Scheduling practices for turnarounds/shutdowns

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Editorial & Greeting
Any major turnaround/shutdown in the process industry has dramatic repercussions on the annual results. The opportunity costs of operators of refineries or petrochemical and power plants resulting from a shutdown often exceed the labour and material costs incurred. Any downtime that can been avoided is therefore of benefit. It goes without saying that turnaround projects are very time-critical, especially during periods of strong demand. However, schedules are quite tricky and are all too often neglected by management. The aim of this study is to address scheduling issues in turnaround projects and to show decision-makers the enormous potential optimized scheduling can have on influencing the success of a turnaround project.

Conventional scheduling systems, methods and processes have many shortcomings when it comes to handling the increasing complexity and demands of today’s projects. It is hence not surprising that even seasoned executives and project managers reach their limits and reject any “increase” in systems and tools in order to focus on the human element again. But even the best athlete cannot win without the right equipment. Coming up with a good schedule is a stern challenge in and of itself as it must provide a flexible navigation system to support the team throughout the execution phase. Project managers need to know the up-to-date project status at all times, warn against threatening risks and find the ideal path, even though this changes from day to day. This requires tools that enable an immediate response, and this is what a good schedule is for.

A schedule is not an end in itself. Quite on the contrary, it is the essence of all optimization approaches and expectations of the project team. It contains the complete “script” of the project, but good directors are needed in order to read and successfully implement this script. This is why scheduling is usually a job for experts. All too often, schedules are submitted to management which are not only poor and unsuitable but which have also cost a lot of money to produce. After you have read this study, you will be able to say how demanding your team’s plans are and whether your script can become the basis for a blockbuster.

The focus of this study is not on IT in general. Instead, it addresses the “correct” use of scheduling tools and the appropriate contents of a schedule for the different project phases, independent of the particular IT tool. The issue of the organization and structure of schedules for turnaround in the plant-intensive industry was explored for the first time against this backdrop. This study is broken down into two parts in order to address the different interests of the different reader groups (executives, project managers, planning experts).

The first part of the study presents the results of the market survey on the status quo of scheduling and contains contributions by experts on up-to-date innovative solution concepts for scheduling tasks. The first part of the study is free for everybody. This enables us to make these contents available to all interested readers. We owe this magnificent opportunity exclusively to the partners who have contributed to this study.

The second part of the study, in the form of best-practice reports, takes a closer look at the scheduling aspects critical for success. This part of the study is meant for schedulers and scheduling experts wishing to familiarize themselves with and understand solutions from third parties as a means of learning lessons for the future. Every best practice provides a detailed description of how the respective solution works in a given turnaround project and the preconditions which must be met.
In order to identify concrete steps and recommendations for executives, project managers and practitioners for the improved management of complex turnaround projects and their optimization through innovative scheduling, we will draw on empirical analyses to answer the following key questions:

- What is a (complex) schedule needed for?
- What do schedulers need to know and master today for a turnaround project?
- What are and should be the general design and structure of a schedule?
- Which scheduling practices can and should be used today?
- Which level of detail is required for schedules for turnaround projects?
- What influence does modern information technology have on scheduling and how intensive should IT be used?
- How can I, as a manager and non-expert, decide whether our schedule is really good enough?

We wish you much pleasure and many inspiring insights when reading this study. And we thank again all the experts, enterprises and study partners who contributed their experience, ideas and expertise to this document.

Yours sincerely

Frank-Uwe Hess

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Plant turnaround is rightly considered to be the supreme discipline in industry services. The high demands on meticulous planning and uncompromising coordination discipline during execution show that efficiency can help both the customer and his service partners to save lots of money. Maximum professionalism and many years of experience along with flexibility and the quest for permanent optimization are crucial for the organization of a turnaround process and hence its economic success. There is hardly any other large-scale project where, due to the narrow time frame, mistakes and shortcomings would lead to domino effects with disastrous consequences. Experts, both at the customer and industry service provider ends, know this. A successful turnaround is a perfect credential for all parties, in particular, for those in responsible positions. In the process, the industry service in the industrialized nations is also setting standards for industrial safety and environmental protection which are receiving increased international recognition.

We are hence very grateful that T.A. Cook, with their turnaround study, is giving new impulses to our community and facilitating the exchange of information. I am confident that this can contribute towards communicating the achievements of our industry to a wider public. This is because the comprehensive expertise in the field of turnarounds is the best way of advertising qualified industry service.

Dipl.-Ing. Gerald Pilotto

Member of the Board of the Association for Industrial Services e. V. (WVIS) and Vice President of the Maintenance and Facility Management Society of Austria (MFA)
I. Opinions & Views
The growing importance of technical service providers for turnarounds

Voith Industrial Services is an international industry service provider with more than 19,000 employees at 170 locations and sales of around Euro 960m. Voith Industrial Services offers a wide range of services related to turnarounds and is capable of handling turnaround projects as lead contractor. The editorial team of the study spoke with Martin Karges, CEO, Voith Industrial Services, about the high importance of integrated scheduling and execution as well as the key role of a determined safety culture.

Editors: How has the importance of scheduling and work preparation for turnaround developed over the past few years?

Karges: It has always been vital for refineries to make sure not to lose a single day when it comes to resuming production. We have conducted studies which showed how important scheduling is in order to keep to deadlines. It goes without saying that the only way to ensure this is through serious advance planning and an approach where some of the contingencies and uncertainties are already included in the critical path. Experience is central to this: With a track history of more than 30 years in turnaround business, we have not yet caused even a single day of delay.

Editors: Have demands on planning increased?

Karges: Yes, absolutely. There are several reasons for this. For many of our customers, it would not pay off to have dedicated maintenance expertise in the company itself so external service firms are commissioned. This trend is known, but the service depth is constantly increasing. Planning demands on service providers are increasing accordingly. Another reason is demographics and higher staff fluctuation rates in all companies. Formerly, many seasoned employees used to work at refineries for decades – much to our regret, this is today no longer the case everywhere. This also calls for seasoned service companies who know the plants well and can plan with the corresponding reliability.

Editors: Can technical service providers close this experience gap?

Karges: They definitely can – if they manage to keep their staff. This is one of Voith’s central goals. Seasoned employees are our USP, especially in the fields of planning, scheduling and consulting. Over the course of decades, we have generated specific plant expertise which we can offer all our customers on a lasting basis.

Editors: Why is close integration of scheduling and execution so important?

Karges: Too many interfaces are often the result of insufficient coordination between scheduling and execution. If activities are planned with no regard to execution needs, this means that problems are pre-programmed – for example, when estimating the time needed for execution. This is why I believe that it is always advisable for customers to commission a single contractor for pre-planning, preparation and execution.

Editors: What is the role of work productivity during execution?

Karges: During the planning phase, it must already be determined how effective and well prepared a contractor is and whether he is able to consistently perform on a high level. Having fitters working efficiently is crucial, especially with a view to costs. How is ancillary and downtime handled, such as the frequency of visiting smoking areas? The goal here is to increase the “time on tools”. In cooperation with our customers, we identify reliable performance indicators for labour productivity so that we can optimize downtime.
Editors: What are the requirements for project management during execution?

**Karges:** Project management is a very demanding task during a turnaround. Typical project management, for instance, during a plant construction project that lasts several years is unable to manage a turnaround when several thousand people have to work at the same time. This calls for handling a large number of interfaces. During a turnaround, one must be able to make very quick decisions depending on what a situation requires, and to quickly implement backup scenarios. Project management is the key to success for a turnaround.

Editors: How does Voith handle the issue of safety culture within its own enterprise?

**Karges:** Our customers have an elaborate safety culture which we as a service company have to adopt as well. I believe that a company must actively implement this philosophy within its own organization in order to prepare its staff for the customer’s specific safety requirements. This is why Voith launched the “Safety – It's Your Life” campaign. Just like our customers in the chemical and petrochemical industry, we are firmly convinced that every accident must be avoided. Educated and well trained staff is a precondition for this.

Editors: How does Voith foster its safety culture?

**Karges:** Our safety concepts are informed by years of experience with our customers and the current best practices in the industry. For this purpose, we use a system which is harmonized on an international level and enables us to transfer experience, once made, to wherever we need it. Detailed analyses of how accidents occur and how they can be avoided form the basis of training scenarios and our continuous training and education programmes. This means that our customers always benefit from our up-to-date safety knowledge.

Editors: How do you envision the future development of service providers in the field of turnarounds?

**Karges:** I believe that the high-performing service providers that cover extensive and crucial parts of the portfolio will become increasingly important.

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Strategic partnerships in turnaround projects

Infracor GmbH, established in 1998, is a member of the Evonik Industries AG group. Infracor’s "Technical Services" business unit employs a workforce of around 700 and offers full-scale, one-stop service. Managing turnarounds/shutdowns is one of the core competencies of Infracor’s Technical Services unit. The company is also increasingly offering its planning, scheduling and management services for turnarounds outside the Evonik organization. The editorial team of the study spoke with Bernd Vendt, Head of the Technical Services unit, about the latest trends in the field of strategic partnerships.

Editors: What do you mean by "strategic partnerships"?

Vendt: To Infracor, strategic partnership means long-term cooperation in the interest of the parties’ mutual goal of cost optimization. On the basis of a system of key performance indicators, we agree to concrete targets in order to achieve savings identified in the maintenance process or to increase plant availability.

The specific parameters of each partnership depend on the customer’s specific requirements, capacities and qualifications. We offer the full range of maintenance, project and turnaround services. The customer decides on the scope of the partnership.

Editors: Which strategic partnerships are you already involved in?

Vendt: We currently have five strategic partnerships with all business units of Evonik which are present at Marl Chemical Park, plus another two full-service contracts which, in contrast to older contracts of this type, also include the optimization component of a strategic partnership.

Editors: Many operators are rather cautious when it comes to full-service or general contractor agreements. What distinguishes your offering from that of your competitors?

Vendt: There may be good reasons for this reluctance to enter into full-service contracts because this used to foster some kind of "all risks covered" mentality among plant operators in the past. This meant that plant operators fully relied on service providers and outsourced much of their own expertise. However, productive cooperation is only possible on a common basis which essentially requires plant operators to contribute their share.

In order to overcome this problem, Infracor has added the optimization component to the full-service concept and this has improved cooperation significantly. As a service provider, we depend on the plant operators’ vast process knowledge. Sustainable cost optimization is only possible by combining our expertise with the operators’ specific plant knowledge.

Editors: Are turnarounds a particularly important topic within Evonik or do you also offer scheduling and project management services to plant operators outside the group?

Vendt: Needless to say, turnarounds are very important for Evonik itself, but we also offer our services to external customers. Our strengths are wherever a certain familiarity with the plant and profound plant knowledge are required – both within Evonik and outside it. This specifically concerns maintenance-related projects. We are no plant builders in the classical sense.

Editors: What can operators expect when commissioning Infracor as their turnaround planners?

Vendt: When we say turnaround planning, we mean, first and foremost, sustainable and good turnaround scheduling. This is more than just planning and repeating the same exercise from scratch again for the next project. The reuse of fundamentals, once developed, must also be possible in subsequent turnarounds.

Opinions & Views
Editors: What is Infracor’s key strength in turnarounds?

Vendt: We are very strong in planning and scheduling because we have both the necessary tools and the expertise in this field. Another key strength of Infracor is project management, i.e., leading, organizing and coordinating external contractors as well as quality assurance. The real turnaround, namely, the provision of manpower, is implemented through contractors who work for us. Optimizing the time schedule for the turnaround, whilst ensuring compliance with all HSEQ requirements, is a major challenge for us. This is typically the area where most value is created for the customer.

Editors: Low prices are often a key factor at times of tight budgets. There are service providers who offer parts of the execution planning “for free” on condition that they receive the execution contract. Others prefer the separate awarding of planning and execution contracts. Which is your favourite model?

Vendt: We do not have any execution teams of our own who could perform the execution work. We source these services from external contractors. We focus on management and turnaround planning. This includes achieving optimum terms and conditions for the execution phase which goes far beyond a mere pricing issue. This is why the planning and execution phases are typically clearly distinguished because this is the only way to offer customers transparent, optimum prices for the different activities.

Editors: Successful scope planning and scheduling is today dependent upon an integrated IT solution. Which IT solution does Infracor use?

Vendt: We offer our customers a combined IT platform on the basis of the scheduling program Comos and SAP. Comos covers the process view, i.e., the plant structures and the activities to be performed are contained in Comos. Microsoft Project Professional is used for scheduling, whilst SAP handles the commercial processes. Both Microsoft Project Professional and SAP communicate with Comos via a database which also enables processing of existing planning and scheduling documents based, for example, on Excel or Access. This tool allows efficient turnaround scheduling and planning.
Editors: One final look at the future: How will demand for turnaround service providers develop among plant operators?

Vendt: I believe that plant operators will in future increasingly focus on their role as operators, on optimising processes and on defining maintenance strategies. Turnarounds will increasingly be carried out by service providers with planning and scheduling expertise and the appropriate IT tools. I find this a sensible approach because plant operators will find it too costly to develop such tools on their own. At the same time, IT solutions are facing increasingly demanding challenges as the degree of complexity of turnarounds increases. Targeted development of our software in cooperation with a customer is currently underway because this is the only way for us to ensure that practical needs will be addressed. Our aim is to provide a standard system that can be used both internally and in external value adding activities.

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Innovative scheduling practices

ep-cm has a long track record in successfully supporting turnarounds in the process industry. The company offers consultancy services and support during all phases of turnaround projects, especially in the fields of planning and scheduling, contracts, execution planning and execution. The editorial team of the study spoke with Björn Zubel (CEO) and Frank Scherzer (General Manager) about the importance of good scheduling during the planning and execution phases.

Editors: ep-cm uses a graded best-practice model to execute turnarounds. During which phases are your customers currently having the largest need for action?

Zubel: This varies and essentially depends on the level of evolution of the customer’s organization and the current demands of the company. The graded model generally includes elements which are easy to implement and hence also promise customers a quick ROI.

Scherzer: Implementation of the elements concerning the topics of sustainability and reusability takes a little longer. They pay off for customers only in the medium to long term, depending on the type of implementation. However, a suitable design of the introduction plan can help to achieve refinancing or cost neutrality in the short to medium term.

Editors: What are the advantages for your customers in availing themselves of your services on all levels?

Zubel: The most important advantages are process consistency and sustainability which are supported by coordinated, tried-and-tested methods. To give you an example: When it comes to organizing the interaction of planning, estimation and scheduling, a high degree of information consistency can be achieved with the right combination of methods and processes, such as a risk-based determination of the scope of work, component-based time estimates and float-based prioritization. This leads to understandable results and a high degree of reusability and sustainability.

Editors: What distinguishes your graded model from the models of your competitors?

Zubel: We have compiled a modular portfolio that provides clearly defined inputs and outputs. However, customers are also free to contribute their concepts and procedures. All services aim to achieve continuous improvement in all areas. One of our strengths is our very hands-on centred approach as consultants. Our staff’s experience enables us to understand things from all perspectives – be it as operator, developer, maintenance company or contractor – and we offer our customers active support during implementation. This is what we call “hands-on consulting”.

Scherzer: Our processes are orientated towards change management. Rather than leaving our customers alone, we guide them through the changes so that they can experience and comprehend the new process themselves. At the end, they are capable of implementing or directing processes from within their own organization.

Editors: What is the importance of scheduling for a successful turnaround?

Zubel: Scheduling, when implemented correctly, has a central role to play in the performance of a turnaround. In conjunction with scope management and cost control, scheduling forms the magic triangle for project management in the turnaround world. It must be ensured, however, that the schedules always provide sufficient flexibility with a view to the specific characteristics of a turnaround in order to enable an easy and quick response to any changes which may become necessary...
during the course of the turnaround. ep-cm achieves this by what we call "float based prioritization".

Editors: How do you proceed when setting up a schedule?

Zubel: Scheduling starts at a much earlier stage of the process by focusing on optimum planning and scheduling depth and the quality of work value estimates. A schedule is, after all, only as good as the information on which it is based. When setting up schedules, we attach great importance to involving those who will implement it in practice in order to constantly focus on reality and the practical world. Prior to commencing execution, a schedule is just one theoretical scenario that leads to success – but it is not the only one. Turnarounds feature a rapid pace of change and the schedule must be able to respond to this at all times during the execution phase.

Editors: Which role does software have to play for scheduling?

Zubel: We consider software to be of secondary relevance because it has to support the processes and methods implemented. This means that the software used is not the completed work, but only the hammer that is used to drive the nail into the wall. The first vital step is to determine the basic practice, before we can proceed to step two, which involves working together with the customer to identify the software which perfectly supports this practice.

Editors: Scheduling does not stop with the planning phase. How do you use the schedule during the execution phase in order to achieve optimum management of the turnaround?

Zubel: The real challenge during the execution phase is not so much planning and scheduling but rather determining the current state of progress. Reliable reporting requires the necessary information to be available in the field at all times and at the same time to be made available to management in the form of condensed reports. For this purpose, we have created a new language in the field. When speaking with locksmith or welder foremen, we do not talk about Gantt charts, float variances or other theoretical terms. Instead, we use hands-on terms to capture priorities, such as "must", "should" and "can". Condensed information for management is the other side where we provide reports on three levels. The top level contains all relevant facts on the topic of time schedule and execution, such as critical paths, milestones and s-curves. Every report is supported by underlying reports containing, if necessary further details in order to enable a quick identification and analysis of the causes of potential problems. The underlying concept is based on the management by exception principle. Turnaround projects are very complex and fast moving. In order to make good and well informed decisions, we must restrict ourselves to the exceptions from the rule. As long as we are able to master these we will also have the entire turnaround under control.

Editors: Is there any further potential for optimization in your practices?

Zubel: Yes, there is always potential for improvement. Whenever we introduce new practices with a client, we distinguish between theory and practice. Although the theoretical basis of our practice remains unchanged, the practical implementation is always tailored to the needs of our customers, the type of underlying contracts and the degree of planning detail. Every new project teaches us something new which we often then integrate into our standard methods. It goes without saying that any new elements are validated before they are used in other projects, i.e., they must generally make sense for all customers. Methods must pass the practical suitability test in order to really become best practices.
Editors: Which differences do you see when it comes to planning and scheduling in the international turnaround business?

Zubel: Differences exist, for example, in the area of work estimation calculation using standardized work values. These are less developed in North America than, for instance, in Europe and are mostly based on expert judgement. We strongly advocate standardization and the introduction of component based estimating because only with more precise, integrated and comprehensible job evaluation can modern contract types for the contractors be introduced.

