
COMMERCIAL ANALOGS TO THE RCOH PROCESS

In this report, we emphasize the differences between new construction and overhaul. Such differences are not restricted to aircraft carriers. The private industrial sector must also overhaul large capital assets. The goals and challenges of such overhauls are in many ways similar to those involved in carrier RCOHs. In this appendix, we examine the shutdown, outage, and overhaul practices in the process and power industries.

BACKGROUND

The chemical, refining, and power-generation industries all employ multimillion-dollar facilities and assets to conduct their business. These facilities, while designed to last 25 to 30 years, require constant maintenance and upkeep. Furthermore, many plant owners seek to extend the lives of their assets beyond this initial design life to improve their margins by minimizing capital expenditures. Every few years, therefore, these facilities must be shut down for major overhaul and improvement work, known as a “turnaround” in the process industries. The objective of these turnarounds is to revitalize, maintain, and improve the facilities. Often, turnaround activities are performed under enormous time pressures, since downtime means no revenue.

The scope of work for a turnaround can vary considerably and depends on the age and type of facility. Activities performed during a turnaround include cleaning and fixing equipment, replacing pipe and wiring, upgrading equipment and instrumentation, replacing obsolete equipment, retraying columns, repacking/replacing cata-

lysts, moving equipment, replacing valves, and repairing corrosion damage.

Turnaround projects are high-risk activities and are among the most difficult in the process industries to execute on time, on budget, and with good operability.

DIFFERENCES BETWEEN NEW CAPITAL CONSTRUCTION AND TURNAROUNDS

Probably the most distinctive aspect of turnaround work is the fact that its scope remains somewhat uncertain until the actual execution activities begin. No matter the level of inspection, testing, and assessment completed beforehand, the status of certain vessels, piping, equipment, etc., cannot be determined until the item is actually opened and inspected, which can be done only when the plant is shut down. This lack of complete definition forces the owner to take a greater risk with respect to scope growth and to contend with the highly onerous management of change problems. For the construction of new facilities, the scope can be well established in advance.

The quality of the scope package for a turnaround depends heavily on the extent and completeness of good operation records and information. Without a good operating history and analysis, work will remain vague and uncertain. For new capital construction, the quality of the scope package is more dependent on the thoroughness of engineering and the consistency of priorities and strategic objectives.

Several aspects of execution differentiate turnarounds from new capital construction:

- Turnaround projects run at much faster pace than new construction. This pace is driven by the owner's need to get the plant or facility back online. As a result, a turnaround team must be able to make decisions and answer technical questions quickly. Failure to do so risks delaying work, reducing productivity, and increasing costs.
- Workforce loading is far more constrained in turnarounds than in new construction. "Throwing" labor at a turnaround delay may not mitigate a schedule impact.

- The work during a turnaround takes place within and near operational systems. One impact of this work environment is a simple constraint on open space to work. In addition, the proximity to live systems imposes stringent safety requirements and procedures.
- Turnaround work must be coordinated with other experts and stakeholders, which usually is not necessary in new construction. Management of new capital construction projects is a relatively straightforward process. Each stage (and gate) can be well controlled and planned. The engineering organization is clearly in charge. For a turnaround, the process is much more dynamic. Issues must be revisited, and different areas may be at dissimilar stages of progress. There are also many more active stakeholders during a turnaround: operations, maintenance, engineering, construction, safety, etc. Despite having differing roles and tasks, each of these organizations is dependent on the others to complete its work. For example, when configuration discrepancies arise, multiple organizations might be needed to resolve the issue. A well-integrated, empowered, and cohesive team is far more critical for a successful turnaround than for a successful new construction project.
- Contractors who are familiar with new construction are often unprepared for the additional burden of turnarounds and the resultant hit on labor efficiency. For example, the contractor does not determine the schedule, as he does for new construction projects; rather, the owner does. Often, the owner gives the contractor windows of time during which work can be accomplished. Also, some contractor activities differ from those associated with new construction. Such differences are particularly evident during the preturnaround period, when tagging, cleaning, and draining must be done. However, they also apply during startup and commissioning.

Similarities Between a Carrier Overhaul and a Turnaround

Clearly, there are many similarities between an aircraft-carrier RCOH and a plant turnaround. Table C.1 shows qualitative comparisons between RCOHs and turnarounds, by major attributes.

