Benchmarking and Optimizing Maintenance Work Scope for Turnarounds

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Abstract

The refining industry has struggled to execute large, highly complex turnarounds on budget and on schedule. Our data indicate that more than two-thirds of turnarounds exceed their planned cost and schedule by 10 percent or have a trip after startup. Forty percent of turnarounds experience a cost overrun or schedule delay of more than 30 percent.

The turnaround work scope is the most critical item related to performance outcomes, as it is the foundation for cost, schedule, and plant reliability. Minimizing the amount of scope and the level of scope growth during the turnaround execution window is the primary driver of competiveness.

This paper discusses the challenges to scope control, describes a methodology for benchmarking scope, and illustrates how this methodology can be used to benchmark scope and provide early and reliable forecasts of labor hours and costs.

1. Introduction

Turnarounds are critical to the bottom-line of refinery and chemical companies. Turnarounds are sometimes referred to as shutdowns or outages and are the periodic planned shutdown of a facility to perform maintenance work and install new capital projects. These can be major events involving more than a million labor hours and impact a company's profitability through the cost of the event, the lost revenue due to the plant being offline, and potential harm to plant reliability if the turnaround is performed poorly. Turnarounds also entail significant safety and environmental risks.

The refining industry has struggled to execute large, highly complex turnarounds on budget and on schedule. Our data indicate that more than two-thirds of turnarounds exceed their planned cost and schedule by 10 percent or have a trip after startup. Forty percent of turnarounds experience a cost overrun or schedule delay of more than 30 percent. The causes of these overruns are numerous, but generally fall into the following categories:

- Poor scope control prior to the shutdown as significant work is added after the budget is developed
- High rates of added scope or "discovery" during the shutdown
- Poor planning and preparation prior to the shutdown
- Unrealistic cost and schedule targets: Planned turnaround duration and cost targets are often established by the business far in advance of the turnaround, and are not related to the scope that actually has to be implemented. Turnaround teams have no choice but to live with these targets, realizing that there is little chance of success.

The turnaround work scope is the most critical item related to performance outcomes, as it is the foundation for cost, schedule, and plant reliability. Minimizing the amount of scope and the level of scope growth during the turnaround execution window is the primary driver of competiveness. Yet, despite the importance of turnaround scope, there has historically been a critical hole in our collective toolset: How do we effectively benchmark and evaluate turnaround scope? There has not been an objective, quantifiable measure of scope that can help us answer this question—until now.

In this paper, we will discuss the challenges to scope control, describe a methodology for benchmarking scope, and illustrate how this methodology can be used to benchmark scope and provide early and reliable forecasts of labor hours and costs.

2. Scope Optimization

Optimizing scope selection helps companies reduce spending by minimizing the scope, keeping scope at manageable levels, and enabling more effective turnaround execution by eliminating the typical Industry scope "churn" (or recycle). In order to realize these benefits and ensure more effective use of maintenance funds, Industry has developed tools to optimize scope selection and to minimize turnaround scope. Risk Based Scope Reviews (RBSR), for example, provide a systematic approach to economically justifying or challenging discretionary scope items.

While these tools have proven effective—teams can realize substantial savings by reducing turnaround scope up to 30 percent (or more) through the application of an RBSR—Industry as a whole struggles to achieve scope freeze and to maintain scope discipline. Based on the AP-Networks Turnaround Database, an Industry database of over 1,350 turnaround observations, Industry average scope growth from scope freeze to execution is 19 percent. By contrast, top quartile performers experience growth of only 7 percent (see Figure 1). This gap tells us that there is more we can be doing as an Industry to optimize turnaround scope.

