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Project Management Services

A partnership

Application of Risk Management to Project Start Up

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Introduction

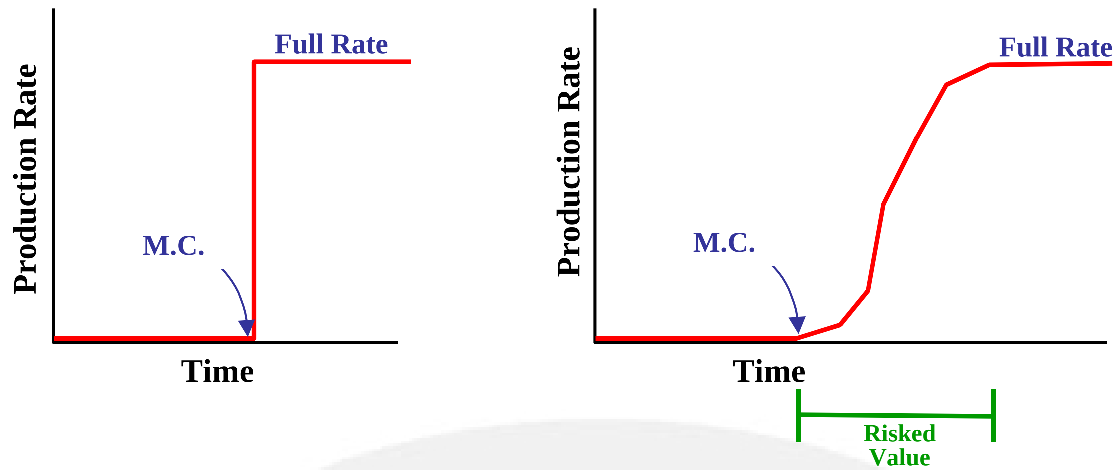
Over the past two decades there have been a number of major capital projects in the oil and gas industry, and particularly in Alberta. These have ranged from oil sands mining projects to insitu oil sands developments, from new refineries to major refinery revamp projects, from foothills gas plants to offshore field development. There have also been a number of petrochemical plants and co-generation plants. Industry growth has been significant, and particularly evident in these major capital projects, with capital expenditures running as high as $5.0 billion for a single project.

A common thread joining these projects, besides their large capital cost and huge demand for skilled manpower, is the tendency for these projects to overrun their budgets and their schedules. Projects have reached the mechanical completion stage on time and on budget, only to stagger through a prolonged start up and ramp up, degrading project value and return to shareholders in the process. Production deferrals at the project start are effectively not recouped until the end of the project life, and therefore the lost revenue comes almost exclusively off the project's net present value.

Project Objectives:
One of the keys to understanding how to protect the project value during start up is to examine the project objectives. While the overall goal is to achieve the Three Mantras of Project Management (Cost, Schedule, and Quality), all too often the project team is focussed on only the construction execution portion and not the future operation. In many cases the project team role stops at Mechanical Completion, leaving the critical project start up to an Operations-based team with a skeleton execution staff.

Definition Of Success:
The first step of effective project management is to determine the definitions of project success. In today's world, commitments to safety and to environmental protection are well understood, and to be considered fully successful, projects must achieve and exceed targets. After this step the success definitions become less clear.

In some projects there is a blurring of the relationship between CAPEX and OPEX. Increasing estimate trends (above the single-point AFE estimate) result in CAPEX reduction exercises that may not consider operational costs or impact on project value. Similarly, many projects focus on capital expenditures and overlook the impact of schedule or even declare that the project is not schedule-driven. In fact, all projects are schedule-driven in that their total value is completely dependent on the time value of money. When teams overlook the time dependency of their project, or fail to plan the project start up with the same detail as the construction, they put the project at risk of some degree of financial failure.



It is important to recognize that for any project the duration from Mechanical Completion to Full Production is a significant project risk, and production lost at the start of operations is lost from project value for more the life of the project.

