Outage Management Best Practices:

Taking the Critical Path to a Successful Shutdown

Planned shutdowns are necessary to your operations functioning at optimal efficiency. Preventive maintenance is performed while process improvements are implemented during this downtime. For shutdowns to be successfully completed on time and within budget, organizations must employ outage management best practices.

Large scale processing industries such as steel mills, foundries, aluminum rolling plants, copper smelters, and others all rely on a 24/7/365 operation for viability and profitability. Due to their continuous processes, the precious days that are dedicated to shutdowns for Preventative and Corrective Maintenance are crucial. During these periods, production must be taken off-line to conduct outages — ideally planning and scheduling well in advance of the event rules the day and the shutdown begins and ends within the planned period without issue. A well-choreographed operation of people, equipment, and materials results in a plant restored to operating order at peak efficiency. Running reliably until the next planned shutdown is the goal of all plant managers and more importantly, critical to revenue.

For many of these large operations, the revenue generated in one day of production can be upwards of $1 million. When you're talking about a planned outage that can last multiple weeks, the investment to ensure proper plant

reliability is significant. Each day is precious, and it is critical to manage outages by applying intricate detail to proven methods to ensure optimal results. The risks of not doing so carry great consequences, namely poor schedule execution and attainment, which lead to overruns of both budget and schedule.

USC Consulting Group has been working with clients for over 50 years to plan, schedule, and execute maintenance outages across various large-scale operations in multiple industries. We have fine-tuned the proven Critical Path Methodology and mastered the practice of utilizing it throughout projects to ensure the job is done correctly, timely, and according to budget.

In this whitepaper, we'll outline the practical application of Critical Path Methodology for managing outages and highlight a recent, real-world example of *how to do it right, every time*.

Outage Management Best Practices: The USC Critical Path Methodology

Objective & Essential Work Scope

Just as a house's durability is dependent on its foundation, the bedrock of a well-planned and executed outage lies in the objective statement and essential work scope. A concise and clearly articulated objective statement identifies the timing of the outage as well as the operational and financial implications and expectations once resuming operation. Regardless of the size or scope of the project, the budget and calendar guide decision making. With a general scope and objective defined, it falls to key stakeholders to refine them. The goal of a strong objective statement is to get all stakeholders involved with the outage to understand depth and breadth of scope, what the implications are, and to set expectations for planning and execution.

- **Why is the outage necessary?**
- **When will the outage occur? Why will it take place at that time?**
- **What will the outage entail? What are the key pieces of equipment that will require maintenance?**
- **What CAPEX projects need to be incorporated into the outage timeframe?**
- **What critical inspections need to be carried out?**
- **What is the outage budget?**
- **Is inventory at a sufficient level to sustain sales throughout the outage?**

From the goals and operating parameters defined in the objective statement, the essential work scope transforms the goals and objectives into actionable elements for planning and scheduling. Work scope items identify the failure modes of the objective statement. That is, what are the consequences of NOT completing these scope items? A common flaw that plagues outage planning is including non-critical items into the outage scope. When this occurs it depletes resources, time, and budget. So, it falls to the key stakeholders to "trim the fat" and include only the tasks that are absolutely mission critical. Those scoping items that do not support the objective statement will not be included in outage planning and execution.

Tight constraints on the work scope also drive a fundamental change in thinking. Traditionally with outage planning, there are two primary constraints: time and budget. When one of these expires, the outage ends and production will hopefully resume with little to no infant mortality. When planning in under traditional thinking, scope is guided via asking: What **can** we do during this outage? An essential work scope focused on delivering the goals in the objective statement changes that thinking and therefore changes the question: What **MUST** we do to plan and execute the outage to ensure we can run reliably until the next outage?

This question ensures we begin the planning process with only the necessary items and begin to establish the project work activities and timeline accordingly.

