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"Focus & Finish" Work Management, Not High Resource Utilization: A Paradoxical Way to Increase Speed and Throughput in Shipyards

ABSTRACT

This paper outlines a work management method that can reduce Turnaround Times (TAT) for Availabilities for NAVSEA by 15% to 20%, and free up enough capacity to execute one-and-a-half more Availabilities[1] every year[2]. It is already used successfully in NAVAIR for aircraft MRO as well as in the industry for other complex and multi-year projects.

Given the shortfall in size and readiness of the US naval fleet, public and private shipyards can use the above improvements to make a significant impact on Fleet Operational Availability by improving on-time delivery, reducing deferred maintenance, and retrofitting old vessels.

The proposed work management method differs from traditional methods in that it emphasizes "Focus & Finish" rather than "High Resource Utilization" even if resources have deliberately stay idle for some of the time. As paradoxical as it sounds, not focusing on resource utilization not only reduces TAT but also increases shipyard throughput because it:

1. Reduces waiting time for downstream resources
2. Improves synchronization among highly interdependent activities, especially among different trades and functions.
3. Prevents bow-waves of work and the delays and inefficiencies caused by those peaks and valleys, especially at integration points.

Focus & Finish Work Management also leverages many of the Lean practices that many shipyards already use, e.g., Full Kitting (don't start work without all inputs being available) and WIP Limits (limit the amount of work on the deck plate based on resource constraints).

While Focus & Finish Work Management can be implemented swiftly, it does require changing how projects are planned, and how project progress and resource efficiency are measured.

INTRODUCTION

US Navy's current fleet of 273 is the smallest since 1916. In about a decade, our fleet of attack submarines will shrink, reflecting decisions taken in calmer times. Even if new boats are built as fast as possible, the number will fall from 52 now to 42 or so by 2028. Meanwhile, on-time delivery of maintenance is also an issue, further affecting fleet operational availability. For example, 60%-70% of the submarines in maintenance are typically behind schedule.

The Navy has a goal of rebuilding to 355 ships by 2050 by building new ships and extending the life of the current fleet, but China's combat fleet will reach 415 ships by 2030. As ADM John Richardson, the Chief of Naval Operations, told a congressional panel in March 2018, China's rise and a resurgent Russia meant America no longer enjoys a monopoly in sea power or sea control.

Some argue that we can hit our 355-ship target sooner by refitting old vessels, but that too requires executing currently planned Availabilities faster and more efficiently. Not to mention the mounting pressure on the readiness of the current fleet, especially after a recent bad run of accidents, and the constant struggle to deliver Availabilities on time.

HISTORY OF IMPROVEMENT INITIATIVES IN THE PUBLIC SHIPYARDS

Public shipyards in NAVSEA have a rich history of reviewing and implementing new quality and process improvement methods.

For example, prior to NAVSEA's Quality and Performance Improvement Conference in June 2000, shipyard managers were taught systematic approaches to problem-solving and decision making (Kepner & Tregoe, 1965) and principles for improving quality and productivity (Crosby, 1979; Deming, 1986; Juran, 1989). Total Quality Management, the High-Performance Organization, and managing according to the Baldridge National Award Criteria using the right metrics to keep score (Brown,

[1] A "normalized" availability is the size of a typical PIA on a CVN and a typical DMP on an SSN.
[2] Based on man-day, cost, and turnaround time data for all eighty-two (82) Availabilities completed in the four Naval Shipyards from October 1, 2001 through September 30, 2009 (eight years):
- PSNS & IMF: 24 Availabilities completed on 9 CVNs, 4 SSGNs, 1 SSBN, 9 SSNs, and 1 AS
- NNSY: 23 Availabilities completed on 8 CVNs, 2 SSGNs, 1 SSBNs, 10 SSNs, 1 MTS, and 1 LHD
- PHNS & IMF: 18 Availabilities completed on SSNs
- PNS: 17 Availabilities completed on SSNs

1996) were part of Shipyard management and operations as Advanced Industrial Management was implemented. There was also a shift from MIL-Q-9858 to an ISO 9000-like quality program and reengineering the corporation (Hammer & Champy, 1993) prior to the Quality and Performance Improvement Conference. After the conference, the Shipyards took on Lean, Six-sigma, and Theory of Constraints to continue the improvement efforts. Gardner led initiatives in Lean and Six-sigma while CAPT Joseph Bradley and CAPT Jonathan Iverson championed Theory of Constraints at the Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility. These led up to the Naval Shipyard Transformation Program of 2005.

The question is, “What next?” How can the public and private shipyards reduce turnaround times by 15% to 20% to make an impact on Fleet Operational Availability? How can they do so with the resources and capacity they already have instead of waiting for capacity expansion? Can they realize such improvements in one to two years rather than a decade or two? What’s the leverage point?