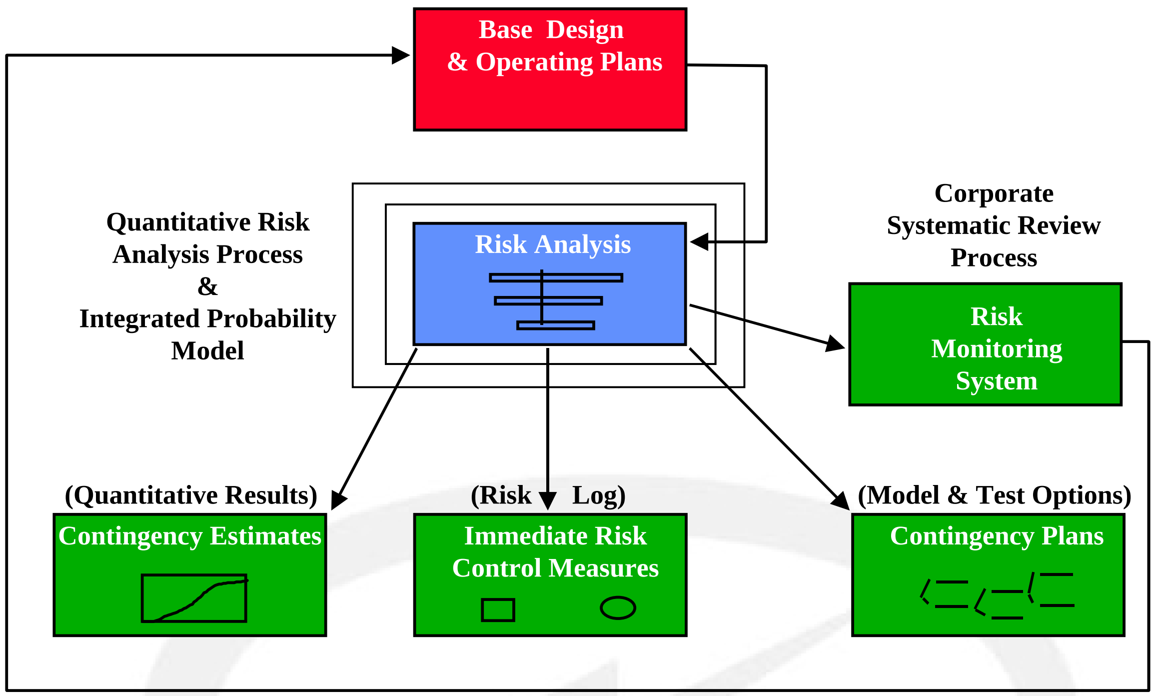
In order to reach maximum project value and meet the definition of success, the project must be completed with zero safety and environmental incidents, it must achieve Full Production on time and on budget, and it must achieve the forecast total project value.

Risk Management Process

The Risk Management Process uses the Base project design and operating plans in conjunction with a quantitative risk analysis to provide the information and tools that assist the project team in managing the risk exposure.

The project's base information provides a deterministic look at the project cost and schedule, and is the yardstick against which the risk-adjusted performance is measured. The risk analysis should incorporate a quantitative risk analysis in a fully integrated probability model (Monte Carlo) to provide the definitive outcomes required for the risk management. The integration of cost and schedule in the model is important to ensure that the individual risk impacts are not considered in isolation, but rather in combination with other risk impacts, as they actually occur on the project.

Risk Management Process



The Risk management Process has four main outputs, which serve different purposes for the project team. The quantitative probability distributions for capital expenditures, operating expenditures, schedule, and net present value can be examined to provide an understanding of the project contingency required and more importantly an understanding of the probability of achieving the project's targets. The Risk Analysis will highlight key risk issues through tornado and step diagrams, and should assist in generating a comprehensive Risk Log, with specific risk item impacts, mitigation steps, and responsibility for action. This provides the project with immediate risk control measures that don't require the risk to be realized to instigate action.

The probabilistic model will also provide the ability to identify and test contingency plans to ensure that they realize the planned outcome. By testing the various mitigation options in advance of the risk events occurring, the project team has the advantage of knowing that the mitigation will be most effective. The understanding of the risks and their impacts also serves to make the team more aware of the warning signs on the project and implementing the mitigation strategies at an early stage where they can be the most effective. This leads to the Risk Monitoring System, whereby the identified risks are monitored and new risks are identified continuously through the project life. In some cases a corporate review process evaluates the projects at specific milestones through their life.

Key Elements of the Risk Management Process:
The Risk Management Process must encompass a number of key elements in order to be successful and provide value. The first element is that it must meet the requirements of the

project's management, the Owner's Board, regulatory bodies, and any other stakeholders or shareholders. With the recent focus on corporate governance, companies have realized that part of their due diligence extends to having effective risk management. The size and scope of these major projects makes them subject to the new rules that are evolving for corporate governance, and the project management team needs to have a comprehensive Risk Management Plan.

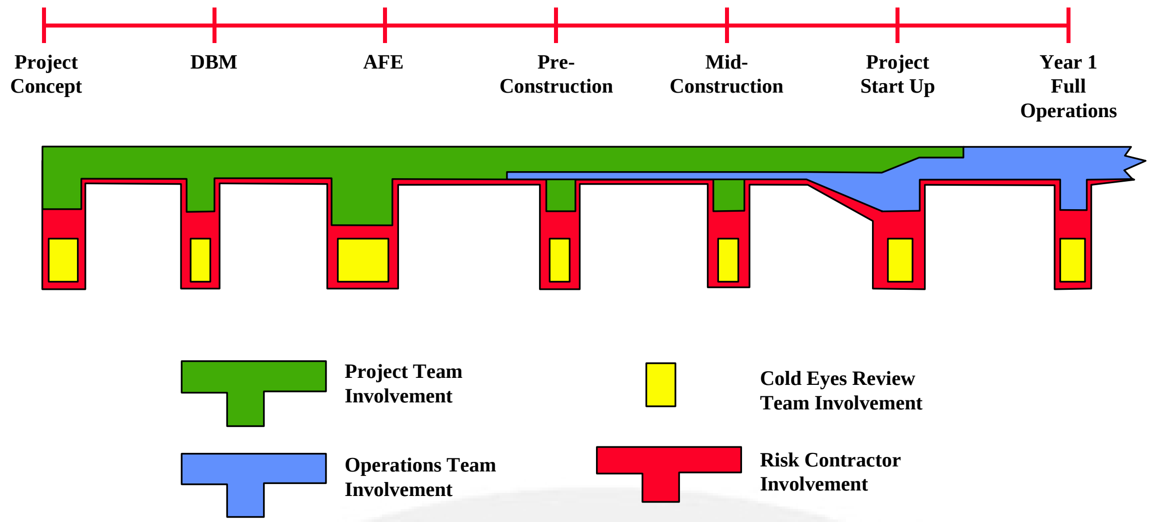
A second element is that the process needs to be consistent, transparent and defensible. The process consistency is important, as the model will be run many times using different cost or schedule variations, and inconsistency would make analysis difficult. The transparency is important because the project team must understand the model and how it functions. Utilizing a "Black Box" approach is not effective, because it doesn't provide the team with an understanding of the tools. Defensible results are also important. In many cases risk analysis results are surprising to the team and are not welcomed. With much of the focus on today's projects on fast-tracking and minimizing costs, a risk analysis that flags time or capital cost variances are not popular. However, if the results can be substantiated with the process, the project team can then move to the important step of mitigation.

