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McKinsey on the Maritime Industry

New perspectives on strategy, operations, and the workforce of the future

November 2024

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Introduction

Because 90 percent of the world's traded goods, representing more than $14 trillion in commerce,[1] travel by sea, the global shipbuilding industry plays a vital role in the global economy by constructing and maintaining both the commercial ships on which goods are transported and the naval ships that secure critical sea lanes. It is encouraging to see order books filling up for ships powered by alternative fuels, special-purpose vessels, and naval ships and submarines. Given this momentum, the industry is well positioned to navigate a course of innovation and growth.

While these developments provide reason for optimism, they also raise important questions about whether the industry is poised to meet demand and accelerate technological advances. Multiple factors are increasing uncertainty and complicating strategic decisions, including geopolitical tensions and the "gray to green" workforce transition that is under way. Additionally, the industry faces challenges such as raising significant capital investment, navigating the complexities of integrating Industry 4.0 technologies into aging infrastructure, and accelerating efforts to decarbonize global fleets.

This issue of *McKinsey on the Maritime Industry* provides a snapshot of the maritime industry's prospects and strategies for keeping a competitive edge while navigating uncertainty. The topics covered include opportunities for shipyards to increase productivity and modernize operations, strategies for investing in shipyard infrastructure through brownfield development and the scaling of complex manufacturing, a perspective on aerospace and defense disruptors, and the role shipyards play in naval mission readiness. We also examine two issues that are crucial during this expansion period: the need to accelerate throughput in shipyards and strategies for attracting critical talent amid fierce competition for employees in skilled trade roles.

As you read these articles, we hope you will find novel approaches to your most pressing challenges, as well as new opportunities for innovation. We would be happy to elaborate on any topics covered in these articles, or on other areas of interest, as you chart your company's path forward.

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[1] Spencer Feingold and Andrea Willige, "These are the most vital waterways for global trade," World Economic Forum, February 15, 2024; "Shipping and world trade: Driving prosperity," International Chamber of Shipping, accessed October 21, 2024.

Charting a new course: The untapped potential of American shipyards

Amid escalating demand, aging infrastructure, and a strained talent supply, the American shipbuilding, sustainment, and repair industries can accelerate growth by activating latent domestic capacity.

This article is a collaborative effort by Brooke Weddle, Nick Mellors, and Ryan Brukardt, with Andy Voelker, Benjamin Plum, and Sean Cassady, representing views from McKinsey's Aerospace & Defense Practice.

American shipbuilding has reached a critical inflection point—can supply keep up with demand? The US Navy, the industry's principal customer, increased its shipbuilding budget by 12.5 percent per year from fiscal year 2020 to fiscal year 2024, and its most recent 30-year plan calls for the construction of 290 to 340 new ships by 2053.[1] Beyond this domestic demand, there is additional demand to meet the anticipated needs of the AUKUS nuclear submarine partnership among the Australian, US, and UK defense agencies.[2] Meanwhile, overall shipbuilding production has fallen to historic lows largely because of the decline in commercial production: US shipbuilding output has decreased by more than 85 percent since the 1950s, while the number of American shipyards capable of building large vessels has fallen by more than 80 percent.[3]

Shipyards, once the backbone of flourishing communities, now face myriad challenges—from talent gaps to outdated operating models—that threaten their ability to grow and thrive. The US has gone from building 5.0 percent of the world's ocean-going commercial ships in the 1970s to building about 0.2 percent today, as measured by gross tonnage. Conversely, China, Japan, and South Korea now combine for more than 90 percent of global commercial shipbuilding.[4]

Increasing output quickly and efficiently is the greatest challenge currently facing American shipyards. But despite the obstacles, there is reason for optimism: the industry does not have to start from scratch. The United States has substantial latent shipbuilding, sustainment, and repair capacity, including aging but not obsolete capital assets, a strong base of potential skilled-trade labor, and a middle-management and engineering talent base that has become geographically separated from shipyards. Rapidly increasing output requires tapping into this latent capacity quickly and confidently.

To do so, shipbuilders and suppliers can prioritize five focused interventions:

— *rebuild the workforce* from the frontline through middle management to the next generation of leaders

— *reenergize the existing shipyard footprint* to bolster near-term capacity

— *modernize digital systems and tools,* focusing first on low-hanging, high-ROI opportunities

— *align the organization and culture around performance* to create transparency and promote accountability

— *engage in strategic economic development* to support long-term sustainability of the industry, the workforce, and the business

Rebuild the workforce

Despite strong demand for ships, talent supply has struggled to keep pace—especially as industry labor needs and jobs have evolved. Manufacturing is a prime example, as the industry is projected to shrink[5] in response to factors such as high rates of retirement,[6] pipeline slowdowns across key trades, and the strains of "pinchpoint" roles (those with a significant supply-and-demand imbalance, slow career progression, and risk of migration).[7] Some of the manufacturing areas most affected, such as primary metals and transportation equipment, will have a direct impact on maritime operations (Exhibit 1). At the same time, jobs in adjacent areas of manufacturing relevant to modern shipbuilding—including electrical equipment, appliances, and components—are projected to grow rapidly.

In addition to skilled-trade labor, gaps in other shipbuilding professions cannot be overlooked.

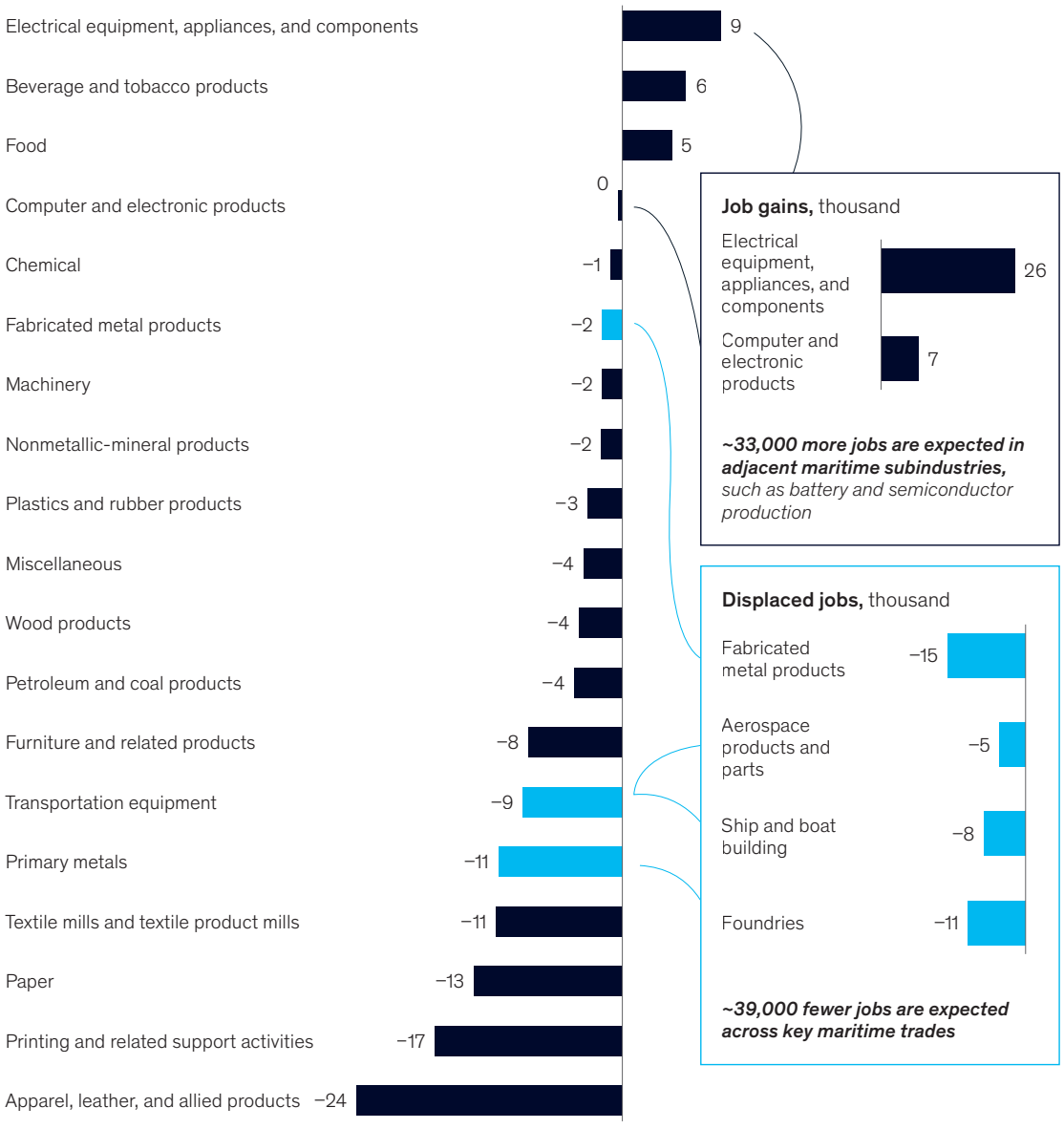
[1] *An analysis of the Navy's fiscal year 2024 shipbuilding plan*, Congressional Budget Office, October 2023.
[2] Sam Lagrone, "SECNAV Del Toro tells U.S. shipyards 'invest more', encourages foreign investment," USNI News, March 7, 2024.
[3] Megan Eckstein, "Del Toro aims to reinvigorate US shipping to strengthen fleet," Defense News, December 5, 2023; www.shipbuildinghistory.com.
[4] *U.S. commercial shipbuilding in a global context*, Congressional Research Service, November 15, 2023.
[5] "Employment projections: 2022-2032 summary," US Bureau of Labor Statistics, September 6, 2023.
[6] Varun Marya, Michael Park, Andy Voelker, and Brooke Weddle, "Navigating the gray-to-green transition in aerospace and defense," McKinsey, March 16, 2023.
[7] Ezra Greenberg, Erik Schaefer, and Brooke Weddle, "Tradespeople wanted: The need for critical trade skills in the US," McKinsey, April 9, 2024.

Exhibit 1

Key maritime manufacturing trades will be displaced by higher demand from battery and semiconductor production.

Projected change in tradecraft employment[1] by manufacturing subindustry, % change, 2022–32

Key maritime tradecraft populations



[1]Data presented here is the "production" occupation within subindustries of the "manufacturing" industry.
Source: Bureau of Labor Statistics Employment Projections, 2024

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Shipbuilding is as much about scheduling, production control, and critical chain management as it is about steel fabrication. In highly complex production and construction environments, talent gaps in the many production-support and -management functions that surround fabrication and construction can have an equally deleterious effect on output.

Shipbuilders that are winning this battle for talent are doubling down on creating a talent advantage, which requires immediately addressing two of the biggest levers of value:

— *Talent acquisition.* Most shipbuilders have long relied on volume-based hiring, or hiring any available talent and training them up to proficiency. As competition has increased, so too has the importance of "quality of hire"—that is, attracting employees who cost less to acquire, are more likely to learn quickly, and are less likely to leave. To compete effectively in this new environment, shipbuilders should treat hiring as a science, not as an art. Shipbuilders' ability to attract quality workers will be further tested as the US industrial base expands to meet the demands of the AUKUS partnership, which is expected to require an additional 100,000 workers across submarine yards nationwide.[8] Those proactive in quality talent acquisition start by identifying the business outcomes they seek to achieve, use analytics to identify the markers of the employees who are most likely to propel those outcomes, and focus their hiring on candidates with those characteristics.

— *Talent retention.* While past generations of shipbuilders typically stayed with one company for their entire careers, today's employees—particularly those with valuable trade skills—face much lower barriers to switching employers.[9] To augment traditional talent-retention techniques, employers are increasingly using analytics to understand not just where attrition has occurred but also what causes it, and using this insight to predict where attrition might come from in the future and take action. One US shipbuilder, for example, used analytics to reduce attrition by as much as two times in certain employee populations, resulting in significant annual cost avoidance and bottom-line impact.

Regardless of a company's specific starting point and strategic goals, leaders will need to take clear, deliberate, and proactive actions to shape the company's workforce and, in so doing, create a competitive talent advantage.

Reenergize the existing shipyard footprint

Many US shipyards have been in service for decades, with some infrastructure dating back to the World War II era or even earlier. Despite their age, domestic shipyards still have a great deal of life: the existence of robust ecosystems for sustainment and repair have allowed them to remain functional and relevant, though often in need of targeted operational and productivity improvements.

To better address the challenges faced by aging shipyards and unlock their full potential, maritime leaders must understand the dynamic and intersecting production value streams in the yard and systematically address both structural and transient bottlenecks. More acutely than many other industries, shipyards face large, shifting bottlenecks that are difficult to eliminate, resulting in bottom-quartile overall equipment effectiveness (OEE) and labor productivity relative to other sectors. Indeed, a small bottleneck in one shop can have a yardwide ripple effect, leaving assets idle and labor waiting.

