current criterion catalog, which operates at the level of functional concepts, should be filled in as completely as possible at the presented level of detail. It is the result of numerous discussions with specialists, experts and experienced industry representatives and has been validated and recommended by leading associations. It can therefore be considered as constituting "best practice".

If problems are identified during in-house schedule management activities then this may be due to objectively discernible causes in each individual project (high level of complexity, demanding project environment etc.) or to systemic causes (absence of planning logic, inadequately trained users etc.) or system-related causes (insufficient tool functionality, inadequate implementation depth of the support-ing tools etc.). The criterion catalog can be used for a rapid search for these causes or to perform a weak-point analysis designed to evaluate the existing solution and its implementation depth.

If these analyses reveal circumstances that have to be considered as 'partially present' then it makes sense to specify the status accorded to the particular values of individual criteria in greater detail and differentiate between these statuses. Thus, for example, the partial presence of information in a specific view in a tool may be unproblematic because only details are missing (the full change history). It may also, however, be extremely serious if the small amount of information that is missing is exactly the information that is important (end date of an activity and note on the following activity). As a result, in the case of partially fulfilled requirements, the extent of the inadequacies should be categorized in more detail so that the implemented measures can be prioritized and targeted better. All forms of internally defined maturity level categorizations are helpful in this task provided that they are easy to use and cannot give rise to misinterpretation. To avoid the 'golden mean' that is frequently used when there are an uneven number of statuses, a simple, four-level status grid is recommended for the evaluation of the status of the value of a criterion. This can, for example, take the form of the example in Tab. 3.

Tab. 3: Status of documentation as part of an internal evaluation

Status		The requirement placed on the tool...
3	complete	... has been completely and therefore satisfactorily implemented, provides high performance and is fully integrated in the other functions
2	accepted	... has been implemented and is therefore acceptable. The performance of the functionality and/or its integration in the context of other tool functionalities still leaves room for improvement.
1	implemented	… has effectively been implemented but does not as yet provide the required effect/value added and therefore needs to be significantly improved in the next release.
0	not implemented	… cannot be confirmed.

The following approach to the internal evaluation of existing solutions for tool-based schedule management:

1 Validation of the status grid from Tab. 3 for the categorization of the fulfillment or partial fulfillment of criteria (optionally you may also construct your own status grid.)

[2 optional: Prioritize criteria (possibly based on the categorization in Tab. 4) if individual criteria or groups of criteria are of special significance]

3 Identification of the values of the criteria for the system to be evaluated through tool analysis or user surveys (attention when conducting surveys: the limits to the potential of the tool solution should not be influenced by the limitations to the user's know-how.)

[4 optional: Add the points and calculate the totals per group of criteria as a percentage of the maximum number of points. This results in an abstraction level above the evaluation of the individual criteria consisting of a profile of the strengths and weaknesses of the evaluated solution which permits initial conclusions concerning the frequency of problems at the level of the methods and/or tools.]

2.2. Benchmarking solution suppliers

If it is necessary to compare a number of existing solutions or the offerings proposed by solution suppliers then it is advisable to prioritize the required criteria. The same thing applies again here: The priorities must be categorized into a sufficient number of levels, must be easy to use and must not give rise to misinterpretations. It is essential for this prioritization to be performed against the background of a concrete use case, i.e. a concrete (potential) application scenario for the schedule management tool.

It is helpful to use a range of values consisting of a small, even number of categories. If this type of range of values is not yet available for the use case then a range of categories as in the example in the table below is recommended. (see Tab. 4)

Tab. 4: Range of values (example) for categorizing the priorities of criteria

Priority		The requirement placed on the SM tool...
3	very high	… has a very high priority, i.e. it is a mandatory or KO criterion
2	high	… has a high priority and supports the implementation of the schedule management philosophy including the methods selected by the party specifying the requirement
1	medium	... has a medium or relatively low priority, i.e. it is a nice-to-have requirement whose implementation is not considered important if it involves significant extra effort or extra costs
0	low	… has a low or no priority, implementation should be deliberately avoided in order to provide a streamlined tool.

The following approach should therefore be adopted when benchmarking different SM tools or tool concepts for schedule management:

1 Validation of the status grid from Tab. 4 for the categorization of the priorities of the criteria (op-tionally you may also construct your own status grid.) Alternatively, or additionally, it is also pos-sible to assign priorities to the groups of criteria.
2 Identification of the values of the criteria for the system to be evaluated through tool analysis or user surveys (attention when conducting surveys: to guarantee objectivity, one neutral analyst / one neutral group of experts should perform the evaluation. (Different analysts may sometimes come up with different results for one and the same situation.)
3 For each criterion, the priority value and status value are multiplied and the products totaled for each group of criteria. The level of fulfillment of the criteria - weighted by the importance of the criteria - can now be compared at different levels of abstraction for any number of comparison solutions: at the level of the criteria, the groups of criteria or the entire SM tool.

2.3. Product specification for solution suppliers

If a Request for Proposals is issued for a tool that is to be employed for schedule management pur-poses or if the custom programming of such a tool is commissioned then the work of the solution or service supplier must be guided by a product specification. In this third application scenario in which the current criterion catalog is used as the product specification, it is necessary to adapt the requirements to meet individual circumstances. Although the work involved in this task should not be under-estimated, it also offers the greatest potential time savings of the three application scenarios.

Whereas in application scenarios 1 and 2, the categorization of the individual criteria is simply recorded or quantified, in this case it is necessary to define concrete specifications (e.g. for storage volumes, system response times etc.). Although the criterion catalog helps remind those responsible of the wide range of requirements, it does not make it possible to formulate concrete requirements when the pre-cise nature of the application is unknown. The weighting or assignment of priorities to requirements as in application scenario 2 is also recommended in order to ensure that the bulk of the financial and human resources involved are focused on the implementation of the most important requirements. These considerations result in the following procedure for the derivation of a customized product spec-ification based on the current criterion catalog for tool-based schedule management:

[1 optional: Restrict the group of criteria to the key points considered as necessary for the concrete application. (Caution should be exercised if certain details or consequences are unknown: if in doubt, it is better to remove one or more criteria from within a group than to delete an entire group)]

2 Eliminate individual criteria within the remaining focused groups of criteria.

3 Adapt the remaining criteria to your individual circumstances if the presence of text requiring completion (☝) or checkboxes (☐) indicate that this is necessary. When doing this, it is neces-sary to take account of both the requirements placed on the SM tool and the constraints resulting from the IT environment.

4 Assign priorities to the criteria in accordance with Tab. 4 or a comparable system of prioritization. Alongside the absolute scope of the criteria, this assignment of priorities specifically influences the balance between performance, flexibility, costs and the ease of implementation of the tool.
(The prioritization operation may also provide for a release strategy if it is not necessary to meet all the criteria immediately.)

5 Extend the criteria with your own criteria that are not mentioned here or are not specified in sufficient detail.

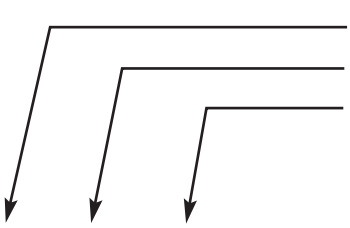
This approach also provides the suppliers of SM tools or relevant consulting service providers with an additional way of developing their products and services. The systematic definition and disclosure of the requirements placed on an SM tool by leading suppliers in the automotive sector will make it pos-sible to address the industry's consolidated requirements at an early stage free from the pressure im-posed by a concrete Request for Proposals. It will make it possible to identify ideas contributing to the further development of supplier-specific tools. Non-specialized tool suppliers will have the opportunity to progressively focus their activities in the sector. This applies in particular to solution suppliers whose core skills historically lie not in the field of project management methods but in the development of IT tools. Such suppliers are recommended to study the modes of operation and main requirements that characterize the sector as set out in section 1.2 and to use the knowledge acquired to initiate a dialog with typical users of such systems. Only when the practical reasons underlying the requirements are understood is it possible to develop innovative extensions or alternative solutions.

3. Criterion catalog: Requirements placed on a tool-assisted schedule management solution for networked project partners

The criterion catalog for the systematic definition of the requirements placed on a tool-assisted sched-ule management solution for networked project partners is presented as a structured list of requirements in tabular form. These should be understood as follows:

Specialist concept: Requirements in terms of the content of the schedule management solution = *Requirement category*

Operations, operation lists and internal links within the schedule = *Requirement group*



= *Optional specification of priority of requirement (e.g. as per sec. 2.2.)*
= *Optional specification of status of requirement (e.g. as per sec. 2.1)*
= *Specification of requirement ID*
(informative key formed from number of requirement category
+ number of requirement group +sequential number of requirement)

Prio.	*Stat.*	ID	Requirement	
			Operations can be linked with one another to map dependen-cies between contents and timings. • In the event of changes to the location or duration of an operation, links between operations result in the postponement of all linked operations or, optionally, the display of the resulting scheduling con-flicts.	= *Requirement* = *Supplementary req.*
		☝	Menu guidance, i.e. the language used for interaction with the system, is possible in the following languages: ☐ … German ☐ … English ☐ ……	= *Requirement variant* = *Invitation to customize the requirement*

* Definition in accordance with DIN 69900:2009 = *Requirement reference*

=> Requirement was considered to be relevant by all surveyed automotive OEMs or can be viewed as a generally acknowledged customer requirement for an IT-based project management tool.

• *=> Supplementary requirement was considered to be relevant by the majority of surveyed automotive OEMs or consists of an extension, more detailed specification, explanation.*

☐ *=> Requirement variant is usually part of a set of mutually exclusive variants. The concrete variant is considered to be relevant by some automotive OEMs or was explicitly rejected by at least one of them.*

☝ *=> Customization of requirement invites you to enter a text of your choice or extend a parameter. The requirement should preferably be extended or given a concrete definition in the light of each enterprise's specific situation.*

3.1. General requirements

At the points in the criterion catalog below where the respondent is asked to customize or enter a con-crete definition for a requirement, a range [x] of expected parameter values is often provided for non-specialists and potential solution suppliers. These are NOT guidelines, means or maximum values but simply expected ranges delineated in powers of 10. Several 10s means that customization parameter values between 10 and 99 are expected here while several 100s means that values between 100 and 999 are expected etc.