While the Risk Management Process should cover the three mantras of Project Management (Cost, Schedule, and Quality), it should focus on them from the perspective of Value Management, rather than just capital expenditure or schedule. It is important that all the project decisions are grounded on the Total Project Value. In this instance the Risk Management Process provides an independent view of the project which is not focused on one element or another. This grounding helps the project team to avoid "target fever", in which the team focuses on one number and makes decisions that may not be in the project's best interests.

Project Risk Management Timeline:
Project risk management is an ongoing project team responsibility, rather than a one-time event. All too often, capital projects are subjected to a pre-AFE risk analysis with all the risks identified and mitigation plans outlined, only to have the analysis shelved once finding is approved and project execution starts.

Project risk management is a fundamental responsibility of the project team, and it is important to note that there may be times when significant updates to the risk management plan are required to ensure that it meets the needs of an evolving project. A key time for all projects is the period before and after project start up. In this area there is a need for significant risk activity to identify and mitigate the inherent risks.

Project Risk Management Responsibility Timeline



The core responsibility for the risk management at this point remains with the project team, although strong operations team involvement is critical. As the project proceeds toward mechanical completion and start up, specific commissioning and start up plans must be generated, and a comprehensive update is required to capture the identified risks.

Quantitative Risk Analysis:

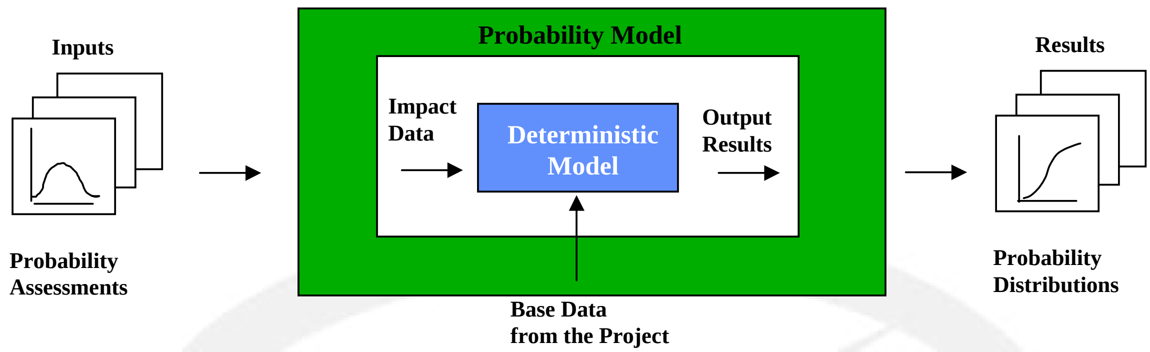
Throughout the paper we have talked about the need for quantitative risk analysis as a key element of the Risk Management Process. The reason for this emphasis on quantitative rather than qualitative work is that the analysis results must provide discrete, measurable impacts so that potential mitigation strategies can be tested to insure that they provide an improvement in project value.

An example is for a mitigation step that requires the addition of a piece of equipment, purchased at some capital cost. Without an understanding of the risked cost impact, the justification for the expenditure cannot be made, other than by intuition. If the project team becomes concerned about a risk, identified in a qualitative analysis as a "medium risk" with a "high impact", they may initiate mitigation plans or equipment purchases that outweigh the true risked impact value.

A quantitative risk analysis identifies the specific risk areas impacting the project results such as CAPEX, Completion Schedule, OPEX, Production Rates and Total Project Value. The analysis identifies the specifics of each risk, namely the probability of the risk occurring and the range of impacts when it does occur. It also provides an integrated evaluation (over the total project) of the risked impact for all the identified risks and showing the connection to all the project results identified above. Another feature of the quantitative analysis is that provides the project team with a baseline model which can be used to compare to the project performance, and provides the modeling tools required to evaluate and quantify the impact of various project mitigation plans.