The silver lining to these challenges is that the ceiling of performance is much higher than most yards currently experience. By focusing on the right bottlenecks in the value stream, shipyards can unlock outsize throughput quickly and cost-effectively.

[8] "SECNAV Del Toro tells U.S. shipyards 'invest more'," March 7, 2024.
[9] "Navigating the gray-to-green transition," March 16, 2023.

Two levers can help shipbuilders get the most out of their existing footprints:

— *Lean improvements.* Lean initiatives are the fastest, most cost-effective way to drive a step change in throughput, rebuild a performance culture, and reveal structural bottlenecks in a matter of months by driving out deeply rooted waste. But effectively deploying lean principles in highly complex systems such as shipyards can be challenging.

— Shipyards that do this well focus on reducing complexity, improving operational discipline, and building operating systems focused on cross-functional execution and transparency. They develop a detailed understanding of the intersecting value streams throughout the shipyard, eliminate barriers to the flow of material through the value stream, and improve the cross-functional coordination needed to support flow through service-level agreements and enhanced daily execution routines. And the impact is well worth the effort: one US shipbuilder used this high-complexity lean approach to double throughput and compress cycle times by more than 40 percent in a bottleneck facility in less than six months.[10]

— *Targeted capital investments essential to core business operations.* Where structural bottlenecks emerge and a lean approach is not enough on its own, targeted capital investments that prioritize the most restrictive issues may be needed to improve throughput. However, because of their complexity, shipbuilders are at an elevated risk of sinking millions of dollars into ineffective capacity expansions. Two common pitfalls include expanding capacity where it's not needed and replicating unproductive operating systems in new facilities.

— To avoid these expensive mistakes, shipyards should ask two questions when deciding whether and where to invest in new capacity: are new capital investments targeting current or future bottlenecks on the critical path of production? And are we currently reaching the full potential of our existing capacity? When asset and labor utilization are at capacity, and output is still failing to meet demand, yard leaders can be confident they will fill new capacity with a high-performing operation and experience its benefits.

Modernize digital systems and tools

Transparency motivates performance, but creating transparency into daily shipyard execution is notoriously difficult. A primary reason for the obscurity is often a lack of digital integration among various systems, metrics, and departments within the yard. Operating-system fragmentation can lead to delays, miscommunication, and inefficiencies that ultimately affect the shipyard's overall performance.

For example, at one shipyard, a disconnect between the data sets used by the industrial engineering team and the planning team resulted in two different production schedules. Unclear on which to follow, the production team created a third. Resolving these disconnects through targeted digital interventions can be "quick wins": another US shipyard proactively addressed a disconnect in schedules and metrics by digitally linking its downstream demand signal to production targets, updated its delivery metrics to match, and built dashboards to track performance.

To achieve substantial near-term improvements in transparency and performance, shipbuilders don't necessarily need the latest and most expensive automation or digital twins—yet. While these advanced technologies can take a production system from good to great, they may be inaccessible without the foundation of an already mature and digitally connected operating system. To accelerate digital maturity and maximize near-term benefit, shipyards can take four immediate and accessible steps that close information gaps, create digital transparency, and enable the benefits of cutting-edge technology:

— *Digital engineering.* Design-to-manufacturing tools and digital engineering solutions offer powerful ways to improve quality, shorten

[10] For more, see "Why flow matters most in highly complex manufacturing," McKinsey, May 3, 2024.

development cycles, reduce rework, and streamline production. Moreover, they accelerate the learning curve, enabling more-transparent feedback between production and engineering, robust issue documentation, and improvements from hull to hull.

— *Digital supplier management.* Shipbuilding requires highly synchronized parallel work, and any disruptions can quickly evolve into delays and cost overruns by throwing the sequence of work out of balance. Supply chain management is crucial because delays to the start of the sequence can be particularly disruptive. Creating digital early-warning systems to transparently map supplier risk can signal issues before they become delays, enabling proactive intervention.

— *Digital performance management.* Digital tools can also bring transparency to shipyard performance. By cascading dynamic cost and schedule targets into weekly, daily, and shift-by-shift requirements, performance management dashboards can simplify daily planning, allow shop leaders to identify issues quickly, and promote informed problem solving across functions and teams.

— *Digital value stream management.* A pervasive challenge in shipyards is knowing what work to prioritize when, to provide the most global benefit to the interconnected shipyard—all while managing constant supply chain and operational disruptions. An integrated digital thread of the value stream can create transparency into the trade-offs and constraints faced by each shop, facilitating productive decision making across the yard.

Targeted improvements can often be implemented in a matter of weeks or months, rather than the years-long timelines associated with more complex digital transformations. The key is parallel processing: in addition to long-term investments, shipyards can focus on areas where a lack of transparency and integration is causing the most pain and inefficiency, and then implement targeted solutions to address those specific problems. Effective digital adoption requires harnessing the existing workforce's extensive experience while also adapting to new technologies and processes. By taking a high-velocity, high-ROI approach to process improvement, shipbuilders can achieve significant gains in performance and productivity while laying the foundations for the next generation of digital innovation.

Align the organization and culture around performance

Shipyards have a clear purpose: to build, sustain, and repair high-quality ships quickly and efficiently. However, this clarity of mission has been challenged by decades of boom-to-bust cycles, frequent shipyard acquisitions and sales, and the increasingly technical demands of the latest advanced ships. Together, these forces have inadvertently created a complicated organizational system of functional silos that hinder efficiency and collaboration.

McKinsey research shows that shipbuilders are plagued by legacy norms around slow and siloed decision making, with a 30 percent gap in perceived speed of decision making compared with other sectors.[11] Further complicating organizational ways of working and effectiveness is a culture that lags behind: 70 percent of advanced industrial companies, including shipbuilders, have lower organizational health scores than the global median (Exhibit 2). McKinsey research has found that the healthiest companies deliver three times the TSR of unhealthy organizations, regardless of industry.[12] Moreover, employees of healthy organizations are about 50 percent more likely to continue working there and 36 percent more likely to endorse their organization to friends and relatives.[13]

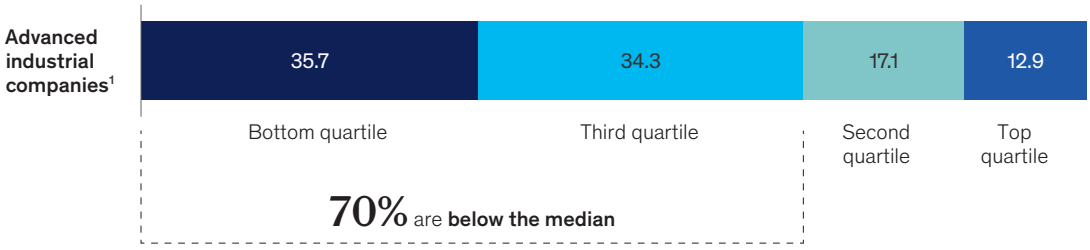
A key issue is that organizational metrics often fail to align with the overarching goals of delivering flawless ships on time and on budget. This disconnect can lead to conflicting priorities and

[11] McKinsey Organizing for Speed Survey, 2022 (n = 853 respondents).
[12] Alex Camp, Arne Gast, Drew Goldstein, and Brooke Weddle, "Organizational health is (still) the key to long-term performance," McKinsey, February 12, 2024.
[13] McKinsey Organizational Health Index, global database, 2019–24 (n = eight million respondents).

Exhibit 2

Seventy percent of advanced industrial companies, including shipbuilders, have lower organizational health scores than the global median.

Overall organizational health of companies



[1]Data presented here is based on a 5-year rolling benchmark created with data on 70 advanced-industrial companies.
Source: McKinsey Organizational Health Index, advanced-industrial companies database, 2019–24

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a lack of clarity about what truly matters for the success of the shipyard as a whole.

But shipbuilders can break free of these counterproductive ways of working and inject speed into their operations by ensuring that the organizational structure is clearly set up around sources of value and by resetting the culture to focus on value, accountability, safety, and speed. For instance, some shipbuilders are revisiting how they are organized, questioning legacy norms, and embracing new ways of working. They have dedicated functional resources to product lines or facilities while maintaining functional excellence through dotted-line authority to ensure that each program receives the support it needs to meet its delivery goals. In addition, they have publicly committed to targets and then cascaded their goals out to the front line to ensure the entire shipyard is pulling in the same direction.

Crucially, resetting culture requires setting behavioral aspirations for how the place should be run, understanding current behaviors, and designing targeted interventions to shift behaviors toward the aspiration, often by addressing the underlying mindsets. This helps to create a clear vision for what "good" looks like and allows every employee to participate.

Engage in strategic economic development

Revitalizing the shipbuilding industrial base in the United States requires a collaborative effort between shipyards, suppliers, communities, government, and others. Strategic investments in centers of excellence, which themselves are strategically located near shipyard communities, can foster the development of skilled trades, engineering, and management talent.

Key coastal locations across New England, Hampton Roads, and the Gulf and West Coasts will benefit from bold and innovative private and public investments to kick-start shipbuilding and sustainment ecosystems. These investments should focus on attracting and growing the various components necessary for effective shipbuilding, including a local supply base, a talented workforce, and educational institutions that produce skilled workers. This collaboration is particularly important in maritime communities, where shipyards are often the largest employers and have been the backbone of the community for generations.

Some regions are leading the charge in addressing vast hiring needs. For example, one workforce development council in the eastern United States is on track to increase job

placements in skilled trades by more than 30 percent without any additional funding by using historical ROI analytics to rebalance its portfolio of workforce initiatives.[14] Shipyards can also take inspiration from other industries by increasing their focus on nonfinancial factors that affect employee health and outcomes, including flexibility, purpose, learning, and belonging.[15] For example, when a Land O'Lakes manufacturing plant offered flexible shift schedules for some part-time workers, it tapped into a key employee priority and saw both an influx of applicants and an uptick in productivity.[16] While the right solutions for a given shipbuilder may look different, the core takeaway remains: widening the aperture on what drives employee well-being can result in stronger, more productive, and more sustainable economic outcomes.

What's more, key stakeholders are modeling a proactive approach to supplier constraints by developing upstream partnerships to increase transparency, reduce fragmentation, and mitigate cybersecurity risks. For example, supplier health is a key priority for the AUKUS nuclear submarine partnership. Roughly 200 suppliers have received grants to increase capacity, automate processes, and ensure efficiency to meet increased demand for new ships, with additional funding expected in anticipation of repair spikes.[17] Investing in the capabilities, security, and transparency of the shipbuilding, sustainment, and repair industrial base is critical both to meet current delivery requirements and to position the industry for efficient future growth.

The American shipbuilding industry is in need of repair. Fortunately, the industrial base already has many of the ingredients for success. Industry leaders can accelerate growth by leveraging latent capacity, but the window to do so is closing fast. The trades gap is widening as fast-growing industries that compete for similar entry-level talent (such as Amazon and Uber) beckon with higher wages and easier lifestyles, college-educated talent gravitates toward tech and the allure of AI, and existing shipyards continue to age. With a few bold strategic moves, shipbuilders can dramatically increase the performance of existing yards while strategically positioning new capacity to prepare for the demands of the next age of shipbuilding.

[14] Ezra Greenberg, Erik Schaefer, and Brooke Weddle, "Tradespeople wanted: The need for critical trade skills in the US," McKinsey, April 9, 2024.
[15] For more on improving productivity by focusing on drivers of health, see Jacqueline Brassey, Lars Hartenstein, Barbara Jeffery, and Patrick Simon, "Working nine to thrive," McKinsey Health Institute, March 13, 2024.
[16] Bruce Crumley, "What your business can learn from Land O'Lakes' embrace of flexible shift scheduling," *Inc.*, March 6, 2024.
[17] Megan Eckstein, "The US Navy is spending billions to stabilize vendors. Will it work?," Defense News, September 8, 2023.

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The talent gap: The value at stake for global aerospace and defense

The aerospace and defense industry is under pressure from labor shortfalls and increasing demand. By focusing on five talent imperatives, it can unlock productivity and create value.

by Brooke Weddle, Giulietta Poltronieri, and Hugues Lavandier with Andy Voelker

The global aerospace and defense (A&D) sector is booming. The return of air travel to prepandemic levels is one factor behind soaring demand. Another is greater geopolitical instability, which has led to growing national defense spending (in Europe, for example) and rising demand for ammunition.[1] Order volumes across products have increased significantly, and a burst of talent recruiting is under way in the sector.[2]

However, headwinds persist. Matching the growing demand for talent with the right labor supply has been an enduring challenge. This talent gap continues to cause substantial strain on employers, affecting their ability to compete with other sectors for top talent, hire at the pace required, reduce the time to proficiency, and retain key employees—all of which have an impact on performance.