3.1.1. System philosophy and system properties

Important *system properties*[1] take the form of flexibility, universality, modularity, compatibility, transparency and prevention.

Prio.	*Stat.*	ID	Requirement
		1-1-1	The *flexibility* of the system is reflected • by the scalability of the function scope (both during installation and during use) • by its tolerance to methodological errors, i.e. omitted inputs or data inconsistencies should be regularly indicated but should only rarely prevent continued operation.
		1-1-2	The *universality* of the system is reflected in its ability to provide constant high performance in changing applications. I.e. the SM tool used for the planning and control of product development projects must, with minimal modifications (e.g. by integrating another underlying process-related procedural model), also be useable for the implementation and control of implementation, rollout or other typical organizational projects.
		1-1-3	The *modularity* of the system is reflected • in the license model (business economics perspective), i.e. small-scale function modules can be licensed individually or in combination • in the way the system is made available and operated (technical IT perspective), i.e. small-scale function modules can be installed individually or in combination with others and are fully func-tional either on their own or when networked, and • during the utilization of the system (individual user perspective), i.e. links between modules do not lead to obligatory operating paths with-in the SM tool. The user decides on the type and extent of the use to be made of the provided modules.
		1-1-4	The *compatibility* of the system is reflected • in methodological aspects, i.e. multiple/different process models and procedures can be stored and implemented simultaneously. • by the powerful, harmonious design of interfaces to other IT-based tools. (see: Method and data interfaces)
		1-1-5	The *transparency* of the system is reflected • by the visibility of sequences and interrelations, i.e. through the ability to trace the development of the data and information content. (Ability to trace data and information back to its sources without excessive effort, displays of references, units etc.) • by the visual/graphical design of screen forms in which everything is identifiable and fast, easy and intu-itive to find.
		1-1-6	The SM tool supports *prevention* through • the clear separation of scheduling and schedule control, e.g. through the attainment of specific milestones, electronic releases or similar. • the early detection of the emergence of future problems, e.g. through completion date forecasts, MTAs, automatic identification of discrepancies between target and actual values including the tracking of causal chains etc.
		1-1-7	*Other applicable documents:* • DIN 69901-1:2009 "Project Management – Project Management Sys-tems, Part 1: Fundamentals" If the system exhibits system functionalities or system properties that differ from those listed in the other applicable documents then this must be indicated at an early stage together with the reasons and consequences.

[1] Definition in accordance with DIN 69901:2009

3.1.2. Master data

Prio.	*Stat.*	ID	Requirement
		1-2-1	The scope of the *master data* is minimal. Master data is preferably taken over from other enterprise systems via permanent or cyclically synchronized interfaces. (see LDAP in 3-3-9) • An exception here is highly invariant master data (e.g. cost categories) for which the effort involved in implementing an interface would greatly exceed that of performing redundant data maintenance.
		1-2-2	Human or technical resources are mapped in *structure trees*. The structure trees reflect the enterprise organization, i.e. the assignment of the resources to departments, sectors etc. • Human resources are not stored as separate master data but, for example, are read in via LDAP (see data interfaces, 3-3-9)
		1-2-3	Resources are assigned a basic level of availability, i.e. a *load limit*. It is additionally possible to define extended load limits for a resource (e.g. in the categories (a) own employees, internal staff, (b) together with integrated external employees, hired-in staff, work contracts etc., (c) together with external resources such as third-party services, cooperative partners, resident engineers etc.). (The exploitation of different load limits is important in order to ensure compliance with deadlines but even more important for the subsequent conversion into cost and budgetary amounts.)
		1-2-4	Projects are mapped in a *project structure tree*. The levels of detail and/or consolidation (e.g. portfolios, programs, projects, subprojects etc. down to the level of the individual schedule or similar) are structured separately, outside and independently of the enterprise/resource structure tree. • The assignment of schedules to organizational units can be specified by means of links or references. • The nodes of the project structure tree are subject to the rights and roles concept (see 3-2-4). The authorization for associated schedules is handled independently.
		1-2-5	When setting up a new project, it is possible to copy a structure known to the system (standard structure or operational structure of existing project plans). It is possible to implement cross-schedule and cross-project links throughout the hierarchy of the project structure tree. (see structure of schedule, 2-3-6 ff.)

3.2. Specialist concept: Requirements in terms of the content of the schedule management solution

3.2.1. Compliance with standards, creation of and adherence to standards

Regulatory standards, guidelines, recommendations, industry standards and quasi standards shape the terminology, definitions and procedures used in the schedule management field. By adopting just one or a limited number of standards, it is possible to avoid the misunderstandings that can quickly arise in internationally staffed project teams.

Prio.	*Stat.*	ID	Requirement
		2-1-1	The *concepts and specialist terms* used for project management are based on the habitual, generally accepted standards and guidelines applicable ☐ … in Germany ☐ … in ……..
		2-1-2	The methods *procedures and bases for calculations* used for project management are based on the habitual, generally accepted standards and guidelines applicable ☐ … in Germany ☐ … in ……
		2-1-3	The *main focus* (the tool philosophy) is placed on … ☐ … German industry and regulatory standards (issued by DIN, GPM, etc.) ☐ … American industry and regulatory standards (issued by ANSI, PMI, etc.) ☐ … international industry and regulatory standards (issued by ISO, IPMA, etc.) ☐ … Sector-specific industry and regulatory standards (issued by VDA, A-SPiCE, after APQP, etc.)

Prio.	*Stat.*	ID	Requirement
		2-1-4	*Cross-enterprise collaboration* is still possible even if the two partners are using different scheduling tools. The methodological basis for this is the use of a standardized, secure data exchange format for schedules or schedule items which adheres to the following standard: ☐ … CPM, Collaborative Project Management, based on the ProSTEP iVIP Reference Model, Vers. 3.0. (In particular the tasks assigned to the roles listed there (section 4.4.: project manager, subproject manager, member of project team, member of project steering committee) must also permit implementation at cross-enterprise level. ☐… ……
		2-1-5	Particular importance is attached to the implementation of: ……
		2-1-6	It is possible to define multiple *Product Engineering Processes (PEP)* as enterprise standards. Each PEP is defined on a project, customer and product-independent basis and is stored centrally. • PEPs can be versioned within the framework of continuous further development. • PEPs can consist of multiple schedules with links between the schedules (see 2-3-6 ff.). • PDPs can be instantiated, i.e. any number of operational projects can be generated from one and the same PDP.
		2-1-7	An operational, specifically configured schedule can be stored as a PDP, i.e. as a *neutral process template* and then be copied for use in other projects. Selected contents (columns) can be set to be empty when creating a copy of a template. This approach, which preserves acquired experience, can be used to create enterprise or parallel industry standards.
		2-1-8	A schedule template is representative of a group of projects and has concrete properties. • Administrators decide whether the properties are binding or whether the project-specific customization of templates is to benefit from the same flexibility as is available when setting up a new project.
		2-1-9	It is possible to *combine at least two PDPs*, i.e. link (reciprocally reference) their phases and milestones. If internal process specifications are equally relevant as those of the customer or development partner then the processes can be linked even before they are instantiated.
		2-1-10	The operational development project is uniquely instantiated from a process. The phases and milestones of the synchronized PDP are referenced from the operational project.

3.2.2. Operations, operation lists, internal links within the schedule and scheduling

The term operation is used as a synonym for activity, task, project step, work operation etc.

Prio.	*Stat.*	ID	Requirement
		2-2-1	The *Project Structure Plan (PSP)* can be viewed and maintained as a structure tree/as a list and graphically in the form of an organization chart.
		2-2-2	The *operations list* is displayed as a table and can be flexibly configured. • Range: An operations list can contain several 1000 operations, i.e. the corresponding number of lines (plus summary operations).
		2-2-3	The *default parameters* parameters for an operation are the name of the operation, start, end, duration, responsible resource and a comment (short text). • The start, end and duration are interlinked in such a way that if two of the items of data are entered, then the third field can be calculated subsequently • It must be possible to set the behavior when making a change in advance: if one of the three values is changed, it must be possible to declare which of the other two will be recalculated. Example: the duration of an operation is changed. It shall be possible to define whether the start or end date is changed accordingly.
		2-2-4	Any required number of *parameters can be added* for operations – either for individual schedules or as the default logic for the entire SM tool. Additional parameters that should be reserved by the system are ☐ … Note on the operation (long text) ☐ … ……