Risk Identification and Quantification

Risk Planning Tools:
The risk model is developed from the base case data and assumptions in a series of logical steps. The basic project information is incorporated in the model as a deterministic case,

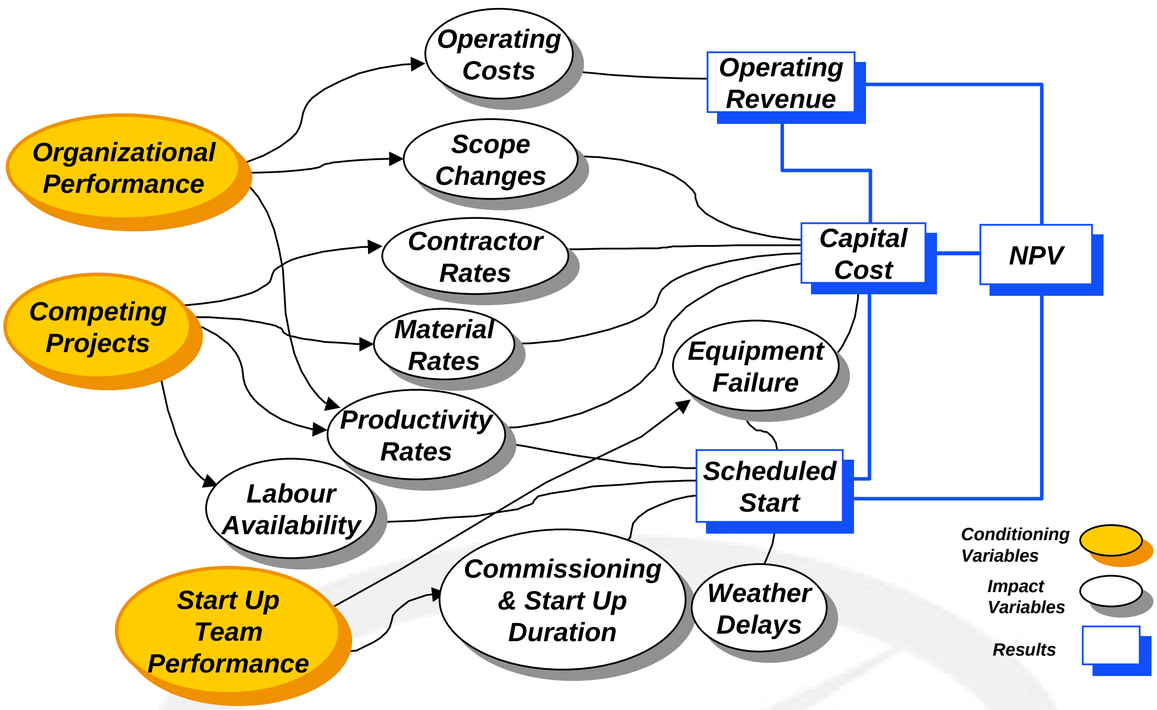


and is used to generate the Base Case Model. Project uncertainties are then added to the Base Case Model to create a probabilistic risk model (Monte Carlo). The model logic, describing how the various risks combine to impact on the project, is validated with the project team, and then the specific probability assessments are captured in the model.

The model itself is based on a spreadsheet platform. This allows the project team to access the model logic and data, and avoids the perception that the model is a "Black Box". This understanding of the model logic and how it has been applied helps to give the project team more insight into the risks and how they impact the project.

The Influence Diagram:
The Influence Diagram describes the logical connection between the project outcomes or results, and illustrates the relationship between the issues and the results. This helps to identify the specific risks that impact specific project outcomes. Some risks are related, and act to influence project outcomes in a linked manner. It's important that these relationships are captured in the Influence Diagram so that proper correlation of risks and their impacts occurs.

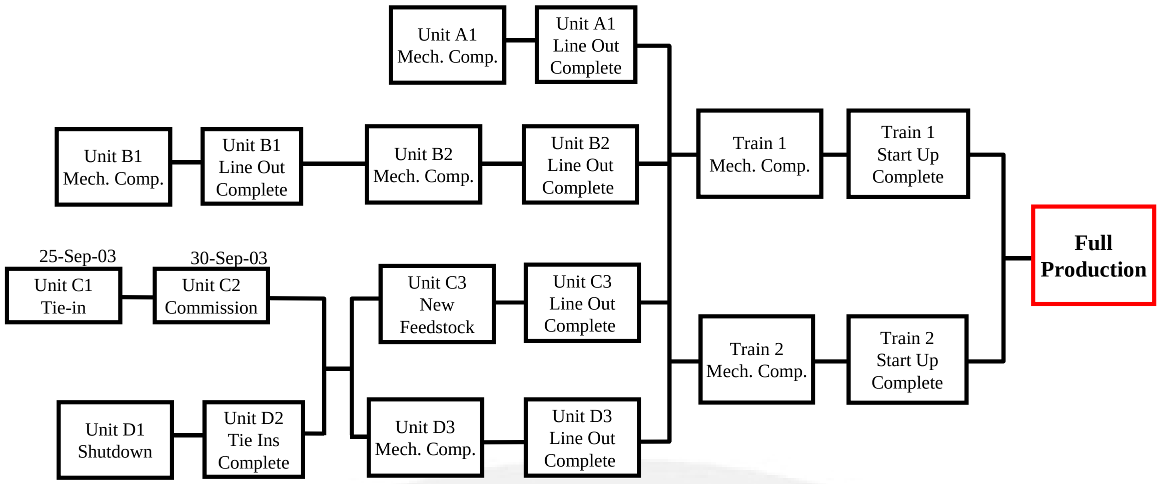
The simplified Influence Diagram illustrates how the risk logic is developed. The boxes represent project result areas, while the ovals represent risk areas. The conditioning variables