THE OPPORTUNITY LIES IN REDUCING WAIT TIMES

There are many valid arguments as to why Availabilities cannot be executed faster: uncertainties and increasing complexity of maintenance; a shrinking supply base; the natural progression of promotions and retirements; and the cycles of workload peaks and valleys; etc.

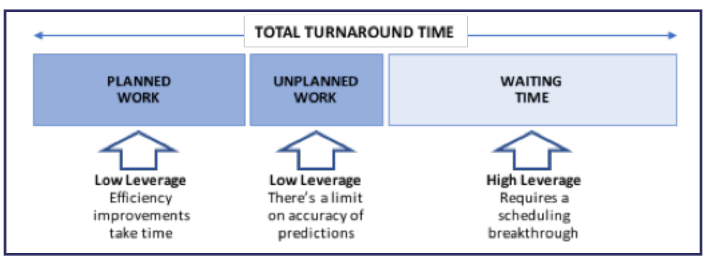

FIGURE 1: LOW LEVERAGE VS. HIGH LEVERAGE

Yet, it is also true is that planned and unplanned work are only 50%-60% of the total turnaround time for an availability (or any project for that matter). The remaining 40%-50% of the time is wasted in waiting: work waiting for resources; resources waiting for work, tools, equipment, engineering dispositions, paperwork, decisions, etc.

The quantitative and qualitative data is sufficient to support that reducing waiting times is a major area of opportunity to reduce turnaround times. For example:

- Work flows in bow waves, both within and across availabilities. Earned Value (EV) measures are good at the start of the project, even better than the norm, but decline over time. This points to a deficiency in how resources and work are balanced.
- Mechanics on the deck plate are productive only for 4 to 5 hours of an 8-hour workday; the rest of their time is spent waiting or scurrying around.
- Supervisors, project managers, and senior leaders spend as much time and attention on resource and work schedules as on technical issues.

Scheduling large projects, or multiple projects with shared resources, is not easy. Even if all the work scope were certain, and the time and resources required to perform tasks were deterministic, the scheduling of work for a few thousand resources would be a very complex problem (an NP-hard problem in mathematics). As the entropy of project anomalies injects delays, technical problems, uncertainties of work scope, and unknowns related to resources, the scheduling problem becomes intractable.

However, there is now enough evidence from MRO and other industries that the problem can be solved, and performance can be substantially improved.

CASE 1: Engineering and Construction of a Power Plant

Performance Metric	Before	After
Project Duration	56 months	44 months

CASE 2: US Navy F-18 Depot Maintenance

Performance Metric	Before	After
Project Completions	6/year	11/year
Group Readiness or Fleet Availability	36 aircraft on station	17 aircraft on station

CASE 3: Delta Engine Maintenance

Performance Metric	Before	After
Project Completions	476 engines per year	586 engines per year
Project Cycle Time or Duration	30 to 90 days, mean 46 days	15 to 65 days, mean 32 days

CASE 4: Pearl Harbor Naval Shipyard and IMF

Performance Metric	Before	After
On Time Completions	Less than 60%	Over 95%
Cost per job	$5,043	$3,355 ($9M savings in first yr)

CASE 5: US Navy Fleet Readiness Center, Cherry Point

Performance Metric	Before	After
Hours of Work Performed	160,500 hours per month	178,750 hours per month
Labor Rate	Mean Labor Rate of $112/hr	Mean Labor Rate of $94/hr

UNTYING THE GORDIAN KNOT

Optimizing schedules to keep resources busy all the time (in planning as well as execution) is not only infeasible, but any attempts at optimizing an environment riddled with uncertainty and variation actually make the problem worse. Consider this thought experiment.

Imagine three crews (BLUE, RED and GOLD) that are assigned to three streams of work. Each stream of work has three groups of tasks: disassembly, repairs, and testing. The BLUE crew does disassembly, the RED crew does repairs, and the GOLD crew performs testing.

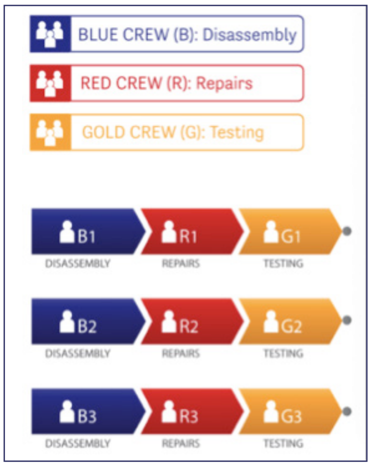

FIGURE 2: THOUGHT EXPERIMENT SETUP

Now imagine that these crews embrace two very different modes of managing their work.