Prio.	*Stat.*	ID	Requirement
		2-2-5	*Hyperlinks* to the intranet, internet or to a file server can be set for operations. (Caution in the event of contradictory access authorizations inside and outside of the SM tool.)
		2-2-6	*Milestones* (operations without any duration in time) are depicted as simple dates whose observation/ attainability are key control elements for the project. Milestones can be linked to one another as well as to operations or summary operations.
		2-2-7	*Milestones* can be configured in the same way as operations. The default parameters are the origin (customer, internal), target date, status (achieved, not achieved) as well as freely definable parameters to be configured individually based on enterprise-specific requirements.
		2-2-8	Milestones are recorded in the history. This history shows the development and possibly also the change history of the milestone up to the present time. The milestone history can be consulted without significant effort (without hav-ing to search in underlying baselines; see 3-4-13)
		2-2-9	Operations can be additionally flagged using intuitive comment icons, for example as • modified (operation modified or not on last call of schedule) • critical (adherence to deadline critical or multiple categorizations) (see critical path, 2-3-5) • completed (quantified by means of a value [%]) • Owner information (operation only visible to the owner of the schedule)
		2-2-10	It is possible to define *operation classes*. Each operation can be assigned to an operation class that is recognizable in the operations list - including on the basis of the graphical representations used. • Operation classes, for example the distinction by domain (hardware, software, mechanical) or sector (purchasing, development, test laboratory) can be defined centrally and extended by decentralized users. • The classification shall be applicable to milestones as well.
		2-2-11	It is possible to define *operation characteristics*(e.g. via checkboxes). Typical characteristics are • Operation cannot be moved or can only be moved within certain limits (e.g.: winter tests cannot be performed in the summer.) • Time optimization of operation is not possible or only possible with restrictions (e.g.: a long-term test cannot be completed quickly even if additional resources are assigned.) All operation characteristics can be combined with all the operation classes.
		2-2-12	*Uncompleted operations* can be renamed or rescheduled at any time. • Optionally (configurable), closed operations can be renamed or re-scheduled as well.
		2-2-13	Operations can be *linked with one another* to map dependencies between contents and timings. • It is possible to choose between different links/relationships1 (normal sequence, start sequence, end sequence, jumps within sequences). The type of relationship can be changed at any time and as often as required. • In the event of changes to the location or duration of an operation, links between operations result in the postponement of all linked operations or, optionally, the display of the resulting scheduling conflicts. These latter would then only be eliminated through manual intervention ("informational link").
		2-2-14	*Relative start and end dates* can be specified for linked operations. This applies in particular to process templates (PEP or similar). It is possible to convert between relative and absolute time specifications at any time.
		2-2-15	It is possible to create links between operations, between a process and a milestone and vice versa as well as between different milestones. (The direct linking of milestones contradicts normal planning logic (a milestone represents the conclusion of an operation or a sequence of operations) and can be restricted to the master schedule if necessary.)
		2-2-16	It is possible to specify different milestone characteristics (for example moveable/moveable subject to conditions/not moveable, target date/actual date, attainment of milestone requires/does not require a decision, etc.). Milestone characteristics can be configured, for example, via checkboxes and can be different on different planning levels (series, project, object, etc., see Abb. 5).
		2-2-17	*Calculation procedures*, in particular forward and backward scheduling, must be performed in accordance with DIN 69900. All operations that are not scheduled by means of automatic calculation (e.g. unlinked operations) must be indicated in a suitable way until manual scheduling has been performed. It must be possible to disable automatic calculations for selected items, in order to keep in control of particular events (e.g. a leading milestone).

Prio.	*Stat.*	ID	Requirement
		2-2-18	When the *project network is compressed*, substitute operations[1] (including summary operations, grouped bars) and substitute relationships[1] (linking of an operation with a summary operation) are used.
		2-2-19	Selected operation parameters (e.g. start, end, duration) can also be maintained manually for summary operations. ☐ … If an operation class or responsible resource is defined for the summary operation then this information is transferred to all the underlying operations.
		2-2-20	Entire schedules can be *compressed or lengthened* (e.g. from 48 months to 32 or 72 months). When this is done, all the operations belonging to the schedule are lengthened or shortened by a corresponding percentage amount. • A prompt is then issued asking the user to confirm the automatically resulting detailed schedules. • Changes or intended changes to operations and milestones with special characteristics are indicated in a suitable way. (see 2-2-11 and 2-2-16)
		2-2-21	Operations and milestones *are assigned* an ID. The range of numbers used for IDs may not be repeated within a project, including at other planning levels. The ID helps guide the scheduler and forms the basis for subsequent comparisons between schedules (see comparisons of schedules, 2-4-6).
		2-2-22	*Other applicable documents:* • DIN 69900 "Project Management – Project Network Techniques; Descriptions and Concepts" If terms, computational algorithms or representations that differ from those in the other applicable documents are used then this must be indicated in good time together with the reasons and consequences.

[1] Definition in accordance with DIN 69900:2007

3.2.3. Structure and display of the schedule, cross-schedule links

Prio.	*Stat.*	ID	Requirement
		2-3-1	Different *display forms* can be chosen for the schedule, such as … ☐ … bar chart with time axis/Gantt chart ☐ … Event node project network
		2-3-2	Summary operations can be displayed in different types of bar chart. The preferred types are: • Grouped bar charts (related/continuous operation bars) • Single-line/serial display of all the operations belonging to the summary operation (may not be of use if individual operations overlap) The graphical display is supported by the appropriate identification of items in the operations list, e.g. by the use of indents. The structure levels below a summary operation can be hidden either generally for an entire schedule or specifically for the operations belonging to a summary operation.
		2-3-3	All *calculations of dates* for milestones as well as for the earliest or latest start or end times for linked operations are performed in accordance with DIN 69900. This applies in particular to the determination of buffer times and the time-critical path through the project.
		2-3-4	*Schedule buffers* are issued and defined[1]. (free buffer time, total buffer time, independent buffer time etc.)
		2-3-5	Critical operations in the project plan which are not derived from the time-critical linking of operations can be stored separately. (E.g. ´First use of the technology; patent situation not yet adequately checked´).

Prio.	*Stat.*	ID	Requirement
		2-3-6	Project networks can be connected to one another via *connecting interfaces*[1] (cross-schedule links) to permit networking across different schedules. • A project network can be linked as often and to as many other project networks as required. • Project networks can be called and edited individually or in partially or fully networked form.
		2-3-7	The *connecting interfaces* must be unambiguously indicated via an ID. All key figures, operation parameters or similar must be transferred at the connecting interface from or to the linked project network.
		2-3-8	*Operation mirroring* is is used to mirror an operation in an external schedule in the local schedule (pull principle for schedule information). The mirrored operation is identified as such. If the location, duration or characteristics of the operation change in the source schedule … ☐ … then the mirrored operation in the target schedule is modified in the same way. As the mirror image of the source schedule, it is the only element to be independent of the principle of ownership in the target schedule. ☐ … then inconsistencies between the operation in the source schedule and the mirrored operation are indicated in the target schedule. The principle of ownership is retained. The owner of the schedule decides whether the changes are taken over.
		2-3-9	With the creation of a *cross-schedule relationship*, the timing of an operation in the local target schedule is made directly dependent on a preceding operation in the source schedule. (Pull principle, i.e. responsibility to retrieve dominant schedule information). If the location, duration or characteristics of the operation change in the source schedule … ☐ … then the location of the cross-schedule linked operation also changes in the target schedule. In this way, dates are continuously updated automatically and displayed to the schedule owner. ☐ … then scheduling conflicts between the preceding operation in the source schedule and the cross-schedule linked operation are indicated in the target schedule. In accordance with the ownership principle, it is the responsibility of the owner of the target schedule to resolve the scheduling conflict.
		2-3-10	Through the *transfer of operations* (push principle, i.e. responsibility to supply dominant schedule information or schedule information requiring synchronization), it is possible to actively transfer operation end dates to other schedules. The owner of the target schedule can … • … accept the proposal (handshake) and integrate the schedule information in his/her own schedule. This results in a non-directed synchronization of two operations (on the same level) during which both parties are informed of possible inconsistencies following changes to schedules. • … reject the proposal. (Planning competences based on ownership principle.) • … make an alternative proposal. In this case, the originally queried target schedule becomes the source schedule for operation transfer.
		2-3-11	The *cross-enterprise transfer* of milestones is also possible; in particular if one of the partners involved does not have access to standardized data exchange formats (see 2-1-4). Data transfer is then performed solely using the push principle, i.e. quality gates and milestones can be sent (for example, by e-mail) from the source schedule at company A to company B where they are read into the target schedule. (*Cross Company Planning*)
		2-3-12	All types of cross-schedule links are displayed in the local schedule and al-ways work as agreed, even if, for example, the owner of one of the linked schedules changes, linked schedules are not opened etc. • Owners of a schedule shall be able to select which cross-schedule links are displayed in their own schedule. They shall be able to select and show the links relevant for their monitoring tasks, and to hide the irrelevant links from their view for better clarity.
		2-3-13 ☝ ☝	The SM tool makes it possible to link *schedules horizontally on the same level as well as vertically through the hierarchy, including between adjacent levels or flexibly across different levels. Hierarchical aggregation is possible via substitute operations which represent a schedule at the next higher planning level.* • *Below a master schedule and the main milestones, it is possible to link and simultaneously display up to … ……… [range: several 100s] further schedules.* • *The pyramid-shaped schedule hierarchy can comprise up to ..... [range: several 10s] levels.*
		2-3-14	If completely new operations are defined in a schedule then all *schedule owners* to whose schedules cross-schedule links already exist are informed of this. (push principle, responsibility to supply new information)
		2-3-15	It is possible to perform planning activities internally within teams or specialist departments. These plans, which are not visible to other users in the wider environment, are not administered in the project structure tree (see master data, 1-2-4) but in areas that can only be viewed by the relevant organizational unit.

Prio.	*Stat.*	ID	Requirement
		2-3-16	• Every user known to the system can be a *member of a project team*. • The *project manager* is designated but does not necessarily have to be the owner of the plan. • Project groups can be members of a higher-level project group *(sub-teams and subproject managers)*.
		2-3-17	When setting up a new project, it is possible to *copy* a standard structure stored in the system (a structure tree or a part of a structure tree). When this is done, cross-schedule and schedule-internal links are also copied.