on this diagram (the shaded ovals) influence a number of the risks that then impact the result areas in similar ways. They are called conditioning variables because they set the environment that the risks occur in. An example of this would be a heated competing project environment (one with many similar projects active), which would result in higher than base values for materials, contractors and labour.

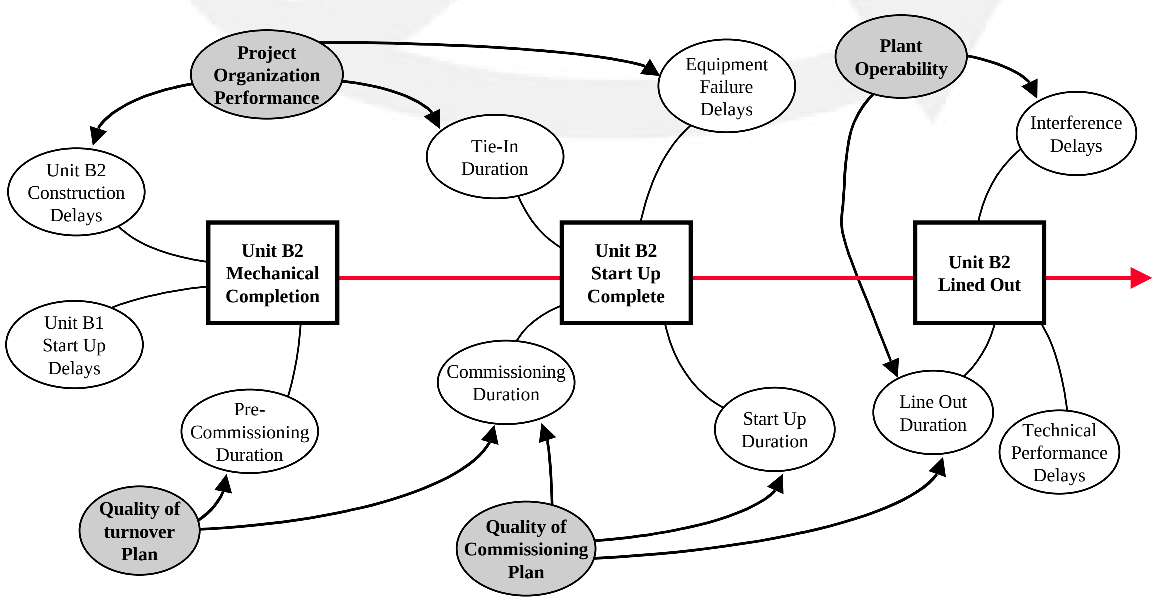
Start Up Logic:
The logic associated with project start up is often complex, in particular large projects with interfaces to existing operations. In order to model this stage of a project correctly, the model must incorporate the need for sequenced unit or processes, the need for operating plant shutdowns for tie-in of facilities, and perhaps the conversion of existing units to different feedstock. These elements may all be part of the start up plan, and need to be captured in the model and assessed by the project team.

Start Up Logic



The example Start Up Logic represents a fairly complex combination of existing process units and new units, and indicates that some form of sequencing has been designed into the start up plan. In some projects where the existing operation footprint is limited, there may be a need for a new unit to be commissioned and started before an old unit is decommissioned and another new unit installed.

Start Up Influence Diagram



Once the start up logic has been identified, a risk assessment should be applied to each individual unit, taking into account the start up process (pre-commissioning, commissioning and lining out (or ramping up)) as well as the impact of preceding or succeeding units or processes. It is important to realize that the quality of work in one phase can impact the duration of a subsequent phase. An example of this would be a poor job on pre-commissioning increasing the duration for commissioning, or a good job of commissioning shortening the duration for start up.

Conditioning Variables:
As indicated earlier, conditioning variables are used to describe the general environment surrounding the project under consideration. Typical conditioning variables for major projects are Project Organization Performance, Competing Project Environment, Operations Organization Performance and Operability Performance. Each of these conditioning variables can be defined by a number of attributes that help to define how they interact with the project.

Project Organizational Performance:

Competing Project Environment:

Operations Organizational Performance:

Operability Performance:

For risk analysis of a project start up, some additional factors need to be considered to capture the more integrated aspect of this phase, and to capture the important interface between the project execution team and the project operations team.

Given the number of processes and physical plant units that need to be prepared for start up, a detailed plan is of paramount importance and clear documentation is required. The quality of these plans is important in determining the success or failure of the start up operation.