MODE A: "STAY BUSY, SHOW PROGRESS"

In Mode A, the BLUE, RED, and GOLD crews tackle all three work-streams simultaneously, constantly moving people wherever they can find work.

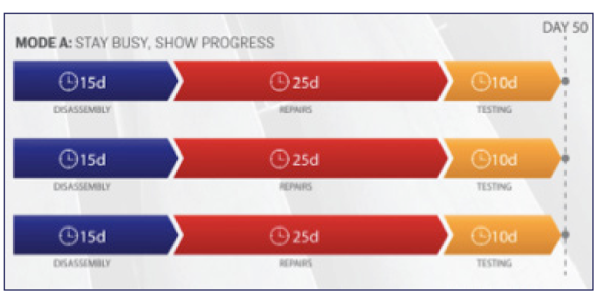

FIGURE 3: SIMULATION OF "STAY BUSY"

It is the familiar approach most organizations take. It is driven by "resource utilization" measures, trying to ensure that workers are always busy and never idle. Managers also assume that the earlier a work-stream is started, the earlier it will finish. In this "stay busy" mode, the BLUE crew can complete all three disassembly tasks in 15 days, the RED crew completes all three repairs in 25 days, and the GOLD crew can finish all three tests in 10 days.

MODE B: "FOCUS & FINISH"

In Mode B, each crew focuses on one work-stream at a time and does not start their work on the next stream until completing their work on the current one. Please note that this mode is not the same as sequential processing of three work-streams because the BLUE, RED, and GOLD crews can be working on different streams at a time.

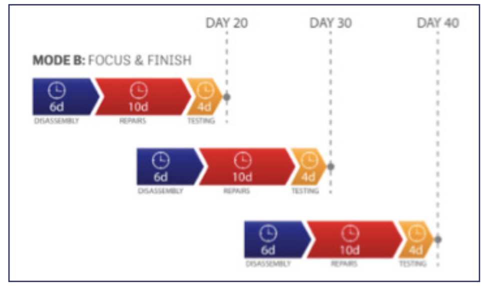

FIGURE 4: SIMULATION OF "FOCUS & FINISH"

Completion times in Mode B look like this: 6 days for BLUE to complete each disassembly task, 10 days for RED to do the repairs, and 4 days for GOLD to complete each test.

On the face of it, Mode A appears more efficient for every crew as far as completing their work on all three work-streams is concerned:

	MODE A: STAY BUSY	MODE B: FOCUS & FINISH
BLUE	15 days	18 days
RED	25 days	30 days
GOLD	10 days	12 days

Although the conventional approach driven by resource utilization may appear more efficient, is it really so?

When we look at turnaround times and shipyard throughput, the metrics that count, Mode B delivers all three works-streams in ten fewer days, forty versus fifty, exposing additional time to accomplish 33% more work.

FIGURE 5: IMPACT ON CYCLE TIME AND THROUGHPUT

The paradoxical results can be explained by a simple fact. In Mode A, downstream work starts much later. Observe that in Mode A, the RED crew cannot start work until Day 16 whereas in Mode B, they start on Day 7; in Mode A, the GOLD crew cannot start work until Day 41 whereas in Mode B, they start on Day 27.

Coordination is also easier in Mode B. Supervisors do not have to juggle resources across the three workstreams. Another advantage of Mode B is that each crew experiences a smooth inflow of work rather than valleys followed by peaks, leading to better utilization of resources and fewer delays. Finally, Mode B also makes efficient use of physical assets like dry docks. The faster Availabilities get done, the more the shipyards can accomplish with the same number of dry docks.

HOW TO BUILD PROJECT PLANS TO ENABLE "FOCUS & FINISH"

In the uncertain world of projects, project plans need to be organized as two-tiered workflows to enable "Focus & Finish" Work Management.

- **Tier-1 Workflow:** the end-to-end flow of work that (a) can be established at the time of planning and (b) remains stable in execution. This workflow should be granular enough to establish a project's critical path and resource requirements. Tasks in this workflow should be defined to minimize wait time and switching losses. Size the task so that it is faster and more efficient for resources to "focus and finish" a given Tier-1 task before starting the next task, rather than getting spread thin among many Tier-1 tasks.