Scherzer: Modern contracts should always enable a real win-win situation and make sure that operators and contractors work together rather than against each other. With the "time & material" contract type that prevails in North America, contractors usually try to integrate as many workers as possible into the turnaround. Operators, on the opposite, are interested in having the turnaround completed with a minimum of resources and within the shortest time possible. This often causes trouble, preventing optimum cooperation and long-term relations. Better advance estimates and planning facilitate the negotiation of modern contract types where the interests of both parties are reconciled.

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Scheduling and execution as a one-stop solution

KIEL Industrial Services AG is a full service provider for the process industry. With eight companies and more than 30 facilities, the family-owned business successfully pursues the philosophy of “planning – building – supporting.” The editorial team of the study spoke with Jörg Eichler, KIEL Key Account Manager, about the importance of scheduling and execution as a one-stop service.

Editors: How did the turnaround competence develop in your company?

Eichler: Our company, with its more than 65-year history, has its roots in the maintenance business. We soon started to employ the staff originally involved in maintenance also for turnaround projects. We currently have maintenance contracts with nine petrochemical sites which also cover execution work during turnarounds.

Editors: What is your manpower philosophy for turnarounds?

Eichler: 60 percent of our personnel are currently employed for maintenance, 20 percent for turnaround and 20 percent for new construction projects. The problem is to find productive maintenance positions for staff before and after the turnarounds or projects. This is why some of the workers employed in turnarounds originally belong to maintenance teams whilst others come from specialized teams that were created for project and turnaround work. Finding the right balance is not always easy, but we are now big enough to make this manpower mix a success at 33 locations all over Germany as well as in Belgium, the Netherlands and Denmark.

Editors: Where do you see potential savings by offering one-stop implementation, scheduling and execution services?

Eichler: Two concepts exist in this field, the first one being the classic weak point/pipeline programme. In small and medium-sized projects as well as during maintenance jobs, we learnt that the error rate is lower when we prepare the isometric drawings and also examine the local conditions. This is the basis for the second concept for savings: We are involved in the planning of the mechanical design of heat exchangers, vessels and columns at an early stage. This creates an early awareness of the plans and specific work preparations among our staff and reduces the learning curve significantly, especially during the mechanical execution phase of a turnaround.

Editors: Would you also perform turnaround contracts without scheduling with a workforce of up to 500 people?

Eichler: Yes, we do, and these are also our roots. We do not restrict ourselves to turnarounds of a certain size as other service providers do. If we do not know the plant in detail, we do not want to offer our customer services involving more than 150 people. Here we think that small is beautiful. If we know the plant, we handle turnarounds which, in terms of manpower, are three times as big as our maintenance activities.

Editors: Do you see any changes in future contracts?

Eichler: Yes, especially with a view to independent engineering firms who are commissioned with turnaround scheduling and project management tasks. Demand in this area is very high, mainly because plant operators are increasingly short of job coordinators. This gap is increasingly filled by maintenance service firms and this will lead to a growth in one-stop scheduling and execution jobs.

Editors: What are your core competencies, and what makes you different to your competitors?

Eichler: We achieve a quality lead through our scheduling and execution experience in project and maintenance business which we bring to our turnaround jobs. We can then offer the resultant planning security as a full service provider. We consider ourselves to be
a planning maintenance contractor that also handles turnarounds for his customers. This strength is also reflected in our broad customer base with more than 40 customers and more than 30 sites. Our focus is on Germany, Austria, Switzerland as well as the Benelux countries and Denmark.

Editors: Are there any country-specific differences in turnaround jobs?

**Eichler:** At times, philosophies differ from country to country. The philosophy of our Dutch colleagues deserves a special mention as they were the ones who in fact perfected the scheduling and work preparation process. They also continue to be a driving force in the development and use of software tools.

Editors: What is your opinion about the use of IT tools? Is planning without these tools possible at all?

**Eichler:** This is no longer possible. However, the key priority should be execution-centred planning with good preparation and integration of tools. But many customers can still improve the process of mapping turnarounds in their entirety as a digital chain and of preparing documents in such a manner that they can be easily reused during subsequent turnarounds.

Editors: In the future, will plant operators increasingly turn to service providers like your firm for turnarounds?

**Eichler:** Yes. Two to three large enterprises will dominate the market in the future, plus maybe the same number of medium-sized enterprises like ours, whilst the number of local, regional firms will decrease.

Editors: Does this mean that specialization of one’s own service portfolio will then be the key to success?

**Eichler:** Yes, definitely. Another crucial asset is to have staff who are experienced in these specialist fields, something we have managed to achieve through acquisitions over the past 15 years.
Editors: Most operators of process plants consider turnaround projects to be some kind of everyday job because they are continuously repeated at defined intervals. Do you think that operators have enough empirical values and data in order to use these earlier jobs as templates for the next schedule?

**Hess:** Most operators have very good experience when it comes to scheduling a turnaround. Furthermore, detailed work lists and technical specifications are usually available for the turnaround work of the main mechanical work trades which can then be used as templates for project schedules. But these templates are where problems already start.

Editors: Which problems do schedule templates cause? Ideally, they should increase the scheduler’s productivity?

**Hess:** There is a huge difference between planning and scheduling. The main task of a schedule is not to plan but rather to manage a time-critical project. However, planning data – such as data from standard work specifications – is often automatically imported via an interface into a project management programme. However, this data is chiefly required for work planning and costing purposes. At the end of the planning process, one then knows that, for example, 30,000 work values of trade “X” will be needed. If this information is then imported to the schedule, especially in the case of large projects, the schedule than often contains more than 50,000 or sometimes even more than 200,000 activities. The schedule is then too fragmented and thus no longer of any use for turnaround management. Many project managers have not yet really understood this.

What is needed is simply a different kind of information, especially on a more detailed level.

Editors: The survey results of this study suggest that more than half of the schedules are used only for planning rather than as a day-to-day management tool during the execution phase. What is your opinion about this situation?

**Hess:** The management of projects based on schedules with such a high level of complexity is, in fact, neither practical nor possible. It seems to be quite easy to compile these complex schedules, but it is definitely impossible to update so many details on a daily basis during the execution phase. On the second day of the turnaround project at the latest, the reality on site is different from what the schedule implies. Many operators and project managers thus consider the schedule to be completed once the execution schedule has been signed off. They interpret the schedule as an inflexible and fixed system which is used primarily as a plan presentation tool rather than an instrument for managing the execution phase. The schedule is often printed and displayed like “wallpaper” in the project manager’s office. This is not surprising, since any attempt to manage day-to-day work with such complex schedules would eventually lead to chaos.

Editors: Which general requirements must a schedule fulfil in order to be used as a management instrument during the execution phase?

**Hess:** First of all, managing execution on the basis of a dynamic schedule requires the profound expertise and skills of those involved. A “good” schedule then materializes as the
Other important qualities are courage, perseverance and discipline. A "good" schedule must generally fulfill the following criteria: First: It must reflect the information needs of those involved by providing different schedule levels. Second: The number of hook-ups (control activities) should be minimized. Third: It must map the complete project in terms of plants and trades involved with sufficient precision. Fourth: The daily update cycles of the schedule and the contents of status messages must be defined precisely. Fifth: Simple rules must be defined as to what is to be managed centrally by project management and which daily execution decisions have to be made autonomously by those involved.

A good schedule is like a modern traffic management system. There are traffic lights and signs which are centrally controlled and control everything, but there are also roundabouts which enable smooth traffic flows without traffic lights (self management).

Editors: How large must a project be for a schedule with the corresponding scheduling software, i.e., MS-Project or Primavera, to be needed?

Hess: The dimensions of the project are not really the criterion. Even seemingly smaller turnaround projects, such as a two-week cleaning turnaround costing 450,000, will require a schedule just like a million-euro job if one condition is fulfilled, i.e., if the project is time and/or resource critical. A critical activity grid with several hundred activities cannot be effectively managed without scheduling software. However, it goes without saying that a smaller schedule is much easier to set up than a schedule for a million-euro project. But the benefit is the same, namely, lower opportunity costs due to shorter downtime. In the case of a cleaning turnaround, this could reduce the completion time for the plant shutdown from 14 days down to nine, at the same cost.
Editors: New project management approaches, especially the critical chain method, have been increasingly advocated recently. Are these the solutions of the future to today’s scheduling issues?

Hess: Critical chain project management is not really new – at best, maybe, for turnaround project managers. However, I am not yet aware of even a single customer project where this method is being applied. Eliyahu Goldratt published it already in 1997. What makes the critical chain model attractive is its underlying theoretical concept, which includes ideas to reduce the number of activities, to integrate risks in the form of floats or to increasingly focus on forecasting activities rather than the process. These approaches are definitely relevant for turnaround projects and, in my opinion, also very realistic. They do, however, require a different form of understanding among stakeholders. The aim is not to do one’s utmost to keep the schedule in order to be eventually rewarded for a “good” schedule. Instead, the goal is adaptive management of the schedule in order to complete the work ahead of time. If the aim is to make one’s plant “on-spec” again as quickly as possible, the critical chain model has really good concepts to offer. But one should not forget that this method is not a panacea that solves all problems. As always, many things must come together to make a project a success. And these are, first and foremost, highly skilled practitioners.

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II. Methods & Solutions for Scheduling
Innovative methods and best practices for turnaround scheduling

Dr. Tobias Laiblin, Head of Turnarounds Department, Infracor GmbH

Infracor GmbH operates the Marl Chemical Park and offers its services to the companies located there and elsewhere. Infracor is a wholly owned subsidiary of Evonik Industries and belongs to the Site Services Business Unit. Infracor offers process industries focusing on chemistry the full gamut of services needed in this sector and also provides the necessary infrastructure. These services include maintenance, inspection, repair, assembly, materials management as well as optimization of plants and production components. Infracor is also a competent partner for scheduled turnarounds and optimum support during unscheduled shutdowns.

Infracor is a value engineering provider of scheduled turnaround services. Turnaround management includes targeted support during the following phases:

- Structuring of turnarounds (scope of work)
- Task planning
- Scheduling
- Resource and materials planning

When it comes to handling turnarounds, seasoned Infracor staff manage the construction site and the execution process, thereby ensuring effective and efficient work by all trades.

One central goal of turnaround management is the use of a consistent IT solution and an integrated project management centre so that process can be standardized and central data processing and evaluation ensured. The focus is on integrating existing IT systems into a central project management system that improves, in particular, the interaction between technical and commercial as well as scheduling and resource planning systems. Infracor uses several IT systems with multiple bidirectional interfaces between them and the individual systems (see Fig. 1).

![Diagram of the Infracor system landscape](image)

Fig. 1 | Diagram of the Infracor system landscape

Methods & Solutions for Scheduling
Following identification of the scope of work (customer's task list), the technical information necessary for execution is then available as maintenance specifications in Comos. Comos includes an interface via which customer data can be imported (for example, from Excel) where it can also be specified, if necessary. More in-depth details (including a list of activities) are then laid down within the individual maintenance specifications. Subsequent changes in the scope of work are similarly integrated into the schedule.

This is where the central project management system (DBDS) comes into play by enabling data communication between the technical basis in Comos (or Excel), the schedule and resource planning function in MS Project (MSP) and the commercial data in SAP. All the other systems shown in Fig. 1 are connected directly to one of the above-mentioned systems. Fig. 2 illustrates the underlying principle of the DBDS.

Following receipt of the turnaround order in SAP, a schedule template containing the general structure of the turnaround schedule is generated via the DBDS in MS Project. The first draft schedule for the turnaround is subsequently generated on the basis of the activities in Comos. The following detailed schedules and resource plans are created in MS...
Project. A corresponding order structure for execution is then generated in an analogous process via the DBDS in SAP. This in-depth principle of data integration ensures a persistent exchange and reconciliation of the three IT systems: from adequate scheduling and resource planning to monitoring of budgets and actual costs right through to optimized task and cost developments during the turnaround. During the planning and downtime phases, Infracor offers its customers state-of-the-art, IT-based turnaround management services. Cost-effective and schedule-compliant turnaround means crucial benefits for operators:

- No data redundancy, no double entries
- Regular, up-to-date reports and accounting
- Increased schedule and cost reliability
- Structured transition from turnaround planning to execution management

Infracor’s project management system facilitates sustainable turnaround scheduling. Thanks to the experience of its seasoned turnaround staff, Infracor is a full-service provider capable of handling turnarounds of any magnitude and complexity.

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World-class turnarounds

Dipl.-Ing. (BA)/SFI Torsten Nies, Turnaround Manager, Bayer Technology Services GmbH
(Co-authors: Hans-Jörg Kamp and Dirk Kruse, both Bayer Technology Services GmbH)

The basis for world class in turnarounds

The task of asset life cycle management is the optimum management of a plant’s assets through operational excellence. While meeting statutory requirements, the relentless quest to achieve this task sees asset life cycle management used to define measures and attribute these to maintenance (OPEX – operational expenditure) and capital investment (CAPEX – capital expenditure). The costs and time frame for these activities are defined by the maintenance, turnaround and project management functions as shown in Fig. 1.

The performance of the task implementation process is evaluated with the help of key performance indicators (KPIs). Central KPIs are safety, quality, costs and plant availability (time) as shown in Fig. 2.

These KPIs are designed to help achieve the following aims:

- No accident (safety)
- No touch-up (quality)
- Minimum expenditure for the defined measures (costs)
- Maximum plant availability (time)

The aims for the “safety” and “quality” KPIs can be clearly defined for all areas. In contrast to this, defining the aims for the “costs” and “time” KPIs is a complex process which requires deciding whether a particular activity is to be carried out without interrupting operations or during a turnaround.

Professional, structured management means that these decisions are made in an optimum manner in the sense of operational excellence, fully integrating the maintenance, turnaround and projects areas.

To sum it up, world-class turnaround management is only possible if asset life cycle management, in the sense of operational excellence, clearly defines the scope and KPIs for the different areas, namely, maintenance, turnaround and projects.

Why does the character of your turnaround determine the execution practice?

A distinction between equipment-driven and process-driven turnaround is made in the process industry.
During an equipment-driven turnaround, the plant is usually devoid of products. As shown in Fig. 3, the turnaround time is defined by scheduling and resource planning on the basis of a defined scope and the resultant activities. For this purpose, standardized management methods and practices are available which are used, in particular, during turnarounds in the oil, gas and energy industries. The above-described KPIs can be clearly defined. Delays or technical modifications can be compensated for by increased resource input.

During process-driven turnarounds as shown in Fig. 4, the plant is usually not void of product. Turnarounds in the chemical industry are often process-driven because many areas of the plant are not built dead-leg-free so that certain hazardous substances (phosgene and other chlorine compounds, ammonia, etc.) may remain in certain areas. This involves a great deal of work by operators in order to ensure the absence of product before the necessary technical measures can be carried out.

On the basis of process requirements, such as cleaning processes, subsystems which are still working or which have not yet been emptied out, the activities are implemented in time windows as shown in Fig. 5.

Time windows define process-related activities (by operators) of scheduled turnarounds (by the contractor) in order to enable a clear-cut separation of the activities from a safety and organizational perspective.

In view of very strict safety requirements, operational and technical measures sometimes require considerable additional effort (workers having to wear heavy respiratory protection, complete evacuation of the plant, only a single activity per time window, etc.). These conditions pose additional problems during turnaround preparation and execution and affect the entire schedule and resource planning complex as well as the definition of the “cost” and “time” KPIs. Conventional optimization methods (critical path, critical-chain method, etc.) do not suffice here.

Only seldom can delays or technical modifications be compensated for by increased resource input because the turnaround is subject to process restrictions.

Key members of the turnaround team are the process expert (plant management) for project design and execution and the TAR manager whose cooperation is vital, especially when it comes to scheduling and resource planning as the key interface for planning.
**BTS as your partner – world class in turnaround**

Besides expertise in the execution of standardized, equipment-driven turnarounds, Bayer Technology Services can draw on special industry experience in the fields of project design (TAR planning) and execution management of process-driven turnarounds in the chemical industry. This expertise is based on the know-how and vast experience of the company’s staff, resulting, amongst other things, from job rotation schemes in the fields of business and turnaround management.

With its wealth of owner competence and experience in plant, maintenance, project and turnaround management, Bayer Technology Services offers the perfect basis for implementing world-class turnaround management for your plant too.

Bayer Technology Services – Word Class in Turnaround

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Why a turnaround schedule must remain flexible
Björn Zubel, CEO, ep-cm

What makes turnaround projects different from conventional jobs is the relatively short execution phase with a lot of short individual activities, leading to a rapid execution pace. Furthermore, a large number of resources must be coordinated and optimally employed within limited space. An analysis of different turnaround schedules has shown that 95% of the activities performed are on a critical path: They merely represent a large volume of work that needs to be optimized and completed in a structured manner. The special challenge is to make the schedule reasonably flexible without sacrificing the necessary control mechanisms.

This flexibility is necessary because turnaround projects include a host of variables:

- Unscheduled repair work (faults and damage that are first detected during the initial inspection)
- Uncertainty about the order in which equipment will become available for processing
- Availability and capacity of resources
- Logistical challenges
- Restrictions due to limited space in the plant

Conventional scheduling methods, such as "critical path" or "critical chain" are not the solution of choice for turnaround projects because they thwart an adequate response to changes. Purely dynamic scheduling practices are not recommended either because the optimum completion of the large number of non-critical activities requires a certain measure of control.

What is the "float based prioritization" method?

The method underlying float based prioritization is "dynamic scheduling". The difference is the additional use of phase-related milestones that enable the definition of structures for an otherwise dynamic schedule. These milestones are integrated into the schedule relative to the total execution time and subject to defined boundary conditions. The task is to determine time windows for certain activities and to achieve a sensible resource employment schedule over the turnaround execution time.