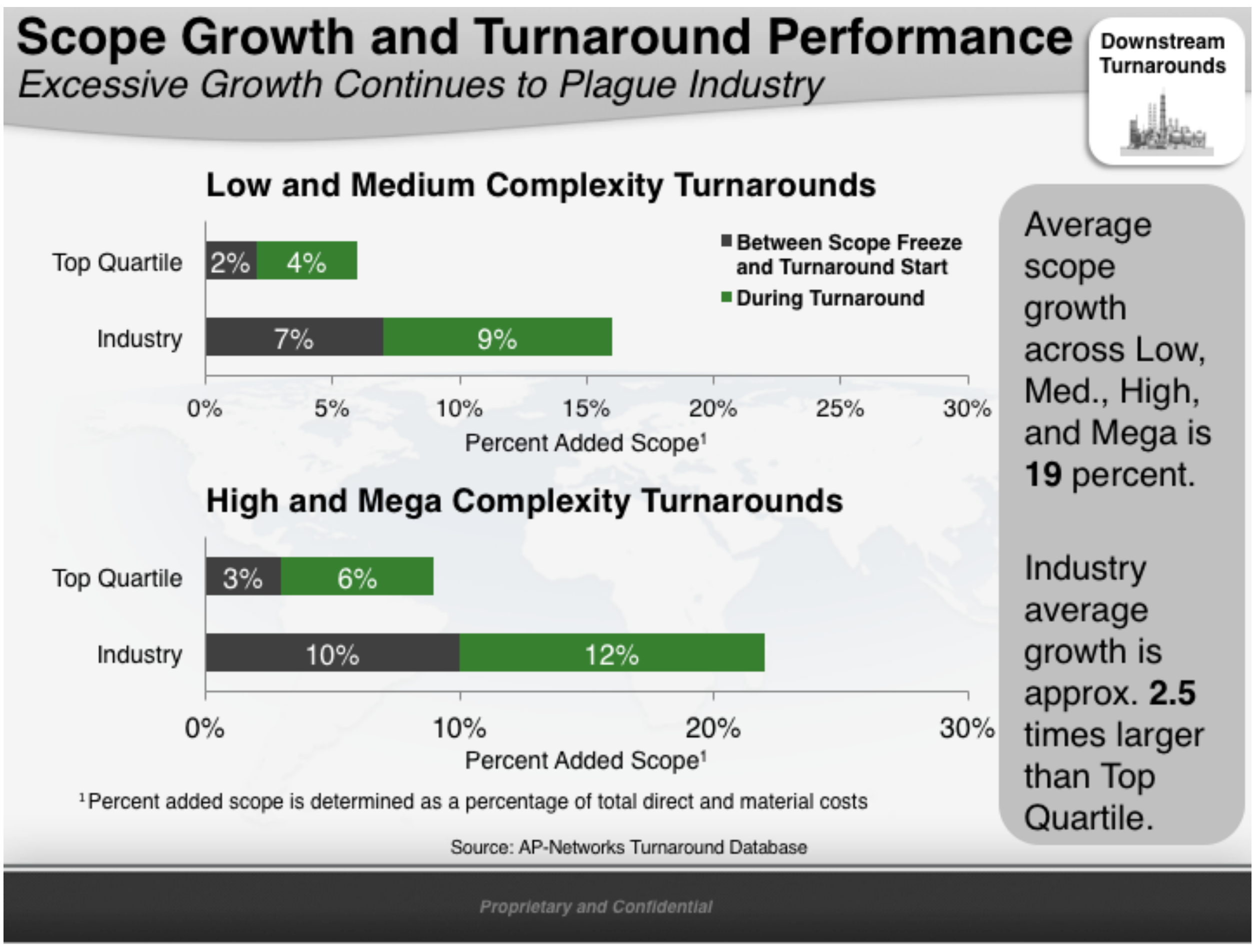


Figure 1

While an RBSR provides significant benefits, taking the subjectivity out of scope selection still presents a challenge. Applying RBSR and other similar scope challenge tools requires reliability and integrity data, as well as historical data on scope and outcomes, to forecast equipment and asset conditions. These tools also require in-depth analysis, and are time consuming and labor intensive to apply due to the need for multiple stakeholders to contribute to the analysis. While the effort in applying these tools is rewarded, the interpretation of the data is still somewhat subjective.

The Turnaround Scope Index (TSI) complements the RBSR and provides a quantitative means to validate scope selection, thereby removing the subjectivity that has historically plagued scope challenge methodologies. The TSI empirically quantifies the amount of turnaround scope, and enables the benchmarking of scope relative to comparable Industry events. It allows Industry to look at scope objectively, and to compare scope against Industry norms. For example, the TSI allows a team to understand if they have more or less mechanical scope (in terms of pieces of equipment) than their peers, and if they have established reasonably competitive estimates for the labor hours necessary to execute this mechanical scope.