As a result, the value at stake for A&D organizations has never been higher. Companies that treat the need for talent as a top priority see higher total shareholder returns (TSR) than their competitors. Below, we share highlights from our new research and analysis, which show that for a median-size A&D company, closing the gap between talent supply and demand could be worth more than $300 million in potential cost avoidance and bottom-line impact.

The research represents a clear call to action for employers: evolve quickly to obtain and retain talent. In this article, we look at the challenges that A&D companies face because of this talent gap, examine why the stakes are so high, and recommend five areas where employers can focus their attention to address this gap: figuring out what kind of talent is missing, streamlining hiring processes, reskilling existing talent where needed, reforming talent and culture to propel performance and experience, and transforming HR to lead the return on talent.

What the A&D talent gap looks like

Across all work areas—including skilled labor, supply chain, and cutting-edge tech roles—the A&D talent supply is not meeting demand. This is due to a number of factors, ranging from the macroeconomic environment to cultural specificities of the A&D sector.

To start, unemployment rates in the United States and across Europe remain relatively low, and as the A&D workforce continues to get younger, employers are left without the critical skills and knowledge needed for production. Attrition in management also plays into the challenge of transferring knowledge from tenured "gray" employees to newer "green" employees. Our research shows that A&D frontline managers and middle managers say they intend to leave their current employer at a rate nearly two times higher than individual contributors. In the United States, one A&D employer had to rehire retirees last year to restart production of a legacy weapon systems line that the current workforce was unfamiliar with.[3] In Europe, the aging workforce was highlighted as a critical issue in the newly released European Defence Industrial Strategy.[4]

In our observation, the A&D sector also hasn't reaped many benefits from changes in the tech sector leading to more available talent. Laid-off tech employees haven't been flocking to A&D, and the emergence of generative AI (gen AI) may exacerbate the competition for labor, especially in STEM areas, which are expected to experience the biggest potential simultaneous increase in automation adoption and labor demand.

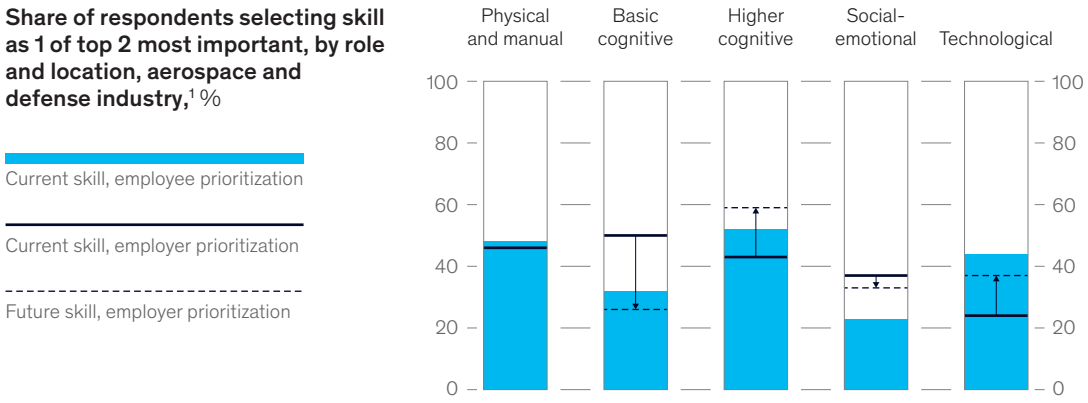
Further complicating the supply of talent is a mismatch between what employers and employees value regarding the skills they deem most important (Exhibit 1). We updated McKinsey research on core workplace skills categories with a deep dive into A&D, and found a divergence in priorities between employers and employees. Half of employers say that basic cognitive skills are among the top two skills most important to their organization, while only 32 percent of employees say the same. When it comes to more specialized technological skills, the prioritization is flipped,

[1] Sebastian Sprenger, "Europeans are building a war economy. Can they master it?," *Defense News,* February 23, 2024.
[2] Sylvia Pfeifer, Clara Murray, Arjun Neil Alim, and Sarah White, "Global defence groups hiring at fastest rate in decades amid record orders," *Financial Times,* June 16, 2024.
[3] Marcus Weisgerber, "Raytheon calls in retirees to help restart Stinger missile production," Defense One, June 28, 2023.
[4] "A new European Defence Industrial Strategy: Achieving EU readiness through a responsive and resilient European Defence Industry," European Commission, March 5, 2024.

Exhibit 1

Aerospace and defense employers and employees are not on the same page when it comes to the skills they deem most important.

Share of respondents selecting skill as 1 of top 2 most important, by role and location, aerospace and defense industry,[1] %



[1]Share of employers that selected each skill area as 1 of the top 2 most important to meet the current demands of their organization vs share of employees who selected each skill area as 1 of the top 2 most important to their ability to perform their current job.
Source: McKinsey Talent Trends Survey, aerospace and defense subsection (n = 1,546), Jan 2023

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with 44 percent of employees saying those skills are critical right now, and only 24 percent of employers agreeing. Interestingly, employers' future skills outlook is similar to employees' skills prioritization today. In other words, A&D employees are adapting to future needs more quickly than employers are evolving their own business models.

There are also geographical differences regarding A&D employee value propositions that matter (Exhibit 2). In Europe, employees often have stronger ties to their employers, while those in the United States tend to be more attached to the sector itself. Last year, a McKinsey talent survey revealed that in Europe, employees join and leave companies due to the importance they place on factors such as compensation, career development, and meaningful work, while employees in the United States join and leave their companies due to factors such as workplace flexibility and their relationships with coworkers. Employers with a global presence may need to deploy regional or country-specific strategies in their efforts to close the talent gap, since solutions are not geographically universal.

Gaps in perception of culture and performance management also contribute to the talent gap. McKinsey research has found that the healthiest companies deliver three times the TSR of unhealthy organizations, regardless of industry. But when we looked at data for advanced industries in the McKinsey Organizational Health Index, we found that 70 percent of A&D companies have lower organizational health scores than the global median. The healthiest A&D companies prioritize a culture of strong performance goals, yet according to a 2024 McKinsey Performance Management Survey, one out of five A&D employees feel that their employers' approach to performance management doesn't motivate them to perform.

To combat this perception, one A&D organization in Europe approached the redesign of its performance management process by first looking to understand the concerns of their employees (for example, too much time spent by managers on paperwork, limited differentiation, and no consequence management), and then designing to resolve pain points. The new process is expected to drastically reduce time spent on rote activities and increase overall performance and productivity.

The price of the A&D talent gap

Our new analysis identifies and quantifies the value of lost productivity and underlying drivers due to the A&D talent gap. This distinct analysis is

Exhibit 2

Aerospace and defense employees in Europe and the United States value different aspects of the employee experience during their careers.

Top employee experience factors, by career phase and region, advanced industries,[1] ranking

US	Why they join	Why they stay	Why they leave
Meaningful work	1	3	8
Coworkers	2	4	5
Workplace flexibility	3	2	4
Inspiring leaders	4	10	6
Community	5	11	10
Compensation	6	1	1
Health and well-being	7	7	3
Career development	8	6	2
Sustainable work expectations	9	8	9
Geography and travel	10	9	12
Safe workplace	11	5	7
Resource accessibility	12	12	11

Europe	Why they join	Why they stay	Why they leave
Compensation	1	1	1
Career development	2	6	2
Workplace flexibility	3	3	5
Meaningful work	4	5	4
Safe workplace	5	2	9
Geography and travel	6	7	10
Coworkers	7	4	8
Sustainable work expectations	8	9	6
Health and well-being	9	10	7
Community	10	8	11
Inspiring leaders	11	12	3
Resource accessibility	12	11	12

[1]Survey question posed to respondents based on their career status (eg, new joiner, in role and planning to stay, or in role and planning to leave).
Source: McKinsey Talent Trends Survey, advanced industrial companies, including aerospace and defense (n = 1,546), Jan 2023

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based on previous McKinsey research on the return on talent across all industries, which finds that there are three clear and measurable reasons for a lack of productivity among individual employees:

— *The skill gap:* They don't have the skills needed to be successful in a role.

— *The will gap:* They aren't engaged or energized by the work.

— *The time gap:* They spend time in ways that don't increase value, such as poor prioritization and low-value meetings.

Companies need to understand how various levers might be holding them back and how they might vary by employee group. If left unaddressed, these gaps can reduce the output an organization gets from its workforce, leading to costly attrition and vacancy rates.

Specific to A&D, we utilized input data from the profile of a median-size A&D company that has 20,000 to 30,000 full-time employees, annual revenues of $5 billion to $8 billion, takes an average of 70 to 90 days to fill a vacant position, and has roughly a 15 percent attrition rate.

Combined, the skill gap, will gap, and time gap factors are substantial and could cost the median A&D company approximately $300 million to $330 million per year in lost productivity (Exhibit 3). While productivity is a broad term, it is important to have a clear view on what this could mean for different areas within a company, such as HR, supply chain, or engineering.

Charting a new path forward

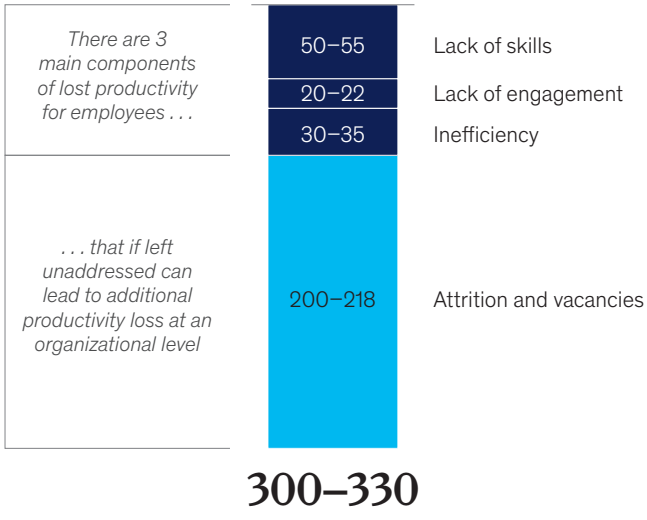
Some organizations are using changing labor dynamics and evolving workforce preferences to create an advantage. To help close the talent gap, A&D leaders should identify their companies' needs, and the people to fill those needs, by focusing on five key dimensions of talent management (Exhibit 4).

— *Figuring out who you need to win.* A&D companies are no strangers to long-range planning. But in many organizations, the teams responsible for navigating the talent gap (including business development, HR, and those charged with estimating and contracting) are simply too disconnected from one another to be able to do so in a coordinated and strategic way. In a talent management process led by finance and business development, involving HR is often

Exhibit 3

The talent gap could cost a median-size aerospace and defense company $300 million to $330 million a year.

Annual value at risk from loss in employee productivity, median-size aerospace and defense company,[1] $ million



Lack of skills

19%

reduction in productivity when employees do not have the right skills to do their jobs

Lack of engagement

3%

reduction in productivity when employees are not focused on or excited about their jobs

Inefficiency

$5,900

annual cost to companies for 1 hour of unproductive labor per week, per employee

Attrition and vacancies

$80,000

average cost for a company to replace a full-time employee

[1]Analysis based on median-size aerospace and defense company profile with 20,000–30,000 full-time employees, $5 billion to $8 billion in revenue, 70- to 90-day period to fill job vacancies, and approximately 15% attrition rate.
Source: Dr. Steven G. Rogelberg and Otter.ai research; US Bureau of Labor Statistics; McKinsey analysis

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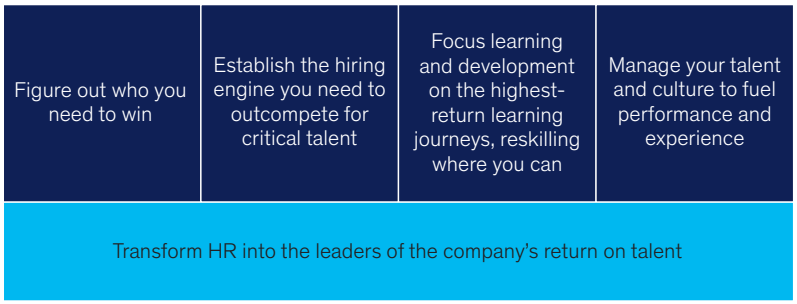
Exhibit 4

Leading aerospace and defense companies follow five critical actions to maximize their return on talent and capture the value at stake.



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an afterthought. This did not surface as an issue when there was a steady and reliable supply of talent that was easy for A&D employers to capture, but that is no longer the case. The value at risk of incorrectly forecasting labor needs to meet program demand is significant. Those that capture that value have taken the time to understand how different skills pools are evolving, what that means for program demands, and how that translates into a strong hiring plan for the next three to five years. They have learned that each job family calls for different talent (for example, direct labor and skilled trades, as compared with supply chain) and isn't one size fits all. They also have made HR a strategic partner in finding and keeping talent.