Examples of such phase milestones are:

- Scheduled repair welding work completed
- Initial inspection completed – unscheduled repair work identified
- Disassembly of various types of equipment, including repair or cleaning needs
- Ensuring disassembly of equipment for necessary inspections

These milestones are determined in line with the requirements of the turnaround project. By identifying correlations between tasks related to these milestones, activities which are otherwise dynamic can be integrated into a manageable grid. This makes it possible to identify and communicate priorities based on floats. At the same time, the definition of time windows in the schedule leaves enough leeway to be able to respond to execution needs and to ensure efficient resource employment. This method also helps to identify and address exceptions in the schedule. Management of the activities thus focuses on really critical processes with regard to the entire project and important phase milestones. When, for example, the milestone "initial inspection completed – unscheduled repair work identified" is reached it is possible to make early, reliable forecasts of the project completion date whilst at the same time providing necessary resources for repair work.
The calculation of floats refers to the intermediate deadlines and project milestones. These floats are analysed and combined into groups. The priorities are usually defined as follows:

<table>
<thead>
<tr>
<th>Priority</th>
<th>Conditions for float</th>
<th>Statement</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prio 1 (HIGH)</td>
<td>&lt; 24 hours</td>
<td>MUST</td>
<td>&lt; 1 %</td>
</tr>
<tr>
<td>Prio 2 (MEDIUM)</td>
<td>&gt; 24 &lt;= 72 hours</td>
<td>SHOULD</td>
<td>&lt; 4 %</td>
</tr>
<tr>
<td>Prio 1 (LOW)</td>
<td>&gt; 72 hours</td>
<td>CAN</td>
<td>&gt; 95 %</td>
</tr>
</tbody>
</table>

Table 1 | Definition of priorities via floats

All activities of priority 1 are called critical processes which do not leave any or, at best, little leeway for delays. These activities can also be described as a critical path. Priority-2 activities are near-critical paths which also require a high level of attention because they are soon about to become critical activities. Priority-3 activities have usually little or no impact on the final completion date of the overall project as long as the scheduled degree of performance of the individual resources is achieved. If this is not the case, the priority of these activities is automatically increased so that these are then identified early enough. Project management focuses on two components: i.e., the priority-1 activities which should not account for more than 1% of total activities and the performance of the resources employed to complete the bulk of the work. Indicators of declining performance are available right from the outset so that suitable countermeasures can be implemented.

Just like all other scheduling practices, float based prioritization is also dependent upon meticulous progress monitoring during the execution phase. Scheduling software, such as Primavera, and optimized data capture systems (bar code) can help to automate the processes for progress monitoring and capture, as well as prioritization, thereby minimizing the effort needed to update the schedule. This reduced effort ensures that the execution will be as accurate a reflection as possible of the schedule and helps to generate the maximum level of accuracy possible. This is a fundamental condition for early management decisions which lead to proactive action.

**Methods & Solutions for Scheduling**

**Fig. 2 | Example of an overview of milestones and priorities**
Turnaround scheduling – scope freeze and reality

Dirk Träger, CEO, T/ANGO Turnaround Management Group GmbH

A central element of a successful turnaround is a reliable schedule that precedes the real shutdown phase. Depending on the magnitude of the turnaround, the schedules may contain a six-digit number of individual activities. The scheduling process means that this complexity is actively managed. The schedule is a binding document for all stakeholders that sets forth the sequence of operations. A reliable schedule is a prerequisite for the smooth execution of a host of individual activities on time and within budget as well as within the shortest possible time window.

Those responsible for the turnaround know this success factor. Several TAR optimization projects were recently conducted in order to improve the TAG front end loading (i.e., the planning process) and hence to guarantee the quality of the schedule. One of the measures was the definition of a “scope freeze” as a technical term. This refers to a defined point in time at which all the turnaround operations (scope) of the respective specialist divisions, including all projects, have to be reported to TAR management and the schedulers. The scope is then frozen and the schedule prepared using optimization techniques. Ideally, this is carried out twelve months before the shutdown phase of a turnaround. The schedule is finalized in cooperation with the specialist divisions and forwarded to the contractors.

However, the central problem in turnaround reality remains that the scope of work grows continuously until the shutdown phase begins. Ensuring a frozen, valuable schedule can be thwarted by additional short-term measures which have not been sufficiently analysed with a view to their relevance for the turnaround. Besides fatal consequences, for example, on the reliable provision of additional resources and infrastructures, this can also lead to budget violations, problems in the field and exceeding the originally planned shutdown time.

Many turnaround managers have learnt their lesson from the past and have had to rethink. The implementation of several different turnaround processes was an important first step in order to guarantee the quality of the schedule and educate the specialist divisions with regard to ways of handling the scope. The “known scope” is communicated to the schedulers at an early point in time so that it can be mapped as quickly as possible. However, despite a binding scope freeze, one should not ignore the fact that the need for various repair interventions or weak points is identified during inspections before and during the shutdown. Part of this additional work must then be completed during the turnaround. This is often overlooked in the field and not properly prepared and managed by plant operators.

The staff at T/ANGO Turnaround Management Group has many years of experience in turnaround scheduling. Their expertise recommends that the following aspects should be considered in conjunction with the scope freeze issue.

So-called cold eyes reviews (expert groups)
• are a proven best practice approach when it comes to handling additional scope by exploring the need for additional measures during the turnaround.

Furthermore, regular examinations, for example, in the form of risk analyses, should be conducted throughout the entire shutdown phase concerning the impact of additional measures on the schedule.

The external contractors must be involved in
• the continuous challenge of the scheduling process in order to integrate their experience.
• The responsibilities for the release of measures after the scope freeze must be defined. During practical implementation, conflicts of interests often arise between turnaround management, specialist divisions and production. We recommend appointing a unit having central budget responsibility and releasing the measures.

**Conclusion:**

Due to the unknown scope variable, the development of schedules continues to be dynamic until the end of the turnaround execution phase. The impact of a short-term increase in scope on the schedule must be scrutinized in a continuous process that integrates several specialist divisions in order to complete the turnaround successfully.
A look at the turnarounds of the 1980s and 1990s shows that 90 percent of all turnarounds failed to adhere to the set schedule. 75 percent of the schedules even had to be revised during the first days of the shutdown, with the scope of the entire turnaround increasing by 10 to 50 percent. Furthermore, the budget of 80 percent of turnarounds was exceeded by 10 to 40 percent.

However, a positive trend can be seen in recent years. Schedules and budgets can increasingly be adhered to. What are the reasons? Is it constantly growing cost pressure? Or does increasing awareness of the turnaround scheduling issue have a key role to play? We found that both factors contributed towards an increasing focus on detailed planning and that many managers have come to understand the related costs as an investment in plant availability. The cost of a single day of downtime during a turnaround in the energy or petrochemical industries often reaches high six-digit levels. This explains why availability is the top priority for many plant operators and why solutions are sought to optimize this parameter during a turnaround.

Operator management focuses on optimizing both duration and costs of a turnaround. The on-site operational (production) and technical department focus on inspecting, cleaning, maintaining and revamping the plant. The question is now how both approaches can be adequately addressed. At the end of the day, duration and cost optimization also means reducing the scope to what is required by law. The tasks of the production department are to thoroughly clean and maintain the plant in order to optimize it for the following operating period. But it is often also necessary to implement complex projects which then lead to an increase in scope, costs and duration. We consider the task of optimizing costs and duration despite an increased scope to be one of the greatest challenges when it comes to planning a turnaround.

This now leads to the question under which aspects the scope of work is compiled. One very useful tool is certainly to assess the risk of individual components under economic aspects as well as a close look at redundant systems. The motto “do whatever you WON’T be able to do during the next five years” can also provide some guidance.

Once the scope of work resulting from statutory requirements and operational needs has been determined and approved by management, the foundation for a successful schedule is in place.

But when should the scheduling and planning process start? When must this be completed? How much detail is necessary? What can it cost? Are there any planning standards? These and other questions are what we are regularly faced with.

Answers to these questions can also be derived from the planning mistakes of earlier years: delayed commencement of planning (for unjustified fear of rising planning costs), inaccurate planning of turnarounds and projects, a scope that was defined too late, lack of coordination between the different specialist divisions as well as poor resource planning. For many years, our staff have been working on optimizing workflows in the field of scheduled process plant maintenance. A key topic is scheduling and resource planning of turnarounds and projects of all magnitudes. Until the end of the 1990s, our staff still planned every single component on an hourly basis. However, the attempt to really integrate the full scope of information of the turnaround into a schedule...
often meant an increased time and cost input. For many years now, we have been focusing our planning and scheduling activities on work preparation and the identification of the scope of work under economic aspects. Successful scheduling and resource planning are thus ensured according to our philosophy of "lean & effective".

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Daily feedback during execution – bar code, manually generated reports, portal, mobile communication?

Gerd Braune, Head of Planning, BIS Maintenance Nord GmbH

To handle an average of 20,000 to 40,000 activities or even 100,000 tasks or more in major plant turnarounds, with typically 40 to 60 contractors involved, and within the shortest possible time slot whilst at the same time adhering to all applicable safety and budget restrictions – this is the aim of every turnaround. The schedules are the linchpin of any such project.

In order to enable active management, completion reports and scope changes must be captured as quickly as possible and daily progress recorded. This information serves to coordinate tasks and prioritize activities. Feedback from all stakeholders is a precondition for success.

Static schedules, dynamic management with no float based prioritization, manually generated reports, use of bar code lists in complex projects only, progress feedback for reporting purposes only – these were the basic parameters and normal practice of old-fashioned turnaround planning up until just a few years ago.

Change has started

Detail planning, RFID (radio-frequency identification) chips for electronic feedback attached to the equipment and the use of intranet portals are today state-of-the-art for turnaround projects.

However, reporting and visualization are mostly still paper-based, with wallpapers being used as a project management tool. The familiar bar code lists are also still in use. Daily feedback concerning the actual status serves to update the schedule, prioritize activities, and prepare work packages for the next day.

The future of turnarounds

What will turnarounds look like in three or five years? How will project management change? Progress will happen wherever new technologies and adapted processes contribute towards even more efficient turnaround execution.

The increasing speed of communications will generate essential impulses. Information about up-to-date completion rates, work released and activities pending will be permanently available via mobile solutions. Staff can track the current status on PDAs and tablet PCs. Information for localization, identification and work contents is also available for retrieval by RFID at the equipment. Completion reports will take the form of realtime feedback which will be ensured through communication via WLAN or GSM transmission.

Compared to today’s workflows, this means active dynamic management, direct reporting to the downstream trade and instantaneous communication of test results. This is the basis for immediate response to changes.

In order to make this possible, it is not only necessary to create the technical conditions for the new communication channels, but also to adapt processes and structures to the new situation. In order to fully utilize the improvement potential offered by mobile communications, the higher speed of information transmission must also be supplemented by accelerated workflows and processes as well as further training of staff with regard to the new IT tools.
The future extent of planning and scheduling and the related level of detail will be comparable to the present status, also because a higher degree of complexity in the planning process would not lead to better quality.

The increasing speed will place higher demands on staff. The speed and quality of feedback and the corresponding adjustment of workflows will also determine whether turnarounds will become more efficient. Customers and service providers must join forces in order to master this challenge. Creativity and flexibility will be crucial in addition to a high level of technical expertise.

Gerd Braune is Head of Turnaround & Revamp Planning at BIS Maintenance Nord GmbH in Leuna, Germany, a company of the Bilfinger Berger Industrial Services Group. He and his team have for many years been involved in scheduling, planning and executing turnarounds in the process industry. The service portfolio ranges from separate scheduling and planning assignments to the preparation of tender documents right through to the full-scale scheduling, planning, executing and documenting of turnarounds as managing contractor.
Conversion of cat section at Total Antwerp in April/May 2011

Martin Karges, CEO, Voith Industrial Services GmbH

Turnaround scheduling is a major challenge for industry service providers. The following example provides a detailed insight into the individual steps during the modification of the FCC plant at Total’s Antwerp refinery and highlights the breadth of technical competence at Voith Industrial Services. Execution planning for critical equipment in catalytic crackers, where efficient workflows are often crucial for the turnaround’s success, is certainly a task that must be performed by experts. A time window of six weeks is foreseen for the complete modification project.

This, apart from many minor tasks, covers two main modifications.

Riser pipe

The riser pipe (13mm, material A516, grade 70) is lined with 100mm anti-wear concrete. It has a diameter of 1,750mm and is approx. 45m high. It connects the regenerator to the reactor. Feed is injected through the feed nozzles into the riser pipe and subsequently cracked by the catalyst in the reactor.

As part of the turnaround, approx. 35m of the vertical and 4.5m of the horizontal stretch of the riser pipe are to be replaced. Four vertical and one horizontal pipe stretches each weigh-

hing more than 20 tonnes are to be changed. Before the pipe segments are cut off, the riser pipe is secured on the steel structure at several points.

One of the challenges is that the riser pipe must be installed in a prestressed condition. When cold, the pipe is 28mm shorter than the distance between the two pipe connectors. It is hence of utmost importance to determine the cut line with maximum precision. Therefore a surveying contractor must accurately determine the length of the new pipe stretches as well as the exact position of the cold pipe in the steel structure. These dimensions must then be checked whenever a new segment of the pipe is installed in order to maintain the correct position of the upper pipe connector. The vertical pipe stretches are fitted with backing strips. When two pipe segments are mounted, adhesive cement is applied to the wear-resistant concrete before the segments are joined together. The riser sections were already pre-assembled and adapted at the manufacturer’s works so that the weld gap is optimally adjusted after joining.

Regenerator: Temporary intermediate floor

Due to restricted space, it is not possible to change the regenerator head completely so that all parts to be changed must be brought in and out through a manway or a window in the regenerator wall.

Extensive lining work is planned in the primary and secondary cyclones in the head area of the regenerator. Heavy steel parts are to be replaced in the lower area. In order to enable work to be performed simultaneously in the upper and lower parts of the regenerator, a temporary intermediate floor consisting of
Regenerator: Changing the primary diplegs

The regenerator contains eight primary diplegs made of 304 H all of which are to be replaced with diplegs of a new design, each 7.5m long and weighing around three tonnes. Following dismantling of the bracings (i.e., the connecting supports on two different levels), the existing diplegs are plasma-cut into pieces that can be easily handled and removed from the regenerator.

Regenerator: Replacing the air spider with an "air ring"

The conical area of the regenerator currently contains an air spider in a cruciform arrangement that regenerates spent catalyst with air. This will be replaced by a new design called the air ring. It consists of three concentric rings measuring 10", 12" and 20" which are connected to the central pipe. The air ring is made of stainless 304H steel whose exterior is lined with anti-wear concrete.

The central piece, including the 10" ring, weighs 3.6 tonnes and is mounted via the inner trolley track. The central 12" ring is brought into the regenerator in two parts, each weighing 1.6 tonnes, whilst the outer 20" ring is brought in in 4 parts, each weighing 1.8 tonnes, via the crawl beams. The rings will then be welded together on the scaffolding and mounted by means of the crawl beams to the spokes which connect the central pipe and the rings. The air ring has many nozzle holes which render forming for TIG welding very difficult. This is why the welds are rooted with an electrode, something which constitutes quite a challenge.
As a precondition for installing the new diplegs, the installation sequence must be exactly defined because space is extremely limited and because installation of all the diplegs would not be possible if the wrong dipleg would be installed first. This is why a 3D computer model was generated during the turnaround planning phase in order to simulate the entire assembly process and thereby determine the correct sequence of work steps.

The dipleg pipes are brought into the regenerator on a trolley that travels on a rail system in the apparatus.

**Regenerator: Partial replacement of the secondary diplegs**

The discharge level of the new secondary diplegs is 1m higher than that of the old ones. The orientation of the discharge openings is also very important. This requires the cutting lines to be exactly measured and their orientation to be checked after fixing.

**High scheduling and planning expertise required**

The planning for installation of the diplegs shows that scheduling calls for a high degree of problem solving competence due to the large number of complex restrictions. Every detail of workflow planning must be right in order to avoid delay in the turnaround. Voith Industrial Services offers this expertise, drawing on many years of successful work in the turnaround business.

**Martin Karges**

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After the turnaround is before the turnaround – and this automatically means analyses. What went well, and where is further optimization needed? Turnarounds call for enormous effort by all stakeholders. A very tight schedule with a non-negotiable deadline for the restart of the plant determines the concept and execution of all activities. Other crucial factors that influence the project include safety, execution quality and the usually tight budget.

A turnaround is always a challenge for those in charge of organization and logistics. Professional preparation and detail planning as well as good follow-up and debriefing are essential for success. At the same time, practical experience also shows that unforeseeable tasks can occur time and again.

Drawing on experience from a host of turnaround projects, EagleBurgmann has identified two factors for success. The planning tools and work plans define the exact framework as well as the workflows and demands so that all the trades can deliver on schedule. All stakeholders can thus rely on a defined starting position and a complete overview. Furthermore, the concrete work carried out on site must meet the specifications and agreed scope. It is the committed and experienced staff with their mobile service equipment who ensure smooth service during the “hot phase” and a flexible response to varying job situations. Our job as seal manufacturers goes beyond the agreed services, but also involves additional tasks related to packing technology. We understand our role as that of a service provider in the turnaround team, and we act accordingly. This means that our staff on site are there to address any issues which may arise and to do whatever they can in order to provide a quick and reliable sealing solution. Another factor that should not be underrated is the precise documentation of all services performed and materials installed during a turnaround phase. Two practical examples illustrate successful interaction between the operator, sealing specialist and other service firms during a turnaround.

Unterweser nuclear power plant (Stadland, Germany)

Subject matter:
• Keeping a seal inventory (70 different items) in a service container
• Manufacture of seals (flat gaskets and packings) on site
• Documentation and issuance of certificates for seals delivered (nuclear grade)
• Flexible deployment of two experts

Result:
• Manufacture of more than 600 flat gaskets from plate material
• Special gaskets measuring up to 2,400mm in diameter
• Provision at short notice of graphite packings, cover plate gaskets and special seals
• Provision of certificates for all seals and gaskets
• Management of all the seals and gaskets supplied and electronic reconciliation with the operator
• Identification of all the seals and gaskets supplied using a label printer
• Immediate availability of all certificates at a central point in the Unterweser nuclear power plant

Peter Linier, EagleBurgmann Germany GmbH & Co. KG (peter.linier@de.eagleburgmann.com)
• Response at short notice to unscheduled tasks, including provision of materials
• Ongoing provision and ordering of materials as required
• Documentation management for the Unterweser nuclear power plant
• Successful MvA completion

Fig. 1 | Specialist in front of the service container holding a gasket

Fig. 2 | Installing a flat gasket

Fig. 3 | Installing a compressor seal
Total Spergau refinery (Leuna, Germany)

Scope of work:

- Measuring spindles and housing seals at the service contractor’s workshops or directly on site (welded valves)
- Manufacture of packing sets for spindle packings in a specially equipped service container on site
- Cutting flat seals of different grades and gauges
- Reworking groove packings
- Provision of cover plate gaskets and special seals (including tool manufacture)
- Keeping inventories of mechanical face seals, packings and packing material of usual dimensions and designs
- Coordinating and ordering additional services for mechanical face seals in close cooperation with the nearest EagleBurgman service centre in Halle/Leipzig, Germany.