3. Developing the Turnaround Scope Index Model

The AP-Networks Turnaround Database, referenced earlier, comprises more than 1,350 turnaround observations covering turnarounds from the onshore and offshore upstream, gas processing, refining, chemicals, and power generation industries. When considering the complexity of the turnarounds represented in the database in terms of the number of labor hours, the amount of capital executed during the event, and the interval between turnarounds, over 60 percent of the turnarounds are High to Mega Complexity events (measured on a scale of Low, Medium, High, and Mega Complexity). Of course, many of these larger events span multiple units.

The database has information on inherent turnaround characteristics, turnaround planning and preparation practices, and turnaround outcomes. Inherent turnaround characteristics described in the database are unit type, unit capacity, time between turnarounds, and equipment count by type opened, inspected, and repaired. The database also includes information on estimated and actual labor hours, costs, and schedule by unit and by overall turnaround event. AP-Networks used this database to develop the Scope Index Model. This model is applicable to typical refinery units, as well as many chemical processes.

As shown in Figure 2, there are two components of benchmarking turnaround scope: the Scope Index Model and the Direct Field Labor Hour (DFL) Model.

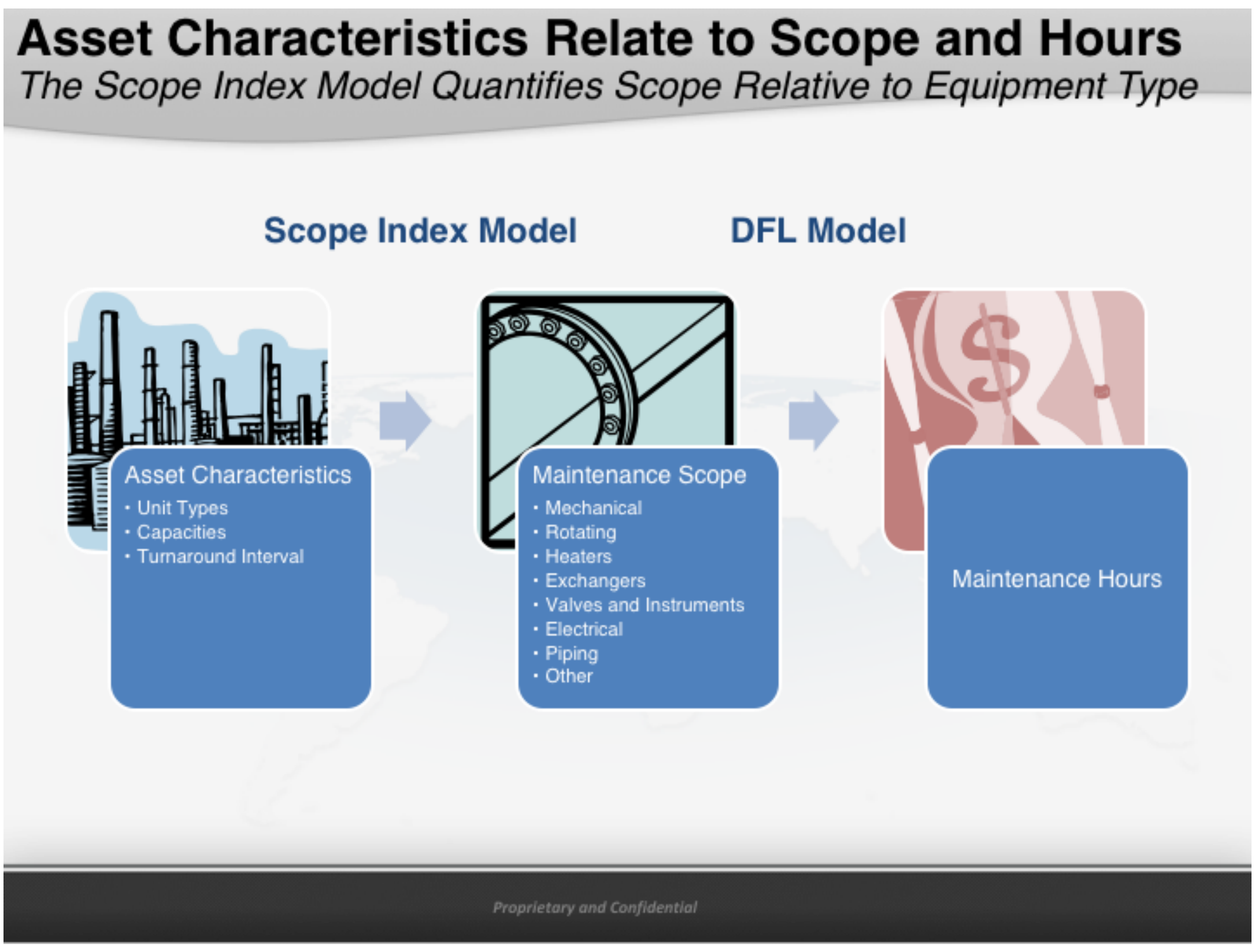


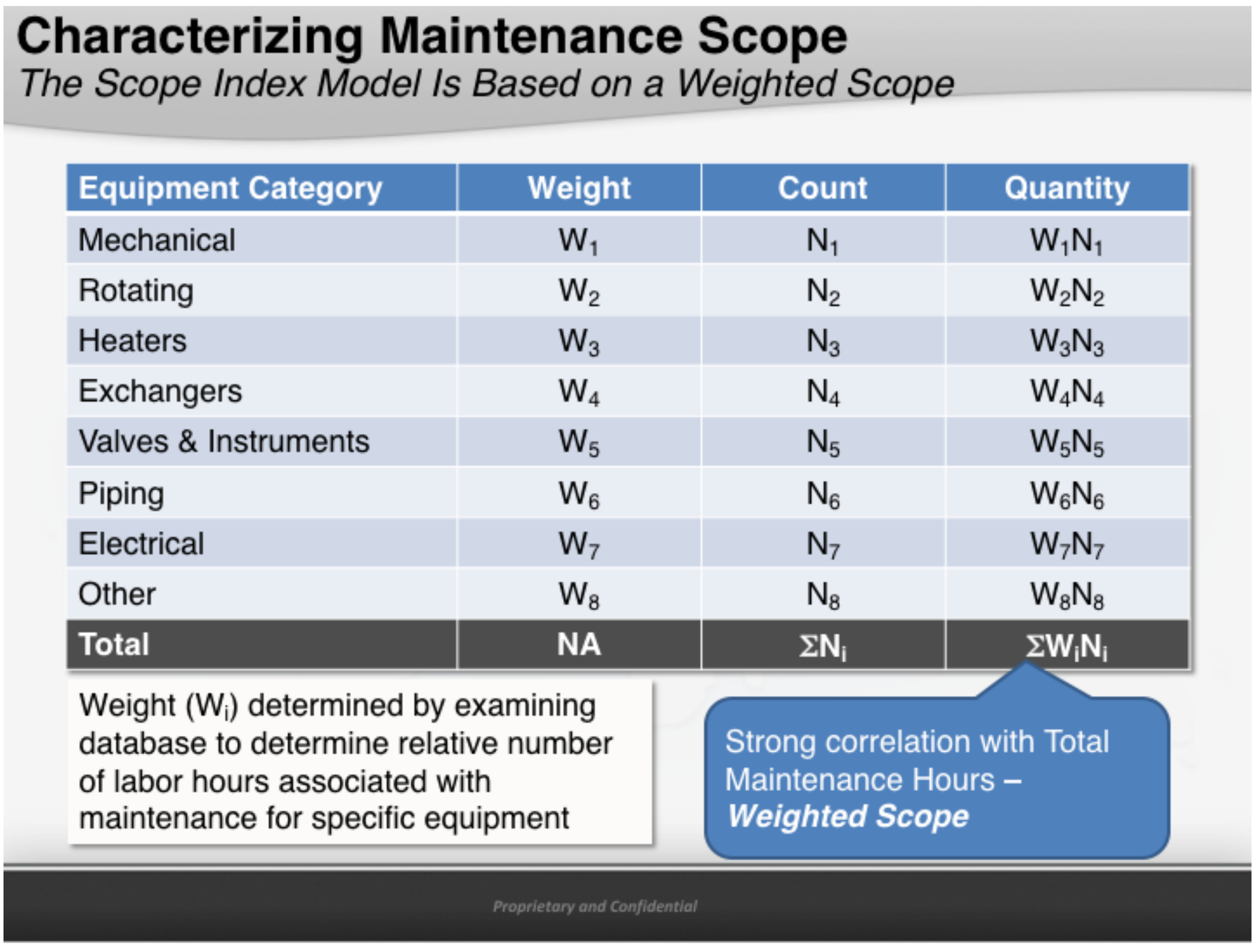
Figure 2

The Scope Index Model relates asset characteristics—unit types, unit capacities, and turnaround interval—to the maintenance scope in terms of number of pieces of equipment by type opened, inspected, and repaired. The DFL Model relates the maintenance scope to the maintenance labor hours. Together, these models allow us to benchmark:

- Scope relative to turnarounds for comparable assets
- Labor hours relative to turnarounds with similar amounts of scope
- Labor hours relative to turnarounds for comparable assets

These empirical measures allow companies to understand how much mechanical scope they have relative to their peers, how their estimated labor hours compare to those for similar assets, and if their estimated labor hours are reasonable for the amount of scope.