— *Establishing a hiring engine to compete for critical talent.* Gone are the days of relying on volume-based hiring and the overwhelming likelihood that an employee would stay at a single employer for their entire career. With job hopping more common (especially among lower-tenured employees) and the prospect of many people leaving the A&D sector altogether, the case for change is clear. The modern A&D talent acquisition capability can be structured quite differently from the way it has typically been set up in the past: it should function more like a sales organization, driven by daily stand-ups focused on a single source of truth—with universal clarity on reliable talent pools, alignment on new white space talent pools, a test-and-learn mindset, and a relentless focus on ROI. Focusing on the quality of hires requires strong relationships among talent and acquisition, HR business partners (HRBP), talent management, and people analytics. One tactic that is picking up traction in A&D is to build a "talent win room" that brings together resources from across the organization—including professional development programs, human resources, data science, analytics, and IT—to create a faster, more agile, and more streamlined employee value proposition and hiring process.

— *Reskilling where possible.* As the battle for experience and skill intensifies, more A&D employers will have to hire entry-level frontline talent and invest in upskilling them to basic proficiency levels. That comes with a cost. Companies can instead refocus their learning and development (L&D) opportunities for existing employees on skills with the highest ROI. However, this must center on outcomes, rather than activity. A strong L&D capability starts with a strategic plan aligned with company strategy, as well as a solid understanding of how each individual L&D program contributes to business outcomes. As gen AI capabilities continue to grow, we anticipate that they will become a substantial

aid to L&D in improving onboarding and time to productivity. In the meantime, L&D can play a role in creating more agility and flexibility in the organization by helping employees gain comfort with new skills and prepare for a future that continues to evolve.

— *Managing talent and culture to propel performance and experience.* As previously stated, the global A&D sector has a way to go to improve culture and perceptions of performance management. The A&D sector also lags behind its highly competitive tech and automotive peers on many of the touchstone perceptions of employee value propositions. Shifting this dynamic to affect employees' day-to-day mindsets is no small undertaking, especially for traditional A&D companies that are steeped in history and legacy. Those that are making progress in improving their culture and performance management perceptions follow a clear recipe: setting a behavioral aspiration for how the company needs to be run, understanding the current behaviors within the company, and designing targeted interventions to shift behaviors toward the aspiration, often by addressing underlying mindsets. One US A&D player has taken this process to a new level by upskilling all employees in the company on the aspired behaviors. Employees spent an entire day, away from distractions, learning about the new behaviors that were critical to performance, identifying what gets in the way of adopting those behaviors, and practicing the new behaviors together in different scenarios. All leaders are expected to facilitate this training for the next layer of employees.

— *Transforming HR into leaders of the return on talent.* HR has been slow to evolve in the A&D sector. One reason for this may be that the composition of the sector's workforce (for example, a large population of early-tenure frontline employees) and the pace of the A&D build cycle requires HR to continually perform routine tactical tasks, such as manually responding to inquires that could likely be handled through an automated process. HR leaders in A&D should ensure that their annual talent plan is not created in a vacuum from the company's enterprise strategy, that each HRBP is equipped with the data and skills to partner deeply with their programs and functions, and that HR constantly articulates the value and ROI of their actions. To help create the space to meet these goals, HR can automate many administrative tasks using gen AI—it's an area ripe with opportunity. Of those organizations that say they are currently using gen AI in at least one function, only 3 percent of them report using gen AI in HR.

Leading A&D companies understand how critical it is to shift the narrative from being at the whim of the sector's current tight labor market to being in control of one's fate and creating a talent advantage. They also understand the degree of change management that is required to shift an industry that has long benefited from a stable approach to talent management. Those that are making moves in this area are doing so quickly and boldly.

As talent supply and workforce dynamics continue to evolve, the aerospace and defense sector must match that pace of evolution. Aging employees will take years of experience and know-how with them when they retire, while new employees will usher in a wave of change—but that change brings opportunity. The stakes are far too high not to meet the challenge, and as they do so, A&D employers will need to be mindful of the gap.

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The authors wish to thank Alison Chard, Hannah Lee, Jaclyn Eng, James Paguay, Katharina Wagner, Larissa-Helen Mahaga-Ajala, Marino Mugayar-Baldocchi, Matt Anderson, Samuel Leone, and Sirui Wang for their contributions to this article.

Europe's gray-to-green workforce transition in aerospace and defense

The global aerospace and defense sector is facing a talent crisis as its workforce ages, particularly in Europe. Attracting and retaining younger employees will require a radical new approach.

This article is a collaborative effort by Hugues Lavandier, Dana Maor, Giulietta Poltronieri, Andy Voelker, and Brooke Weddle, representing views from McKinsey's Aerospace & Defense Practice.

The race for talent is intense across industries, and aerospace and defense (A&D) is no exception. The best employees, including skilled tradespeople and those with software development and engineering skills, are in high demand globally and know their value. In this environment, A&D companies around the world, despite their strong reputations, may find themselves at a disadvantage when attempting to recruit the best talent; they must compete with big tech companies and start-ups that have created strong value propositions that emphasize the importance of innovation and the creation of leading-edge technologies that change the world. Adding to the burden, A&D companies are dealing with the talent challenge at a time when the sector is growing rapidly, digitalizing many processes, and navigating other pressing challenges, including supply chain disruptions.

While we have previously written about the challenges from a US perspective, Europe faces its own share of pressing workforce issues that represent a significant call to action. The latest European Commission reporting found that 75 percent of companies report difficulties in finding workers with the necessary skills, and 40 percent of adults lack basic digital skills—all of which has been the impetus for the Commission to kick-start the "European Year of Skills."[1] In response, partly because of the war in Ukraine, a shift in the perception of the European A&D industry and its purpose (specifically the defense side of the sector) has taken place, including at the unexpected intersections of defense and start-ups and tech. For younger talent, for whom purpose matters significantly, this presents an opportunity.

Globally, the A&D sector faces multiple challenges as it attempts to attract younger or "green" employees to companies in which the workplace often skews "gray" and in which many of the most valued staff members are approaching their retirement years. While the United States leads on this trend with about one-third of industry employees aged 55 or older,[2] in Europe, it's closer to about one-fifth of the industry. A significant proportion of the A&D workforce is aged 50 to 54, however—approaching the retirement window. This trend is present among both highly skilled manufacturing trades and advanced technical engineering professions. In the context of broader labor challenges across Europe, this presents a significant risk to the ability to deliver on future, growing industry demand (Exhibit 1).

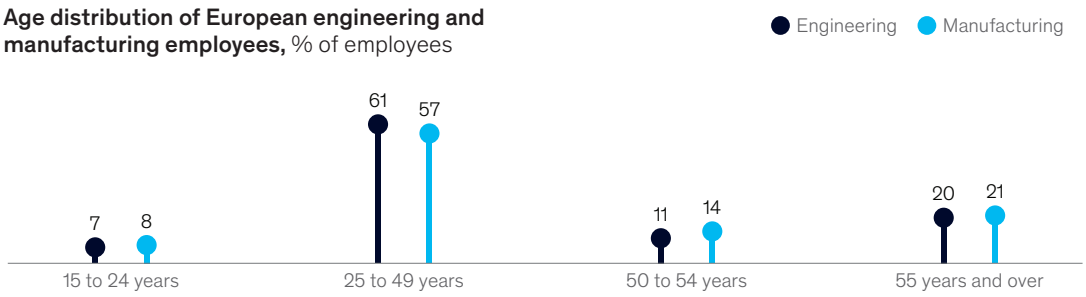
In another major postpandemic shift, workers are now more open to pursuing new opportunities, even if it means moving to a different employer. In

[1] "Commission kick-starts work on the European Year of Skills," European Commission, October 12, 2022.
[2] Varun Marya, Michael Park, Andy Voelker, and Brooke Weddle, "Navigating the gray-to-green transition in aerospace and defense," McKinsey, March 16, 2023.

Exhibit 1

The transition from 'gray' to 'green' employees in Europe creates significant headwinds.

Age distribution of European engineering and manufacturing employees, % of employees



Note: Figures may not sum to 100%, because of rounding.
Source: Eurostat

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Europe, as many as one-third of employees are thinking about changing jobs in the next three to six months.[3] This number is lower compared to the United States, where 46 percent of employees are thinking about changing jobs in this time frame; however, this statistic is still notable in a region with a traditionally less dynamic job market.[4] Younger workers with less job experience are the most likely to make a shift, with research showing they are twice as likely to change employers compared to long-tenured employees.[5]

The demographic shifts, as well as the new attitudes about switching jobs, have decreased talent replacement rates at A&D companies.[6] If companies cannot replace long-tenured employees who retire, and if the turnover rate for young employees is high, A&D companies may find that their workforce lacks some of the most essential skills. In Europe, the situation is even more acute, with employers struggling to keep pace with their American counterparts on this front. This is evidenced by a lower hiring rate and higher attrition rate, especially in areas critical to the future of the industry, such as digital and advanced-analytics profiles.[7] This trend in Europe will likely continue to worsen: as shown in McKinsey's earlier research on female technical talent in Europe, women's graduation rate in higher education from STEM disciplines is declining. At current rates, the share of women in tech roles in Europe is set to decline to 21 percent by 2027.[8] For A&D players in Europe, this is a sobering reality that will require extraordinary measures to change.

New generation, new expectations

Younger workers—the "green" contingent—tend to have a different conception of the employee–employer relationship than do older employees in the "gray" group.[9] Younger workers grew up in a world where the internet made goods and services readily available—often instantly or with same-day delivery—and allowed them to conduct much of their social lives online. Not surprisingly, these experiences have shaped what many younger employees now expect in the workplace, and our global research shows that six factors are particularly important to them:

- an easy application process with clear communication and a quick time to hire
- rapid career progression and clear performance feedback (for example, information on how an employee compares to others in similar roles)
- the ability to work in a hybrid workplace (at least in nonmanufacturing roles), with face-to-face interactions primarily reserved for situations where they clearly add value[10]
- the option to explore multiple employers or even multiple careers[11]
- a strong focus on diversity, inclusion, and sustainability, including a workplace that allows for self-expression and sanctions noninclusive behavior[12]
- compelling and engaging communications throughout the hiring process and during the entire workplace tenure, in keeping with younger employees' significant preference for consuming news and information via social media[13]

In this environment, the employee value proposition (EVP) that A&D employers offer has never mattered more. On a global level, the industry lags its highly competitive tech and auto peers on many of the touchstone perceptions of the EVP, including pay and differentiated benefits.[14]

[3] Vincent Bérubé, Dana Maor, Marino Mugayar-Baldocchi, and Angelika Reich, "European talent is ready to walk out the door. How should companies respond?," *McKinsey Quarterly*, December 12, 2022.
[4] McKinsey Great Attrition/Great Attraction Survey, 2022.
[5] "Navigating the gray-to-green transition," March 16, 2023.
[6] McKinsey analysis of data from Eurostat, 2023, and the Bureau of Labor Statistics, 2023.
[7] McKinsey Org Data Platform.
[8] Sven Blumberg, Melanie Krawina, Elina Mäkelä, and Henning Soller, "Women in tech: The best bet to solve Europe's talent shortage," McKinsey, January 24, 2023.
[9] Kari Alldredge, Jeff Jacobs, and Warren Teichner, "Great Expectations: Navigating challenging stakeholder expectations of brands," McKinsey, December 9, 2021.
[10] McKinsey analysis of data from Eurostat, 2023, and the Bureau of Labor Statistics, 2023.
[11] McKinsey Org Data Platform.
[12] Sven Blumberg, Melanie Krawina, Elina Mäkelä, and Henning Soller, "Women in tech: The best bet to solve Europe's talent shortage," McKinsey, January 24, 2023.
[13] "The news consumption habits of 16- to 40-year-olds," American Press Institute, August 31, 2022.
[14] Eric Chewning, Matt Schrimper, Andy Voelker, Brooke Weddle, "Debugging the software talent gap in aerospace and defense," McKinsey, July 18, 2022.

That said, when it comes to the A&D industry, Europe leads the United States on most elements of the EVP, especially as it relates to perceptions of senior leadership, corporate culture, and work–life balance. This is evidenced at a macro level by data from employee sentiment analyses, as well as at a more granular level by a recent ranking of the best employers in France (in which two A&D players are in the top ten[15]) or by Universum's yearly pulse survey of French engineers, which highlights that six out of the top 15 most attractive players are in A&D.[16] However, beyond what employers offer their employees, Europeans are less in tune with the values, mission, and collective purpose of the aerospace industry than their American colleagues (Exhibit 2).[17]

Despite geographic variation, the global trend is clear: the prize is high for creating a healthy organization with a strong EVP. For industrial manufacturing companies, including those in A&D, those who get it right are perceived by employees as making faster decisions and having strong leaders, tighter control, and better innovation. Additionally, such companies are better able to hire critical, highly competitive technical talent (Exhibit 3).