Result:

- Quick and smooth seal and packing supplies for packing service firms
- Permanent availability and active support when it comes to measuring and installing packings and seals, thus avoiding practically any measuring and installation errors
- Quick provision of special packings and seals
- Especially in the case of hand valves, the dimensions are often not known until the valves are reworked, so that local presence and quick response pay off.
- Even customers who prefer off-the-shelf material avail themselves of the packing service, for instance, when blanks need to be sealed quickly.
- Fitting and setting into operation of mechanical face seals for compressors and pumps as well as the pertinent seal supply systems

The main factors for service success include flexibility, speed, planning safety and reliability. Overhaul cycles are becoming increasingly long, especially for large plants. On the other hand, there is also a trend towards ever-shorter turnaround times. Besides their own maintenance staff, plant operators are increasingly relying on external service specialists. One of the key challenges for external service firms is to render as many services as possible on site. This is vital in order to tackle the many diverse tasks that arise during a turnaround.

EagleBurgmann has tailored its services to these needs: With our mobile service centre solutions, we are there on site, bringing with us the technical equipment to address the customer’s specific demand. Our seasoned specialists warrant quick and smooth work at the construction site in order to ensure impeccable scheduling, from planning right through to plant restart.
Sulzer Pumpen Service creates added value for customers during turnaround

Frank Nissen, Business Development Manager, Sulzer Pumpen (Deutschland) GmbH

The Sulzer Pumpen service organization offers a comprehensive service portfolio for the oil + gas processing and chemical industries, the energy sector and the paper industry. We see ourselves as technical service providers offering efficient and state-of-the-art maintenance, repair and optimization services for the customer's rotating machines. Our service offers our customers substantial cost and time savings and also ensures higher plant availability.

Our technical expertise enables us to maintain, repair and modernize the entire range of rotating machines from different manufacturers, including:

- Pumps
- Compressors
- Gears
- Extruders
- Agitators
- and other units.

These measures are designed to reduce the energy consumption of the machines, to enhance their reliability and adapt them to changed operating conditions, to use state-of-the-art materials or to simplify maintenance operations.

Our services in turnaround projects include:

- Analysing the machine status on the basis of user data (machine history)
- or based on own measurements (condition monitoring)
- Planning the necessary work steps, including time demand (resources, such as manpower and machine times)
- Identifying and providing the necessary spare parts
- Planning and organizing of external crafts
- Issuing recommendations for plant optimization (energy efficiency, reliability, life cycle costs)

Sulzer Pumps offers specific machine optimization services during turnarounds in such a manner that real value is added. One example of this successful partnership is the cooperation between the Sulzer Service Center in Schkopau, Germany, and the customer Styron Deutschland GmbH.

The Schkopau facility of Styron Deutschland GmbH produces synthetic rubber and polystyrene. The Sulzer Service Center at Schkopau is the competent and qualified partner for maintaining the rotating machines during the annual turnarounds. The customer lays down the turnaround schedule and identifies the relevant units as well as the time frame for the service work whilst Sulzer is responsible for technical detail planning in close cooperation with the customer. The individual maintenance operations are defined on the basis of the machine history and extensive experience.

Fig. 1 | Pumps and rotating equipment from different manufacturers are optimized at the Schkopau Service Center.
Reliable information concerning the resources available at the workshop warrants completion of the maintenance work on schedule. This includes recommendations concerning the provision of relevant spare parts.

During the major turnarounds, the plants are adapted and optimized to reflect state of the art so that they can continue operating with minimum trouble for another five years.

When it comes to revamping its rotating machines, Styron Deutschland GmbH relies on the technical competence and expertise of Sulzer Pumpen, for instance, for the modification of its FBC dryer (Fig. 1).

Before the dryer could be modified, the complete bearing system had to be dismantled on site because of bearing damage. In the run-up to the 2009 turnaround, the Schkopau Service Center suggested modifying the bearing system for the flywheel discs so that the bearing system forms a complete plug-in unit that can be removed in its entirety from the enclosure. This modification reduced the dryer repair time by 40% so that future maintenance work can be performed much faster and at a lower cost.

The Schkopau Service Center is located at Dow Value Park Merseburg. With its seasoned staff of around 50, the Service Center is one of 15 facilities of the service organization of Sulzer Pumps in Germany.

The fact that the Service Center is located on the premises of Dow Deutschland GmbH underpins the implementation of this customer-centred service concept that enables Sulzer to respond to customer requirements at very short notice. In line with this concept and its policy of being close to the customer, Sulzer Pumpen (Deutschland) GmbH set up a new service station in Pocking (Bavaria), Germany (near Passau/Burghausen), at the end of last year.

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Methods & Solutions for Scheduling 49
Advanced schedule optimization –
dynamic time and cost optimization in the inte-
rest of shorter downtimes

Gert Müller, T.A. Cook & Partner Consultants GmbH

Background

Opportunity costs due to turnarounds must always be reduced to a minimum. This calls for an easy-to-apply schedule to manage the execution phase. Optimization methods ensure the maximum cost effectiveness and speed of the turnaround. However, advanced turnaround optimization also means allowing for sufficient flexibility in the schedule and enabling its dynamic execution. Under the "time-to-cost tradeoff" buzzword, several authors have described a host of optimization models for this. Merely focusing on the critical path method (CPM) is often not enough because it is not only time but – more importantly – resources that drive turnaround projects. Schedule optimization is today usually limited to a final measure on the basis of a completed execution schedule. Daily re-calculation (optimization) during the execution phase, i.e., dynamic "re-scheduling", is too rarely pursued.

Varying resource demand

Standard scheduling software typically provides solutions to static time and resource planning issues. However, turnaround projects are subject to a variety of dynamic influence factors, such as limited resource capacity or unexpected work input by other contractors. This fact must already be addressed during the schedule preparation phase. Schedules are today still characterized by two aspects: A scheduler usually identifies the quantity of resources needed (for instance, six pipe fitters) and the necessary work (72 hours per activity). The project planning tool translates this into an activity time of 12 hours (refer to Fig. 1).

Assumptions regarding work values (work) are often more reliable than assumptions regarding the planned deployment of resources. As a result, the time determined for an activity is relatively imprecise. In order to enable a reliable statement, the planner must variabilize the number of necessary resources. The concrete result is that the planning assumption is changed from six to two (minimum) to nine (maximum) pipe fitters. This gives a theoretical activity time of eight hours minimum or 36 hours maximum. The use of minimum/maximum values for each activity thus enables automated time and cost optimization. Taking the necessary resource input as a basis, a separate project plan thus exists for each of these assumptions and every point on the curve with the corresponding total project time and minimum costs. The costs can be combined with the opportunity costs, leading to a curve like the one shown in Fig. 2. The scheduler can now select a desired maximum total time or set a fixed completion date for the project.

---

Activity 1-2 lasting 12 hours

<table>
<thead>
<tr>
<th>Activity 1-2</th>
<th>Hours of Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>V 1-2</td>
<td>72 hours</td>
</tr>
<tr>
<td>V 2-4</td>
<td>100 hours</td>
</tr>
<tr>
<td>V 1-3</td>
<td>125 hours</td>
</tr>
<tr>
<td>V 3-4</td>
<td>30 hours</td>
</tr>
</tbody>
</table>

Availability 10 W/hrs:

<table>
<thead>
<tr>
<th>Resource</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6 W/12 hrs.</td>
</tr>
<tr>
<td>2</td>
<td>5 W/20 hrs.</td>
</tr>
<tr>
<td>3</td>
<td>5 W/25 hrs.</td>
</tr>
<tr>
<td>4</td>
<td>3 W/10 hrs.</td>
</tr>
</tbody>
</table>

Fig. 1: Activity grid example
Considering risks in process chains

It is normal practice today for “unexpected work” not to be planned at all or to be planned as a process with a time and fixed resource demand. We do, however, know that the time needed for many operations varies so that the resource demand changes accordingly during the turnaround. These risk-prone processes must be taken into consideration in order to make a schedule more robust and hence suitable for the execution phase. A useful approach here is the development of risk scenarios which occur with certain probabilities. These scenarios are set by the engineer in charge. Fig. 3 shows a cleaning process with four scenarios. It normally takes twelve hours. The probability that it will be adhered to totals 80%. The probability that it will already be completed after eight hours totals 5%. The probability that it will take 15 hours totals 10%, or 5% that it will take as much as 20 hours.

This planning data provides the scheduler with a sound basis for assessing the risks in his project schedule. The (weighted average of the) scenarios where the project is in fact delayed are shown together with the expected upper deviation. A distribution function indicates the probability with which a scheduled project time can be adhered to. This enables processes to be identified which are in fact “risky” and delay the schedule completion date directly. Processes with risks which do not affect the delay of the schedule are identified as “non-risky”. Depending on the project manager’s willingness to take risks, the scheduler then selects the maximum total project time (refer to Fig. 4). This sets the course for optimizing resource input (resource levelling) on the basis of this execution schedule.
**Dynamic re-scheduling during the execution phase**

The underlying concept of the solution enables existing planning and scheduling data to be imported from SAP. Tectura additionally implemented the method as an MS-Project add-on. MS-Project users can thus additionally optimize individual sub-schedules, resource groups (such as washing stations) or overall project schedules. A re-calculation (time-cost tradeoff) of schedules with up to 64,000 activities takes around three minutes. This minimum input generates maximum benefits for schedules, i.e., daily re-calculations of the schedule on the basis of the established progress of the project. The schedule is thus updated every day and reliable recommendations can be developed for the optimum deployment of resources for each column and work area, taking the shortest possible time and lowest possible project costs into consideration.

The cleaning process, for instance has three possible variation scenarios:

- Normal case: 12hrs, 3 workers

![Fig. 3: Process with three variation/risk scenarios](image)

![Fig. 4: Project duration vs. on-schedule probability](image)
However, the practical use of time-cost tradeoff models is contingent upon good and sufficiently complete schedules. They then open up completely new options for demanding schedules that enable a more reliable management of turnaround projects in shorter time windows.

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Operators of process plants in the chemical, oil, gas, energy or pharmaceuticals industries are today active in the global market that calls for supplies around the clock. During the life cycles of these plants, operators have to manage a whole range of projects, i.e., not just capital investment, but also maintenance projects involving measures related to shutdowns and turnarounds. Turnarounds as strategic maintenance and repair projects today require professional management.

More measures in less time

Maintenance and repair have been inevitable ever since process plants existed. However, the time available for these operations has changed. Inspection, maintenance and repair as well as modification and expansion projects must be completed within ever shorter time frames. Furthermore, a continuous supply of new environmental or operator directives, safety regulations and laws as well as increasing concentration of measures are calling for meticulous turnaround planning and scheduling.

Logistics is of the essence

Today, operators have to source most of services from external specialists – and this in due time because experts and their availability have become rare in Europe during the course of the economic recovery and the trend towards outsourcing.

Transparent processes

Resource logistics is closely linked to workflow logistics. Resources have to be planned and scheduled along with detailed workflow planning. Transparency means providing information at the right time and at the right place for the right resource and being able to provide early feedback.

Support by IT tools

Workflow logistics, resource and information logistics are key elements of a turnaround. They can be optimized using IT tools.

In order to provide all the specialists involved in projects with the information relevant for each of them, special applications for engineers, technicians, project managers and commercial departments have always been used with the result that many different tools are in use.

There is a solution to this tool conflict, namely, the provision and exchange of information via a single platform. Platforms of this kind are already firmly established in the IT world. Enterprise project management (EPM) systems enable planning, management and monitoring of all projects of an enterprise throughout the entire life cycle of a project, including project portfolio management. The use of web technologies permits the enterprise-spanning integration of customers, suppliers and project partners.
Besides Microsoft Project, which is today already used as a single-user version, Microsoft Project Server is becoming increasingly important as an enterprise project management (EPM) solution for technical projects in general and shutdowns/turnarounds in particular. Microsoft Project Server creates greater transparency because all project and resource data as well as project information is made available in a role and web-based project portal using a browser and can be evaluated by Microsoft Excel or Microsoft Reporting Services for all the stakeholders of a project. Operation via the web on a project portal is easy, with Microsoft Project commonly used as a Windows-based planning and scheduling front-end. Microsoft Project Server is based on Microsoft SharePoint Server and Microsoft SQL Server and permits flexible scaling. Embedding in Microsoft SharePoint enables in-project communication and information management as well as management of in-project information, documents and workflows.

**Tectura Shutdown Management to supplement ERP and the engineering DB**

Tectura has configured an industry solution based on Microsoft Project and Microsoft Project Server that is designed specifically for turnaround projects. The solution is suitable for both small and partial turnarounds with up to 1,000 activities as well as major turnarounds with more than 100,000 activities. It enables planning, scheduling and monitoring of all phases and resources of a turnaround. The software solution facilitates communications between the operator and his contract partners on a web-based platform. Interaction with commercial workflow systems, such as standard ERP solutions (for example, SAP or Microsoft Dynamics AX and NAV) and repository-based engineering systems, is possible at any time.

Tectura’s shutdown management solution is a Microsoft Project Server which has been specifically pre-configured for shutdowns and which can be customized to specific demands. Tectura’s shutdown management system has been in use for many years at reputable enterprises in the refinery and chemicals industries as well as providers of industrial services.

**Udo Ramin**

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Tectura AG
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Plant shutdowns are expensive and time-consuming due to loss of production and the cost of the turnaround itself, however well planned and executed. Emphasis is rightly placed on planning, scheduling, procurement and contract awards to ensure minimum disruption to the business, but are the same considerations applied to the supporting documentation?

Accurate and validated documentation improves predictability during the planning stage and reduces the risk of unexpected corrective work resulting in longer shutdowns. As far as possible, as-built documentation should be revised and any new documentation created prior to shut down, or better still be accurate to begin with. To ensure a smooth start-up and subsequent operation of the plant new documentation will need to be validated ready for use by the operations teams.

Health and safety, policies and procedures, technical drawings, P&IDs, datasheets and equipment maintenance history all have a part to play in the success of a turnaround project. The challenge is to ensure all planners, engineers, designers and contractors are able to participate easily in the document control process to avoid incorrect documentation being used at any point of the turnaround.

Can a streamlined, electronic document control process have a significant effect on the efficiency of a turnaround? Yes, by avoiding the pitfalls and consequences of inaccurate documentation.

The ability to assign the same documents and drawings to concurrent projects executed on a single plant during a turnaround can significantly reduce uncertainty, mistakes and time for a shutdown. Project teams can benefit from an auditable retrieval, revision, review, approval and release process, increasing the confidence of engineers that they are using the right version of a drawing or manual.

The time taken by individuals to validate documentation with colleagues or document controllers is one of the biggest hidden time-consuming activities in any project and is rarely accounted for. Projects using a software-driven reconciliation and release process can ensure as-built documents are both auditable and validated for start-up and subsequent operation. McLaren Software’s Enterprise Engineer application helps ensure document control processes are followed by all involved. The trick is
to make it easy for users to participate, which increases the value of the document control system significantly.

Users can access and use the system from any device (laptop, mobile phone or tablet etc.) or application (email, Microsoft Office, AutoCAD, MicroStation etc.), remaining a flexible part of the document control process. It is then that the benefits can be reaped by all involved, not least by the company itself.

Streamlined document control processes provided by Enterprise Engineer assure the integrity of asset documentation supporting concurrent projects including revamps, capital projects and turnarounds.
III. Expert survey on the status quo of scheduling
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**Methodology and participant structure**

**Methodology**

This survey was conducted from December 2010 to March 2011. Several methods of empirical data capture were employed and combined to attain an in-depth insight into the turnaround scheduling praxis (Fig. 1).

**Online survey**

In online surveys and telephone interviews, around 500 selected experts (schedulers, planners, coordinators, project managers) working for plant operators and technical service providers in the process industry were asked to comment on their scheduling approaches and strategies. The study was conducted as an international survey. The questionnaire that was developed for this purpose addressed the following key areas:

- Organizational framework conditions
- Approach, structure and methodology of scheduling
- Schedule usage during the execution phase

Table 1 provides an overview of the key parameters of the quantitative field phase.

**Table 1 | Key parameters of the online/telephone poll**

<table>
<thead>
<tr>
<th>Polling method</th>
<th>International online/telephone poll</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>Project managers, coordinators, planners and schedulers at plant operators and service providers in the process industry</td>
</tr>
<tr>
<td>Sample size</td>
<td>n=507</td>
</tr>
<tr>
<td>Selection method</td>
<td>Ad-hoc random sample</td>
</tr>
<tr>
<td>Number of questions</td>
<td>35 (including filter questions)</td>
</tr>
<tr>
<td>Feedback</td>
<td>n=109 (21.5%)</td>
</tr>
<tr>
<td>Field time</td>
<td>15 December 2010 to 9 February 2011</td>
</tr>
</tbody>
</table>

**Desk research**

A detailed information research (desk research) process was used to capture facts and was conducted throughout the entire term of the survey. Sources used included published articles, press publications, conference proceedings, the Internet and talks with experts. The desk research results were used as input for the following work processes:

- Role and rank of scheduling during turnarounds
- Strategies and innovative methods, as well as their practical application
- Scheduling issues in anticipation of and during the turnaround execution phase
Best practices

Within the scope of the poll and by drawing on T.A. Cook Conferencing’s exclusive expert network, interview partners were identified who claim to have best-practice knowledge for optimum scheduling. These experts were invited to a best-practice interview.

The individual interviews were case-oriented and conducted on the basis of a qualitative, partially structured interview guideline document. The aim was to identify “good examples” along the different scheduling phases, namely, from the preparation of the scope of work right through to organizing the feedback process during the execution phase of a turnaround project. Thanks to the structured analysis and presentation of best practices, it is possible to understand practical scheduling examples and to use these examples to optimize turnarounds at one’s own plant.

Following the analysis of best practices, the results were evaluated and validated. This was then used as a basis for identifying important practical recommendations for optimum turnaround scheduling. The presentation of best practices and the practical recommendations derived from this are compiled in a separate section titled “Best practices and potentials”. This part II of the survey is chiefly designed for scheduling “practitioners” and is available for purchase (please refer to page 100 for details).
Participant structure

Scheduling is a specific, but essential aspect of turnaround projects. When it comes to organizing a turnaround, the “scheduling” task is not always a dedicated function that is performed by the “scheduler” as an individual. Instead, scheduling is often understood as a role performed by several stakeholders in addition to other tasks. The English language generally distinguishes between “planners” and “schedulers”. This is not necessarily typical for projects in the rest of Europe. The roles (or functions) of the study participants polled are hence outlined in the diagram (refer to Fig. 2). It shows the typical job descriptions of the participants. 71 percent of those polled referred to themselves as turnaround managers or coordinators, 32 percent as work planners and cost assessors, and 25 percent as schedulers. We can also see that the “scheduler” role is mostly performed by those polled who worked at the technical service provider end.