A weighted function, illustrated in Figure 3, is used to quantify the amount of scope of a turnaround.



Equipment Category	Weight	Count	Quantity
Mechanical	W_1	N_1	W_1N_1
Rotating	W_2	N_2	W_2N_2
Heaters	W_3	N_3	W_3N_3
Exchangers	W_4	N_4	W_4N_4
Valves & Instruments	W_5	N_5	W_5N_5
Piping	W_6	N_6	W_6N_6
Electrical	W_7	N_7	W_7N_7
Other	W_8	N_8	W_8N_8
Total	**NA**	ΣN_i	ΣW_iN_i

Figure 3

Individual weights for pieces of equipment were determined by examining the AP-Networks Turnaround Database to ascertain the relative number of labor hours associated with maintenance for specific types of equipment. The overall Weighted Scope of a turnaround (or unit within a turnaround) is determined by summing the weights multiplied by counts for each type of equipment or work package. We have validated that this Weighted Scope has a very strong correlation with total maintenance hours.

The Turnaround Scope Index (TSI) is defined as the actual or planned Weighted Scope for a turnaround divided by the Industry average Weighted Scope for a similar turnaround based on the asset characteristics. An Industry average Weighted Scope is determined from a regression model based on capacities, unit types, and turnaround interval. Nelson-Farrar complexity factors are used to compare different units to each other. There is less than a 0.1 percent chance that each of the variables in the model are not correlated with the Weighted Scope, and the model explains 65 percent of the variance in the data. After determining the Industry average Weighted Scope, it is possible to consider the counts by equipment type.

The DFL Index is defined as the actual or planned direct field labor hours for a turnaround divided by the Industry average direct field labor hours. The Industry average direct field labor hours are determined from the DFL Model, which is a regression relative to Weighted Scope and capacities of the units. As with the Scope Index Model, there is less than a 0.1 percent chance that each of the variables in the DFL Model are not correlated with the labor hours. The model explains 68 percent of the variance in the data. The model can be used to benchmark DFL relative to the planned scope of the turnaround or relative to the Industry average scope for a similar turnaround.

The Turnaround Scope Index (TSI) and DFL Index provide the ability to objectively evaluate your turnaround scope against that of similar Industry turnarounds. These benchmarks can answer important questions regarding the risk and competitiveness of your event, such as:

- Does your turnaround have more or less scope than turnarounds from comparable units?
- Given your scope, what is the Industry average and range for direct field labor hours?
- Are you estimating more or less direct field labor hours than average given the scope?
- What is the Industry cost and range given the types of units involved?

Case Study

Consider a turnaround for a 30,000 BPD FCC and an 8,000 BPD Alky. The team has developed a work list of 960 items, of which 57 are fixed equipment and 17 are rotating equipment. The team estimates that it will require 300,000 labor hours to complete this work. AP-Networks calculates a Weighted Scope for the event, and then applies the Scope Index Model to determine the Industry average Weighted Scope for a 30,000 BPD FCC and an 8,000 BPD Alky. As illustrated in Figure 4, we can then determine that the TSI for this event is almost 20 percent higher than the norm, and that the mechanical equipment count is high, whereas the rotating equipment count is low.