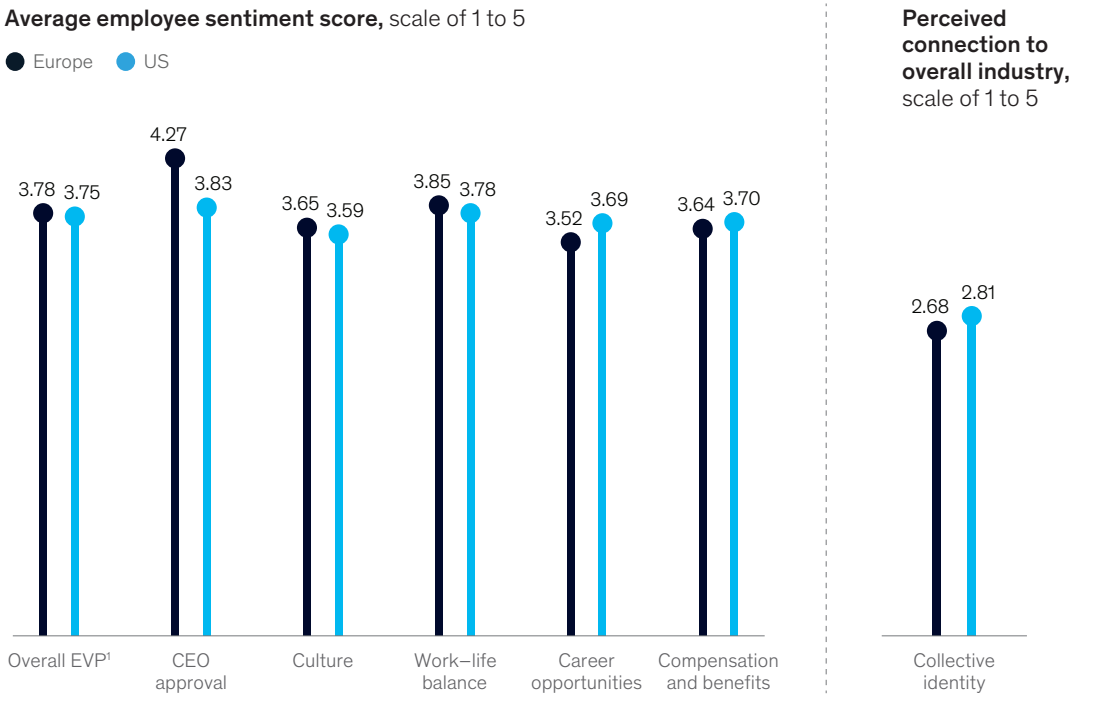
Taking a new approach to recruitment

A&D companies that fail to understand the needs of younger employees will find it difficult to recruit them in this competitive market. This is

[15] Bruno Declairieux, "The 500 best employers in France: The 2023 ranking," *Capital Avec Management,* March 9, 2023.
[16] "The most attractive employers in France," Universum, 2023.
[17] McKinsey Org Data Platform.

Exhibit 2

While aerospace and defense employers in Europe offer a stronger employee value proposition, employees are less connected to the industry overall.



[1]Employee value proposition.
Source: McKinsey analysis of publicly available employee reviews, 2020–23

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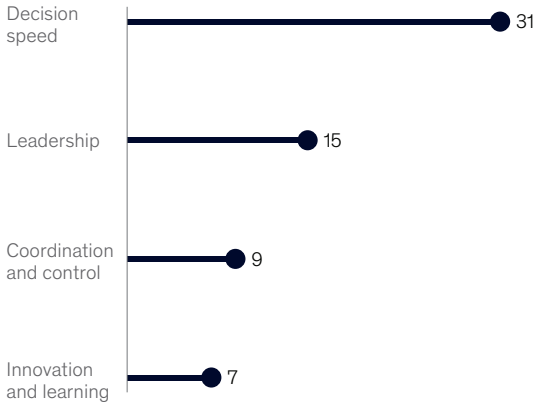
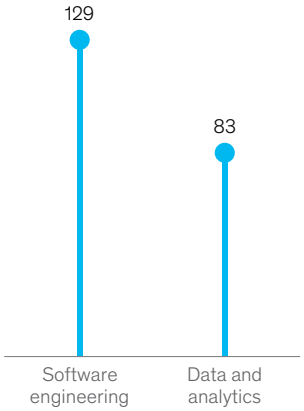
Exhibit 3

The prize is high for creating a healthy organization with a strong employee value proposition.

Advantages for top performers with a 'culture premium,'[1] % premium benefit compared to lower performers



Hiring of technical talent for top performers, % difference in hiring over the past 5 years compared to lower performers



[1]Organizations with a culture premium are those that outperform others on perceptions of culture.
Source: McKinsey analysis of publicly available employee reviews, 2020–23

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especially true in Europe, where the EVP of the A&D employer is stronger than the tie to the actual industry.[18] With demand for workers becoming even more intense, a lack of talent will increasingly limit an A&D company's growth and performance.[19]

Navigating the gray-to-green transition will require entirely new processes and mindsets. For instance, A&D companies must go on offensive when attempting to recruit the best employees, rather than relying on their traditional channels or hoping that their reputation alone will be a draw. Human resources leaders may want to create new knowledge management solutions and retention strategies. As A&D companies rethink their talent approaches, they may benefit from focusing on three key dimensions (Exhibit 4):

— *The quest for meaning.* This relates to elevating the collective sense of meaning in the sector, especially among the younger generations, to create stronger attractiveness (for example, in the fields of national security, innovation, decarbonization, and new space frontiers) and retention. Middle managers (for instance, forepersons and supervisors) play a critical role in establishing this sense of meaning, and investing in them pays off: new research shows that having more top-performing middle managers leads to much better financial outcomes.[20] This suggests that upskilling and shifting the responsibilities of middle managers is a significant lever to instill meaning at scale.

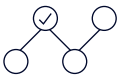
— *Expanded talent pools.* This includes widening the aperture for talent sources to consider nontraditional talent, strengthening partnerships with external parties, and rethinking cooperation with educational systems. Often, A&D players limit their views

[18] Ibid.
[19] Doug Cameron and Alistair MacDonald, "Weapons makers can't hire enough workers as Ukraine war drives demand," *Wall Street Journal*, April 24, 2023.
[20] Emily Field, Bryan Hancock, Stephanie Smallets, and Brooke Weddle, "Investing in middle managers pays off—literally," McKinsey, June 26, 2023.

Exhibit 4

Effective action will focus on three key dimensions.





Dimensions	The quest for meaning	Expanded talent pools	New career paths and recognition measures
Levers	Employee value proposition Talent attraction Middle management	Workforce development Skills-based hiring Schedule flexibility	Non-promotion-based advancement Recognition and rewards

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of expanded talent-pool levers and primarily develop their own academies, but that tactic has proved not to be enough. In the United States, early traction has already been made by including nontraditional sources in the scope of hiring. A&D players in Europe could look to the many European workers that are skilled through alternative routes but not formally educated. This workforce often has the skills for higher-wage jobs but is overlooked. According to LinkedIn,[21] adopting a skills-first approach for hiring could increase the size of the talent pool for European countries by six times. Another global theme picking up steam but not yet fully embraced in Europe is the desire of older adults to continue to work in their old age. Many feel this way (as much as 20 to 25 percent) but are not currently acting on it.[22] This represents another talent pool for Europeans to consider.

— *New career paths and recognition measures.* A&D companies could begin offering more nonlinear career paths or could allow employees to assume new roles and responsibilities before they receive a formal promotion. Recognition could also take new

[21] "A 'skills-first' strategy for a resilient European labor market," Politico, July 5, 2023; *Skills-first: Reimagining the labor market and breaking down barriers*, LinkedIn Economic Graph, 2023.
[22] "Age is just a number: How older adults view healthy aging," McKinsey, May 22, 2023.

Leading A&D companies understand how critical these changes are and how they are essential to driving future value creation.

forms. For instance, employees could receive badges if they acquire new skills or receive mentoring from senior employees if they demonstrate strong potential. In some cases, they could even be given responsibility for high-priority projects normally given to those with more experience. Such changes may help companies satisfy employee needs for rapid career progression, visible performance acknowledgment, and the opportunity to try out different roles. Given A&D's commitment to both security and reliability, the talent management of tomorrow will have to focus on expertise and performance, both technical and managerial.

Leading A&D companies understand how critical these changes are and how they are essential to driving future value creation. They also understand the degree of change management that is required to shift an industry that has long benefited from a stable approach to talent management. Those that are making moves are doing so quickly and boldly.

While all A&D companies are struggling to navigate the ongoing gray-to-green transition, European players face the most intense challenges. If they do not adopt a new approach to talent recruitment and retention, they may find that their workforce has multiple capability gaps that hinder both productivity and performance. But it is within their power to reverse the situation if HR and top executives across the C-suite are willing to go on the offense and create new strategies for recruiting younger employees, all backed by sufficient investment and resources. A&D companies can potentially enhance such efforts by working with educational institutions and members of the public sector to develop training programs that provide their students with critical skills. It's a winning proposition for all involved—including the young employees who will find challenging and rewarding work in the vitally important A&D sector.

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The authors wish to thank Drew Goldstein, Jonathan Healy, Karl Hujsak, Matt Schrimper, and Neslihan Ana Sönmez for their contributions to this article.

Why flow matters most in highly complex manufacturing

To meet escalating demand for the latest advanced products, companies need a better way to handle the interactions and uncertainties of increasingly complex manufacturing.

This article is a collaborative effort by Ryan Brukardt, Sean Cassady, Kevin Goering, Nick Mellors, and François Soubien, representing views from McKinsey's Operations practice.

Meeting demand is a growing challenge in complex manufacturing. Manufacturers of highly complex products, including aerospace companies, shipbuilders, and producers of industrial equipment, are experiencing unprecedented demand from impatient customers, but they also face acute headwinds in ramping up production to meet it. These companies' products are becoming increasingly complex to manufacture, as designs evolve over decades, adding new functionality and additional requirements to legacy platforms. High levels of customer configurability further complicate manufacturing operations, with few products built exactly alike. Companies also face workforce challenges, with many of their most experienced workers reaching retirement age, and replacement constrained by long learning curves and certification times. The challenge ahead is daunting: manufacturers must rapidly increase throughput to record levels, on products that are more complex than ever, with the least experienced workforce in decades.

Traditional lean tools break down in complex environments

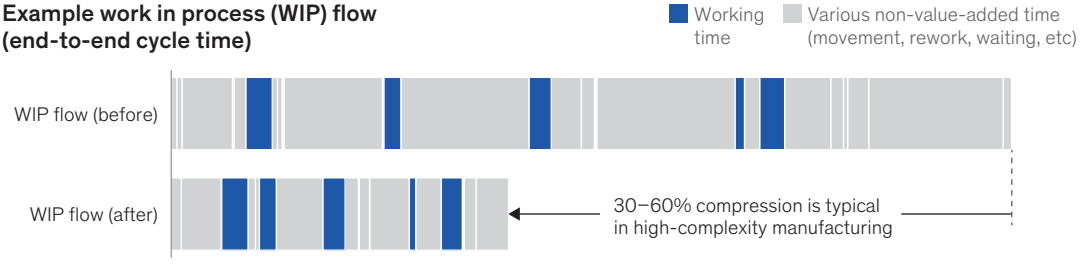
To make matters worse, the lean tools typically used to efficiently ramp up production are difficult to apply in complex manufacturing. In traditional high-volume factories, takt—the pace of production needed to meet customer demand—is visible and measurable in real time as repeatable products move down the line. Complex manufacturing is fundamentally different for three main reasons. First, cycle times tend to be much longer, more variable, and harder to measure. Second, each piece of work in process (WIP) may have a unique path to completion due to special configuration requirements, rework, or the need for engineering work-arounds, and each path may intersect other paths in unexpected ways. Third, production requires a high degree of cross-functional coordination, with synchronized handoffs between engineering, quality, transportation, and other groups. As a result, bottlenecks constantly shift, the information needed to optimize operations is highly dispersed, decisions are made with incomplete data, and WIP gets stuck.

A relentless focus on flow streamlines complexity

Complex manufacturers can overcome these challenges by rethinking their approach to lean. In traditional factories, lean tools such as overall equipment effectiveness, overall process effectiveness, or line balancing analyses are typically applied to process steps, assets, and individuals to uncover waste that limits productivity at bottlenecks. Complex manufacturing, however, is more often constrained by flow: the end-toend cycle time it takes to move WIP through production. Therefore, applying these tools to WIP flow, rather than asset or labor productivity, is far more effective at uncovering and prioritizing the often shifting sources of waste (exhibit). Once constraints are

Exhibit

Targeted initiatives to address flow constraints can reduce end-to-end cycle time.