Fig. 3 shows that 53 of those polled were employed by plant operators and 47 percent by technical service providers. This, approximately equal, distribution is a positive element of the survey since it enables a balanced view of the groups involved. A more differentiated view of these two groups from the scheduling perspective will be given later in this survey.
Fig. 4 provides an overview of the survey participants’ industry structure. Multiple answers are permitted here because technical service providers usually work in more than one industry. In the overall view, 69 percent of all those polled stated that they work in the petrochemical sector. The chemical and/or pharmaceutical industries account for 56 percent. Among plant operators, there is a clear focus on refineries, petrochemistry and chemistry. 42 percent of technical service providers additionally serve the energy sector.

42 percent of technical service providers additionally serve the energy sector and 27 percent the paper industry.

In summary, the response by around 22 percent of experts can be considered to be above-average and hence very representative.
Scheduling organization and strategy

Three phases

Turnarounds are complex projects and characterized by a narrow time frame, high work density on relatively restricted space, a large number of active participants and a potentially high economic risk. Scheduling is a central tool for the successful preparation and management of turnarounds and thus for minimizing risks. The purpose of scheduling is to create adequate schedules for the execution phase of the turnaround in order to support the related management, steering and decision-making processes. The scheduling process can be generally broken down into three phases:

1. Concept phase
2. Creation phase
3. Usage and update phase

Depending on the specific turnaround project, every single phase has a different scope and should always be completed. Viewing the three phases from a work input perspective, the 2nd, i.e., the "creation", phase often seems to be the most complex work step. In fact, however, it is relatively simple (albeit sometimes work-intensive) to set up a schedule. What is much more difficult is to keep a schedule up to date – especially during the execution phase of the turnaround. This is why the concept development phase is so important as the following hypothetical summary of inputs and outputs of a schedule shows.

The foundation for effective and efficient scheduling is created during the concept phase. The following parameters should be defined during this relatively short, but important phase:

- Schedule structure
- Standards for schedule elements
- Progress feedback procedures during the execution phase
- Schedule reporting procedures for the execution phase

The complexity trap

As a precondition for scheduling phase 2 to be entered, the scope must have been defined and the detailed technical planning results must be available. The following example illustrates the importance of this input:

Assume that a turnaround project is planned for a major olefin plant that is broken down into around 1,200 relevant equipments. This involves up to 10,000 tasks (SAP orders) which are reproduced in the enterprise management system. Each of these individual tasks, for its part, is split up into 10 different sub-tasks (according to the trades involved). This can be mechanical assembly, pipe, tank and valve work, scaffolding as well as electrical or insulating work. Other activities include corrosion protection, cleaning, inspection, crane operations, transport as well as heavy assembly and welding work.

Specific information is required for each of these sub-tasks, for instance, a description of the particular tasks to be carried out by each trade.

This also includes information concerning the “earliest start” and “latest finish” of each sub-task. Other important technical information includes nominal width, nominal pressure, temperature, specifications, drawings, piping and instrumentation diagrams, blank plans, dimension drawings, photos, as well as physical and chemical data, if necessary. This information serves as a basis for calculating the required capacity for each activity, such as manpower, material, equipment and special tools. This constitutes the basis for the overall calculation. This planning information is accompanied by the projects to be integrated, logistic interdependencies between activities, go-aheads, transport and removal operations, schedules for cleaning or blank programmes.
Multiplying the data results in the complexity: 10,000 tasks with ten sub-tasks (trades) each and another ten details per trade as well as five related calculation values translate into some five million bits of detail information that need to be handled. This shows why phase 1 of the scheduling process is so important. The core question to be answered here is: Which parts of the diverse detail information are needed for scheduling? A typical example could look like this:

- 1,200 equipments
- Average of five tasks per equipment
- An activity chain of ten jobs (activities) per tasks

The result is 60,000 activities in the schedule, i.e., 1,200 x 5 x 10.

Every expert is aware of the need for good turnaround scheduling. The right schedule structure must be established during the “schedule concept” phase. This concerns questions of scope (which information from detail planning goes into the schedule?), feasibility during the execution phase (how does the schedule work as a management instrument during execution?) as well as the updating capability of the schedule (how are activities kept up to date?). In the second part of the survey, you will also find best practices for execution and progress management.

The larger a turnaround project, the greater its complexity usually. This means that everybody (and every scheduler, in particular) needs to resolve the planning complexity issue before commencing their work. However, contrary to widespread belief, it does not suffice to simply reduce the complexity of a large turnaround project in order to make it easier to manage. The challenge is to master this reduction exercise too. One approach is to deliberately increase complexity. Although this may sound paradoxical, for the scheduler’s practical work it means more detailed or more precise scheduling on the one hand and less precise management on the other.

Detailed (more precise) planning means including in the schedule certain information (or even trades) that was (or were) previously omitted, such as removal/transport plans or electrical work, whilst at the same time eliminating other types of (planning) information, such as bulk equipment with their degree of detail.

Two examples from everyday road traffic serve to illustrate the applied strategies of increasing or reducing complexity. Traffic is today chiefly managed through massive technical input, such as GPS with dynamic routing, signage and traffic lights. We are all familiar with street crossings with ten or more traffic lights (cars, pedestrians, cyclists, buses, etc.). Another “traffic light” strategy is self-management with fewer rules. The solution: roundabouts. Both systems may require the same level of capital investment and planning effort. However, the crucial advantage of roundabouts is control and technically independent self-management even in the case of a power outage.

**Planning the scheduling process**

It is helpful to have a great deal of information from upstream IT systems. Another asset is reliable data (such as work units). It is not good to merely import most of the planning data via an interface to a scheduling tool without prior examination merely in an attempt to “keep it simple”. This would lead to schedules with thousands and sometimes several hundreds of thousands of activities.

In addition to IT support, manager experience and competence are further decisive requirements. This is illustrated by the results of a poll conducted during a seminar among schedulers and time assessors in the petrochemical industry. The participants were asked to schedule a
series of processes on the basis of identical information. The schedulers’ views varied significantly. Between three and 26 activities were defined for an identical case with total time ranging from four to 38 hours.¹

Demands on a schedule are thus high. During the scheduling process, schedulers are confronted, for instance, with the detail depth issue: The work processes must be coordinated with the related time requirements and floats, but a certain degree of freedom in executing

with the related time requirements and floats, but a certain degree of freedom in executing tasks is also necessary in order to ensure efficient work and to master events that are very likely to occur but which are nevertheless unexpected. The underlying approach, i.e., “planning the scheduling process”, is hence vital for a good schedule.

As can be seen in Fig. 5, different ways to create a schedule are in usage and no one way dominates.

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These different basic approaches also determine the way in which schedules are updated as a sub-aspect of information management (Fig. 6). 31 percent of participants did not update the schedules of completed turnaround projects. The majority, i.e., 43 percent, document updates of cost estimates and work plans to a certain extent. Around one quarter of those polled archive all the as-is data of a schedule in a template database.

Asked to describe a “typical” scheduling approach, 21 percent of participants replied that scheduling is a very special exercise. General rules or standards did not exist. Six percent of those polled stated that they plan to introduce process instructions because these skills are still exclusively available to schedulers. Around one third use scheduling rules and standards. 43 percent go one step further, using detailed step-by-step instructions (27%) or using and adapting schedules from historical turnarounds (16%).

Fig. 6 | Ways of updating schedules

- No updating of schedules of completed turnaround projects
- Partial updating of data for work planning and cost estimation in a central database for use in future scheduling projects
- Archiving of all the as-is data of a schedule in a template database

Expert survey on the status quo of scheduling
**Organization and experience**

The scheduler is usually a member of the turn-around project team. Depending on the number and size of turnarounds, scheduling is either performed by the technical planner or as an independent function (division of functions between technical planner and scheduler).

This job can be generally performed by internal or external experts. 50 percent of TAR managers at the operator end stated that their schedules were handled internally throughout (Fig. 7) whilst 36 percent also resort to external firms to handle bottlenecks. A minority of 14 percent outsource scheduling completely.

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**Fig. 7 | Distribution of resources for scheduling (plants only)**

- Scheduling as a completely internal task: 50%
- Use of external firms to handle bottlenecks: 36%
- Scheduling as a completely external task: 14%

**Fig. 8 | Organizational task-sharing for scheduling (plants only)**

- Scheduling as an internal task: 32%
- Dedicated unit in charge of integrating previously completed detail schedules into an overall schedule: 11%
- Internal scheduling and cost estimates, detailed scheduling by external service provider: 5%
- For the greater part, creation of the framework schedule: 22%
- Each area is responsible for its own schedule: 30%
Scheduling is hence predominantly a core function at the operator end. With regard to staff responsibility, all the participants were asked whether an employee existed in their organization who is responsible for maintaining the scheduling data of previous turnarounds (Fig. 9). 70 percent of participants answered that they used a dedicated system for documenting historical turnarounds. This shows that the majority of those polled are aware of the importance of this follow-up exercise. Schedulers at the service provider end seem to be even more active than their colleagues at the plant operator end. This can be seen by the fact that the formers' share totals 74 percent and is hence twelve percentage points higher than that of their counterpart.

The question concerning the organizational responsibility for scheduling among plant operators revealed an interesting picture (refer to Fig. 8): Around one third (32%) of those polled performed the scheduling internally. Another third (30%) stated that a support function/unit is in charge of integrating the detail schedules, for example, from different plant areas, and the schedules of technical service firms into an overall schedule. These answers suggest that only one third of the schedules are in fact integrated, while the schedules are incomplete. Although 22 percent of those polled prepare the work plans and/or cost estimates, they rely on external service firms when it comes to preparing the schedules.

 Fig. 8 I Appointment of an employee in charge of maintaining schedule data of previous turnarounds (differentiated according to participants from service providers and plant operators)
**Scheduling: A matter of experience**

The majority of those polled were familiar with the scheduling process. 74 percent stated that they had been involved in the creation of ten or more schedules (Fig. 10). 22 percent even had a track record of 50 or more schedules and hence very extensive experience. Practical experience is hence a scheduler’s key advisor.

Just one fifth (20%) of study participants stated that they attended regular scheduling training (Fig. 11). 13 percent of those polled had attended once-off, methodological scheduling training, while another 15 percent had been trained in the use of scheduling software. However, almost half (45%) of those polled had acquired their scheduling skills through learning by doing.
These facts also explain the participants' assessment of their own level of experience. The terms shown in the illustration below were additionally explained in the questionnaire in order to enable their classification. Nine percent considered themselves to be beginners with knowledge of only a few fundamental facts and principles. Almost a third (32%) considered themselves to be “knowledgeable” with a certain level of knowledge, but little practical experience, whilst 31 percent classified themselves as “professionals”. Members of this group have no difficulty creating correct schedules using a project management tool. Only 24 percent of those polled claimed to be experts with a perfect command of even very demanding scheduling practices.

This result underlines the structural training and further qualification shortcomings. It is very likely that more than half of the schedules are not state of the art so that they are hardly suitable for the practical management of the turnaround project during the execution phase.

Initiation and strategy selection

A turnaround typically begins with its launch by the operator (customer) and the appointment of the project manager. In as far as the proposed turnaround project is critical in terms of time and/or resources, a good schedule becomes indispensable. The relevant framework for the schedule is determined by the time windows set, the number and type of sub-plants to be included in the turnaround as well as the planned integration of project work.

This serves as the basis for developing the first framework schedule covering the preparation and execution phase. The time window for the complete turnaround is then determined and optimized on the basis of turnaround experience, if available, or “historical” schedules. Good scheduling means that the method includes a “V” planning stage (refer to the best practices for integrating shutdown/start-up phases into the schedule as described in the second part of this study).

Fig. 12 | Self-assessment of the level of experience in turnaround scheduling
The term “V” planning refers to the shutting down and restart of the plant, a process that can be symbolized by the letter “V”. From a scheduling perspective, the plant is broken down into logically separate systems, including their respective shut-down and restart sequences. First optimization is already possible at this stage with a view to work that can be done simultaneously or technical work that can already be carried out during the shut-down process. The output of the project initiation phase of the scheduling process is an optimized time window for the shutdown, including possible scenarios and a suitable schedule concept. Fig. 13 provides a general overview of inputs and outputs which are relevant for the schedule.²

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The scheduling process

Assuming the planning complexity of the example given earlier (60,000 activities), experience suggests that this phase will take around 20 months. The central goal is to complete a schedule for the execution phase. In contrast to the shutdown/start-up plan, this is a bottom-up rather than a top-down exercise. The key inputs are the results of the internal and external technical planning teams. According to experience, scheduling can start when technical planning has reached a 70% to 80% completion level. Scheduling is hence a step by step process which depends on the progress of the technical planning work.

The majority of the information used in the scheduling process is based on planning data from upstream software processes, such as AD-Solution, Comos, MainTask, NSpace, Primavera Templates, RoserConsys, TechDo or SAP. But this also means a major risk since this data often constitutes calculation data that is very “fragmented” and often not suitable for managing a turnaround project during the execution phase.

The most important output of the execution phase is an optimized schedule. Optimization covers the following issues:

- Determining different implementation scenarios
- Detailed analysis of the critical paths
- Analysis of critical equipment and potential project risks
- Resource leveling, and other issues.

The execution phase

The benefits of a schedule materialize during the execution phase in that it enables a tool-based adequate response to irregularities. Schedules that are “frozen” at the beginning of the execution phase are sometimes also referred to as “wallpaper”. One reason for a freeze is that the stakeholders are well aware of the fact that the existing schedule is not good enough for managing day-to-day business. Using the schedule would therefore generate rather than avoid risks. The table below shows the features of schedules that are not suitable for management purposes.

Scheduling tools

Schedules for turnarounds are today developed using project planning and/or scheduling tools which are vital especially for time-critical projects. Their full benefits come into bearing during day-to-day management, i.e., during the execution phase, of a turnaround.

<table>
<thead>
<tr>
<th>Planning</th>
<th>Execution</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Too many restrictions and fixed deadlines</td>
<td>- Out of date on the 1st day of the turnaround</td>
</tr>
<tr>
<td>- Too much leeway and undefined activities</td>
<td>- Existence of several schedules</td>
</tr>
<tr>
<td>- Many activities requiring very little time</td>
<td>- Feedback in several systems</td>
</tr>
<tr>
<td>- Activities with no resources assigned</td>
<td>- No clear standards for feedback contents</td>
</tr>
<tr>
<td>- Non-standardized workflow chains</td>
<td>- Insufficient updating of the schedule</td>
</tr>
<tr>
<td>- Orphan activities</td>
<td>- No use of schedules for management purposes</td>
</tr>
<tr>
<td>- Activities distributed over several days</td>
<td>- Lack of transparency of floats</td>
</tr>
<tr>
<td>- Lack of transparency for activities</td>
<td>- Unreliable three-day forecasts</td>
</tr>
<tr>
<td>- Planning mistakes in activity chains and critical paths (soft logic errors)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 | Characteristics of schedules not suitable for management

74 | Expert survey on the status quo of scheduling
However, a crucial requirement is that the scheduler and the entire team can

- handle the tool as such,
- master the different scheduling methods, such as CPM, CCPM, PERT, GANTT, etc.,
- and that a “good” schedule is available.

If even just one of these requirements is not fulfilled to 100 percent, effective use of the tool becomes practically impossible.

Most scheduling tools applied are derived from project management systems that can be universally used (Fig. 14). These are, first and foremost, MS Project (used by 75 percent of those polled) and Primavera Project Planner (42 percent). These are standard scheduling programs and must hence be adapted to the specific needs of turnaround projects with a view to data mapping and reporting requirements. Selected consulting partners of this provider group also offer project management tools which are pre-configured for turnarounds.

Furthermore, a group of specialized software suppliers, such as MainTasc (16%), RoserConsys, Comos SD or TechDo (each used by 7% of those polled) include their own scheduling functionalities in their software suites. 22 percent of the schedulers polled also use Excel as a type of scheduling tool. 13 percent of those polled use Project Server. It can be assumed that these firms handle large and demanding turnarounds for which MS Project is less suitable.

The second part of the study contains detailed case studies on the use of specific IT tools for turnarounds.
The scheduling process

Methods and practical concepts

A host of different methods and practical models are available for project planning. The PMBOK guide (A Guide to the Project Management Body of Knowledge) or the P3O guideline (Portfolio, Programs, Project Offices) provide a detailed overview. As far as scheduling is concerning, two models basically vie for the favour of project managers, namely, the critical path method (CPM) and critical chain project management (CCPM). The essential difference between the two approaches lies in the analysis of resource dependencies, floats (uncertainties) and the number of necessary activities/jobs. A precondition for the use of both models is ultimately a work breakdown structure with relevant activities.

As a result of the work breakdown structure (for instance, of “V” planning), the work packages and activities are arranged and interlinked to form a realistic project workflow. The project is subsequently refined by adding project phases, work packages, activities and milestones with start and end dates. The timeline of the activities depends on interdependencies between the individual activities which are a function of duration (number of resources covered by the schedule and necessary work input). Scheduling can be generally carried out as a forward or reverse calculation.

The forward calculation supplies the earliest possible, the reverse calculation the latest possible points of the activities. The differences between the earliest and latest points supply the floats for rescheduling.

The result of the scheduling process is the base schedule which then serves as the basis for further optimization.

Determining the scope of work

The first question to be answered during the turnaround planning phase is related to the maintenance work to be carried out, i.e., the scope of work. As already mentioned, the different plant areas (such as production, maintenance, safety) are called upon to draft work lists. The job of the planning team is then to collect and analyze these lists. Unnecessary work and redundancies must be eliminated and the work that really needs to be performed must be defined in line with the existing maintenance strategy. By answering the questions below, it can then be decided whether or not each of the activities reported is to be integrated into the turnaround (validation of the job list).

This phase ends with the scope freeze, i.e., the time when the list is closed for entering new maintenance tasks. The crucial question for the scheduling process is how large the scope is and how much time remains after the scope freeze for the creation and discussion of the schedule and for briefing staff. Depending on the size of the project, the scope should be frozen no later than six to eight months before the turnaround begins. Problems that threaten the quality of the schedule arise when additional repair work is announced after the scope freeze.