[1] Definition in accordance with DIN 69901-3:2009

3.2.4. Schedule control and cross-schedule operation

Prio.	*Stat.*	ID	Requirement
		2-4-1	Based on the *initiator/owner principle*, interventions made for control purposes, i.e. subsequent modifications to the schedule data, can only be made by the initiators of the schedule data. The identity of the schedule owner is always clear and can subsequently be changed as often as required. It is possible to define deputies which have the same rights as the initia-tors/owners. The deputy definition is related to roles, not persons.
		2-4-2	The attainment of milestones can be tracked in a *Milestone Trend Analysis*[1] (MTA). The results of the MTA can be taken over into scheduling automatically, manually if preferred, or not at all.
		2-4-3	The administrators must define whether it is possible to *move milestones* that have been defined in a master schedule (manually, intentionally) or whether they may be moved as a result of the consequences of automatic replanning. It may also be possible to declare milestone classes (automatically moved, manually moveable, not moveable etc.). (see 2-2-16)
		2-4-4	If milestones or operations that are identified as relevant are moved then all the team members affected by this are *informed automatically*. The affected team members are ... ☐ … all persons authorized for this schedule ☐ … all human resources specified for the moved date and directly linked operations ☐ … all persons who have reported an active interest in being actively informed at the relevant date ('subscription' to information)
		2-4-5	If *changes are made to a schedule*, the originally planned date continues to exist, and can be viewed and processed for the purposes of comparison. Suitable reports must be provided to permit the rapid indication of scheduling changes and the semi-automatic analysis of scheduling conflicts. Standard reports that serve to initiate control interventions are: ☐ … movements of milestones since the last time the project was called ☐ … scheduling conflict report ☐ … .....
		2-4-6	It is possible to create *variants* of schedules, in particular for simulation pur-poses It is also possible to perform *comparisons between schedules*. When this is done, a selected operational schedule is ... ☐ … compared with another selected operational schedule. ☐ … compared with the initial version of the original schedule. ☐ … compared with a selected schedule template. ☐ … During *baselining* (see 3-4-13), (see 3-4-13), it is possible to compare any two versions of a schedule. The changes/discrepancies are indicated in both schedules.
		2-4-7	The origin of all operational data and information in the system can be traced back to the person who entered the data (surname, first name). The person is unambiguously identified in the context menu (user ID, site, department etc.) and contact options are displayed (phone, e-mail etc.).
		2-4-8	Each operation and each milestone is linked to a status network presented in the form of a traffic light system (green/amber/red). • The status within this traffic light system of operations and milestones is administered in the same way as an operation parameter or reporting value. • Optionally, this status can be displayed in a Gantt chart where it takes precedence over the display of the operation class or similar.

Prio.	*Stat.*	ID	Requirement
		2-4-9	An operation or *milestone class contains a status network*. This is used if verifications are performed by two different persons. The passage through the status network (e.g.: MS is attained > checked/confirmed > released) is performed on the basis of a mini-workflow for which roles are stored.
		2-4-10	It is possible to create user-specific or team-specific *views*, i.e. schedules which do not contain any operations of their own but consist solely of mirrored operations and milestones resulting from cross-schedule relationships. This makes it possible to create information nodes in central sectors and sectors subject to bottlenecks (test laboratory etc.)

3.2.5. Usability, handling and menu guidance

Prio.	*Stat.*	ID	Requirement
		2-5-1	Operations are maintained via the *operations list*. Scheduled dates are also maintained in the operations list/date list or are inserted in one of the graphical display forms (e.g. in the Gantt chart) by means of drag & drop. The Gantt chart interface shall support established user interface mechanisms such as mouse over to enable working in an intuitive, comfortable way. • It is possible to perform either the detailed [day], [time] or rough [CW] scheduling of the operations in the operations list.
		2-5-2	All *links* between operations are *indicated* in a suitable way. Different internal or cross-schedule links are identified in different ways. The critical path is identified separately. (see 2-3-2)
		2-5-3	Unlike calculated values or values based on experience (very close to reality), *estimated* values (very inaccurate) must be identified in a suitable way.
		2-5-4	An ´*Undo*´ function can be used to revoke data entry and function calls. • The 'Undo' function can undo up to the last 10 operations or is operational back to the last retrieval of data from memory. • The 'Undo' function includes calls of the 'delete' function, i.e. schedules that are to be deleted are initially moved to a temporary archive from which they are then later irrevocably deleted. (see deleting schedules, 3-4-15).
		2-5-5	Graphical *displays can be zoomed*, i.e. • percentage enlargement or reduction of the screen section • separate scaling of the horizontal time axis in steps based on the usual units of time (days, weeks, months etc.) ☐ … The level of detail along the time axis can be different for different time periods (e.g. display of the first six months after the bar marking the current date in weeks, all following months displayed as month units, or similar.)
		2-5-6	*Tabular displays* can be zoomed step-by-step, e.g. by adapting the font size, line heights and column widths.
		2-5-7	There must be commands making it possible to *filter and sort* each list of records and it must be possible to combine these within a view. • Each combination of filter and sort criteria can be saved as a user-defined view (see list of favorites, 2-5-10). • The criteria for a user-defined view can be modified at any time. • The system 'remembers' the last filter or sort criterion, in particular in the case of user-defined actions.
		2-5-8	A *background calendar* is integrated and stored to permit the convenient input of data. • Sundays and public holidays are marked in the calendar. A weekday can automatically be allocated to each date. • By incorporating indications of regional public holidays and works holidays, the calendar can be extended to create a customized works calendar. • Calendars or works calendars can be extended by further project-specific date restrictions on a decentralized basis.

Prio.	*Stat.*	ID	Requirement
		2-5-8	• A hierarchy of calendars (default system calendar, project, schedule, operation) exists. In all cases, the calendar associated with the re-spective object shall be used. If no calendar is defined, the one related to the parent element will be used. ☐ … CW (calendar weeks] and WCD (works calendar dates) are displayed in the background. ☐ … If there is a reason to assume an error has been made during scheduling, the system issues intuitive messages (e.g. ´DD.MM.YYYY is not a working day´). Calendars can be imported and exported via MS Excel.
		2-5-9	The SM tool provides a *company or division-specific entry screen* (customer Look & Feel).
		2-5-10	The SM tool provides *user-specific lists of favorites* (my projects, my reports, my prefiltered and presorted analyses etc..). • Individual lists of favorites can be transferred (for alternative use) and copied (for simultaneous use by multiple users).
		2-5-11	Proven core functionalities for the simple, reliable handling of modern operating systems must be provided in a form that ensures the intuitive utilization of state-of-the-art software. This applies in particular to functionalities (*in the Windows look & feel*) such as drag & drop, copy & paste, search & replace, mouse-over effects, right-click for context menu, zooming, optimization of window sizes, etc.
		2-5-12	*Multiselect*, the simultaneous selection of multiple records even if these are not contiguous, is also possible following sort and filter calls for the data store. Multiselected operations can be moved together. This does not change the relative positions of the operations.
		2-5-13	For each project, it is possible to generate a *list of participating team members*. (It is important to generate these lists dynamically so that changes of division or company have an immediate impact on the make-up of the team).
		2-5-14	The system has a *help function*. This is characterized by • a search function, keyword searches and • context-sensitive help in certain modules or situations
		2-5-15 ☝	An error message is issued if the user's actions violate fundamental planning or tool concepts. Every *error message* is issued in combination with one or a small number of plain text comments which indicate the (possible) nature of the violation. *Training requirements* are very low due to the Windows Look & Feel (2-5-11), the powerful online help system (2-5-14) and the enterprise-specific customization of the user interface. • For experienced users of project and scheduling management solutions, training in the use of the tool will not take longer than …….. [2-4 ?] hours.

3.2.6. Data outputs, reports and print functions

Prio.	*Stat.*	ID	Requirement
		2-6-1 ☝ ☝	Data transfer from or to a *computation and calculation program* must be possible whenever the display of information in the SM tool makes use of a table structure. This applies in particular to functionalities for dragging and dropping items from or to the operations/date list (incl. all associated parameters) as well as to exports from reporting and report tables. The preferred system environment for the provision and further processing of data is ☐ … Microsoft Excel version …… ☐ … ……
		2-6-2	To permit *presentations*, large data volumes can be exported to a suitable environment for graphical further processing (see interfaces, 3-3-5) while smaller quantities of data can be prepared in the SM tool itself. The latter case involves, in particular, the custom design of the graphical presentation of the schedule through • the addition of text boxes • the addition of graphical symbols (see 2-2-9) • the individual coloring of selected operations or groups of operations (possibly including the (semiautomatic) generation of a legend or the background display of swim lanes)

Prio.	*Stat.*	ID	Requirement
		2-6-2	All additional graphical elements must be stored and must be combined with the elements used in operational planning (operations, milestones, periods etc.) in such a way that the logical connections are not lost when schedules are added to, compressed, lengthened etc.
		2-6-3	Schedules are not only an important basis for calculations but also serve as a basis for presentations and discussions. As a result, it is important to be able to use powerful, flexible *print options*, i.e.: • Print options from DIN A4 to A0 (incl. plotting on fanfold paper) • Optional adaptation to the paper size or printing on multiple pages • Realistic print preview incl. zoom (with incorporation of logo etc.) • Flexible design of headers and footers • Optional printing or omission of hidden or linked information (e.g. notes on operations or the dates of operations linked across schedules) • Optional omission or printing of legends (with individual positioning if necessary) • Extraction as a visual for presentation, i.e. conversion of the print image to a graphics file that can be further processed and graphically enhanced. (see interfaces, 3-3-5)
		2-6-4	The SM tool provides informative standard reports for the different issues addressed by project participants and stakeholders. Typical report categories are • Quality gate reporting (outline view) • Project status reporting (detailed view with changing focus, e.g. control of maturity levels) • Forecasting (extrapolation of data, extrapolation of trends, scenarios for the resolution of scheduling conflicts, MTA etc.)
		2-6-5	Every reporting screen (possibly down to data field level) must be assigned a reporting cycle and a person responsible for the cyclical creation of the corresponding report. If the actual data is not recorded and released on time, workflows are initiated to send reminder e-mails to the persons responsible or subsequently to escalate these reminders to the level of the project participants and/or departmental superiors.
		2-6-6	There can only be one report on one topic at any one time. Past reports are archived and can be viewed whenever required.
		2-6-7	All reporting information is aggregated from the lowest (component) level through to the highest (master schedule) level, if possible pre-consolidated in ascending hierarchical sequence in reporting sheets or lists of key figures where it can be overwritten by the person responsible if necessary.
		2-6-8	There are two *output options* for reports i.e. list or table form, on the one hand, and graphical form, on the other. • The data of reports presented in list or table form can also be exported (e.g. in ASCII format) for comprehensive further processing outside of the SM tool. In general, extremely extensive, powerful and versatile reporting functions must be provided since the number of projects is rising, the associated level of complexity is increasing and the information requirement for planning and control purposes will continue to grow.
		2-6-9	All reporting operations can optionally be preceded by a tool-assisted *reporting dialog*. A small number of team members (to be defined in advance) develop/complete the report before this is released by an authorized person for handover to the report recipients.
		2-6-10	If, during the course of the project, schedule (capacity or cost) overruns occur compared to the original planning then this is always indicated in a suitable form (colored or bold type etc.)
		2-6-11	To permit the configuration of custom reports, a *report generator* (socalled Report Wizard) permits access to the data store via the user interface without the need for any programming knowledge. • In the case of complex database queries, additional reports can be programmed to order even without the support of the tool supplier (no access protection for the database).