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diagnosed, improving performance typically requires three levers:

1. *Reinvigorating information flows* with streamlined decision making and simplified dashboards. Some companies use digital twins of their production systems to identify dynamic constraints in real time, allowing teams to synchronize and prioritize their work to keep products moving.

2. *Standardizing cross-functional performance* with service-level agreements designed to support rate and performance visibility. This may include changes in performance metrics that encourage teams to minimize delays and improve flow, rather than focusing on "internal" measures such as labor or equipment utilization.

3. *Eliminating barriers to WIP flow* with targeted initiatives. For example, one company implemented a new staging point to verify the presence and quality of all required components before beginning a critical assembly step. Removing this work from the critical path dramatically reduced delays caused by missing parts or defects discovered after assembly had begun.

Notably, these initiatives are rarely confined to the four walls of manufacturing; instead, they often involve integration with critical suppliers to mitigate parts shortages and maintain quality requirements. Sustained improvement depends on building frontline capabilities to identify new constraints and lead initiatives to solve them. In complex manufacturing, resilience to disruptions requires a particularly nimble and capable team.

Opportunity for a step change in performance

One aerospace company improved production speed by 45 percent in six weeks by implementing just four prioritized initiatives to address the biggest flow bottlenecks they faced. Likewise, a shipbuilder doubled throughput in less than a year by uncovering and targeting flow constraints not captured in existing lean efforts. In both cases, the results were achieved without any additional capital investment.

Beyond throughput, both companies unlocked higher productivity, quality, and employee engagement by empowering the front line to remove entrenched barriers that had frustrated them for years. As a result, they both saw accelerated culture change and buy-in for their broader transformation efforts. And these examples are not outliers: our experience and research has shown that complex manufacturers across a range of industries tend to have low single-digit ratios of labor to total flow time: less than 5 percent on average. To meet rising demand while improving and sustaining productivity, manufacturers of advanced products can overcome the challenges of increasing complexity by focusing on flow.

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Taking off: Scaling complex manufacturing in the aerospace industry

OEMs in high-complexity, low-volume industries face skyrocketing demand. But it's now possible to scale production in ways that preserve product portfolios and profitability.

by Ryan Brukardt, Michael Conway, Drew Horah, and Kevin Sachs

Original equipment manufacturers (OEMs) in the aerospace industry are facing unprecedented challenges and uncertainty. Inflation is at a four-decade high, labor markets are tight, skilled labor is increasingly hard to find, and consumer confidence is shaky. Compounding that, supply chains remain stressed, increasing the likelihood of part shortages and uncertainty in supplier service levels.

Nevertheless, demand for production is rebounding—fast. For legacy industrial providers and disruptors alike, the transition from low- to high-rate production represents a monumental change. Many aerospace and defense companies, large industrial suppliers, and early-stage startups have been operating at low-rate production for years—and, as a result, have underinvested in the infrastructure required to achieve scale effectively and efficiently. Without an effective approach to increase capacity, rapidly scaling production may well result in missed targets, significantly overrun budgets, or—more often than not—both (Exhibit 1).

Barriers to scale

A combination of new and old barriers has made scaling production more difficult even as it becomes more important strategically.

A challenging macroeconomic environment. Rising capital costs and inflationary pressures have left OEMs less able to invest in the additional assets that higher production would require.

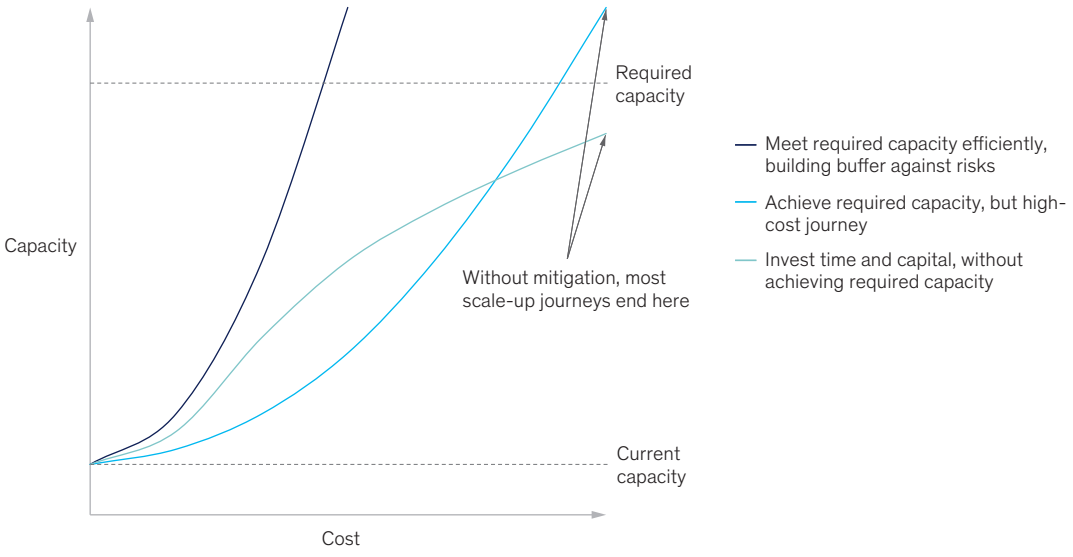
Access to talent. Across the globe, OEMs are facing challenges in finding and onboarding the skilled talent required to meet production demand. Among the main reasons for these shortages are the economic impact of COVID-19, resignations, aging workforces, and a widening skill gap.

Inadequate supply chain. Pandemic-induced disruptions to the global supply chain have continued to hinder the flow of materials to OEMs, creating part shortages and production delays—which may reflect suppliers' inability to match ramped-up production. When suppliers at lower

Exhibit 1

When manufacturing complexity is high, rapid production scaling can be counterproductive.

Overview of typical scale-up trajectories, capacity vs cost



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tiers cannot scale, OEMs must either onboard new suppliers or pay considerable penalties to expedite shipping.

Demand shift. High-complexity industries are making a dramatic shift away from low-rate, bespoke production to larger-scale operations. For years, lower production rates were sufficient for OEMs to meet demand. However, the resurgence of postpandemic demand has encouraged a transition to high-rate production—representing a monumental change to not only the daily production operations, but also the operating model to sustain and deliver a higher output operation. Across an OEM's value chain, the increased tempo means an evolution of current operations to maintain production assurance, quality, and profitability.

A multifaceted approach to increasing scale

Achieving scale has never been easy. It is a complicated, often lengthy process that is all the more difficult for OEMs seeing postpandemic demand increases. No longer do companies have three to four years to incrementally scale production—now, the expectation is to accelerate changes in production at two to three times the previous speed, while remaining profitable and maintaining diverse offerings.

That means fulfilling an existing book of business while adding assets, onboarding new hires, and redefining the operating model. To manage the strain, a foundation of core infrastructure is critical to mitigate cost overruns while transitioning to full-rate production. The most important elements include:

— *A deliberate, methodical, and codified approach* to scaling production

— *Tailored strategies by capital asset* to forecast and mitigate disruptions

— *An agile operating model* to inculcate new ways of working for high-rate production

— *Effective capital-project management* to run simultaneous projects, including teardowns and installations of new assets

— *Enhanced supply-chain resilience* to proactively mitigate risks for lower-tier suppliers

— *Refined talent strategies* to hire and train the right people, while strengthening capability building programs to close skill gaps

Core ingredients and accelerants for achieving scale

Companies that are succeeding in their production transformations show a common recipe for ramping up, comprising two components: a set of core ingredients, together with a few critical accelerants (Exhibit 2). The core ingredients—maximizing throughput of current assets, augmenting necessary labor hours, and efficiently deploying capital—focus on how best to use existing resources to meet demand. The accelerants—leveraging analytics, scaling the supply chain, and optimizing working capital—provide the ability to both step change output while also creating the infrastructure to sustain higher rate production.

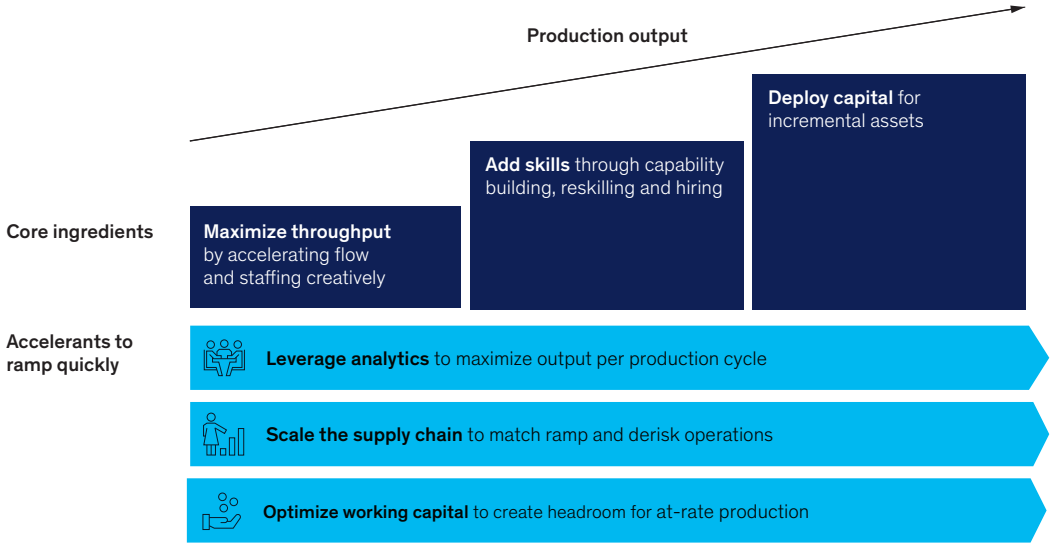
Maximize the throughput of current assets. In addition to traditional lean manufacturing–based improvement initiatives—such as KPI setting and monitoring, visual performance boards, and daily target setting meetings—OEMs seeking to step change production must adopt a utilization-based approach to production. Running machines at near full potential capacity—"sweating" machines—is a concept innately familiar to high-volume manufacturers, but is often much less common in highly engineered, low-volume manufacturing. Maximizing throughput per asset requires the development of tailored maintenance strategies and the codified processes required to sustain higher output levels. These processes include productivity strategies such as improved batching, detailed work planning, and schedule optimization to maintain asset utilization.

Rethink shift design. A non-capital-intensive lever to unlock incremental capacity is decoupling shift structures and developing tailored shift strategies by production asset. Shift augmentation aimed at enabling assets to run at full potential utilization enables OEMs

Exhibit 2

With care, manufacturers in high-complexity industries can scale production successfully.

Recipe to ramp production



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to maximize throughput while balancing labor needs. In a constrained environment, better use of operator cross training or more standardized work, or both, can create redundancy to allocate resources in line with production demand and alleviate any need for overstaffing.

Deploy incremental capital using a total cost of capital approach. Macroeconomic factors are increasing budgetary pressures for OEMs and restricting available capital to invest in incremental production assets. A total cost of ownership approach that considers predictability in future demand, product design specifications, and lifecycle management should be assessed when investing to close capacity gaps. Capital investments can be minimized by evaluating levers such as design-to-build and make-buy decisions, which can smooth production flow and minimize spikiness in temporary demand profiles.

Leverage analytics. In low-volume, long-lead production cycles, it is crucial to maximize throughput and learnings from every production iteration. But by its nature, the most complex types of manufacturing lack the ability to trial multiple production techniques, or isolate batch production for testing. Advanced analytics is therefore vital to accelerating production learnings while also creating an environment capable of simulating different scenario-based pilots. Techniques such as digital simulations (including advanced digital twins) and digital performance management can enable scenario-based modeling, dynamic bottleneck reduction, and real-time feedback loops on performance optimization opportunities.

Scale the supply chain. The availability of necessary parts is critical to ensuring a continuous and efficient production operation. Scaling the supply chain begins with an in-depth look at part criticality to determine if any parts could be simplified, redesigned, or multisourced, as well as a detailed risk assessment of a supplier's ability to match production rate. Assessing supplier risk requires qualifying historical performance, evaluating current production capacity and scalability, and assessing overall reliability—through assessments of revenue criticality and geographic risk that estimate a supplier's ability to consistently deliver parts. Mitigating potential risk may mean tolerating additional redundancy in the supply

chain, with tailored fulfillment strategies based on part and supplier risk profiles.

Optimize working capital. If higher output targets lead buyers to scale their inventory orders accordingly, ramping up production could significantly constrain working capital—while also raising the risk that excess parts will eventually become obsolete inventory. That risk can be compounded by incomplete or unstable engineering designs, which may result in obsolescing whole categories of components. A "plan for every part" fulfillment strategy can help balance part availability and mitigate waste by accounting for variability in demand, consistency of design, and ability of suppliers to deliver parts at the required lead times.