Validating the job list

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the work necessary?</td>
</tr>
<tr>
<td>Is it necessary to carry out this work during the turnaround?</td>
</tr>
<tr>
<td>It is possible to complete the activity during the turnaround?</td>
</tr>
<tr>
<td>Is any special equipment required?</td>
</tr>
<tr>
<td>Are there any safety concerns?</td>
</tr>
<tr>
<td>Are there any other facts or requirements?</td>
</tr>
</tbody>
</table>

Table 3 | Validation of the job list

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4 See the official website: www.p3o-officialsite.com (31 March 2011)
Especially in the case of time-consuming and complicated operations, the extent of any equipment included in the scope freeze should also be estimated. One possible approach, for instance, is to differentiate between the assembly, inspection/repair, reassembly and test work steps.6

**Work to be considered in the scheduling process**

The result of the scope and detail planning phase is a list of the work to be performed during a turnaround. From the scheduler’s perspective, it is now important to decide

- which of these tasks and
- how detailed these tasks

have to be mapped as work packages with activities in the schedule.

Fig. 15 shows the tasks which those polled usually considered to be activity chains. The answers show that the most important tasks to be considered in the schedule include work on main equipment, blank handling, primary trades, transport and removal operations as well as bulk equipment. Further tasks which are considered in schedules include washing stations, special tools (such as cranes, lifting platforms, bundle pullers), transport operations as well as hold and stop points. Hold and stop points are mainly used when a particularly high level of detail calls for an additional group level because the use of hold and stop points enables an aggregated progress presentation. Although hold/stop points increase the degree of complexity because the number of activities in the schedule is drastically increased, they nevertheless facilitate management intervention on a meta level. The second part of the study contains an example of the use of hold/stop points.

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Expert survey on the status quo of scheduling

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**Fig. 15** Work considered as activity chains in the schedules (multiple entries possible)

- Work on main equipment: 95%
- Setting and pulling blanks: 82%
- Primary trades: 79%
- All steps for shut-down, purging and start-up: 71%
- Bulk equipment: 68%
- Washing stations: 59%
- Cranes, lifting gear, bundle pullers, etc.: 59%
- Capex project work as integration points: 57%
- Hold or stop points: 52%
- Transport work: 52%
- Go-ahead/clearance of operations: 43%
- Capex project work, completely in detailed form: 29%

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**Fig. 16** Handling of bulk equipment (multiple entries possible)

- Assignment of all bulk equipment to the respective activity chain: 48%
- Demand-orientated consideration of bulk (dismantling, installation): 35%
- Collect equipment according to type and include as placeholders: 28%
- No inclusion of bulk equipment in the schedule: 11%
Interestingly, two thirds of those polled also map work on bulk equipment (pumps, valves, measuring equipment, etc.) as activity chains in the schedule (Fig. 16). More in-depth talks with experts have confirmed this. One participant in the study, for instance, replied “that there is no such thing as bulk equipment. Any equipment is mapped individually.” Only 28 percent of those polled prefer selective treatment of bulk equipment and do not overburden the schedule with unnecessary information that is almost impossible to manage. Normally, however, bulk equipment is assigned to the respective activity chain (48%).

The large share of project work is typical for turnaround projects. Project work means specific, once-off plant adjustments and expansions rather than routine work that is repeated during every turnaround.

Separating project and turnaround work usually also calls for separate schedules. Fig. 15 suggests that 57 percent of those polled set up a separate schedule for project work.

The turnaround schedule than merely considers the project work in the form of integration points.

Consideration of time losses

Inefficiencies or insecurities must also be taken into consideration when it comes to creating a schedule (Fig. 17). These can, for instance, be walking or waiting times as well as transport operations. The vast majority of those polled (86%) map potential time losses (inefficiencies) as flat times in the activity. 53 percent of those polled stated that this was based on past experience. These time losses are often already included in the work unit which are exported from the detail planning and imported as defaults into the schedule. However, a surprising result is that 33 percent of those polled integrate float by re-evaluating activities on an individual basis and then readjusting them, thereby gaining a deeper understanding of each element of the schedule. Only a few – 14 percent – do not include inefficiencies in their calculations and correct the time and costs actually needed for an activity retroactively.
Due to extensive pre-calculations from various upstream IT systems, initial filling of the scheduling tool can be carried out as an automated process. The majority, namely, 54 percent of those polled import work preparation data automatically into the schedule (Fig. 18). Only 23 percent of those polled use template schedules which are retrieved from the archive and adapted to the new project. The advantage of templates is that the links within the activity chains, both within the chain and between the work packages, are already engineered and hence tried and tested.

Due to the user-friendliness of the planning and scheduling tools (export) and the complexity of the schedules (usually with several thousand activities), only 23 percent of those polled prepare their schedules manually and hence customized.

Work breakdown structure and schedule structure

The first question to be answered when structuring the schedule is how a clearly defined structure can be defined for plants, work packages, milestones, hold points or activities. The standard practice is to distribute plants geographically according to blocks or zones. This is followed by breaking down according to systems and individual pieces of equipment as well as identification of bulk equipment. Certain systems, such as energy supply systems, that are spread across the entire area are split up at the “zone borders”. This structuring exercise is performed on several levels. When applied to all areas, this ultimately creates the work breakdown structure (WBS). The aim is to break all tasks down into manageable sub-tasks.

Fig. 18 | Schedule creation approaches
Any work that is not relevant or that does not relate to the project must be excluded from the WBS. This shows that the schedule is the result of a combined top-down/bottom-up process. Shutdown/start-up planning is a top-down process, whilst detail planning for each piece of equipment is a bottom-up process, with the activities, hold points and milestones in between.

The completion of the WBS marks an important step in the schedule creation process. The last question to be answered is how the concrete structure of the schedule should look. 59 percent of study participants consider the use of a single schedule to be the key requirement (Fig. 19). 35 percent use a separate framework schedule (focusing on the preparation phase in detail and presenting the execution phase in aggregated form) with relatively rough data whilst detail scheduling is carried out using the scheduling tool. Every forth participant (25%) breaks the schedules down further according to systems and pertinent equipment.

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Schedules can also be structured across levels. They then differ mainly in terms of number and type of activities on each level. The schedule can therefore be used for different purposes and at different points in time, for example, for strategic orientation at the beginning or for managing the execution phase at the end of the project. Fig. 19 shows that 22 percent apply this approach to structure their schedules although these are then updated independently and using different tools. 17 percent of those polled use uniform and integrated schedule levels.

The required degree of detail for the schedule levels varies as a function of the time horizon, purpose and criticality of the project. In order to map these different requirements, the schedule has a hierarchical structure according to different levels (schedule structure). Every level is the detailed rendering of a time segment or of the complete level above. The table below illustrates one possible schedule breakdown.

<table>
<thead>
<tr>
<th>Level</th>
<th>Name</th>
<th>Time horizon</th>
<th>Number of activities</th>
<th>Brief description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Portfolio schedule</td>
<td>5 to 8 years</td>
<td>&lt; 50</td>
<td>Strategic orientation of TAR and Capex projects</td>
</tr>
</tbody>
</table>
| 1     | TAR master schedule                 | 2 to 3 years | < 200                | * Planning all project phases of a TAR  
* Main focus on identifying future activities and milestones |
| 2     | TAR management execution schedule   | Execution    | < 1,000              | Planning the execution phase  
* Plant management control plan  
* Based on group activities |
| 3     | TAR execution schedule              | Execution    | < 25,000             | * Planning the execution phase for day-to-day management and progress feedback |
| 4     | TAR execution detail activity schedule | Execution | < 250,000           | * Planning the execution phase on the level of activity calculation and/or work planning  
* No application in day-to-day management |

Table 4 | Schedule structuring according to levels
Designing activities – what activities are for

A good schedule is the result of an appropriate definition of activities. There are no uniform principles that need to be considered when defining activities. There is, however, one general rule: Each piece of equipment and its activities should be considered individually. This is exactly where the interface between planner and scheduler lies. The (specialist) planner defines the work packages from which the scheduler then derives the relevant activities. The activities describe the chronologically connected work processes through arrangement relationships and milestones in order to subsequently manage the project during the execution phase. These activities, however, are not the work or maintenance plan for workers and foremen working on site on the equipment. This is because they receive suitable work folders anyway with all the necessary documents.

There is one more thing to be considered when defining activities, namely, as few and as large activities as possible, as many and as small activities as necessary. Every additional activity increases the planning and scheduling complexity and makes management more difficult. In the simplest case, every system or work package translates into exactly one activity. Fewer activities do not generally help to ensure that a turnaround project continues to be manageable even during the critical execution phase. However, there should also be very good reasons for every additional activity. With regard to the complexity example (with a hypothetical assumption of 1,200 pieces of equipment), this would mean:

- 3 zones corresponding to 3 activities
- 100 systems corresponding to 200 activities (shut-down/start-up)
- 1,200 pieces of equipment corresponding to 1,200 activities

![Fig. 20 | Volume of schedules (in terms of the number of activities/jobs)](image)
The theoretical minimum management schedule includes 1,403 activities, i.e., around 500 activities per zone. This schedule level view provides those in charge with a general progress overview. However, a crucial question is how daily progress feedback and deviations are considered so that the status does in fact reflect reality in the field.

**Current process design practice**

The participants were asked in this context how many activities a typical turnaround project includes in their respective organizations (refer to Fig. 20): 68 percent of those polled replied that their schedules included up to 10,000 activities, 29 percent reported a volume of around 10,000 to 75,000 activities, and three percent reported an even larger volume.

The poll further revealed how activities and activity chains are defined (Fig. 21). 65 percent of those polled reported that they use standardized activity chains for selected equipment categories. This chiefly concerns bulk equipment (such as pumps, valves), where workflows can be planned and where the probability of unexpected, time-critical events occurring is low.

The theoretical structuring approach for defining activities is also important when it comes to the detailed planning and scheduling of the work packages. One variant is the creation of new activities depending on a change in trade within an activity. 43 percent of those polled pursue this strategy. A change in trade, such as the completion of scaffolding and the commencement of insulation in the case of columns, thus marks the end of the old and the beginning of a new activity.

Another approach is to define activities on the basis of their duration, for example, no longer than one shift. In this case, the scheduler already...
designs an activity with a view to the size of the column and thus presupposes how many resources are needed in order to complete this work in one shift or whether he can divide the activity further to distribute it over two shifts.

10 percent of schedulers adopt this strategy. A combination of both variants is also possible. 17 percent stated that they have no standards. This means that the detail schedules for a work package for two identical pieces of equipment are different if two schedulers set up the schedules independent of each other. Table 5 represents a piece of equipment as a standard activity chain in the form of hold points. It is, however, an empirical fact that activity chains for equipment can differ strongly, ranging from around ten to 75 activities for a heat exchanger. The practice chosen here has therefore significant effects on the volume and quality of a schedule.

Table 5 | Standard activity chains for columns

<table>
<thead>
<tr>
<th>Hold points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.Blanks inserted</td>
</tr>
<tr>
<td>2.Manways opened</td>
</tr>
<tr>
<td>3.Cleaning completed</td>
</tr>
<tr>
<td>4.Passages opened</td>
</tr>
<tr>
<td>5.TÜV inspection completed</td>
</tr>
<tr>
<td>6.Passages closed</td>
</tr>
<tr>
<td>7.Manways closed</td>
</tr>
<tr>
<td>8.Pressure test completed</td>
</tr>
<tr>
<td>9.Blanks pulled</td>
</tr>
<tr>
<td>10.Acceptance completed</td>
</tr>
</tbody>
</table>


**Schedule optimization**

Once the execution schedule is in place, schedule optimization is usually the next step – the “high art” of scheduling. A good schedule is a precondition for a good outcome. Otherwise this work step would be mere “management entertainment” rather than concrete value creation. The results of the poll show that the vast majority (94%; refer to Fig. 22) of those polled perform final optimization of the schedule.

The requirements for schedule optimization always depend on the goals. Typical goals of schedule optimization are:

- time cost tradeoff models (time/cost optimization)
- simulations of different schedule variants according to different calendars
- the calculation and optimization of the critical path
- the simulation and analysis of risks as well as final resource leveling and/or bottleneck optimization.

82 percent of the experts polled in the survey considered the identification of the critical path to be the most important aspect of schedule optimization (Fig. 23). This aspect was followed by resource deployment optimization, according to 45 percent of those polled. Simulation and evaluation of potential risks using special mathematical tools are so far a low priority (4%).

However, at least 20 percent of those polled simulate possible schedule variants on the basis of possible risks. This static approach to risk assessment shows that risk assessments have not yet become a strategic design element for schedulers.

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Fig. 22 | Perform final schedule optimization before the execution phase
Selected aspects of schedule optimization will be addressed in the following pages.

The critical path

According to IN 69900-1, the critical path method (CPM) is the path from the beginning to the end of a network diagram on which the sum of all floats is minimal. Individual activities on the critical path have no float so that any change in their start and end dates adversely affects the completion date of the entire project. The critical path thus determines the shortest duration for the entire project and is hence a tool for calculating project duration.

The CPM method should be applied if sufficient experience is available with regard to the time which activities require. However, the larger the share of project work in a turnaround, the greater the risk of wrong time estimations within activity chains. These estimation risks can be reduced by applying the program evaluation and review technique (PERT). However, in reality, PERT is of no practical relevance when creating schedules for turnarounds because activity times are determined on the basis of calculations by partner companies or standard specifications.

The time windows for mechanical work (dismantling/assembly) are usually not on the critical path of turnaround projects. However, shutdown and start-up processes as well as equipment requiring complex and time-consuming special overhaul (such as turbines) are critical.

Resource leveling

Resource deployment optimization serves to ensure optimum resource utilization whilst at the same time considering scarce or limited resources on the critical path.

Tried-and-tested scheduling tools offer the possibility of integrated resource leveling. Automated leveling based on the definition of boundary conditions is typically followed by manual optimization of the resources used.
This is necessary because automated schedule optimization has its limits. The quality of an automatically resource-optimized schedule depends on the quality of the links between all the activities and aggregated activity packages. However, schedulers still have to intervene from case to case because it is not possible with existing software tools to consider all conceivable and real constraints. This applies, for instance, to the consideration of non-permitted parallelism (simultaneous work) that is not necessarily represented by links between activities.

**Prioritizing activities**

Activities must be prioritized whenever the resources available do not suffice for parallel execution of all operations which are independent of each other. Only by prioritizing activities can a decision be made as to which work steps have to be done now and which ones can be postponed. This is exactly what the critical chain project management (CCPM) model considers by additionally supplementing the critical path by an analysis of bottleneck resources. Furthermore, when optimizing a schedule, it must also be examined whether work packages or activity chains, which are subject to time risks and therefore potentially involve negative effects on completion dates, can be executed earlier than scheduled. Once the schedule is optimized, further prioritization of activities or whole work packages during the execution phase can be carried out on a daily basis via the total float. Prioritization thus serves two purposes, namely, to optimize the sequence of activities and the correct management of day-to-day work during the execution phase.

In practical work, prioritization of operations during daily meetings ranks first in 54 percent of answers (Fig. 24). These meetings serve to identify work that has been completed, work not yet completed and issues that are open. These meetings thus provide a direct insight into the work which must be executed most urgently.

Second place in the prioritization process is the view of the critical path (48% of answers in Fig. 24). This illustrates the high ranking which the critical path concept has when it comes to managing the entire turnaround. With this approach, all activities on a critical or a potentially critical path are given higher priority over all other activities.

![Fig. 24 | Managing activity priorities (multiple entries possible)](image-url)
Risk analyses

The most diverse risks can materialize during the planning and scheduling phase of a turnaround project. The greatest risk for scheduling is the increase in total time: “Elapsed time is usually the most important constraint for industrial shutdowns.” Possible causes include resource problems, accidents during the execution phase, touch-up work due to poor quality or additional work due to discovery repairs. Practitioners pursue two basic strategies to integrate risks into the schedule (Fig. 25):

- Mapping risks as floats or time placeholders (75%)
- Consideration of risks outside the schedule (25%)

Another prioritization option is to prioritize activities as a function of the total float of an activity or activity chain. 16 percent of those polled reported this approach in their answers. In this case, the priority and the total float are indirectly proportional to each other. When the total float declines, priority increases. 14 percent of those polled stated that they used prioritization in conjunction with the critical chain model. This method which is still relatively new and based on Eliyahu Goldratt’s ideas, avoids the negative effects of multi-tasking and takes floats out of individual activities, collecting and shifting them to the end of the schedule. The critical chain is a specific further development of the bottleneck theory and serves to identify and eliminate bottlenecks in schedules. Using the critical chain in conjunction with prioritization thus gives higher priority to bottleneck activities.

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Fig. 25 | Mapping of uncertainties in the schedule


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Expert survey on the status quo of scheduling
Several options are available to schedulers for integrating risks into the schedule: Placeholder activities (with or without time) can be added, floats can be explicitly added at various points, or the time available can be extended by implicit floats for individual activities. These approaches already assign a specific time to risks during the scheduling process. This time hence affects the end date from the very outset. The disadvantage of the strategy is that it is no longer absolutely clear during the scenario development process how the risks included in the schedule will affect the end date. One approach is to specifically identify these activities and, when necessary, filter them out. An alternative option for integrating risks into the schedule which does not initially affect the end date is to create zero-time placeholders. These are timeless activities which can be expanded as required during the execution phase.

The advantage of creating zero-time placeholders is that they are already part of the logic structure of the schedule. This means that no additional work is necessary during the execution phase when additional discovery work is to be integrated into the schedule.

A quarter of the schedulers polled consider risks, but do not include them in the initial schedule design (refer to Fig. 25). In these cases, risks are either managed exclusively by assigning priorities, or they are integrated into the schedule during the execution phase only. Another approach is to simulate schedule variants, a procedure adopted by 20 percent of the schedulers polled. This means that different variants of a schedule are generated where the occurrence of specific risks is simulated individually or jointly.
The schedule during the execution phase

The execution phase of the turnaround is the trial by fire for the schedule. Now it must be proven that the scheduling strategy was suitable and that a sufficiently complete schedule is available. The key benefit of the schedule during the execution phase is the day-to-day management of work. Besides a certain degree of courage, this requires, first and foremost, a reliable schedule and a reliable scheduler.