Establishing Precedence

Components of the essential work scope provide the framework from which outage activities are identified and incorporated into the overall plan. Initially, the activities are broad in description, focused more on the asset or asset component. As more information is gathered from subject matter experts (SMEs), activity definition becomes more exact and the level of detail increases proportionately. The basis of building a precedence network results from asking three basic questions of the SMEs:

- **What activity must be complete before the activity in question can start?**
- **What is a reasonable expectation for the duration of this activity?**
- **What resources (human and physical) are required for this activity?**

Too often, outages fail to complete on time or suffer unplanned downtime shortly after startup

because the proper amount of detail and sequencing was missing in the plan. Identifying those activities that must be complete prior to the start of the current activity is similar to the 5 Whys in root cause analysis. Both methods drive to the initial point of activity from which everything transpires, and defines the logic or precedence of activities from which the outage will be executed. This orderly collection of activities forms a ***Precedence Network***, a series of boxes and arrows depicting the relationship between activities.

Similarly, traditional date-driven activities – "*this activity needs to be complete by* ..." place unnecessary constraints on execution and undue stress on planners and schedulers when the defined completion date could be artificial – not truly required to be complete at that time, or unrealistic – an expected completion that does not fit with outage progression. Resources would be assigned at the wrong time, equipment staging becomes cumbersome and costly, and overall outage execution suffers because of inaccurate dates. Duration-based activities focus the outage team on activity sequence and what is required to complete within the defined time.

The key to precedence networks is to think logically, not linearly.

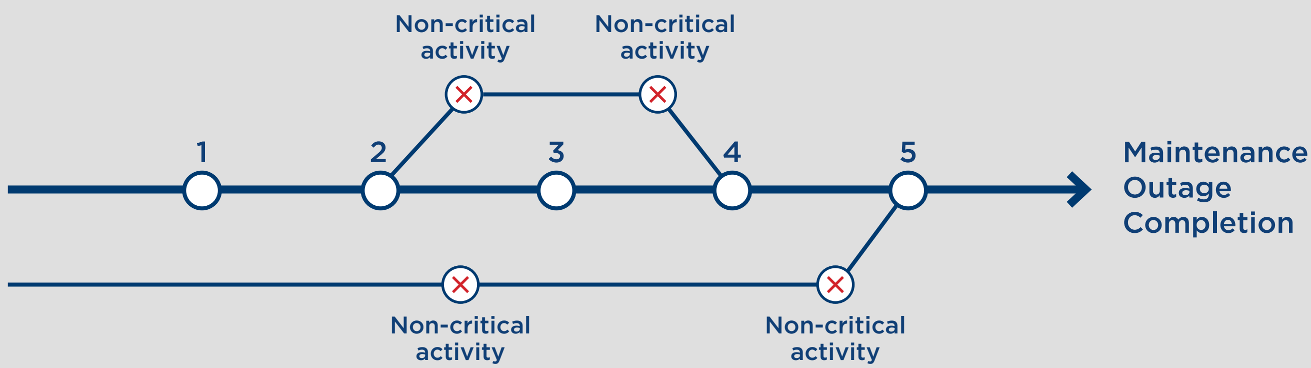
The Critical Path and Float

Within the precedence network, there exists a sequence of activities from start to finish whose durations collectively take the longest time to complete. This sequence of activities is known as the critical path and provides the drumbeat of execution in a maintenance outage. Time lost on the critical path delays production startup and time gained puts money in the bank. Any non-critical path activity is subordinate to the critical path, meaning any resource, equipment, or material conflicts must give way to the critical path activity.

Executing to the critical path enables a key element of predictability. Too often, project execution is blind-sided and ultimately fails because schedule completion becomes a guessing game based on individual activity completion. If an activity is late in completion, does this mean the entire project is late? This can't be answered without a critical path. An unconstrained critical path will intuitively tell the project team when an outage or project will complete.

Not all activities or tasks are included in the critical path. Non-critical activities employ float, which is the time available to complete an activity before a downstream activity and ultimately, the project is impacted. Float allows for resolution of resource and equipment conflicts, accommodation of late-arriving material or tools, and the insertion of found work from maintenance inspections.

Critical Path



Applying the Critical Path Methodology

A mining & metals client operating a copper smelter approached USC to assist in planning and executing an upcoming plant-wide outage. Because of cost and schedule overruns year in and year out, the plant was given an ultimatum from its parent company – make the upcoming outage successful or close the plant down.