3.3. IT concept: Tool and interface requirements

3.3.1. System/tool philosophy and system architecture

The system does not have to shine through specific individual functionalities but instead through its high level of function integration (linking of many different requirements) and a high-performance, con-temporary, forward-looking overall architecture.

Prio.	*Stat.*	ID	Requirement
		3-1-1	The system is based on a *client-server architecture*. The number of clients is not limited.
		3-1-2	The system possesses a database server that is completely separate from the application server.
		3-1-3	The *connection to the client* is based on a ☐ … Rich client architecture ☐ … Web client architecture
		3-1-4	The function scope of clients can be scaled into multiple levels. Multiple function blocks can be combined in any way required so that all users can see and use precisely the range of functions intended for them in accordance with the assigned rights and roles.
		3-1-5	The function scope of a client can be restricted to a small number of basic functions (e.g. reading assigned tasks including notification of their completion) in order to reduce it to the status of an *easy client or lean client*. The target group consists of team members who have only a very limited sphere of responsibility or who participate in the project for only a very limited time. This greatly restricted function scope must be reflected in the lack of any training requirements and reduced license charges.
		3-1-6	Designated *power users work with an extended GUI*, i.e. they see other screens (e.g. more fields and buttons, greater functionality etc.). Within the system concept, power users form the interface between normal users and the administrator(s). In their case, the availability of large amounts of information and extensive functionality gains in importance compared with the need for clarity.
		3-1-7	Data management *is not performed in a single monolithic entity.* • If the database becomes too large during the period of utilization of the SM tool then it must be possible to distribute it over a number of servers. • If a development site or a brand leaves the Group then the database must be disconnected at the IT level at the point of the legal separa-tion of the previously consolidated entities so that each of them can retain "its own" legacy data.
		3-1-8	All s*ystem settings* must be visible in the user front-end. In particular, this applies to all the elements in the schedule. (If a character set for an operation by the administrator is not visible then the consequences of moving this operation cannot be known.) • A harmonized overall concept comprising shapes, colors, information that is visible directly or indirectly etc. prevents users being overwhelmed by a flood of information and helps them focus on key areas.
		3-1-9	The overall architecture should also provide for a needs-oriented, dynamic adaptation of computing and storage capacities in the form of so-called *cloud computing*. The cloud, its usage and environment, as well as the operator, all responsible parties and other participants in its use must be subject to German legislation. (The cloud data of US-American sites must also not be affected by the USA PATRIOT Act[4].)
		3-1-10	The system possesses a *service-oriented architecture (SOA)*. The management of the product engineering process, in particular, is based on the service definitions in order to ensure the continued use and reuse of proven logics and links in subprocesses.
		3-1-11	*Other applicable documents:* • DIN 69901-4 "Project Management – Project Management Systems – Part 4: Data, Data Model" If data models that differ from those in the other applicable documents (in particular section 4.5 Schedule management) are used then this must be indicated in good time together with the reasons and consequences.

[4]USA PATRIOT Act = Uniting and Strengthening America by Providing Appropriate Tools Required to Intercept and Obstruct Terrorism Act (US federal act of 10/2001)

3.3.2. Load and performance requirements

The hardware prerequisites necessary to satisfy the requirements set out below should not exceed state-of-the-art technology and should be specified by the tool supplier, if necessary.

Prio.	*Stat.*	ID	Requirement
		3-2-1 ☝ ☝	The SM tool is a *multiuser system*. • Up to ……...… [range: several 10,000s] clients can be con-nected/users can be administered. • Up to ……...… [range: several 1,000s] clients/users can work in the tool simultaneously, i.e. access the server at the same time.
		3-2-2	The SM tool is a *multiproject management* system, i.e. any required number of projects can be planned and controlled and can be administered in any number of programs or portfolios.
		3-2-3 ☝ ☝	The system can ☐ … administer up to ……...…… hierarchically networked project plans. ☐ … administer up to ……...…… individual schedules.
		3-2-4 ☝	All users can have open and work with up to …….. *schedules simultaneously*.
		3-2-5	The system is available 24/7. *Intrinsic system availability* of 100% must be guaranteed. Any value other than this must be indicated and the reasons for it specified.
		3-2-6 ☝ ☝	The *processing times* of the SM tool are as follows: ☐ … for standard routines, average of …….. sec. ☐ … for complex calculations or search operations, max. ……. sec.
		3-2-7 ☝	The access and response times for an overseas client accessing a server hosted in Germany/Europe must not exceed ..... sec.
		3-2-8 ☝	In the event of errors or problems, the system displays an informative *error message* on the screen after max. …….. sec. In the case of calculation routines or function calls that exceed this time even though no error is present, a dynamic *progress indicator* must be provided.
		3-2-9 ☝	The *down time*[1] on unscheduled stoppages with immediate system restart is max. …… minutes.

[1] = Requirements that are not to be fulfilled by the tool on its own but possibly through an additional Service Level Agreement (SLA) (e.g. reaction times, maintenance periods etc.) must be identified as such and discussed separately. (Caution if the SLAs between tool users and internal enterprise IT services are different from those concluded between the tool supplier and the purchaser/user.)

3.3.3. Method and data interfaces

The implementation of interfaces to other IT tools demands a separate interface specification. The following requirements are simply intended as an indication of the tools and data content for which the investment in an interface is recommended.

Prio.	*Stat.*	ID	Requirement
		3-3-1 ☝	The SM tool is integrated as a *schedule management module* in a wider tool environment. As a result, standard project management functionalities which are of relevance for scheduling and permit an outline assessment and consistency check of schedule management activities are connected without external interfaces. The main function modules that are linked within the tool are ☐ … Resource planning and control ☐ … Budget planning and control ☐ … ...……
		3-3-2 ☝ ☝ ☝	Functional interfaces should be provided from a *process modeling tool to* the schedule management system in order to instantiate a product and project-independent development process (PDP) in the schedule management of concrete projects. Interfaces from the following should be provided for ☐ … ARIS (Software AG), version …….. ☐ … MS Visio (Microsoft), version …….. ☐ ……

Prio.	*Stat.*	ID	Requirement
		3-3-3	Functional interfaces should be provided from the schedule management system to a *process modeling or display tool* in order to generalize product and project-specific schedules as process models. Interfaces to the following should be provided for
		☝	☐ … ARIS (Software AG), version ……..
		☝	☐ … MS Visio (Microsoft), version ……..
		☝	☐ … html for web/intranet-based displays
		☝	☐ … …….
		3-3-4	Bidirectional functional interfaces to other *schedule management tools* must be provided for. Schedules, inclusive of the main parameters for individual elements anchored in them, must be transferred over these interfaces and their content must be interpreted in the same way by both parties. Interfaces from/to the following should be provided for
		☝	☐ … MS Project (Microsoft), version ……..
		☝	☐ … RPlan (Actano), version ……..
		☝	☐ … ……
		3-3-5	Data interfaces from the schedule management tool to a *graphical display* tool must be provided for; in particular from the schedule display capability (Gantt chart) to a highly flexible graphical postprocessing tool that can tolerate content errors. Interfaces to the following should be provided for
		☝	☐ … MS Powerpoint (Microsoft), version ……..…
		☝	☐ … …….
			All preparatory working steps (in terms of sizing and configuration) prior to the extraction of a visual that can be used for presentation purposes (see data output and print functions, 2-6-2) can be performed without IT knowledge. The results can be saved.
		3-3-6	Bidirectional interfaces from or to relational databases must be provided for in the back-end of the schedule management tool. In particular, it must be possible to import data from/export data to:
		☝	☐ … Oracle-DB, version ……..……
		☝	☐ … Suse Linux, version ……..
		☝	☐ … …….
		3-3-7	Project or operation information, i.e. important dates, automatically generated short messages and similar items, can be transferred to an information management system. This applies to ... • the transfer of dates to an individual or group calendar • the transfer of information (possibly predefined text modules) that is sent as an e-mail or SMS when an event occurs. The preferred receiving systems for dates and information are ...
			☐ … MS Outlook (Microsoft), version ……..……..……
		☝	☐ … Lotus Notes (IBM), version ……
		☝	☐ … Dispatch to a mobile number/further processing in the mobile telephone or other mobile terminal device
		☝	☐ … …….
		3-3-8	Bidirectional links must be implemented between schedule management and requirements management. Product requirements from the product requirements specification or functional specifications must be linked to the work operations necessary for their fulfillment and be traceable in both directions. The preferred requirement management tool to be linked to is
		☝	☐ … Doors (IBM), version ……..……
		☝	☐ … …….
		3-3-9	Personal data, possibly including current role assignments, is transferred over an LDAP interface. This preferably performs verification against a reference in
		☝	☐ … …….
			• The LDAP interface makes it easier to log in to the system. • The LDAP interface makes it possible to perform consistency checks when rights or roles are reset or when employees change division or company.
		3-3-10	*SAP* is used in all Group companies, albeit to different extents. Links between an SM tool and SAP are expected for the transfer of the following data:
			☐ … Schedule information relating to major milestones from SAP-PS (as a bidirectional interface if necessary)
			☐ … Connection of response message/completion message between the SM tool and CATS
		☝	☐ … Connection to SAP-CO if operations are also used as account assignment elements.
			☐ … ……..

Prio.	*Stat.*	ID	Requirement
		3-3-11	The SM tool provides an *offline client* or the possibility of operating a client offline. The subsequent harmonization of the data with the database is possible at any time. Any inconsistencies that may arise due to the database harmonization of multiple clients that have further processed the data are displayed together with recommendations concerning the decisions required on the part of the user. ☐ … The offline client is able to make use of the full functionality. ☐ … A restriction to core functionality is accepted for offline use.
		3-3-12	The SM tool provides an *API*, i.e. a flexible interface for application programming that can be used even without the support of the tool supplier.