However, this seems to be different from practical reality. As already shown, comprehensive schedules are set up, but their use during the execution phase is normal practice in every second case only. Put simply: People invest in a racing car, but they don’t drive it.

Almost half of those polled (46%) use the schedule either as wallpaper or as an “expensive typewriter” in that they report back on progress, but fail to recalculate and prioritize work (Fig. 26). Only 54 percent of those polled make full use of the schedule by performing dynamic recalculations and thereby setting priorities based on the latest progress feedback. This result correlates with the answers regarding volume and quality of scheduling.

Fig. 26 | Use of the schedule during the turnaround

Printout of the complete schedule and use as wallpaper (no updating or recalculation)
Feedback on the schedule and preparation of progress reports (no recalculations or updates)
Continuous feedback, including subsequent entry of changes; daily recalculation for planning execution work for the next day

Expert survey on the status quo of scheduling
Around a quarter (26%) of those polled stated that staff worked during the turnaround on the basis of the agreed-to schedule (Fig. 27). Another quarter (27%) assume that the schedule is not suitable for managing the execution phase. Although a majority of 47 percent of those polled confirm that the schedule is a central means of communication, day-to-day work is managed on the basis of separate, private plans for each work group.

As already mentioned, the question of a turnaround’s criticality rather than the volume of a turnaround determines whether the schedule is actively applied or not. The more time-critical the turnaround and the tighter its schedule, the more important an active, dynamic schedule.

The vast majority stated in Fig. 20 that their schedules are in the order of between 10,000 and 70,000 activities.

**The feedback process**

The feedback process ensures that the progress of work during the execution phase is measured with sufficient time precision.

Feedback includes

- Reports about activities started and finished
- Percentage-based activity progress information
- Entries of additional or reduced work and forecasts concerning activities.

Despite the complexity of these projects, around half of those polled use printed documents in order to provide manual progress feedback (Fig. 28). Although this concept is good for documenting work progress, it is also very likely that it is of no help with a view to timely feedback. The more the status of the project in the field deviates from the status in the scheduling system and hence in the reports, the less suitable the schedule is as an active management instrument.
The timeliness of feedback is crucial. This is also why participants were asked to state “how often” during a day or “when” feedback is captured (Fig. 29). The answer to the “when” question depended largely on the form of solution applied. Fully manual solutions permit, at best, feedback at the end of the respective shift (32%) or once a day (38%), whilst mobile barcode or RFID solutions support a continuous feedback process all day long.

Only 27 percent of those polled really use the schedule as a management instrument during the execution phase. 23 percent of those handle it via automated barcode feedback that is connected to the scheduling tool through an interface. Another four percent proceed via the group activity level (level of effort). This concept reduces the large number of activities to a few relevant management activities. The best practice part of the study contains a detailed description of this concept.

The timeliness of feedback is crucial. This is also why participants were asked to state “how often” during a day or “when” feedback is captured (Fig. 29). The answer to the “when” question depended largely on the form of solution applied. Fully manual solutions permit, at best, feedback at the end of the respective shift (32%) or once a day (38%), whilst mobile barcode or RFID solutions support a continuous feedback process all day long.
The answers to the question concerning feedback precision underline the fundamental dilemma of project management on the basis of the schedule during the execution phase. Significant information, such as additional or reduced work or identified delays, is reported only by 25 percent or 21 percent, respectively, of those polled (Fig. 30). However, these types of feedback are management-relevant information that forms the basis for meaningful recalculation. Schedules with simple entries concerning “type of activity”, “completed” or “partially completed” are hence suitable for calculating s-curves or for calculating work completed. They are, however, less suitable for preparing an optimized revised schedule for the next day based on this information.

The additional evaluation of feedback behaviour for activities lasting longer than one day also underlines that the method applied by many users is not designed to manage the execution phase using the schedule. 38 percent of those polled merely reported the “beginning/end” or only the “end” of an activity (Fig. 31).

![Fig. 30 | Feedback content (asked only if feedback is provided; multiple entries possible)]
Dynamic schedule recalculation

Due to the large number of unforeseeable events that occur every day, the schedule often already begins to deviate hugely from the planned situation on the first day. This can begin when systems cannot be shut down as planned. In order to evaluate the repercussions on the workflow, the schedule must be updated immediately and then recalculated. This usually leads to far-reaching changes in start and end dates of activities with floats or an increased demand for resources for critical-path activities. Turnarounds with a very tight schedule must be flexible towards their end because otherwise almost all tasks would become critical, rendering structured management more difficult.

Schedules that are not built correctly are destroyed after dynamic recalculation. If schedules, which include tens of thousands of activities and which were previously optimized and evaluated over many weeks, have to be recalculated within a few hours, an extremely high level of competence is required for all participants. However, the questions concerning training and knowledge levels showed that severe shortcomings exist in this field. This is one of the reasons why dynamic recalculations of schedules during the execution phase are seldom carried out.

Turnarounds are characterized by the existence of several, parallel potentially critical paths. Depending on the progress of work, it may happen that the critical path switches between these alternatives from day to day.

Another reason is that there is little practical experience and knowledge about dynamic schedule recalculations available. Many schedulers mapping additional or reduced work in the form of additional process chains are threatened by information overkill. When a new connector is to be fitted, work in the field is already completed before the required activity is newly created,
checked and the whole schedule recalculated. One participant commented this as follows: “Most of the discovery work is already done before the scheduler is informed at all.” If dozens of such events occur every day, the scheduling teams are no longer able to integrate this additional information into the schedule.

However, around 60 percent of the scheduling managers polled proceed in exactly this way (Fig. 32). This means that divergence between progress as recorded in the system and actual progress in the field increases every day. This is why another 24 percent do not retroactively include any additional or reduced work in the schedule. However, the three-day forecast is not reliable in this case either.

Only 16 percent have come up with a practical approach: Additional or reduced work is considered in the schedule through “retroactive” resource allocation and its effects.

![Fig. 32 | Handling additional work during the execution phase](image-url)
**Intermediate conclusion: Good Scheduling Practices**

Turnaround projects are complex and dynamic. They require relatively long planning time and are influenced by a large number of unexpected results, especially during the time-critical execution phase. This calls for a special methodological scheduling approach. What is ultimately important today is to ensure that the complex system with its many participants remains manageable during the execution phase. However, successful management of the turnaround project should not be achieved on the detail level. This is unfortunately still much too common in practice. There is a trend towards describing work packages and activities in even more detail by adding further planning details (new trades, for instance).

As an intermediate conclusion of this study, selected scheduling problems as well as some fundamental solution concepts will be mentioned below in the form of good practices. The second part of the study provides a detailed and international overview, an orientation guide and practical recommendations. The best practices which are analyzed there form the basis for your path towards optimum scheduling for a successful turnaround process (for more information, please see page 100).

**Some selected scheduling problems**

Readers of schedules will often find some typical recurring problems. The overview below illustrates the major shortcomings of today’s schedules. Their sequence does not represent any order of priority:

- Many schedules contain far too many activities. These activities are usually not relevant for management.
- One often finds, for example, many activities with a duration of an hour or even less although the project manages 100,000 hours in its execution. One hour thus represents 0.001 percent of total time. This is micro-management.

- Fixed rather than variable resources are often assigned to activities on a flat basis. This fixed resource assignment (for example, two pipe fitters for four hours, corresponding to eight hours of work) hugely restricts the subsequent optimization and reduction of time.
- Equipment of the same type is often scheduled in different activity chains. This suggests a lack of sufficient standards between the schedulers involved.
- Schedules are often not logically consistent. Typical indications include too few or too many restrictions (fixed deadlines), activities with no resources assigned to them, orphan activities with no predecessor/successor, activities with no clear beginning and/or end defined. Such schedules cannot be dynamically changed and are therefore unsuitable for practical use.
- Schedulers very often make soft logic errors, i.e., resource conditions are included in the mapping of activity dependencies. This means that schedulers use fixed activity sequences because they are already thinking in terms of a defined team who will be available to perform the work. In doing so, schedulers deprive themselves of many optimization options. Schedules of this kind tend to become static.
- Discovery work (such as repairs) are quite often included in the schedule as a fixed activity with time or as a float. This method distorts the real duration of a turnaround in the schedule because resources are also typically allocated to them.
- While some schedules tend to be too detailed, others are not sufficiently integrated and fail to represent the overall project with sufficient precision. Schedules must include the starting up/shutting down of the plant as well as any relevant work on electromagnetic valves or project work, etc. in order to be suitable as a schedule for overall project management. Things can become worse if several schedules (every mechanical contractor has his own schedule) are in use during the execution phase.
phase. This affects clear communications considerably.

- Schedulers are not sufficiently trained in scheduling practices and the possibilities offered by scheduling tools. This is why many helpful functions are not used. The schedule is basically set up merely as a management entertainment board in order to present s-curves of project progress during the execution phase.

It cannot be said too often: Schedules serve to manage the time-critical execution phase. The result of scheduling must be a dynamic management tool rather than mere wallpaper. The aim is to create a tool that enables day-to-day management of the project by the different participants during the execution phase. This requires:

- greater transparency through “meta views” of the thousands of activities which may have to be considered. A meta view enhances acceptance by providing everyone involved with only the information he or she needs to know.
- the presentation of reliable, up-to-date information (reporting) during the execution phase in a form specifically edited for the respective role or function (installation preparation foreman, project manager, production manager, team leader, etc.).
- the securing of project management through relevant priorities (i.e., real problems), i.e., reducing (focusing) information.
- the daily compilation of forecasts of the completion date for work (work packages) rather than merely collecting status feedback (management) on daily work progress.
- the daily recalculation of the project schedule in order to secure the target completion date, including potential to reduce the project time if work is completed ahead of schedule.

Nine rules to make things easier

The nine rules shown below can help to make complex schedules better and easier to design.

1. Do not automate the initial scheduling process by importing planning data. Experience shows that importing thousands of calculation processes leads to less suitable schedules because calculation information is not the same as management information. This leads to bulky schedules that are almost impossible to update.

2. Define the execution schedule on the basis of start-up/shut-down plans for each system, including the relevant hold/stop points. This is the first step towards optimization. Then add the work packages for each piece of equipment.

3. Create a detailed schedule only for the critical path, i.e., bottleneck resources or equipment with a critical mass. The more precise your plans, the greater your flexibility during subsequent dynamic optimization and recalculation.

4. Make sure that there is precisely ONE schedule. For this, you will need different schedule levels so that every target group receives the relevant management information.

5. Make sure that the schedule reflects the real interdependencies and start priorities.

6. Map risks (delays, optional work) in the schedule as dynamic total and intermediate floats (according to the critical chain principle).

7. During the execution phase, do not create any new activities in the schedule which may become necessary for additional work. Map changes by allocating additional resources so that the new trade receives this work on its priority list.
8. Create so-called hook-ups in order to minimize the absolute number of activities. Manage the turnaround on the basis of a level-3 schedule using forecasts.

9. Grant the contractors involved sufficient leeway for day-to-day self-management.
Scheduling practices for turnarounds/shutdowns

Part II: Best practices & potentials

Your benefits

• Benefit from the innovative methods and practices of experts and avoid typical traps
• Get a deep insight into field solutions
• Optimize your schedule on the basis of the provided solutions

Best Practices

• Planning the schedule creation
• Standards and scheduling in the long-term: comparison of experts and less experienced schedulers
• Use of a template database for scheduling
• Breaking down plants into independent units
• Hook-ups to master complex schedules
• Optimizing dynamic schedules (float based prioritization)
• Integrating shut-down and start-up planning (“V” planning method)
• Cooperation with technical service providers for schedule creation
• Use and implementation of integrated IT platforms
• Standardization of the IT landscape through a data hub
• Progress feedback with barcodes
• Organizing feedback through a uniform IT platform
• Methods for improved execution management

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IV. Company profiles
Our company

Bilfinger Berger Industrial Services (BIS Group) is the leading European provider of industrial services for the process and the energy production industries. Plant turnaround management is one of the group’s key competences.

Portfolio and expertise

The BIS Group offers its customers industrial services for the entire life cycle of a plant using a high proportion of their own internal services. The group bundles core competences in the field of maintenance with complementary trades and combines planning, management and execution competence right through to comprehensive maintenance concepts and full-scale solutions for demanding projects. The group’s mission statement is: We are BIS. We are Best In Solutions.

By focusing on core markets of the process industry, the BIS Group is setting clear priorities and thereby ensures the high level of industry competence which its customers expect. The industries include in detail refineries, chemistry/petrochemicals, pharmaceuticals, power stations/power generation, offshore industry, gas production and processing, the aluminium and steel industry, food industry, the paper industry and mechanical and plant engineering.

Turnaround strengths and specialized fields

- Harmonization and bundling of the statutory inspection intervals and of operational plant turnaround intervals
- Optimum use of resources
- Maximum turnaround efficiency due to optimized interfaces
- Creation of a knowledge base that generates additional value in every repetition cycle and helps to reduce total turnaround costs
- Combining engineering know-how, project management competence, hands-on experience and professional use of state-of-the-art methods and tools
- Integration of the turnaround documentation into the customer’s system
- Execution of national and international turnaround projects

Projects and references

- Borealis AG: Germany, Austria, Sweden
- Kuwait Petroleum Europoort: Rotterdam, Netherlands
- Total Raffinerie Mitteldeutschland GmbH: Germany
- Neste Oil Corporation: Finland
- Shell Nederland Raffinaderij: Netherlands
- TNK-BP: Russia, Ukraine

Facts and figures

In 2010, the BIS Group recorded turnover of more than Euro 2.9bn with a staff of around 28,000.

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Our company

EagleBurgmann is one of the world’s leading providers of sealing technology and production supporting services.

Portfolio and expertise

Our excellent reputation is founded on superb quality, high innovative power and an extensive portfolio of products and services for every industrial process and virtually all sectors and areas of application. Our spectrum ranges from gaskets and compression packings to all types of mechanical seals and supply systems right through to magnetic couplings, expansion joints and a diversity of services. As a part of Germany’s Freudenberg Group and Japan’s EKK Group we have the economic resources to ensure a soundly based, reliable partnership with our customers.

Turnaround strengths and specialized fields

The key factor of our on-site service is the flexibility with which we can adapt ourselves to the specific needs of each and every turnaround job. Depending on the scope of a project and its specifications, we use the appropriate staff, material and equipment. Our specialists are familiar with both sealing technology as well as related disciplines, such as valves, pumps, plants. We offer our customers on site complete sealing management services, from technical consulting right through to the manufacture of seals and packings by mobile service units as well as complete documentation.

Projects and references

Refinery turnarounds: Total Spergau, BP Lingen, OMV Burghausen, OMV Schwechat, PCK Schwedt, MiRO Karlsruhe

Power plant turnarounds: RWE power plant in the Cologne area, E.ON Unterweser nuclear power plant, E.ON Grafenrheinfeld nuclear power plant, EnBW Neckarwestheim nuclear power plant

Facts and figures

- Staff: 5,500 (group worldwide)
- Subsidiaries: 60 (worldwide)
- Distribution and service centres: 250 (group worldwide)

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Our company

ep-cm project management is a consultancy and service company focusing on the turnaround business in the process industry.

Portfolio and expertise

ep-cm consultants analyse the customer’s operations and state of development during all phases of the turnaround life cycle and develop customized recommendations for improvement on this basis. These recommendations are subsequently implemented in the customer’s organization by a team of consultants and professional service experts who accompany the process until the changes have been fully adapted by customer’s teams. ep-cm has coined the term “hands-on consulting” for this process.

Turnaround strengths and specialized fields

The founders of ep-cm, Josef Angeli and Björn Zubel, have a long track record in the turnaround business in the process industry. They saw that something was missing, namely, a merger of specialists who transpose their expertise into a corresponding method and make this know-how available to those involved in a turnaround. ep-cm implements this as a hands-on process, orientated towards the specific needs of each and every customer, and accompanies all the necessary implementation processes.

ep-cm has integrated the individual sub-disciplines into an overall concept and therefore offers its customers a comprehensive and coherent package of services tailored to the turnaround business in the process industry. The methods designed by ep-cm for the individual process phases, such as “scope guarding”, “component based estimating” and “float based prioritization” have already become part of the technical terminology of our customers and a natural part of their day-to-day business. As part of its outstanding consultancy services in the turnaround business, ep-cm is continuously and dynamically developing these USPs further.

Projects and references

The 100 employees of ep-cm are currently working on more than ten international customer projects, most of them being among the Fortune 100 enterprises in the oil and gas industry. The savings potential generated for the customers in these projects are in the three-digit million range.

Facts and figures

ep-cm is headquartered in Austria and with branches in Germany, Eastern Europe, the Middle East, North Africa, the US and Canada is present in all important regions of the world.
Staff: 100

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Our company

Infracor GmbH operates the Marl Chemical Park and offers its services to the companies located there and outside the chemical park.

Portfolio and expertise

As an integrated site operator, Infracor addresses the specific needs of companies of the chemical sector and related process industries. Infracor has a track record of 70 years, offering its customers tailor-made packages, from site operation to targeted custom solutions. The infrastructure and service portfolio includes basic services, site operation, raw material/product logistics, energy supply, utilities, disposal and plant support.

Plant support includes all activities within the scope of ongoing maintenance as well as reliable and quick troubleshooting in operational processes. Besides maintenance, inspection, repair, assembly, materials management as well as optimization of plants and plant parts, Infracor also executes scheduled plant turnarounds.

Turnaround strengths and specialized fields

Infracor’s technical department with its 700 employees offers a one-stop full-scale service. The projects/turnarounds unit supports its customers primarily in the field of turnaround scheduling and management. A seasoned turnaround planning team with IT tools specifically adapted to TAR processes is available for the execution of turnarounds of process plants. Infracor employs mainly its own supervisors (foremen, technicians, construction managers, engineers). Equipment turnarounds strongly rely on the company’s own workshops. Operational implementation is supported chiefly by contractors with whom long-term framework contracts have been entered into.

Projects and references

Turnaround projects with a volume of up to €15m have been executed.

Examples of turnarounds in 2010:
• Marl Chemical Park: Evonik Oxeno GmbH, raffinate plant, syngas and oxo plant, around Euro 6m
• Ineos Styrenics GmbH, cumol plant, ethylbenzol, styrene plant, around Euro 2.5m
• Gas caverns: Nuon Gasspeicher Epe GmbH and RWE Gasspeicher GmbH, around Euro 1m

Facts and figures

Infracor is an Evonik Industries company.
• Year established: 1998
• 2009 turnover: Euro 791m
• Permanent staff: 2,700

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Our company

KIEL Industrial Services AG is a full service provider for the process industry. Kiel consists of eight companies with more than thirty sites which successfully implement our family-owned business’s philosophy of “planning – building – servicing”.