Table C.1
Comparison of Commercial Plant Turnarounds and RCOHs

Attribute	Turnaround	RCOH
Uncertain work scope	Full scope is often unclear until the unit/plant is shut down, cleared, and opened. Quality of scope is heavily dependent on recordkeeping, maintenance logs, and operating experience.	Conditions of many tanks, voids, and other inaccessible areas are uncertain. The condition of the ship evolves while it is deployed.
Faster pace/greater time pressure	Owner pressure to get facility running and generating revenue. Need for timely decisionmaking when issues arise, to avoid delays.	Because TYCOM needs to have operational carriers in the fleet to meet deployment needs, meeting finish dates is important for an RCOH. Shipyard facilities are restricted to one overhaul at a time. Need for timely decisionmaking when issues arise, to avoid delays.
Working within operating environment	Additional policies and procedures result in lower productivity.	Ship with active systems and crew working onboard during RCOH increases difficulty.
Multiple stakeholders	Engineering, operations, maintenance, safety, construction, etc.	TYCOM, ship's force, PMS312, SUPSHIP NN, NNS, SEA08, etc.
Multiple workforces	Contractor and owner maintenance groups each have labor responsibilities—and potential for interference. A high degree of coordination and scheduling is necessary.	NNS, subcontractors, and ship's force each have their own work scope. Close coordination and planning are required to minimize interference.
Less contractor experience with work	Contractor is more familiar with new-construction methods. Work is done in limited or confined areas.	NNS policy, organizational structure, workforce, and procedures are geared toward new construction. Work access is limited compared with new construction.

Differences Between an RCOH and a Turnaround

While there are similarities between an aircraft-carrier RCOH and a plant turnaround, there are also some important differences:¹

¹Another important difference is in maintenance record-keeping. Commercial firms work at keeping complete, comprehensive, and accurate maintenance records. While the Navy has extensive record-keeping processes, the records are not necessarily well

- *Cost.* Process plant turnarounds are typically orders of magnitude smaller than an RCOH (in the millions of dollars, not billions). In fact, very few *new* capital investments approach the size of an RCOH.
- *Personnel.* The Navy has a much higher frequency of routine personnel turnover. This makes preserving institutional knowledge and continuity on programs very difficult. In the commercial world, the turnover is much less frequent and is managed.
- *Organization.* While commercial institutions and the Navy have multiple stakeholders to coordinate, the Navy has many more organizations involved in an RCOH than there are stakeholders in a commercial turnaround.
- *Funding.* Funding of a commercial turnaround tends to be stable once approved. For an RCOH, funding is continually in flux. In the USS *Nimitz* RCOH, shortfalls in funding contributed to cost growth.

TURNAROUND WORK PROCESS

Because of the significant differences between new capital construction and turnarounds, most owner organizations undertake the two activities very differently. First, successful firms have recognized the importance of good record-keeping and historical information in helping to define work scope for turnarounds. This information covers a wide spectrum: maintenance records, operations records, inspection records, and reliability assessments.

Second, firms have implemented separate work processes for the two activities. In the following, we highlight some important features of turnaround work processes.

maintained, complete, and standardized. Furthermore, maintenance records for a ship are not centralized. All these factors make it difficult to determine the material condition of a ship. However, an evaluation of the record-keeping process is beyond the scope of this study. Further research in this area is warranted.

Scope and Change Control

Because of the uncertainty in the work scope, industries executing turnaround projects expect to have a significant amount of unplanned work (called “discovery work”). There are two distinct phases to scope and change control: before and after the scope is frozen. The scope freeze date is the point where the scope of work for the turnaround is fixed. Typically, there are two such dates on any turnaround. The date for freezing modernization work occurs much sooner (about 18 months prior to the turnaround), since it is an engineering-intensive activity. The other maintenance and overhaul work is frozen about three to six months before the start of the turnaround.

When discovery work is found, specific criteria are used to determine whether to include the work within the turnaround scope. Prior to the scope freeze date(s), the criteria are more general and focus on meeting business needs. Such criteria include

- Meets strategic objectives.
- Meets regulatory requirements.
- Demonstrates a return on investment or net present value above threshold.

After the scope freeze date(s), the criteria become much more restrictive. They focus primarily on work that must be done, i.e., work that is important for startup and for safety.

To a lesser extent, additions for reliability reasons may be considered afterwards, although these items are typically rejected. The scope additions for reliability reasons are evaluated on criteria such as

- Necessary to make it to the next maintenance event.
- Delaying causes the next maintenance event to become too large.

Responsibility for scope and change control is distributed through the program organization and is allocated based on cost and schedule thresholds. The smaller the impact, the lower the ability to manage the change resides in the project organization. At the lower

levels, the contractor has responsibility for managing scope and change, subject to monitoring by the owner.

Cost and Schedule Control

The fast pace of the turnaround dictates timely and robust cost and schedule control. Reports/updates are typically done on a weekly basis, with some firms controlling on a daily basis. The reports are at a high level (total hours, total materials, total cost), focusing on progress made. For larger turnarounds, the reporting might be subdivided into key areas. The emphasis is on project status, not on detailed cost reporting.