Achieving scale in action

An aerospace OEM followed this recipe to create a road map towards tripling its production capacity in less than two years, while simultaneously saving about 20 percent of planned capital investment. Starting with a utilization-based approach, the OEM tailored its production strategies by asset—including redesigned standard work, decoupled and batched workflows, targeted maintenance strategies, and a rigorous focus on overall equipment effectiveness (OEE). This combination mitigated the need to invest in six planned assets, at a total cost of more than 10 million. The approach also enabled the production line to reduce excess staffing requirements by 20 percent, through the use of dynamic shifts, improved performance management, and standardized work.

In addition to increasing overall capacity, instituting targeted fulfillment strategies for each part on the bill of materials is on target to improve working capital improvement by $400 million. These savings are expected to be realized over two years by refining on-hand inventory levels and creating mechanisms to optimize the purchase of parts in line with future demand. Reducing obsolete parts and inventory backlogs led to an incremental, one-time cash avoidance of more than $25 million.

This new production recipe enables OEMs to scale capacity holistically by increasing capabilities across all supply tiers, not just within four factory walls. It can be done quickly by unlocking capacity in parallel to address throughput, supply chain, and working capital simultaneously. Leveraging Industry 4.0 technologies and analytics enables maximum throughput in every production cycle, while mitigating the need for large upfront investments. It's an approach that can step-change production both for seasoned industrials and startup disruptors.

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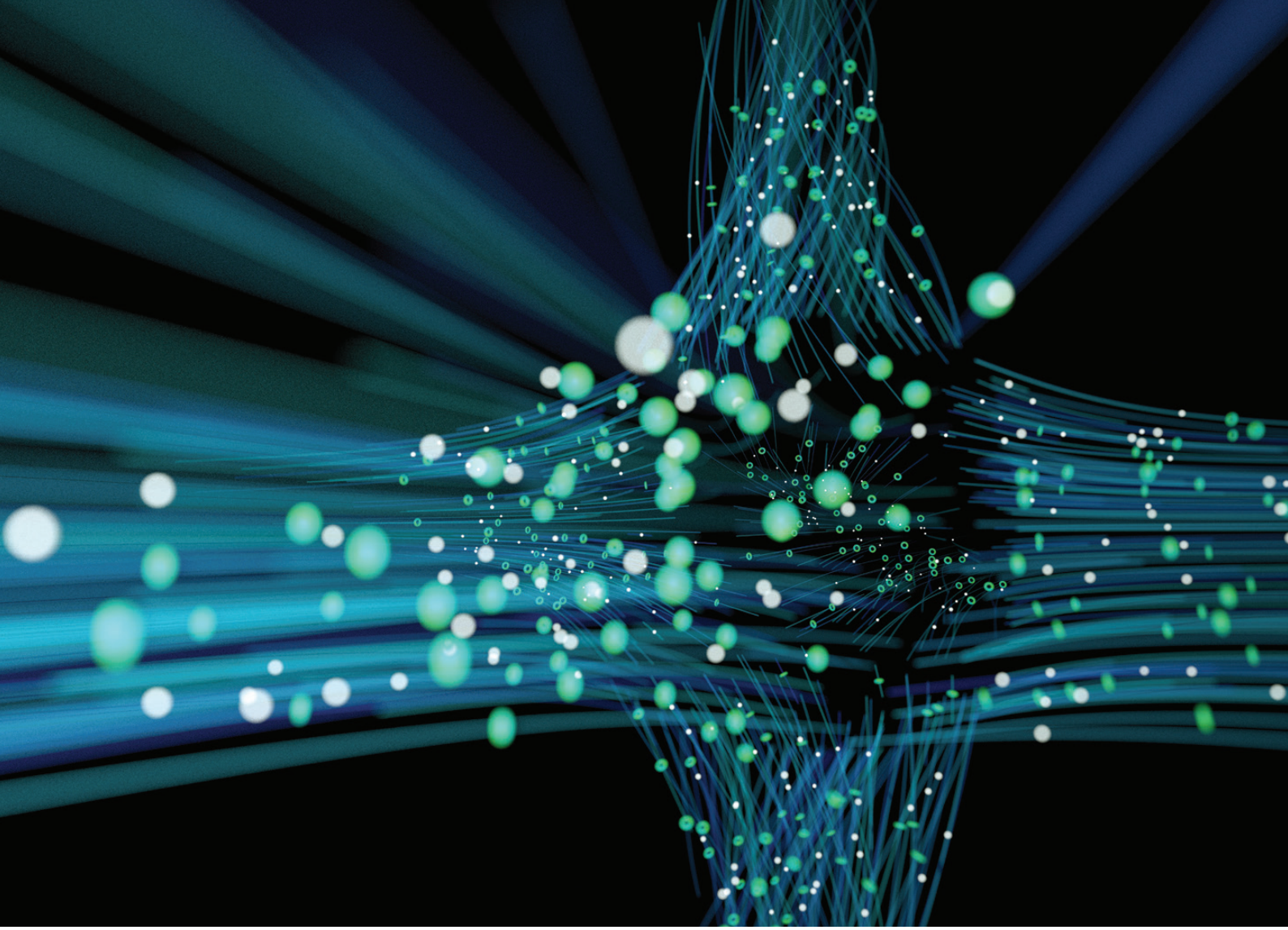


A rising wave of tech disruptors: The future of defense innovation?

Nontraditional sources of innovation are transforming the defense sector with powerful capabilities—but they must overcome obstacles on the path to scalable success.

by Jesse Klempner, Christian Rodriguez, and Dale Swartz

In response to a new era of geopolitical uncertainty and a rapidly shifting national security environment, countries across the world are transforming their military capabilities. And, as new mission needs in this transformation take shape across multidomain operations, different tools are in demand—increasingly supplied by a range of new entrants to the defense industry.

National security customers are showing demand for technologies sourced by firms outside the traditional defense industrial base. This dynamic is not new but has materialized in three distinct waves of defense tech start-ups over the past 20 years (exhibit).

For example, in the United States, SpaceX and Palantir were notable companies in the first wave in the early 2000s; both designed technology for government channels other than the Department of Defense.[1] A second wave began in the mid-to-late 2010s, represented by new entrants like Anduril and ShieldAI—both now unicorns—that leveraged commercially derived technology tailored to defense applications (such as sensor fusion at the edge and AI pilots).[2] A third wave of disruption is now on the rise—a much larger ecosystem of start-ups and nontraditional companies that are driving innovation, attracting significant venture capital (VC) funding, and looking for the means to scale.

In many cases in Europe and the United States, these start-ups (along with their commercial hyperscaler counterparts) are well positioned to fulfill critical national security needs, complementing the traditional industrial base that might not have enough capabilities to respond to evolving demands on its own.[3] Before large-scale solutions can be reliably supplied for national security users, however, challenges need to be overcome. Effective strategies tailored to fit defense customers could ease the journey, and leveraging dual-use technology (suitable for both military and nonmilitary applications) could be critical to accelerated growth for successful organizations in this environment.

New defense priorities spur new technology needs

For several decades, national security agendas focused primarily on asymmetric and transnational threats such as terrorism and cybercrime. However, sometimes the uncertain global geopolitical environment can cause peer and near-peer competition, as evidenced in the national security strategies published since 2022 in Germany, Japan, the United Kingdom, and the United States.[4] These strategies can lead to demand for new technologies to increase resilience and efficacy—in particular, technologies that will support new disaggregated and "joint all-domain" concepts. We have noticed that there is a call for three overlapping sets of capabilities:

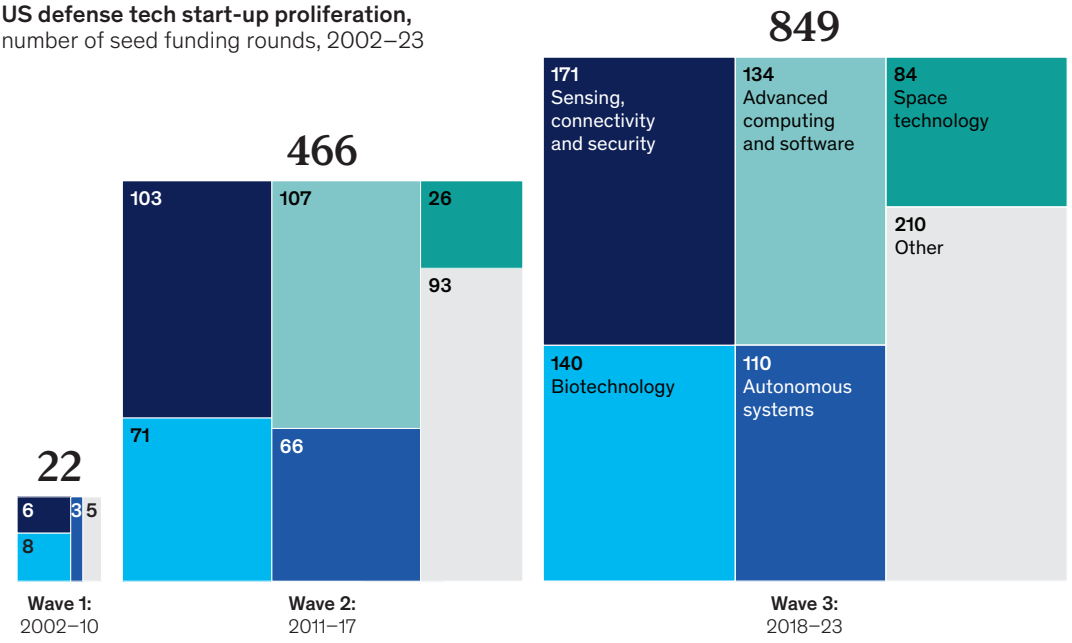
1. *Disaggregating capabilities:* By disaggregating capabilities into networks of smaller nodes, force planners can reduce points of failure and increase the likelihood of successful missions connecting air, land, sea, and space assets. This could improve operational coverage while boosting resilience. Instead of one high-value satellite, for example, the preference might be for an array of smaller, linked satellites; instead of one manned submarine, a coordinated fleet of unmanned underwater vehicles.
2. *Effective communication networks:* For such disaggregated assets to function collectively, real-time intelligence sharing—enabled by resilient and effective communication networks—is important. Resilient networks can ensure instant communication between assets (meshing sensors to effectors) and allow for smooth, responsive operations. Resilient network-enabling technologies such as 5G, phased-array antennas, artificial intelligence (AI), and high-density computing can enable the movement of responsive decision making to the tactical edge where they can have the greatest mission impact.

[1] For further information, see company websites: spacex.com; palantir.com.
[2] For further information, see company websites: anduril.com; shield.ai.
[3] McKinsey analysis.
[4] *Integrated security for Germany: National security strategy*, German Federal Government, June 2023; *Japan security policy*, Minister of Foreign Affairs of Japan, April 2023; "Integrated review refresh 2023: Responding to a more contested and volatile world," Gov.UK, May 16, 2023; *National security strategy*, The White House, October 2022.

Exhibit

Tech disruptors are increasing in numbers, focusing on a range of defense tech.

US defense tech start-up proliferation,
number of seed funding rounds, 2002–23



[1]Other includes advanced materials, human machine interfaces, quantum, energy generation or storage, and semiconductors.
Source: Pitchbook; McKinsey analysis

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3. *New technologies:* Engineering high bandwidth, resilient networks would likely involve retrofitting existing platforms—or developing entirely new architectures (such as AI-powered command-and-control systems that connect users across services and collation partners in air, land, sea, and space). The density of technology-enabled mission systems is likely to continue to increase for the foreseeable future. Either way, new technologies—including decentralized cloud computing, data management, edge analytics, autonomy-enabling systems, and a plethora of hardware solutions and novel materials—are frequently cited capability needs.

In addressing these needs, the traditional defense industrial base can bring various strengths to national security customers: for example, an understanding of specific missions; deep technical expertise in designing for those missions; long-established security protocols and infrastructure to host classified data; business development, customer relationships, and acquisition; program management excellence; and integration opportunities within existing, installed platforms.[5]

These capabilities alone, however, may no longer be enough. In response to evolving needs, a new generation of security tech companies has materialized. This new cohort features both start-ups and commercial technology hyperscalers and can offer different but complementary benefits:

— greater spend on high-risk R&D, relative to size, than the average defense contractor

[5] *National Defense Industrial Strategy 2023*, US Department of Defense, January 2024.