Portfolio and expertise

In the enterprise’s more than 65-year old history, maintenance of piping systems is still accounting for more than 60 percent of turnover and represents a key element of the service portfolio. This core business servicing in the chemical, petrochemical, refinery, power station and food industries has been the basis for the development of additional expertise. The competence centres of plastic technology, final and apparatus assembly, sheet metal processing, mechanical engineering, building machine and furnace engineering have been successfully merged, optimized and constantly developed. The function cornerstone for a modern full service provider offering all ancillary trades was created. New construction of complete production plants, such as methanolysis plants, crackers, rubber plants or power station sub-plants is also a major part of Kiel activities. For many years, these multi-service solutions have been successfully applied to wide range of maintenance and turnaround projects.

Turnaround strengths and specialized fields

KIS AG boasts a wealth of plant expertise and with up to 320 employees executes turnarounds safely and on schedule.

Along with new construction business, our portfolio also includes one-stop turnaround scheduling and execution, for instance, when it comes to generating and checking job cards or scheduling and overall planning. Interfaces are optimized, errors minimized and cycle time reduced throughout the entire process by planning weak points and pipeline points in an assembly-friendly manner right through to the preparation of isometric drawings via the digital chain. This results in customer’s efficiency being boosted by double digit purchases.

Projects and references

KIS AG executes turnarounds in refineries, chemical plants and plants in the energy sector, including, for the following companies: Aluminium Oxis Stade GmbH, BASF AG, Bayer AG, BP GmbH, DOW Olefinverbund GmbH, Evonik Degussa GmbH, Holborn Europa Raffinerie HH GmbH, Ineos Köln GmbH, RWE AG, Shell Deutschland Oil GmbH, Solvay Chemicals GmbH, Statoil, A/S, YARA Deutschland GmbH

Facts and figures

KIS AG currently employs a workforce of 1,262 and records turnover of Euro 129m. The three largest companies are Kiel Montagebau GmbH, IPS GmbH and Kiel Engineering GmbH based in Germany. Further companies are located in Belgium, the Netherlands and Poland.

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Our company

Lobbe Industrieservice GmbH & Co KG is a subsidiary of Lobbe Holding GmbH & Co KG. The medium-sized, family-owned enterprise was established at the end of the 1960s, and since the beginning of the 1990s, has been managed by experienced members of the Edelhoff founder family, warranting quality, safety and efficiency.

Portfolio and expertise

The complete service portfolio covers industrial service, site clean-up, sewer services, waste disposal and spill management. In recent years, the industrial service unit has developed comprehensive service and engineering competence for the producing and processing industries. As a medium-sized, owner-managed business, we are today one of the regular partners when it comes to shutdowns and turnarounds, for example, in the chemical, petrochemical and steelmaking industries as well as in the energy sector. In the industrial service area, we focus on technical cleaning of industrial plants and parts thereof, maintenance management (maintenance, inspection, repair), chemical industrial cleaning, large capacity, tank cleaning and service for large-scale combustion plants.

Turnaround strengths and specialized fields

In the field of turnaround management, our strengths are mechanical industry cleaning using pressurized-water and air conveyance systems. With a suction rate of 8,500 cubic metres of air per hour, our special vehicles for air conveyance are designed for pumping liquid, sludgy or dry matter. With a power of 150 to 2,500 bar, our special pressurized-water vehicles are perfectly suited for interior cleaning jobs of tanks, heat exchangers, reactors and storage tanks, and for the exterior cleaning of plant parts, machines, floors, ceilings and walls.

Projects and references

We work for the market leaders in the chemicals and mineral oil sector, in the steel industry and in the energy sector.

Facts and figures

- Headquarters: Iserlohn
- Locations: 25
- Staff: 750
- Turnover: around Euro 90m

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Our Company

Founded in 2000 McLaren Software is a leading provider of Engineering Document Management and control Applications designed to support the lifecycle of an operational asset or facility.

Portfolio and expertise

Enterprise Engineer supports over 80,000 owner operator users in asset intensive industries including Oil & Gas, Utilities, Life Sciences and Progress Manufacturing.

Comprising of four interoperable modules, Enterprise Engineer is a suite of applications supporting capital projects, transmittals, handover and operations and maintenance. Best practice engineering, document and drawing control processes help ensure the safe, efficient and compliant construction and operation of a plant or facility, further configurable to meet individual work practices.

Accredited by leading Enterprise Content Management (ECM), McLaren provide a full range of consultancy, implementation, training and customer support services.

Turnaround strengths and specialized fields

Plant turnarounds require validated asbuilt documentation to avoid engineering re-work, project delays and to comply with start-up regulations. Enterprise Engineer maintains a secure vault of auditable, synchronized master and released documents and drawings.

Asbuilts may be concurrently checked out to multiple projects. Synchronizing document and drawings between teams, on a single asset can significantly reduce the time for a plant turnaround. As projects reach completion, the reconciliation process ensures the modified asbuilts are further validated for operations.

Projects and References

Enterprise Engineer is used by many of the world leading owner operators in a range of asset intensive industries.

Facts and figures

McLaren Software operates in the USA, Canada, Europe, Middle East, Southeast Asia and Australia.

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Our company

Our business revolves around products and services for measuring the geometry and optimizing the availability of rotating machines and plants. We work as independent partners in maintenance projects.

Portfolio and expertise

Laser measuring systems and industrial maintenance service.

Shaft alignment; measuring the alignment of bores and bearing shells; determining the flatness of flanges, machine beds and foundations; measuring the straightness of rails and guides; measuring the parallelism of rolls using an innovative technology with highly precise ring laser gyroscopes; permanent and continuous monitoring of positional changes in plants, foundations and buildings; complex measurements of plant geometries; precision measurements of gas and steam turbines during new installation and overhaul projects; testing machine functions and evaluating machinery alignment condition; complete range of product training, consultancy services and seminars in proactive maintenance at our facilities or on site.

Turnaround strengths and specialized fields

Precise laser measurement of the alignment of half-shells of gas and steam turbines matched with more than 15 years of experience within the power industry.

Service for determining the parallelism of rolls in the paper, printing, packaging, foil and steel processing industries using a unique and innovative inertial measuring system that incorporates high-precision ring laser gyroscopes. Permanent measuring system for short to medium term monitoring of relative plant displacement or foundation settlements, especially during overhaul work on turbines or large equipment, such as printing machines.

Projects and references

Overhaul of a 60-MW turbine at a power station in Berlin in cooperation with ‘Energie und Umwelt Service GmbH Berlin’ using CENTRALIGN® Ultra - a turbine alignment system.

Complete measurement of roll parallelism on the PM4 paper machine at ‘UPM Nordland Papier Dörpen’.

Facts and figures

With headquarters in Ismaning, Germany, the group has 470 employees worldwide, is present in 70 countries, with an annual turnover of Euro 50m.

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Our company

With a wide range of industry services, the Rohrer Group – ILG Group is today a major, privately owned medium-sized enterprise.

Portfolio and expertise

Turnaround management, AV, as-built, costing, scheduling and resource planning, coordination, controlling, management

Plant service, pipeline construction, steel construction, daily maintenance, plant maintenance, transport, heavy assembly, documentation

Industrial insulation, thermal insulation, cold insulation, sound and fire protection, mattress insulation, sheet metal structures, customer-specific insulating structures, engineering, asbestos clean-up, further training and advanced education

Industrial modular scaffolding, special structures, including engineering, hanging and heavy-duty scaffolds, mobile scaffolds, weather protection, keder and roof systems, freight and passenger lifts

Industrial cleaning, chemical cleaning, tank cleaning/rehabilitation, dry sandblasting, high-pressure water jet cleaning, wet/dry suction work, injection of residues, underpressure maintenance/ventilation

Turnaround strengths and specialized fields

We specialize in the development of turnaround concepts, consultancy and optimization services for planning and scheduling processes, as well as scheduling, execution and management of turnarounds no matter how complex. Effective scheduling and resource planning (Primavera) are top priorities, along with coordination (according to RAB 30 [OSH guideline]) as well as complex work preparation right through to controlling. Our USPs for maintenance jobs include a quick response thanks to the group’s international organization, as well as flexible personnel deployment with permanent and external staff.

Special equipment, bundle pulling, heat exchangers, cleaning, column service

Projects and references

- OMV AG: TAR management, industrial cleaning, technical insulation, scaffolding, coordination
- OMV Petrom S.A.: TAR scheduling, TAR management, industrial cleaning, technical insulation, scaffolding
- Shell: Scheduling/resource planning, industrial cleaning, scaffolding
- OXEA: As-built documentation, complete TAR planning, including controlling, TÜV coordination, technical insulation

Facts and figures

Staff of 1,600 worldwide at more than 40 locations, with annual turnover of around Euro 200m.

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Our company

Sulzer Pumpen (Deutschland) GmbH is part of Sulzer Pumps, a division of the Swiss Sulzer Group. We are successful on the international market and as a technology leader we are a driving force for the industry.

Portfolio and expertise

Sulzer Pumpen (Deutschland) GmbH manufactures single and multi-stage rotary pumps, mainly for the energy sector, the mineral oil and process industries as well as industry in general. With customized design, state-of-the-art production and test bed facilities, we address the changing needs of customers and markets. Our service network with more than 60 locations worldwide, including 15 in Germany, ensures local presence for our customers and hence short response times. Besides spare parts and repairs, Sulzer Pumpen (Deutschland) GmbH offers maintenance contracts to ensure ongoing plant availability. We modify pumps to handle changing operating conditions and optimize pumps with a view to energy consumption and reliability.

Turnaround strengths and specialized fields

Our repair and maintenance services are not restricted to pumps, but cover the entire range of rotating machines and plant parts. Thanks to the excellent qualifications and plant expertise of our service personnel, we are able to identify and eliminate the reasons for shortcomings in plant operations. Within the scope of turnaround projects, Sulzer Pumpen (Deutschland) GmbH executes the work packages of individual trades or even plans turnarounds, including the coordination of other service firms. Our large service organization can respond to peak demand in a flexible manner.

Projects and references

Sulzer Pumpen works worldwide for renowned enterprises of the oil and gas, process, pulp and paper industries as well as the water and the general industry sectors. Its paramount solution expertise renders Sulzer Pumpen the partner of choice for customers who expect more than just a routine job.

Facts and figures

Sulzer Pumps 2010 figures
• Order intake: CHF 1,614m
• Turnover: CHF 1,576m
• Return on Sales: 12%
• Staff: 5,904

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Our company

The T/ANGO Turnaround Management Group is a provider of professional shutdown and turnaround management services.

Portfolio and expertise

T/ANGO plans and manages turnaround projects for refineries, the petrochemical industry as well as companies in the chemical and utility sector. T/ANGO can strengthen or supplement your internal project management resources or perform this service completely on its own. Our turnaround experts are then integrated as interim managers into your organization. This philosophy avoids additional interfaces and enables one-stop project management. We attach great importance to the key levers in this cooperation so that T/ANGO can deliver what you expect: a successful turnaround – on time, in budget.

Turnaround strengths and specialized fields

T/ANGO bundles all strategic project management services and thus creates a central platform for the entire turnaround project (project management centre). Seasoned turnaround staff are employed throughout the entire project. We work exclusively in the interest of our customers and are independent of turnaround service firms.

Our team supports you in the following matters:

• Overall project management
• Scope management
• Overall planning
• Scheduling
• Budgeting and controlling
• Contractor management
• Execution management

Projects and references

T/ANGO successfully plans and manages turnarounds in Germany, the UK and France.

Facts and figures

9 employees generating annual turnover of Euro 1.6m (2010).

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Our company

Tectura's Enterprise Project Management (EPM) business area is part of the global Tectura Group, one of the leading Microsoft business solutions and integration partners.

Portfolio and expertise

Tectura's EPM business area specializes in consultancy/IT solutions for technical project (CAPEX/OPEX) management for operators and service providers in the process industry. We develop IT solutions for company-wide project management and controlling as well as shutdown management. We rely on Microsoft Project, Microsoft Project Server and Microsoft SharePoint technology and integrate our solutions into existing ERP systems as well as the customers’ specific engineering solutions.

Our solution portfolio includes:

- Estimating, costing
- Processing of legacy data
- Interface services, data hub
- Special planning add-ons for Microsoft Project
- Resource optimization
- Tools for simple electronic feedback
- Visual project cockpits with special status and holding points for tracking and monitoring
- Online reporting and evaluation
- A web-based platform for company-wide project management

Turnaround strengths and specialized fields

Tectura has special engineering consultancy and project expertise and has configured Tectura® Shutdown Management as an industry solution specifically for turnaround projects. The solution is suitable for both small and partial turnarounds as well as major turnarounds involving more than 100,000 activities. It enables planning, scheduling and monitoring of all phases and resources of a turnaround. Interaction with commercial workflow systems, such as standard ERP solutions (for example, SAP or Microsoft Dynamics AX and NAV) and repository-based engineering systems, is possible at any time.

Projects and references

Tectura’s shutdown management system has been in use for many years at reputable enterprises in the refinery and chemicals industries as well as providers of industrial services. The solution is successfully being used in major and small turnarounds.

Tectura's customers include, for example, MiRO, Total, IMO and Infracor.

Facts and figures

Tectura employs a staff of 1,600 worldwide and is there to serve you in more than 20 countries.

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Our company

ThyssenKrupp Xervon is one of the leading technical service providers for the construction of new and maintenance of existing industrial plants worldwide, focusing on the chemical, petrochemical, energy, shipbuilding as well as steelmaking and construction industries.

Portfolio and expertise

For more than 40 years, Xervon has been developing intelligent and efficient maintenance strategies, offering its customers a portfolio of services of unparalleled depth and breadth: from technical trades, such as scaffolding, insulation, surface treatment and pipeline construction, to the maintenance of process plants and the related static and rotating equipment, process control/electric control and instrumentation systems, process analysis equipment, including comprehensive turnaround management, budgeting and maintenance planning, infrastructure services, operation of ancillary units (such as supply/disposal), materials management and logistics.

Rounded off by professional subcontractor management as well as the most demanding QHSE standards, Xervon is in every respect a powerful partner for its customers.

Turnaround strengths and specialized fields

Beyond the respective resources on site, ThyssenKrupp Xervon operates an independent turnaround organization for efficient turnaround planning, scheduling and execution.

Highly skilled staff and, more importantly, experienced construction managers working in well-attuned teams along with optimum contractor management and a pool of equipment designed to meet the needs of shutdown projects ensure the necessary flexibility, speed and timeliness for turnaround projects of any size.

Projects and references

To date, ThyssenKrupp Xervon has successfully planned and executed more than 300 turnarounds in Germany and abroad. Examples from 2010:

- Deutsche Shell Holding GmbH: Harburg (03/10), Godorf (04/10), Heide (09/10)
- MIRO Mineraloelraffinerie Oberrhein GmbH & Co. KG, Karlsruhe, Germany, (02/10)
- Neste Oil, Porvoo, Finland, (04/10)
- OMV AG, Schwechat, Austria, (06/10)
- Preem, Lysekil, Sweden, (09/10)

Facts and figures

With a staff of around 9,000, ThyssenKrupp Xervon generates turnover of around Euro 700m (in FY 2009/2010).

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Our company

Voith Industrial Services is an international industry service provider with a staff of more than 19,000 at 170 locations, recording turnover of around Euro 960m.

Portfolio and expertise

Our Energy-Petro-Chemicals division performs technical services for the oil and gas industry as well as enterprises in the energy sector everywhere in Europe. These services include on-site service, assembly, tank and container construction, welding jobs, electric control and instrumentation equipment as well as the planning, scheduling and execution of shutdowns. Drawing on decades of experience in this field, we can execute turnarounds on schedule and at fixed prices. Safety, timeliness and quality are key elements of this service.

Turnaround strengths and specialized fields

We can execute turnarounds as the main contractor. External contractors are commissioned by Voith Industrial Services.

• Turnaround planning, engineering and organization
• Preparation of tender documents
• Turnaround execution as the main contractor
• New construction, conversions and modifications: Voith Industrial Services additionally offers its services in the field of plant and pipeline construction for conversions, connections or modifications of production plants.
• Contract design: Voith Industrial Services offers long-term contracts to ensure the execution of turnarounds at reliable prices and quality.

Projects and references

Our customers include renowned corporations, such as Shell, BP, ExxonMobil, Total, OMV, Basell as well as refineries, such as Holborn, MIRO, H&R and others.

Facts and figures

The Energy-Petro-Chemicals division employs a workforce of 1,478 and generated a turnover of Euro 193m in the 2009/2010 financial year.

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T.A. Cook & Partner Consultants GmbH
T.A. Cook is a management consulting firm focusing on Asset Performance Management with offices in Berlin, Birmingham, Houston, Paris, Raleigh and Rio de Janeiro. The core competence of the consulting business is the sustainable implementation of asset, operations and service-oriented excellence. As a change management specialist, the firm delivers measurable value enhancement and bottom-line productivity gains. In order to achieve these results T.A. Cook offers a wide range of professional services which ensure that all business processes – from strategy definition through management to organisational design – are effective, efficient and sustainable. Complementing the consulting business, the T.A. Cook Academy has become a leading organiser of international conferences and seminars relating to Asset Performance Management. Annual events include the MainDays summit as well as conferences centred on topics such as Shutdowns & Turnarounds and Capex Management. T.A. Cook's clients are typically businesses, their suppliers and contractors working with significant industrial assets across multiple sectors. The company has particular expertise in the petrochemicals, plastics, pharmaceutical, transport, mining and food sectors as well as excellent knowledge of the regulated environments occupied by gas, water and electricity utilities.
For more information please visit www.tacook.com

T.A. Cook Research & Studies
The Research & Studies division conducts detailed market and company analyses in the area of Asset Performance Management. The focus of the team is to systematically investigate and clarify current market concerns and requirements as well as anticipated developments and their consequences for market players. As well as studies on topical issues, we compile trend reports and continually expand our database of specialised knowledge, which can be applied to each study as needed.

Current studies:
• Scheduling Practices for Turnarounds/Shutdowns (2011)
• Technical Services for Turnarounds in Petrochemical Plants – Western Europe (2011)
• How Companies use RFID in Maintenance (2010)
• Technical Services for Turnarounds in Petrochemical Plants – Germany, Austria, Switzerland (2010)
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