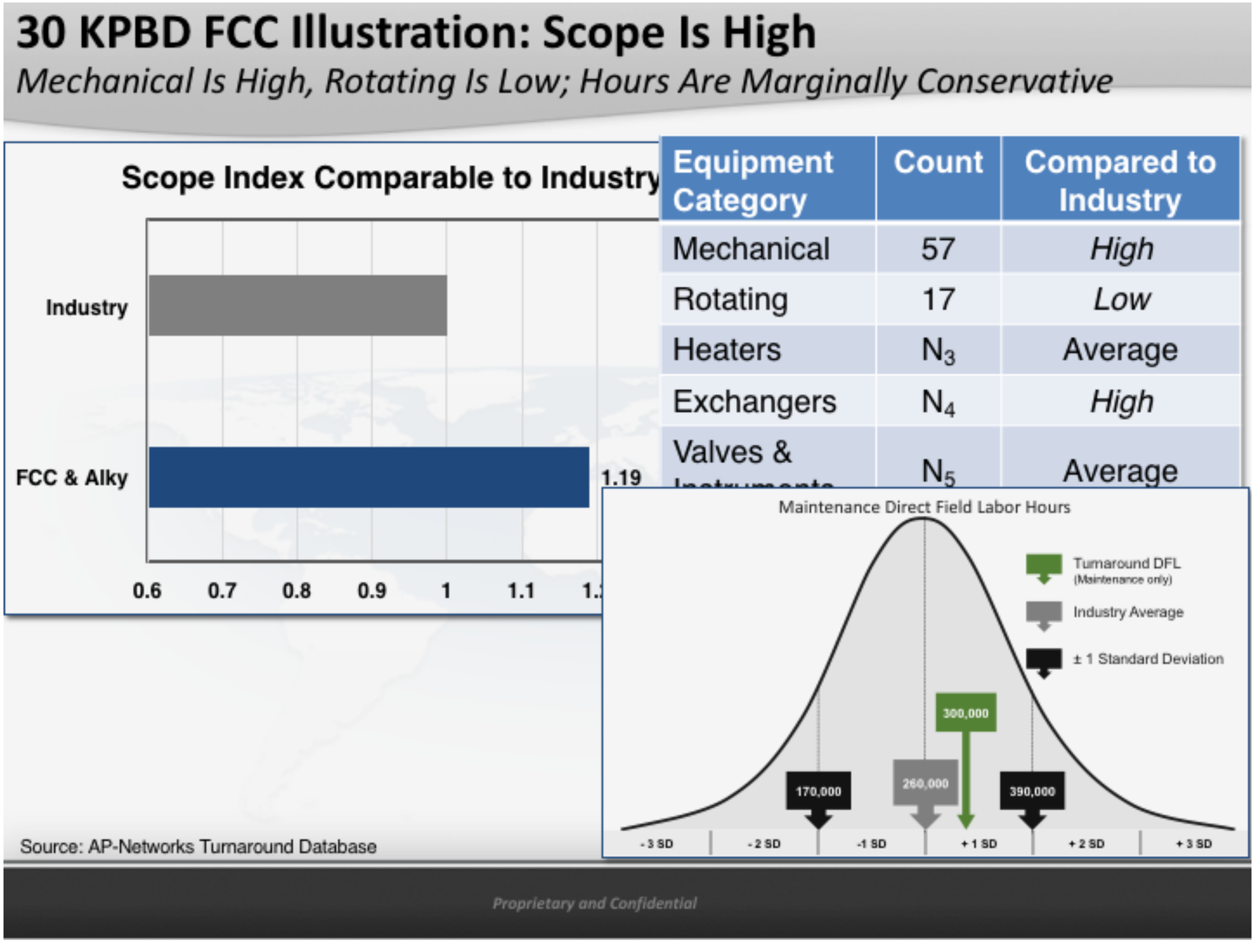


Figure 4

Moreover, as illustrated in Figure 4, we can apply the DFL Model to determine that the estimated DFL is comparable to turnarounds executing similar amounts of scope.

4. Conclusions

We can apply the Turnaround Scope Index and DFL Index to determine how big an impact scope optimization has on turnarounds. Figure 5 shows cost, schedule, and scope predictability for turnarounds that planned less scope than the Industry norm relative to turnarounds that planned more scope than the Industry norm.

The data expressed in this chart demonstrates that well-planned events that establish more competitive scope targets are not subject to more scope growth. In addition, Figure 5 shows actual labor hours relative to Industry average labor hours (i.e., the DFL Index) for similar units for turnarounds with less scope than the Industry norm and for turnarounds with more scope than the Industry norm. The "scope-optimized" turnarounds required 30 percent fewer labor hours than those with more scope.

With the Turnaround Scope Index, AP-Networks has developed a methodology to benchmark the scope of a turnaround relative to Industry norms. This approach complements the RBSR by empirically validating the effectiveness of scope optimization. Moreover, this benchmark enables teams to understand if their turnaround planning and preparation have driven more competitive turnaround outcomes.