Work Definition and Inspection

All the stakeholders are responsible for identifying work scope for a turnaround. Typically, the turnaround manager sends a notification of the impending turnaround to engineering, operations, maintenance, and inspections departments. Each of these departments submits its desired scope. A committee or team then selects work for the turnaround based on the criteria described above.

Some firms use a more sophisticated approach to identifying turnaround (and general maintenance and overhaul) scope. Rather than soliciting scope in a discrete event, the process happens on a continual basis. That is, work is being continually identified for inclusion in maintenance and overhaul activities. Work items are assigned to a specific maintenance event (not necessarily a turnaround). Thus, a plant or facility may have a dynamic list of work encompassing several maintenance events. When it is time to plan the work for the turnaround, most of the work scope should already exist.

Inspections are done on an ongoing basis at most facilities. However, each piece of significant equipment involved in turnaround work is field-verified beforehand. The objective of this verification activity is to find discrepancies between the facility drawings and what exists in the field. Examples of aspects covered by such inspections are item manufacturer, model, location, configuration, and state.

Detailed Scheduling

Scheduling work for turnarounds goes to a much lower level of detail than might be the case for new capital construction. The goal is to make the work as efficient as possible by eliminating redundant work or combining work packages. For example, one might need to use a temporary scaffold to work on a particular item. If two items with similar scaffold requirements are collocated, it is more efficient to put the scaffold up once and do the work on both systems together than it is to put up the scaffold twice. Similarly, work in areas with specific safety or permit issues is often combined to reduce administrative burden.

METRICS OF THE WORK PROCESS

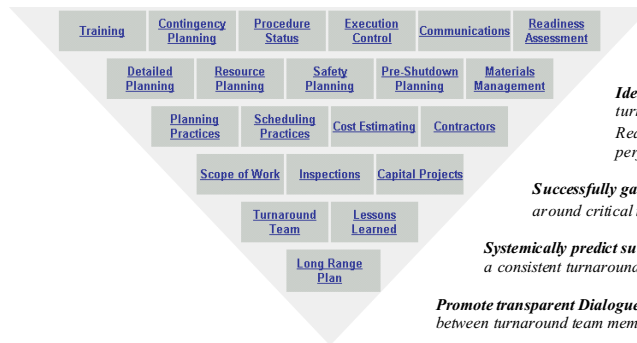
In the same way that turnaround outcomes can be measured (e.g., by cost growth and schedule slippage), the work process for a turnaround can also be measured and assessed. Within the commercial industry, owners use assessment tools of the work process to improve their turnaround planning and performance. Such assessment tools have been developed and are commercially available. Figure C.1 shows a high-level example of one such assessment tool developed by AP-Networks.² The assessment of turnarounds focuses on 21 strategic areas—moving from fundamental issues at the bottom row of the pyramid to very program-specific, detailed, or unique issues at the top row. Each element of the pyramid indicates the gap between the current state of readiness of a particular turnaround and what is considered “best practice.” In addition, the tool also accounts for the time-sensitive nature of the best-practice level, since the level of definition one year prior to the turnaround start should be distinctly different from that one month prior to start.

²The Turnaround Readiness Pyramid is the intellectual property of Asset Performance Networks, LLC (AP-Networks), which reserves all ownership and copyrights. It is included in this report with the permission of AP-Networks. AP-Networks, headquartered in Gaithersburg, Maryland, is a knowledge-management and best-practices firm focusing on improving project and turnaround performance in the processing industry.

The Turnaround Readiness Pyramid



Execute The Right Turnaround Right



Effectively evaluate Readiness for your turnaround at any point during the turnaround process.

Identify gaps between your turnaround's degree of Readiness and world-class performance measures.

Successfully gauge team alignment around critical turnaround issues.

Systemically predict successes and failures with a consistent turnaround evaluation method.

Promote transparent Dialogue and communications between turnaround team members and stake-holders.

A color version of the pyramid would color-code the rectangles in green, yellow, or red to provide a comprehensive overview of a team's preparedness and effectively measure readiness and alignment across various functional and geographic boundaries..

Figure C.1—An Illustrative Assessment Tool: AP-Network's Readiness Assessment Pyramid for Turnarounds

SUMMARY

Although an aircraft carrier RCOH has some unique aspects, there are many similarities between an RCOH and a process plant turnaround. Commercial industry has established a set of best practices and measurement tools that help to achieve better performance in these projects. The U.S. Navy would do well to adapt some of these ideas and methods to help improve its execution of aircraft-carrier RCOHs.