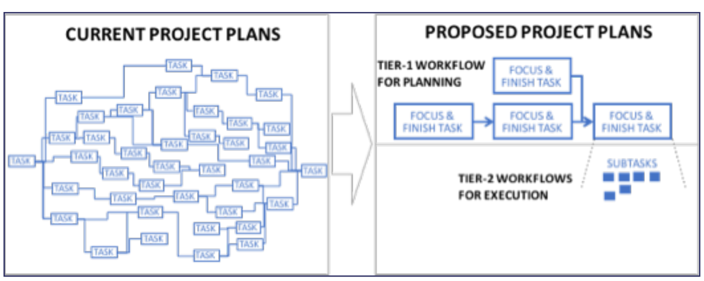

FIGURE 6: PROJECT PLANS THAT ENABLE "FOCUS & FINISH"

- **Tier-2 Workflow:** the detailed flow of work within a Tier-1 task that is required for execution. Supervisors should have the flexibility to define and modify this workflow based on reality during execution. It is acceptable if only partial data about Tier-2 tasks is available during planning. Whatever details are available is good enough.

The ratio of tasks in the Tier-1 workflow to the subtasks in the Tier-2 workflows should range between 1:20 and 1:75. For example, projects that traditionally had about 50,000 tasks are now modeled as ~700 Tier-1 tasks and ~50,000 Tier-2 tasks; and projects that traditionally had about 1,000 tasks are now modeled as ~40 Tier-1 tasks and ~1,000 Tier-2 tasks.

This "Focus & Finish" simplification of project plans is significant in itself. In planning, this new method reduces data entry errors. It also improves visualization, navigation, and ease of maintaining the project plan. In execution, the Tier-1 workflows remain fairly stable, even as (a) requirements change, (b) additional scope is discovered after inspections or during repairs, and (c) technical issues needing resolution are encountered.

Consider tank repairs in a dry-docking availability project, for example. All the tanks that need to be repaired are known, and the sequence in which the tanks are repaired can be established at the time of planning. However, the actual activities required to repair a given tank and, because of interferences, the exact sequence in which those activities will be performed need to be decided during execution by supervisors and resources on the deck plate. Project Managers need not concern themselves with the nitty-gritty details of the work, only with how long the set of tanks will take to complete.

WHAT DOES "FOCUS & FINISH" LOOK LIKE IN EXECUTION?

During execution, the project team focuses on tasks in the priority order, ensuring that a given Tier-1 task is 100% completed before starting the next one:

- Task priorities are calculated based on the task's impact on the longest chain of remaining work.
- Full Kitting of inputs is enforced to enable resources to finish a task without having to pause for additional permissions, supplies, materials, or anything else.
- Work in Progress (WIP) is managed to prevent spreading resources thin.
- Project Managers or Supervisors monitor progress on the highest priority task to facilitate swift and focused completion while preparing the next crew for the handoff.

MEASURING PROJECT PROGRESS AND RESOURCE EFFICIENCY

To support "Focus & Finish" Work Management:

- Project progress should not be measured based on hours of work completed versus total hours of work required. Instead, it should be based on the duration of the completed workstreams versus total hours of work required.

- Resource Efficiency should not be measured by total hours of work completed versus hours of work budgeted at the detailed task level. Instead, it should be measured by hours of work completed versus hours of work budgeted at the Tier-1 level. Credit should be given only when the Tier-1 task is fully complete.

CONCLUSION

"Focus & Finish" is counterintuitive at first. It sounds illogical from a local optimization perspective, but it is the preferred choice for improving Availability TAT, Shipyard Throughput, and Fleet Readiness.

Both the public and private shipyards should consider the "Focus & Finish" method because it can produce results in months rather than years. Increasing shipyard capacity by adding more personnel, improved facilities, and more capable equipment is necessary, but it will take years to increase effective capacity whereas TAT reductions and throughput improvements are required now. Moreover, budgets are also limited; so, making efficient use of resources has to be also pursued in parallel. Finally, planning and executing according to "Focus & Finish" Work Management can also help the private shipyards reduce their costs and earn more of their bonuses based on schedule and cost performance.

REFERENCES

Brown, M. G. (1996). *Keeping score: Using the right metrics to drive world-class performance.* New York, NY: Quality Resources.

Crosby, P. B. (1979). *Quality is free: The art of making quality certain.* New York, NY: McGraw-Hill.

Deming, W. E. (1982). *Out of the crisis.* Cambridge, MA: MIT Center for Advanced Engineering Study.

Goldratt, E. (1997). *Critical Chain.* Great Barrington, MA: The North River Press.

Hammer, M., & Champy, J. (1993). Reengineering the corporation: A manifesto for business revolution. New York, NY: Harper Business.

Juran, J. M. (1989). *Juran on leadership for quality: An executive handbook.* New Your, NY: The Free Press.

Kepner, C. H. & Tregoe, B. B. (1981). *The rational manager: A systematic approach to problem solving and decision making.* Princeton, NJ: Princeton Research Press.

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