Quality of Turnover Plans:

- **Sequence of Systems Turnover**
- **Boundaries and Scope Definition**
- **System-based Progress Measurement**
- **Definition of Terms: Pre-commissioning, Mechanical Completion**
- **Definition of Exception Items**
- **Team Integration (Execution / Operating)**
- **Inspection and Sign-Off Process**

Quality of Commissioning Plan:

- **Durations by System**
- **Sequence of Systems**
- **Cold Weather Contingency Plans**
- **Resource Loading (including Roles & Responsibilities)**
- **Level of Detail for Activities**
- **Tracking Systems**
- **Vendor Rep / Specialist Plan**
- **Organization Structure and Team Integration**
- **Contingency / Response Plan**

Risk Assessment:
The risk assessment of the identified risks requires the use of experts. Many of these experts are the project team members themselves, however additional resources should be applied for start up assessments to ensure that a wide range of start up experience is incorporated. This expertise can come from internal or external consultants. In addition, having experienced facilitation for the process helps to ensure that individual biases do not dominate the assessments.

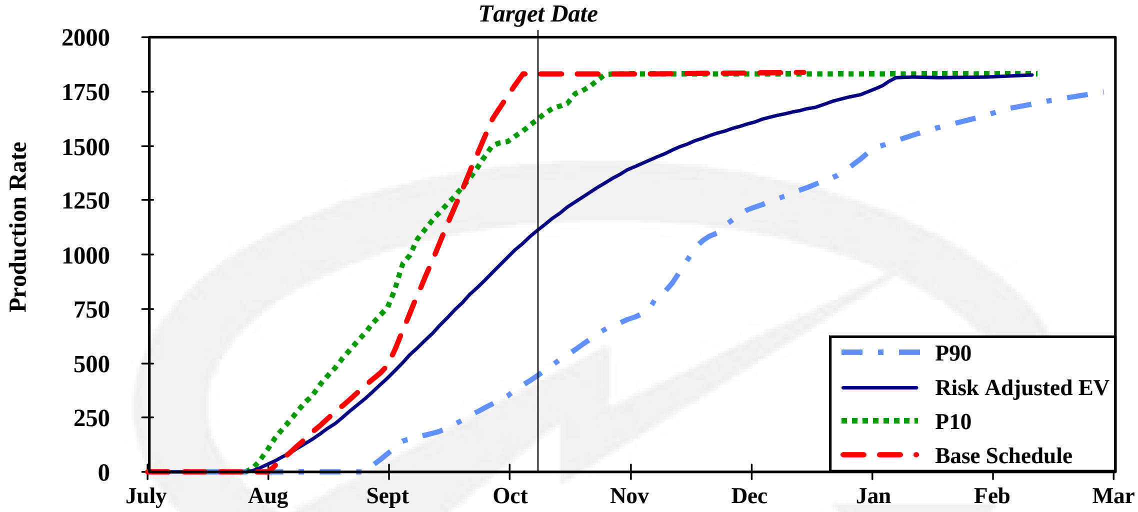
Project teams are uncomfortable choosing specific impacts and probabilities, however as they become accustomed to the process they are able to provide information that is based in their experience and project knowledge. The assessments work best in an open forum setting, where each expert opinion is discussed. Consensus is not required, however it is important to document the assumptions or experience that are the background for each assessment.

The key to quantitative assessments is that for each specific risk there is a probability of occurrence (or a probability distribution of occurrences) and a specific impact for that occurrence (whether it is cost or schedule). An example of this would be for technical performance delays during the Line Out phase, where the risk could be assessed as 30% probability of having a three to ten day delay. The delay itself could be expressed as a range between, for example 10% and 90% probability. This specific assessment is then used in the probabilistic model to generate the overall project's risk results.

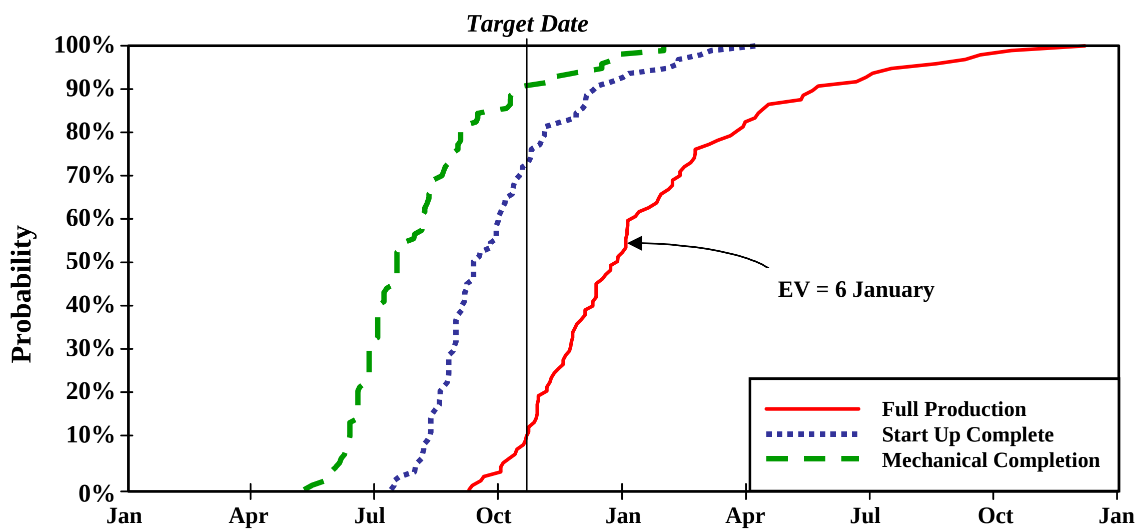
Risk Analysis Results and Mitigation

Once the project start up logic has been documented, the risk issues specific to the project start up have been identified and the individual risk assessments collected, the probabilistic model is used to generate a risked version of the project schedule and costs. Although start up operations are typically dominated by schedule-driven risks, it is important not to forget the potential for capital cost excursions.