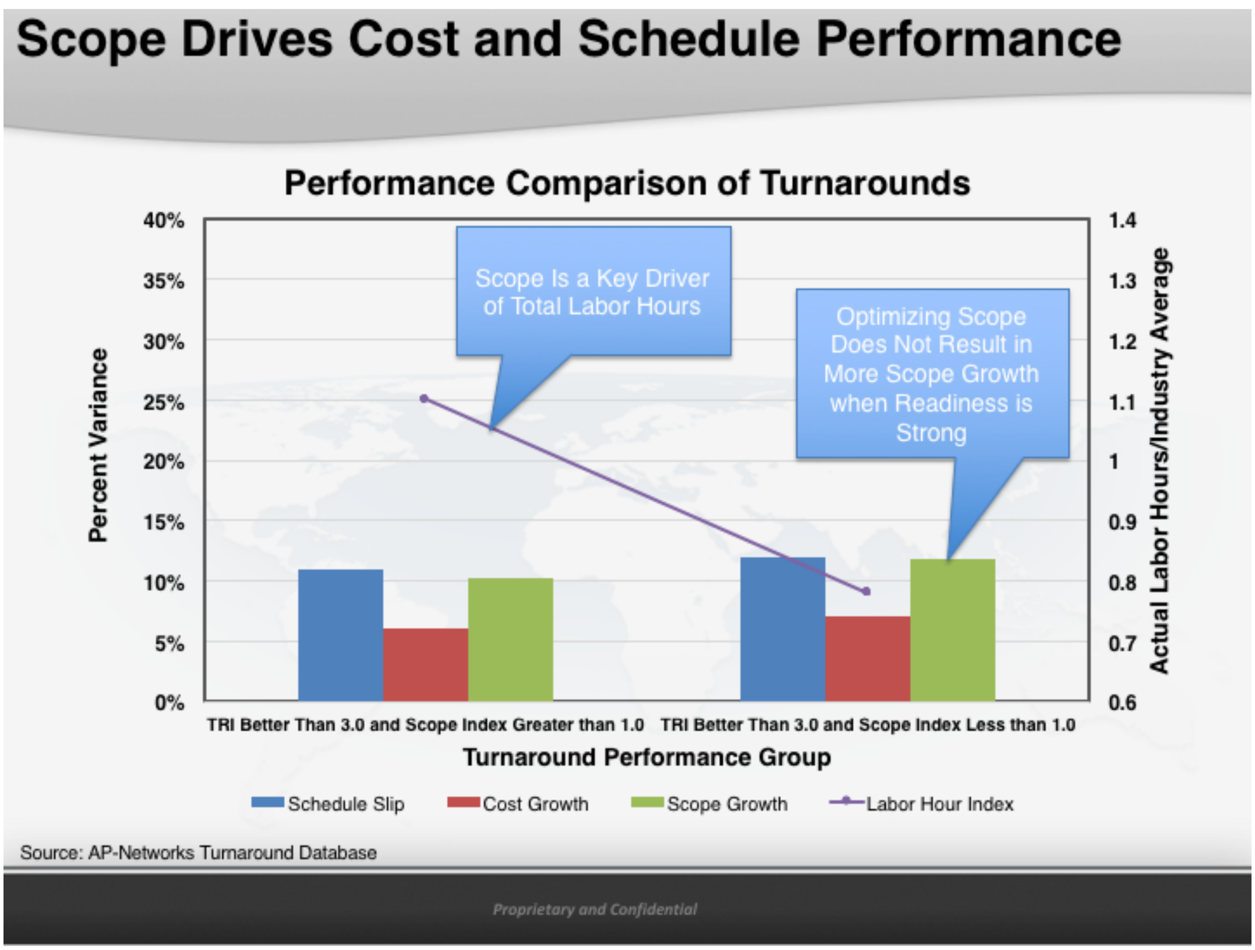


Figure 5

Our results demonstrate that companies can substantially improve turnaround performance and realize cost savings through efforts to optimize scope. Moreover, the Turnaround Scope Index and DFL Index will help teams empirically and quantitatively demonstrate these savings.

The Turnaround Scope Index fills a long-standing knowledge gap and puts a powerful new tool in the hands of Industry. By finally removing subjectivity from scope challenge and selection, companies can effectively optimize scope, and see concrete evidence of how their results compare to Industry average and top quartile measures.