3.3.4. Deletion of data, data security and system security

Prio.	*Stat.*	ID	Requirement
		3-4-1	Data (access) protection is ensured primarily by means of a *role-based authorization concept*. • An authorization concept monitors authorizations to read, perform initial data entry, modify or delete items at data field level. • Function units combine access to multiple data fields into typical activity options for project participants (e.g. project creation) • Roles combine function units to form typical areas of responsibility (e.g. project manager = create project, move milestone etc.) ☐ … Up to …….. [range: several 10s] different roles can be defined.
		3-4-2	Rights can be combined as required to form function units. Function units can be combined as required to form roles. Roles can be combined as required when assigned to team members.
		3-4-3	*Deputization rules* are stored for all assignments to individual persons (schedule owner, project manager, persons authorized to approve milestones etc.).
		3-4-4	*Administrator rights* are also categorized within a 'mini-hierarchy' (regional administrators, power users etc.). External IT service providers or employees at foreign sites with above-average employee turnover must be able to fulfill all aspects of their adminis-trative roles without being able to view, copy or manipulate operational data.
		3-4-5	The enterprise's *project portfolio* is hierarchically structured, e.g. based on the enterprise structure (business unit, division, holding, etc.). A distinction is also made between projects that form part of a project portfolio or program or which are simply used for planning purposes within a team or a division (not public, not included in the reporting path etc.).
		3-4-6	*Authentication mechanism*: The system may be accessed only by authorized persons who are known by name and must be adequately protected against unauthorized access. • The authentication information is transferred in encrypted form.
		3-4-7	At any time, it is possible to determine (e.g. by querying the system or via standard lists) … • … which persons have been approved and with what rights? • … who granted these rights and at what time.
		3-4-8	Authorization to access the system as well as individual rights within the system can be subject to *time restrictions*. In this way, known time restrictions are automatically monitored and enforced.
		3-4-9	*Passwords* may only be saved in encrypted form.
		3-4-10	The system must be protected against access by unauthorized third-parties, including in the case of read-only access or the display of data to unintended parties. Windows open on the monitor that contain secret, confidential or oth-er similarly classified information must be suitably identified by the enterprise's internal administrators.

Prio.	*Stat.*	ID	Requirement
		3-4-11	Schedules are *versioned*. • Any number of versions can be stored for each schedule. • There is only one current version of any schedule. All older versions are assigned a version number and timestamp that reflect their chronological order.
		3-4-12	Schedule versions can be generated manually at any time by all users who are authorized to edit and save schedules. In addition, schedules are automatically versioned when ☐ … the project is initially released ☐ … a major milestone is attained. ☐ … ..……
		3-4-13	It is also possible to perform *baselining* as part of the version management functionality. To do this, baselines (obtained by freezing the available data and documents at a particular point in time) are created. During the subsequent analysis of a baseline, is it possible to identify the precise state of the schedule at time x? Who were the members of the project team at the time and what authorizations did they have in the system etc.? (Baseline at project level including all linked and referenced information ≠ dump of complete database.)
		3-4-14	The file sizes of representations of schedules are sufficiently small to permit their transfer. • At the interface to a supplier or joint venture partner with a minority holding, it may be necessary to transfer schedules or files between two independent SM tools. This must be possible without circumventing habitual security standards. • If schedules are sent back then they can be subjected to a comparison with other schedules (see 2-4-6).
		3-4-15	When an active *schedule is deleted*, it is first moved to a protected area, the so-called recycle bin. • Schedules in the recycle bin can be reactivated at any time and the information and functionalities they contain are retained or can be re-stored.
		3-4-16	Removing a schedule from the recycle bin results in … • … definitive archiving, i.e. the schedule is frozen and can no longer be modified (= default setting) or • … irrevocable deletion. Adequate protective measures must be implemented in the case of the definitive deletion of schedules to ensure that they are not accidentally deleted due to a mistake or user error.
		3-4-17	The SM tool has its own archive. Schedules are archived in ☐ … the original data format so that archived schedules can be consulted again using the full functionality available in the tool. ☐ … a general, tool-independent data format (e.g. as *.pdf file).
		3-4-18	On a restart following a client or system crash, the schedules that were being processed at the time are displayed, each with their most recent processing state. The user decides which save options to apply. (see Windows Look & Feel, 2-5-11)
		3-4-19	For each item of stored information, it is easy to search for the employee who initially completed the data field and the last employee who wrote to the data field.

3.4. Other requirements

3.4.1. Support, maintenance and further development of the tool

Prio.	*Stat.*	ID	Requirement
		4-4-1	The SM tool can be flexibly licensed. Alongside standard licenses and license pools (e.g. consisting of 50 or 100 user packages), site, brand and Group licenses are also possible.
		4-4-2	SM tool optimizations, functional enhancements etc. must be bundled together in a way that minimizes the number of *changes between releases*. Only significant functional enhancements are accepted as releases. Bugfixes, hotfixes, patches etc. are not releases and can therefore be integrated faster and with less effort. The customer is able to decide which releases to install. The decision not to update to a new release, even if this occurs on several occasions, does not result in any prejudice to the customer with regard to new releases.

Prio.	*Stat.*	ID	Requirement
		4-1-3 ☝ ☝	*Changes between releases* of the tool must be possible with a *maximum system down time* of ……. ……. hours [range: considerably less than a working day] so that the SM tool is available to operational users again on the day on which the new release is installed. (=> user view) The total time taken to move from one release to another (incl. preparation, data migration etc.) must not exceed …….. days [range: 1 week]. (=> Administrator view of the productive system)
		4-1-4 ☝	The functioning, interfaces and security mechanisms of the system are *fully documented*. The documentation can still be used even in the event of the (possibly temporary) non-availability of the system (i.e. it is not only accessible via the system). The documentation is available in the following languages: ☐ … German ☐ … English ☐ … …… There are no undocumented interfaces/no access routes that avoid the security mechanisms.
		4-1-5 ☝	Menu guidance, i.e. the *language used for interaction with the system*, is possible in the following languages: ☐ … German ☐ … English (incl. American date format) ☐ … ……
		4-1-6	Alongside the assignment of rights and roles, the system also permits the active *withdrawal of rights* and may make proposals following a consistency check, e.g. • Checking of active roles against a payroll, reference list (LDAP harmonization). • Checks on abnormal user behavior, e.g. significant periods of inactivity on the part of a user compared to preceding periods. The admissibility of the selected solution in the light of personal data protection requirements and the possible need for approval by the works council must be considered.
		4-1-7	The up-to-date, complete system requirements (requirements in terms of hardware, operating systems etc.) can be transferred, explained and justified at any time. In this case, it is necessary to distinguish between servers, clients and other terminal devices. ☐ … The system requirements must not change significantly between two successive changes of release and must be indicated in good time prior to any modification. ☐ … The aim is to achieve high-performance use of the SM tool in a state-of-the-art IT environment without the need for any special requirements.
		4-1-8	Administrators are able to *generate system messages* which are reliably communicated to all users or selected user groups either immediately or the next time they use the tool. (e.g. automatic display of a window announcing "Installation of hotfix on DD.MM.YY at HH:MM ...")
		4-1-9	The SM tool contains a *Transport Management System* (TMS), which permits the automatic transporting of customizing settings and additional programming. As a result, all parameter settings or program code that differ from the standard installation in the application layer can be transferred across staging instances (from test to QA or productive server).
		4-1-10	For the long-term further development of the system, it is necessary to take account of the increasing number of *mobile terminal* devices that are connected online and not only offer new possibilities (e.g. changes in user behavior due to touchscreen use), but also impose additional constraints (e.g. limited screen size).
		4-1-11	For the long-term further development of the system, the increasing process-ing speed of the terminal devices will be used primarily for the graphical interpretation of data and the links between data. The aim is to communicate a large volume of information while keeping operation very simple and intuitive. (Example: Conversion of a 2-dimensional Gantt chart (x-axis= timeline, y-axis= operations list) into a rotating 3D display in which the associated resource loading is displayed on each operation bar.)

3.4.2. Requirements placed on the tool supplier

The group-wide introduction of or change to an SM tool demands considerable confidence in the capabilities of the supplier and the long-term stability of all the companies involved. The recommendation regarding the requirements placed on an SM tool therefore also includes recommendations regarding the tool supplier.

Prio.	*Stat.*	ID	Requirement
		4-2-1	The supplier of the SM tool possesses *certification* based on a relevant quality management system ☐ … ISO 9.000 ff. ☝ ☐ … …..
		4-2-2	The solution supplier is not simply an IT service provider but also has proven *specialist expertise* • in the field of project, and in particular schedule, management • in the industry, i.e. in the automotive or automotive supplier sector (or in related industries which use procedures similar to those in the automotive sector or which are transferrable to it) Evidence of this may take the form, for example, of a significant, tool-independent R&D budget, tool-independent reference customers in the field of consulting services or successful participation in relevant national or inter-national standardization committees.
		4-2-3	There is a *roadmap* for the further development of the company as well as for the further development and optimization of the product. Regular contact between the supplier and the customer as well as among the supplier's main customers (e.g. as user forums) make it possible to influence the product development roadmap.
		4-2-4	The SM tool supplier also *provides training* in the use of the tool. Training courses can be conducted as combined training in the use of the tool and the associated methods.
		4-2-5	The license includes the presence of a telephone hotline or contact person who can be regularly contacted by telephone in ☐ … German ☐ … English ☝ ☐ … …..
		4-2-6	The SM tool supplier should, at the least, ... ☝ ☐ … be able to name …….. [range: several] reference customers who are ready and willing to provide comprehensive information concerning the SM tool ☝ ☐ … have been active on the market as a supplier of SM tools for …….. years ☝ ☐ … have a payroll of ……..... permanent *employees*. ☝ ☐ … achieve *sales* of …….. million € per annum

4. Schedule Management Use Cases

Schedule management in interlinked projects comprises a wide range of different tasks. To some extent, these build upon each other and repeat themselves over the course of a project. These tasks can be grouped in a set of use cases. Their respective priority and specification is company-specific; an assessment of the own key aspects for the application of the criterion catalog, as described in section 2 above, is helpful.