Risk Results:
The risk model results present the comparison between the base plan and the risked result.



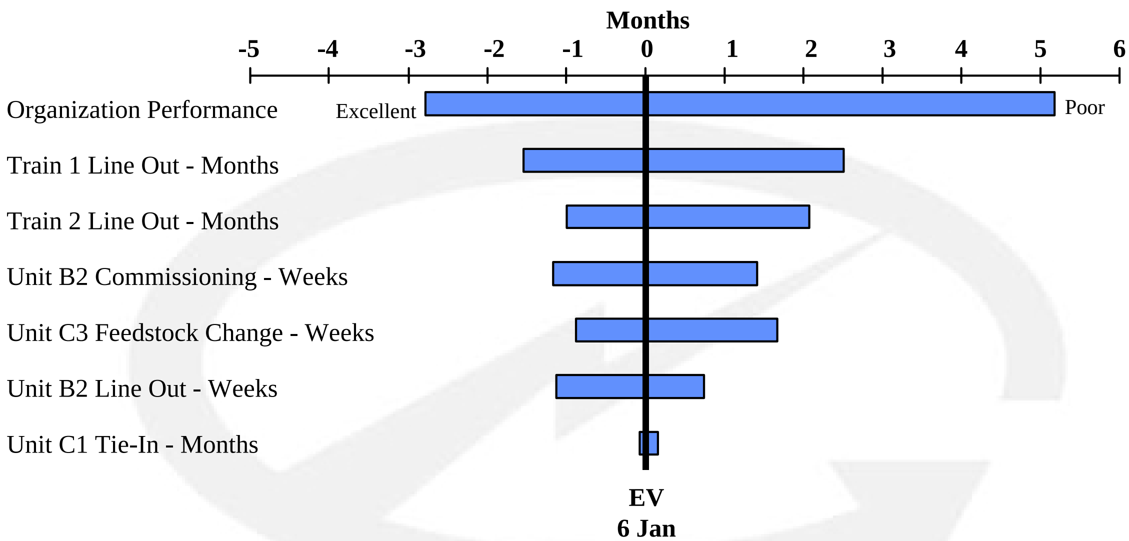
As can be seen from the example, the results compare the base schedule to the risk-adjusted expected value curve. In addition, the range of potential results is expressed by the p10 and P90 curves. Note that for this case even the optimistic (P10) curve fails to meet the target.



The cumulative probability distribution shows the same result in a different format, focusing on the probability of achieving the target date. This curve shows that the probability of achieving the target without mitigation is only 10%. In addition the slope of the Full Production curve is steeper than for the other milestones, indicating a higher level of risk in that phase of the start up.

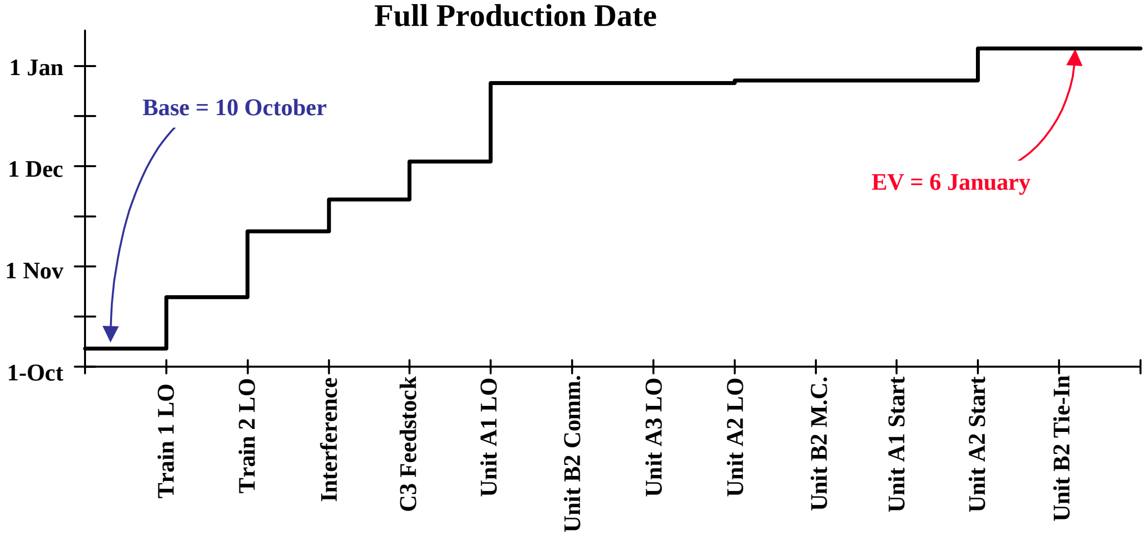
Continuing the results analysis, the next step is to examine the tornado diagram for the Full Production date to determine which of the risks has the largest potential impact on the results. The tornado diagram shows the impact on the overall risk result of varying an individual risk to its high and low extremes.