Issues surrounding previous outage failures included:

- **Lack of planning & execution coordination between four operating entities within the smelter**
- **Lack of planning & execution coordination with contractors**
- **Outage start delays**
- **Operation startup delays caused by both extended outage duration and multiple unplanned plant restarts**
- **Ad hoc scheduling via schedule review meetings**

A typical planning cycle for an outage of this magnitude takes between 12 and 15 months to ensure that the precedence network has been properly vetted & walked down, long lead parts identified and on order, contractors qualified for work, equipment rented, etc. USC's involvement began 45 days prior to the planned outage start.

Given this short-fuse time frame, fortunately, the majority of the planning work had been complete – contractors assigned, material ordered, and equipment rented. USC's focus for success centered on:

- **Combining four individual outage plans into one integrated plan and schedule**
- **Putting rigor and discipline into schedule review meetings, and making planners and work package leaders accountable to the schedule**
- **Keeping the outage schedule current to reflect the reality of what was going on in the plant**
- **Educating management and staff on the basics of the Critical Path Method, and that it is acceptable for a non-critical activity to have a late completion**
- **Ensuring future success in outage planning & execution**

Due to the shortened timeframe for detailed outage planning, little time was available to educate, train, reinforce, and apply critical path methods with planners and managers. Understanding critical path methods was a matter of show and trust – show the client the essential elements of critical path methods, trust the planners and work package leaders to inherently understand the concepts as they are applied in the planning phase.

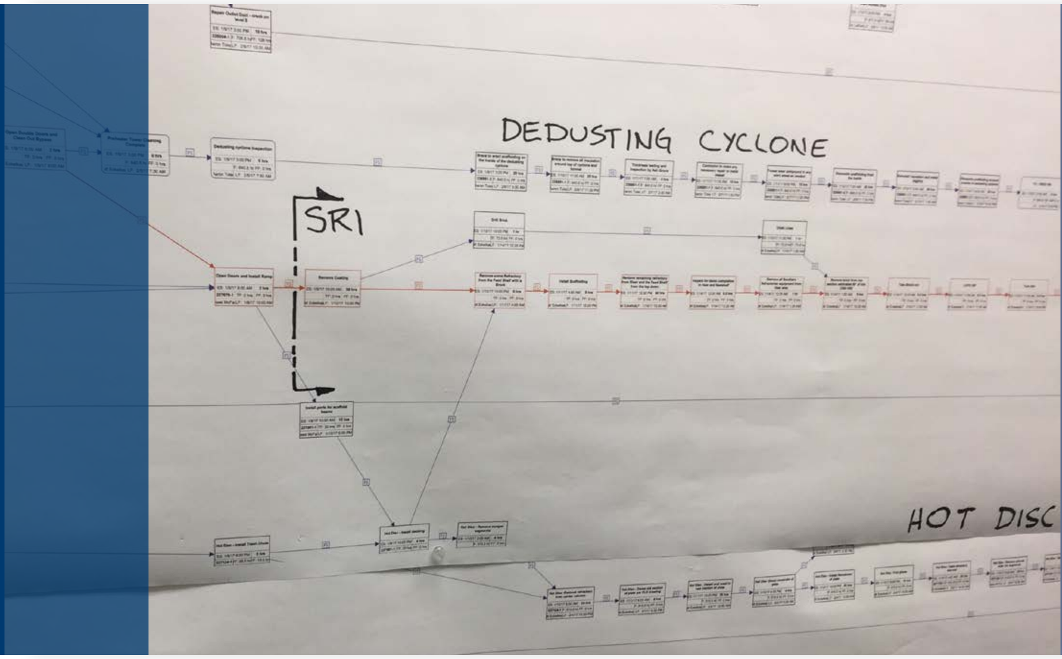
A conceptual hurdle to overcome was the notion that a late-completing activity had a negative impact on the overall schedule. Previously, planners and work package leaders operated under the assumption that a late activity made for a late schedule. Consequently, valuable time was lost during schedule review meetings to develop workarounds and schedule adjustments that often were not necessary. As the short planning phase unfolded, critical path methods became more understood when planners and work package leaders accepted the fact that late activity completion was, for the most part, acceptable and not detrimental to outage completion.

USC also worked closely with the outage manager to transition the outage plan into a robust and executable schedule. In previous outages, each operating entity planned and executed their own outages within the time and budget constraints set by management. This led to loss of visibility for resources and equipment needs and the ability to reconcile and coordinate resource and equipment conflicts.