During discussions with leading manufacturers of the automotive industry, ten essential use cases have been identified. In the following sections, these will be defined in a concise way.

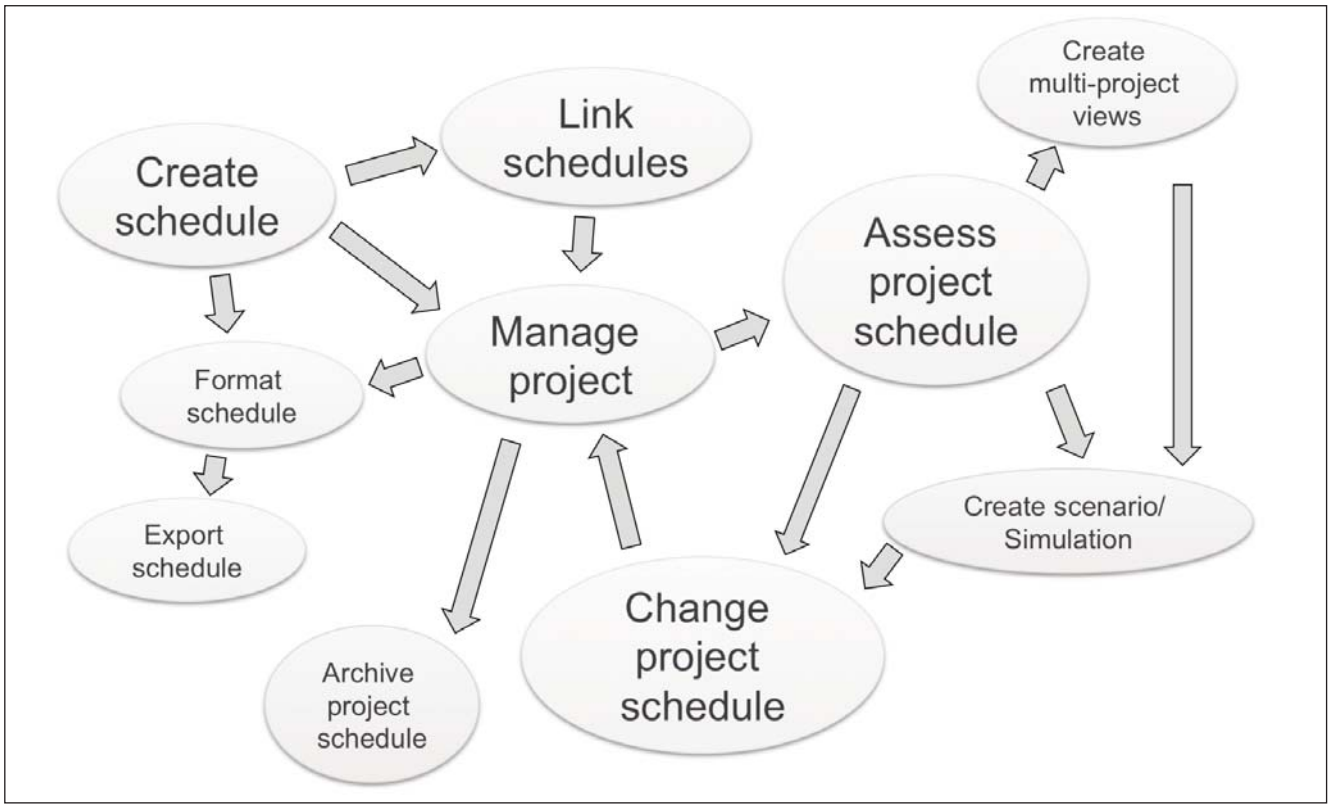


Figure 8: Overview Map of Use Cases.

The description of these use cases shall provide help and orientation to users and SM tool vendors alike, by illustrating how the various requirements work together and thus facilitating easier identifica-tion of the relevant criteria for their own scenarios. As examples, experts and key users have assigned requirements to several use cases which are deemed essential for the respective scope. While the criterion catalog in section 3 has a function-oriented structure, the use cases define a process-oriented grouping of the criteria.

4.1 Create schedule

Tab. 5: Use case "Create schedule"

Predecessor:		*Successor:*	• Link schedules • Manage project • Format schedule
Purpose and background:	Creation of a new schedule (single schedule or network of schedules) including: • Milestones • Operations, including summary tasks with hierarchy		

Approach, tasks:	• Create schedule from a template. This can be either a generic template, respectively master plan, or an actual existing project schedule. o It shall be possible to select the elements to be carried over from the template, with the following options: change, carry over, dis-card. The transfer of milestones, operations and links should happen independently. • Create schedule without template (from scratch)		
Input	• Template or master plan, if applicable • Information about the project	*Output*	• New schedule with mile-stones and operations
Criteria	1-2-5; 2-2-2; 2-2-3; 2-2-10; 2-2-17; 2-3-2		

4.2 Link schedules

Tab. 6: Use case "Link schedules"

Predecessor:	• Create schedule	*Successor:*	• Manage project
Purpose and background:	Creation of links within the schedule as well as to other schedules: • Cross-schedule order relationships • Cross-schedule operation mirroring • Cross-company links (supplier relationships, collaboration projects)		
Approach, tasks:	• Synchronous / automated links; i.e. changes in one schedule will be directly carried over into the linked plans, and the affected elements are adapted automatically. • Asynchronous / manual links; i.e. if changes in one schedule occur, the owners/editors of the linked plans will be notified, but will have to make any changes to the affected elements themselves. • Filter options for the visualization of links to subordinate schedules.		
Input	• Project schedule • Schedules of relevant, to be linked projects.	*Output*	• Project schedule with internal and external links
Criteria	1-2-5; 2-2-2; 2-2-3; 2-2-10; 2-2-17; 2-3-2		

4.3 Manage project

Tab. 7: Use case "Manage projects"

Predecessor:	• Create schedule • Link schedules • Change project schedule	*Successor:*	• Assess project schedule • Archive project schedule • Format schedule
Purpose and background:	Administration of a project during the start-up phase as well as during the project runtime. Trigger for management tasks can be the creation of a new schedule with handover to the project team, as well as changes on the project during its runtime. This applies to scope and timeline changes as well as organizational changes.		
Approach, tasks:	At project start: • Integration into project structure tree • Distribution of subordinate plans to target destinations During project runtime: • Rights management / user administration • Read and write access, incl. visibility rules • Groups, teams, roles, persons • Deputy / successor arrangements • Recycle bin / deletion of schedules		
Input	• Project schedule • Organizational information	*Output*	• Maintained project schedule
Criteria	1-2-4; 2-3-16; 2-3-17; 2-4-1; 3-4-1; 3-4-2; 3-4-3; 3-4-5; 3-4-6; 3-4-9		

4.4 Format schedule

Tab. 8: Use case "Format schedule"

Predecessor:	• Create schedule • Manage project	*Successor:*	• Export schedule
Purpose and background:	The project schedule shall be formatted according to its intended use, so that it can be presented outside of the schedule management tool as well; e.g. for a steering committee meeting or coordination with external project partners. Graphical as well as list / table views shall be supported. This can also be achieved by export into a suitable visualization tool (see section 4.5), if this tool offers sufficient editing capabilities (content and appearance).		
Approach, tasks:	• Selection (filtering) of the scope for presentation o E.g. time period, milestones, quality gates… o Option to save filters for future reuse • Adaption of presentation according to intended use o E.g. by date, by role… o Option to store templates for future reuse • Overlaying of information o E.g. assessment indicators, project phases, vacation periods… • Preview of formatted view • Recycle bin / deletion of schedules		
Input	• Project schedule	*Output*	• Schedule formatted according to intended use and target audience
Criteria	2-6-2; 2-6-3		

4.5 Export schedule

Tab. 9: Use case "Export schedule"

Predecessor:	• Format schedule	*Successor:*	
Purpose and background:	The project schedule shall be made available to other systems and in various formats (read only). This shall include the possibility for (limited) further editing of the exported data in the target application.		
Approach, tasks:	Export into desired target format, for instance: • MS PowerPoint • MS Excel • MS Project • PDF • XML • Vector graphic / meta file Additional formats – standardized formats?		
Input	• Formatted schedule	*Output*	• Exported schedule
Criteria	3-3-5		

4.6 Assess project schedule

Tab. 10: Use case "Assess project schedule"

Predecessor:	• Manage project	*Successor:*	• Create multi-project views • Create scenario / Simulation • Change project schedule
Purpose and background:	Goal is a regular planned vs. actual comparison in order to detect required schedule changes in a timely manner, as basis for reporting to: • Overall project lead • Sub-project lead • Milestone / operation owners		
Approach, tasks:	• Assess objects: o Entire project or subproject o Operations, milestones, roles o Ad hoc or regularly • Enter assessment: o Progress, status, traffic light o Due date forecast o Measures proposed or taken o Comment, cause		
Input	• Project schedule	*Output*	• Assessed project schedule
Criteria	3-3-5		

4.7 Create multi-project views

Tab. 11: Use case "Create multi-project views"

Predecessor:	• Assess project schedule	*Successor:*	• Create scenario / Simulation
Purpose and background:	This use case is for the most part a combination of "Link schedules" (see 4.2) and "Format schedule" (see 4.4), with focus on complexity management. Goal is the creation of multi-project views and reports for the identification of con-flicts and bottlenecks, in order to support reports and decisions across projects.		
Approach, tasks:	The points mentioned in sections 4.2 and 4.4 apply, especially: • Selection of existing project plans • Selection of objects of interest o Dates, resources… • Filtering of objects for summary views • Creation of overlay diagrams o E.g., resource availability / needs • Visualization of links		
Input	• Project schedule	*Output*	• Multi-project view
Criteria			

4.8 Change project schedule

Tab. 12: Use case "Change project schedule"