Full Production Date



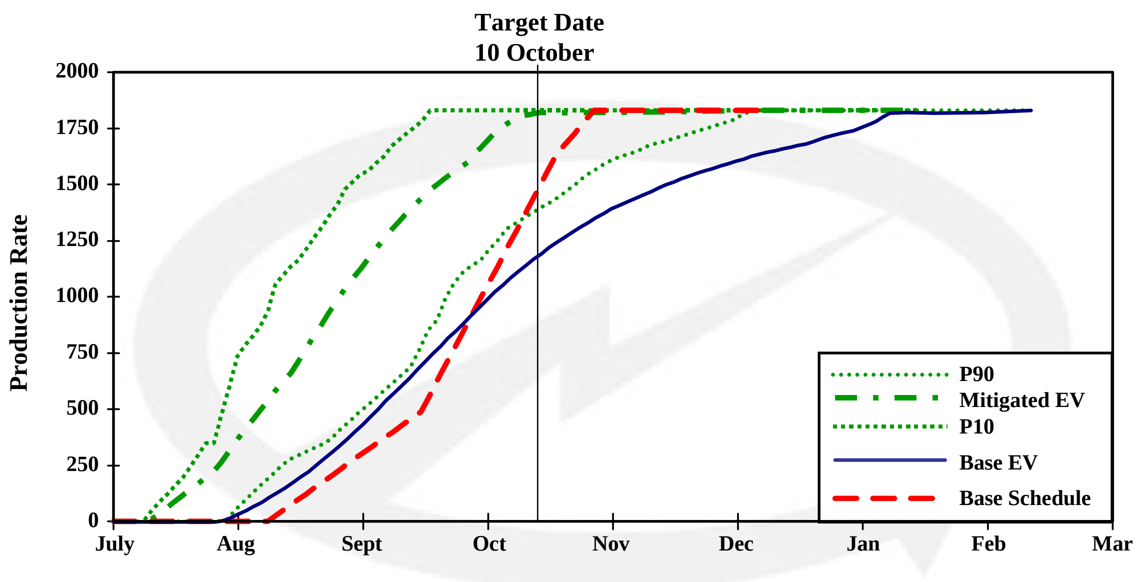
In the tornado diagrams the conditioning variables often appear at the top of the chart. Because they impact on a number of risk variables, their cumulative impact is significant. This also illustrates that for most projects organizational and planning aspects often have more impact on the project outcome than any single risk.

Full Production Date



Step diagrams are used along with the tornado diagrams to identify the largest impact on the project outcomes. The step diagram shows how the project is expected to progress from the base date (Target) to the Expected Value. It is also an indication of where there are discrepancies between the base schedule and the risked schedule for each particular activity.

Mitigation Planning:
The project team can use the risk analysis results, along with the documentation of risk issues to identify corrective (or mitigation) action. The model can test each action separately and the cumulative impact of the various steps captured in the probability diagrams. Mitigation steps that have little impact or insufficient impact for the associated cost can be replaced with more effective plans.



In the example, the mitigated case has an Expected Value that meets the Target Date. This result was achieved by an acceleration plan for one of the critical units, combined with additional focus on developing a high quality Start Up Plan, and taking steps to ensure improved Organization Performance. For this mitigated result it should be noted that the pessimistic case (P90) is still better than the original risked Expected Value.

There are many variations that can be applied to improving the project results. The key to this mitigation step is in understanding the risks that are acting on the start up process and what the impacts could be. Development of specific action plans uses the documented risk outcomes to eliminate or avoid the negative effects and to optimize the project schedule where there is opportunity. Another important factor is timing, in that development of mitigation plans at an early stage ensures that there is sufficient time to make the necessary changes and achieve the desired results.

<u>Summary</u>

The paper has described how many capital projects are negatively impacted by poor start up of operations, which results in a degradation of the projects' financial performance. Achieving a successful project means considering the total project value.

A quantitative risk analysis plan that fits with the overall Risk Management Plan is an effective way of evaluating and improving project performance during start up of operations. The analysis should be an approach that is integrated in cost and schedule, and considers the specific risk issues appropriate for start up. This includes considering the impact of the various detailed plans that are prepared by both the project execution and project operations teams.

A key element of any risk process is documentation of the risk issues, including probability of risk occurrences and specific impacts. Following this with documentation of the risk results in terms of probability distributions, tornado diagrams and step diagrams will assist in understanding how the risks combine to impact the project and aid in the development of mitigation plans.

These mitigation plans should be tested using the risk model to ensure they have the desired effect, and to ascertain the optimum combination of mitigation steps to achieve optimum results. Early application of the risk analysis process will also ensure that there is sufficient time to develop and test these mitigation plans.