Integrating the disparate plans provided
two distinct benefits:

1. **A single critical path that dictated the pace of outage execution**
2. **Resolution of contending resources and equipment through pooling them in the single plan**

The more time planners and work package leaders spend in schedule review meetings, the less time they have to monitor and follow-up on activity completion. To maximize engagement and minimize meeting time, USC deployed a two-prong approach to twice-daily schedule review meetings – time box the meetings by formal agendas, and visually focus attention on narrow topic areas. Introduction of a formal agenda set expectations for meeting participants as well as demonstrated what parts of the meeting were owned by whom and set a time frame for discussion. Visual focus was driven by the use of whiteboards – one per shift, to identify potential issues that may arise and identify what is to be accomplished by the next shift.



Focus Topics Included:

Safety – near misses, blocked access, high-risk activities, and lock out-tag out issues

Schedule – activities affecting the critical path, constraints to the outage plan, constraints posed by support equipment

Job issues – resource risks and constraints, major impacts or found work

Next shift – major tasks, critical path and plan, housekeeping

Narrow focus and a structured agenda enabled the various teams to identify, and more importantly, anticipate any issues that may arise in the upcoming shift. A critical path precedence network combined with a robust outage plan and a disciplined reporting and follow-up structure enabled the client to be forward looking and forward thinking in relation to outage progression. Schedule review meetings were centered on issue identification, not on resolution.

A schedule is only as good as the reality it reflects. Is the outage schedule timely and realistic? Does the schedule accurately portray the status of project activities? USC worked side by side with the client to gather outage progress and return updated schedules to the outage planners and work package leaders. Over 57,000 hours of work was scheduled for the outage, yet the frequency of updates ensured schedules were no more than one half shift old. A poorly maintained schedule will not match the reality on the plant floor and with that, confidence is quickly lost in the schedule update process as well as in overall outage progress.

Post Mortem

Upon outage completion, an essential and concluding part of USC's Critical Path Methodology is to conduct a post mortem review with the client.

The post mortem has two key aspects:

1. **Engage all stakeholders to review lessons learned from objective setting to planning and through to outage completion. Identify what went well, what needs improvement, and what should be done better or different for the next outage**
2. **Review inspection results to determine if maintenance repairs should be performed in the next outage. These inspection results also assist in budget formulation for the next outage**

The maintenance outage post mortem also sets the stage for planning the next outage. The heavy lifting of detailed planning for the plant-wide outage is performed once as this becomes the baseline for subsequent outages. Depending on maintenance cycles and inspection results, some activities may be made inactive while new ones created. The process and methodology is cyclic, and with each new outage, the plan is refined, additional experience gained, and efficiency and effectiveness improved.

Did the client return to production on time and on plan?

Unfortunately, no. Gaps in the work identification process prior to shut planning led to unforeseen found work extending the critical path, causing an extension of the outage. Sometimes, outages turn out this way. However, tremendous insight was gained by the client:

- The entire process is repeatable. The client deployed the same planning, execution, and follow-up methods for a subsequent smaller outage and was back on line according to plan.
- A thorough review of the plan will be undertaken to identify potential time savings. The process is in place, the client's understanding of critical path methods will enable planners to properly sequence activities by asking the same basic questions: what must be complete before this activity can start, what resources are required, and what is a reasonable expectation for completion of this activity?
- Implementation of USC's Critical Path Methodology instilled confidence in the client to understand critical path methods and how this can be a predictive tool. When the found work was identified and planned, the client knew *to the hour* when the smelter would be back on line. This in turn, provided the necessary confidence by its parent – the plant is still in operation today.

Critical Path Methodology is not unique to maintenance outages or exclusive to USC. The value comes through the experience and refinement USC has gleaned over years of successful outage managements. Specializing in not only the development and creation of the project schedule and critical path, but also the boots-on-the-ground approach to ensuring project completion. Critical Path Methodology can be applied to brownfield expansion, facility buildout and transformation, aircraft conversion, as well as equipment installation for public & municipal utilities. Any business experiencing rapid growth, marketing products sold as projects, under-going plant consolidation or in-sourcing, all are prime candidates for applying USC's approach to Critical Path Methodology.