Predecessor:	• Assess project schedule • Create scenario / Simulation	*Successor:*	• Manage project
Purpose and background:	The objective is to carry out required schedule changes.		
Approach, tasks:	• Identification of affected milestones and operations • Manual change of dates relative to the reference point, without interlinking of all milestones in the schedule • Highlighting of resulting modifications o Date shifts shall initially be visualized only; only after assessment of the subsequent effects, final acceptance / refusal. o Special marker for already ongoing operations. • Assessment of feasibility o Dependencies / links o Calendar, working time models… • Deliberate decision to conduct date change o Manual definition of new date o Acceptance of resulting automatic shifts o For affected ongoing operations: deliberate decision for either re-planning, restart, or abort. • Distribution of adapted schedule: o In advance to selected responsible persons for review with request for approval / improvements. o To entire project team		
Input	• Project schedule • Change requests	*Output*	• Approved and communicated adapted project schedule
Criteria	2-2-12		

4.9 Create scenario / Simulation (optional)

Tab. 13: Use case "Create scenario / Simulation"

Predecessor:	• Assess project schedule • Create multi-project views	*Successor:*	• Change project schedule
Purpose and background:	The objective is to simulate several possible planning alternatives, so that they can be assessed, compared, and finally a decision can be taken which alternative shall be realized. The creation of the alternative plans shall have no side-effects on the active project schedule.		
Approach, tasks:	• Influences during the project runtime require schedule adjustments. Several possible solutions are possible or being discussed. • Creation of an alternative schedule for every solution proposal. • Without side-effects on the original schedule o Including links • For every alternative, the steps according to „Change project schedule" (see 4.8) are carried out: o Identification of affected operations and milestones o Highlighting of resulting modifications o Assessment of feasibility o Communication in advance with responsible persons • Deliberate decision for one alternative, and implementation o Integration of the selected schedule into the running project		
Input	• Project schedule • Change requests	*Output*	• Adapted project schedule with documented decision
Criteria			

4.10 Archive project schedule

Tab. 14: Use Case "Archive project schedule"

Predecessor:	• Manage project	*Successor:*	
Purpose and background:	Goal is to preserve the traceability of decisions. Hence, it shall be possible to: • Create a project history • Store different versions of project schedules • Store baselines		
Approach, tasks:	• Storage of a defined snapshot of the project planning, e.g. when a project change occurs o Entire project or subproject o Versioning of schedules o Locking of old versions • File export • History visualization in the schedule (before–after comparison) o E.g. old version greyed out in the background • History evaluation o Display of latest changes o On milestone and operation level o Taking into account legal requirements		
Input	• Project schedule	*Output*	• Archived project schedule
Criteria	2-2-12		

Relevant regulatory and industry standards

… that have a direct or indirect influence on schedule management in vehicle development projects:

Regulatory standards:

DIN EN ISO 9000:2005	"Quality management systems - Fundamentals and vocabulary"
DIN EN ISO 9001:2008	“Quality management systems – Requirements”
DIN EN ISO 9004:2009	"Managing for the sustained success of an organization – A quality management approach"
DIN EN ISO 10007:1996	"Quality management – Guidelines for configuration management"
DIN ISO 15226:1999	"Technical product documentation – Life cycle model and allocation of documents"
DIN 69900:2007	"Project Management – Project Network Techniques; Descriptions and Concepts"
DIN 69901:2009	"Project Management – Project Management Systems"
DIN 69901-1	Part 1: Basics
DIN 69901-2	Part 2: Processes, Process Model
DIN 69901-3	Part 3: Methods
DIN 69901-4	Part 4: Data, Data Model
DIN 69901-5	Part 5: Concepts
DIN 69909-2:2012	"Multi-Project Management – Part 2: Management of project portfolios, programs and projects (draft)"
ISO 10006:2004	"Quality Management – Guidelines for Quality Management in Projects"
ISO IEC 12207:1995	"Software Life Cycle Processes" (so-called process reference model in the SPiCE standard)
ISO IEC 15504:2007	"Information technology – process assessment" (so-called process assessment model in the SPiCE standard)
ISO TS 16949:2009	Quality management systems for the automotive industry
ISO 21500:2012	"Guidance on Project Management" (draft)

Standards:

CMMI 1.3	Capability Maturity Model Integration current version 1.3 of 2010
ICB / NCB 3.0	"International Competence Baseline 3.0" 3rd edition of IPMA, International Project Management Association, 2009 as German NBC, National Competence Baseline 3.0 issued by PM-Zert, certification board for GPM e.V.
PMBoK® 4th edition	"PMBoK Guide – A guide to the Project Management Body of Knowledge" 4th edition of PMI®, Project Management Institute, 2008
Stage Gate®	Stage Gate® Process Model (see Coo1 and www.stage-gate.de)
VDA 6.3	“Quality Management in the Automotive Industry", Part 3: Process Audit

References and additional material

Coo01	Cooper, R.G. "Winning at new products: accelerating the process from idea to launch" Basic Books, 3rd edition 2001
CPM10	ProSTEP iViP Recommendation "Collaborative Project Management" (CPM) Reference Model; PSI 1-1, Version 3.0, Feb. 2010
GPM11	GPM & Gessler, M. (publishers.) "Kompetenzbasiertes Projektmanagement (PM3) – Handbuch für die Projektarbeit, Qualifizierung und Zertifizierung auf Basis ICB 3.0" GPM, Nürnberg, 4th edition 2011
Hab10	Hab, G./ Wagner, R. "Projektmanagement in der Automobilindustrie – Effizientes Management von Fahrzeugprojekten entlang der Wertschöpfungskette" Gabler Verlag, 3rd edition 2010
Kru12	Krull, D./ Mattfeld D.C. "Terminmanagement in Fahrzeugentwicklungsprojekten der Automobilindustrie" Proceedings of the multi-conference on business IT at Braunschweig Technical University 2012
Mey11	Meyer, M.M./ Ahlemann, F. “Project Management Software Systems – Requirements, Selection Process and Products” BARC/ GPM study, 6th edition 2011
Rie10	Rietz, S. "Prozessmanagement mit Engineeringstandards" in Jochem, R./ Mertins, K./ Knote, T.: Prozessmanagement – Strategien, Methoden, Umsetzung" in Symposion Publishing Verlag 2010

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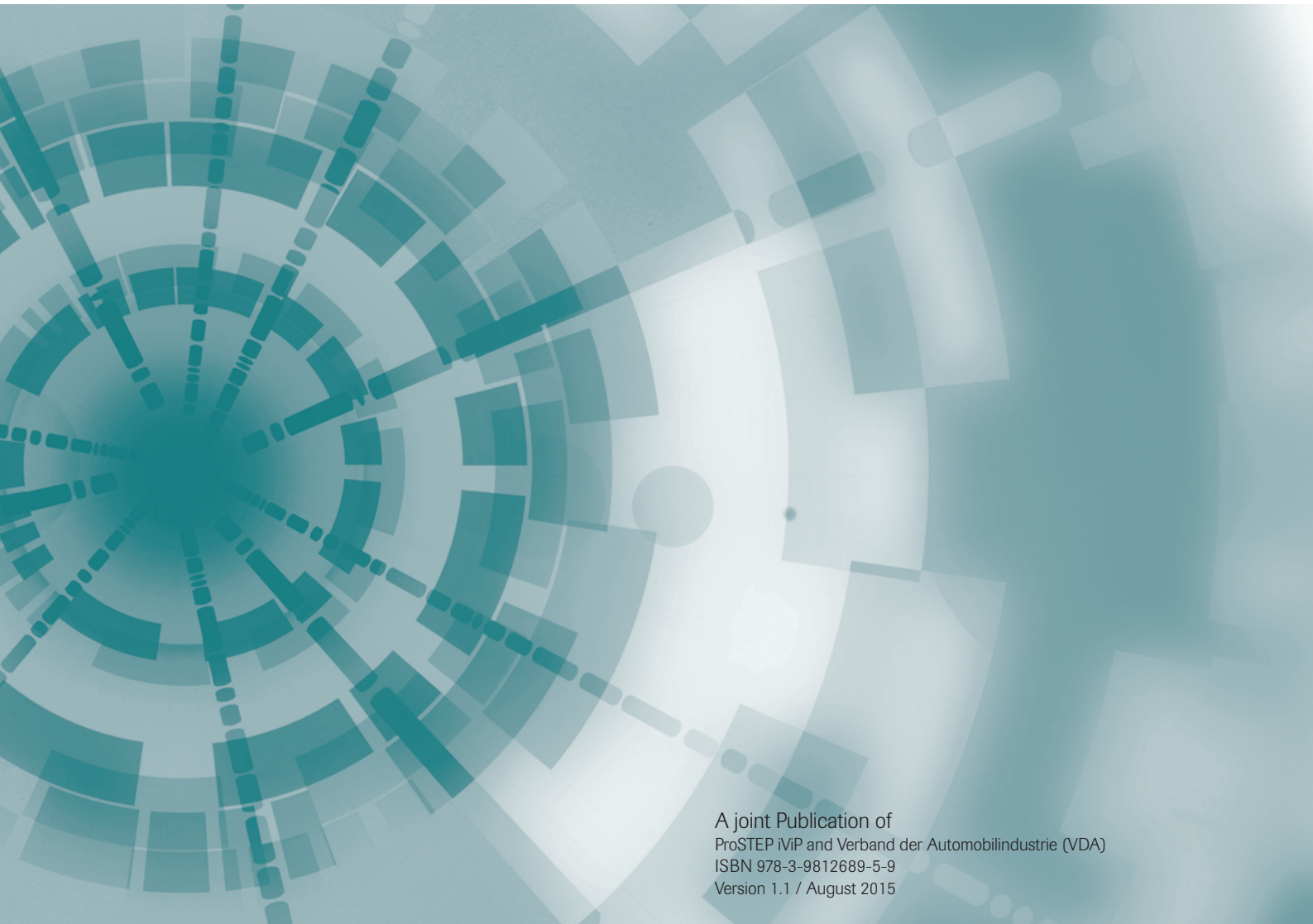

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