- top-tier software and a new generation of STEM talent with fluency in digital technologies such as AI, quantum computing, and advanced microelectronics
- product-oriented business models that tend to be faster, cheaper, and more innovative
- a focus on commercially priced, scalable products and services

The European Union and the United States have signaled interest in these novel capabilities. The US Department of Defense has taken steps to access commercial technology through new acquisition and budgeting authorities—for example, increasing the prominence of the Defense Innovation Unit and establishing the Replicator initiative in 2023 to rapidly field autonomous, attritable systems.[6] NATO has formed an innovation accelerator (DIANA) to foster collaboration with start-ups and other tech companies, and has announced the €1 billion NATO Innovation Fund focused on dual-use technologies.[7]

Private capital has also indicated an intent to pursue defense tech opportunities, and we have observed that VC investment in such technologies outpaced the overall growth in venture spending between 2019 and 2023. Meanwhile, traditional defense firms have increased their corporate venture funds to be able to access the emerging tech.

New defense tech companies face obstacles

Despite this momentum, many next-generation defense tech firms have struggled to do business at scale with national security organizations.[8] This is likely due to three main challenges:

Reconciling program-centric versus product-centric operating models. National security customers often seek bespoke solutions to very specific problems versus an "out of the box" commercial offering. With limited access to classified information and other sources of insight, tech firms can struggle to understand the precise nature of these problems. The effort to tailor an existing solution to the "last mile" in defense may also not be compatible with the commercial scale business models favored by tech companies.

Building a go-to-market muscle for defense markets. New defense tech companies can be constrained by unfamiliarity with the government sales and contracting landscape. Scaling a solution in defense markets requires a robust government affairs operation and an understanding of unique government procurement processes. Start-ups, in particular, often lack a track record of performing on programs of record at defense agencies, which can be an important requirement for winning new contracts.

[6] "Memorandum for senior Pentagon leadership, commanders of the combatant commands, defense agency and DOD field activity directors," Secretary of Defense, US Department of Defense, April 4, 2023; Joseph Clark, "Defense officials report progress on replicator initiative," DOD News, US Department of Defense, December 1, 2023.
[7] "NATO Innovation Fund closes on €1 billion flagship fund," North Atlantic Treaty Organization, August 1, 2023.
[8] Heather Somerville, "Investors are betting on defense startups. The Pentagon isn't," *Wall Street Journal*, January 25, 2023.

Start-ups (along with their commercial hyperscaler counterparts) are well positioned to fulfill critical national security needs, complementing the traditional industrial base.

Aligning revenue timelines with investor expectations. Government contracting often offers an atypical return profile to private capital (such as VCs and growth equity) that has become the primary backer of defense tech start-ups. Private investors tend to look at three- to five-year horizons for returns—which can be out of sync with the slower (traditionally seven- to ten-year) pace of defense programs of record. A start-up may run short on funding before consistent revenue from government contracts begins to materialize. This mismatch is likely to deter private investment.

Public markets are unlikely to fill this gap entirely, given their emphasis on short-term results and an aerospace and defense investor base that often emphasizes stable cash flows versus at-risk investments in novel technologies. Meanwhile, governmental entities in Europe and the United States generally invest less in innovation than their private sector counterparts: for example, the US national security community has recently been spending less than 5 percent of its total budget on developing innovative technologies, whereas a typical commercial technology firm spends three to four times that share of revenue annually.[9]

Successful defense tech disruptors use five strategies

How to tackle these challenges? Lessons learned from successful defense tech companies include five strategies that they effectively employ.

Lay the infrastructure for scaling from the outset. Most defense tech companies ultimately become hardware companies, and many are now facing the same scaling challenges as their more at-scale peers and competitors—such as maintaining manufacturing speed and quality, resilient supply chains, and machining or technical talent. Building scaling infrastructure into the initial plan, from prototyping resources onwards, can make the difference on time to market.

Lower barriers by leveraging more established partners. Once a product's validity has been demonstrated, partnership with an established industrial defense company could facilitate its entry to market. Established suppliers can bring installed bases, mission expertise, and customer familiarity that complements tech companies' capabilities. Established suppliers often shape access to the aircraft, land systems, and ships that new mission systems will be integrated into by providing the "socket" into which a disruptor's "lightbulbs" can plug. The list of recent partnership announcements between defense tech disruptors and traditional defense organizations span hardware and software across a range of technology focus areas, including 5G, hypersonic aircraft, autonomy for next-generation tactical aircraft, AI, and edge networks.[10]

Take, for example, defense disruptor, Helsing, which was able to get to a program of record in fewer than three years by partnering with an

[9] Eric Chewning, Will Gangware, Jess Harrington, and Dale Swartz, "How will US funding for defense technology innovation evolve?," McKinsey, November 4, 2022.

[10] "Northrop Grumman, AT&T, and Fujitsu demonstrate new 5-G powered open capabilities to support joint force," Northrop Grumman, January 18, 2023; "Strategic relationship 5G.MIL solutions," Lockheed Martin, February 22, 2023; Jaspreet Gill, "ShieldAI, Boeing ink agreement to push AI, autonomous development," Breaking Defense, March 8, 2023; "GM Defence and Anduril announce teaming agreement," Anduril Industries, October 10, 2023.

Lessons learned from successful defense tech companies include five strategies that they effectively employ.

existing defense prime (Saab). Helsing's AI and signal processing expertise complemented Saab's hardware-based sensors and self-protection systems. As a result of the two companies growing closer, Saab in September 2023 made a sizeable investment of €75 million in Helsing's most recent venture round, at an overall valuation of €1.5 billion.[11]

Go dual use. Purely can struggle to achieve scale defense-focused start-ups before investors become frustrated with delays. But, companies that find nonmilitary applications for their technologies can build scale in commercial markets, while buying the time needed to secure a long-term defense contract. However, pursuing dual-use innovations may also mean designing a two-speed business model to accommodate disparate timelines and unique international security requirements.

Strong demand and healthy capital inflows have allowed certain dual-use tech organizations to thrive. Private investors, who have a higher tolerance for risk than public markets or government R&D appropriators, in many cases are looking to back dual-use technology, given its large potential returns and broad applicability.[12]

Vertically integrate to provide software and hardware in one solution. Defense customers generally are comfortable with purchasing integrated hardware and software products, rather than stand-alone software capabilities that can be applied to a range of hardware. For tech disruptors, opting to sell a piece of differentiated software packaged within hardware can be beneficial (for example, a fleet of ready-to-deploy drones rather than a drone operating system).

Tailor sales capabilities to the customer. Selling to defense customers can be a challenge if a company hasn't set up a government affairs unit with proper clearances and extensive experience. Tech companies can look beyond a defense organization's broad requests for proposals and focus on communicating with potential customers about granular needs.

Defense oriented technology is a vital and enduring component of national security. Start-ups, scaled commercial organizations, traditional defense contractors, and investors all have roles to play in integrating innovative new technologies into the defense ecosystem.

[11] "Saab signs strategic cooperation agreement and makes investment in Helsing," Saab, September 14, 2023.
[12] McKinsey analysis.

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How product-focused operations can accelerate global shipbuilding

A new operating model can help the global commercial and defense shipbuilding industry address bottlenecks and ramp up production as demand continues to soar.

This article is a collaborative effort by Brooke Weddle, Nick Mellors, and Ryan Brukardt, with Benjamin Plum, George Naughton, and Sean Cassady, representing a private sector perspective from McKinsey's Aerospace & Defense Practice. Our A&D Practice focuses on helping executives improve outcomes for companies in the Aerospace & Defense sector.

Every large ship is an engineering marvel that requires the combined efforts of an entire shipyard ecosystem to produce. The complexity of each vessel is topped only by the complexity of the shipbuilding operation, which requires significant resources—teams of skilled welders, fitters, electricians, engineers, inspectors, and schedulers, to name a few—working in unison across acres of waterfront and on the deckplates to produce a seaworthy vessel. Across the global commercial and defense shipbuilding industry, producers must manage competing constraints, complicated and intersecting value streams, and dynamic critical paths for multiple products to deliver on schedule and on budget.

Recent growth in demand for ships has created even greater delivery challenges. Multiple factors contribute to these delays, including a surge in employee retirements, the unmatched complexity of new vessels, aging shipyard infrastructure, and operational challenges.[1] Faced with relatively low and stable demand over the past 30 years, the global commercial and defense shipbuilding industry has streamlined costs by implementing efficient, process-focused operations in which people, equipment, and other assets are consolidated based on the tasks that they perform. This model allows shipyards to create specialized centers of shared resources, but it also has some downsides for yards that are trying to increase throughput: reduced visibility into complex value streams and constraints, and suboptimal cross-functional coordination.

To meet rising demand and eliminate delivery backlogs, shipbuilders and their suppliers must quickly increase their manufacturing velocity. One successful approach involves pivoting to an operating model that focuses on products, rather than processes, for targeted, critical components. In product-focused operations, overall end-product throughput is prioritized over traditional functional area performance metrics. Employees are assigned to a dedicated product or product group, working as a single, multidisciplinary team. Physical assets are similarly allocated, ensuring that work in process (WIP) does not queue while waiting for shared equipment. For rapid implementation, maritime producers have reserved this model for only the most constrained or complex components for critical products, for which the cost of delays outweighs the cost efficiencies of the process-focused model.

Although product-focused operating models are common in many industries, they remain rare in shipbuilding. But some leading shipbuilders are rapidly deploying this model with dramatic results. One shipbuilder doubled throughput of critical, bottlenecked components less than six months after making the shift from process to product focus. Such experiences make a compelling case for targeted deployment of product-focused operations to accelerate shipyard velocity.

Old systems, new challenges

Process-focused operations were a logical strategy across the maritime industry for many years. The shift of commercial building to Asian shipyards combined with limited demand for naval vessels to create an environment in which shipyards and suppliers manufactured relatively small quantities of custom-made (often one-off) parts and components. By emphasizing process-focused production with shared-service functions (including production facilities and their support organizations), global shipbuilders and suppliers could maximize cost and physical capacity efficiency.

However, cost and capacity efficiency often come at the expense of velocity. In a process-focused operation, functional leaders set group-specific budgets, metrics, and incentives. Although these targets may increase functional productivity at the shop level, they often create or exacerbate operational complications that slow throughput at the product level. Product cycle times tend to increase, driven largely by several commonly observed pitfalls:

— *Focusing on a small segment of the value chain.* When all leaders are vertically focused on their functional shops, no single leader or team is horizontally focused on the entire value stream or empowered to improve cross-cutting inefficiencies. There is often no centralized authority to rebalance priorities

[1] "Charting a new course: The untapped potential of American shipyards," McKinsey, June 5, 2024.

and modify targets to support program-level delivery objectives.

— *Prioritizing low-hanging fruit.* Functional leaders may decide to meet shop targets by cherry-picking the parts they manufacture. They may decide to prioritize less complex parts or those for which all required material is on hand, regardless of downstream need.

— *Creating footprint constraints with excess WIP.* When one function concentrates on its own cherry-picked targets and fails to consider downstream needs or delays, internal congestion in the value stream can result as WIP builds up. Without excess capacity in the yard to absorb this disruption, yards can quickly become constrained by their footprints and lose the ability to move material quickly and efficiently.

— *Creating excessive loss, damage, and rework.* Idle WIP must be handled and stored properly to avoid damage from corrosion and material deflection, but without centralized management among functions, maritime players may overlook such requirements as excess material accumulates and WIP is stored in overflow areas. When WIP is predictably missing or damaged when downstream customers are ready for it, shipyards must undertake rework, resulting in lost productivity and velocity.

While individual functions may meet their cost and efficiency targets under a process-focused model, overall product throughput is suboptimal (Exhibit 1). Complex production systems such as shipyards may also struggle to adjust their highly specialized operations—for instance, deploying employees to different tasks—in response to demand shifts. With functions operating in silos, transparency across the value chain is limited and teams may have difficulty working in sync because they have different incentives. The extremely complex value chains may also mask technical constraints that cause bottlenecks with an outsize effect on manufacturing velocity.

Amid a backdrop of complex functions optimized for cost, the recent rise in demand is exposing the inherent risks of process-focused operations. Although the global commercial and defense shipbuilding industry has recently made major investments in workforce attraction and development programs alongside major facility infrastructure upgrades, these additional costs have not always translated to throughput; many programs remain behind production targets. In many cases, entrenched process-oriented operations stand in the way of efficiently deploying these new people and assets. With order volumes remaining high, the cost and schedule impacts of process-driven delays will likely be further magnified.

A product-focused approach to operations

A shift to product-focused operations can help global shipyards and suppliers rapidly and efficiently accelerate throughput. For speed and simplicity of implementation, product-focused operations are best reserved for shipbuilders' most critical components: those with the greatest impact on schedule and cost along key programs' critical paths. Maritime players have successfully deployed this model in two ways: by implementing product-focused management systems within their existing shipyards, or—if they need even more improvement—by combining those management systems with enhanced physical layouts.

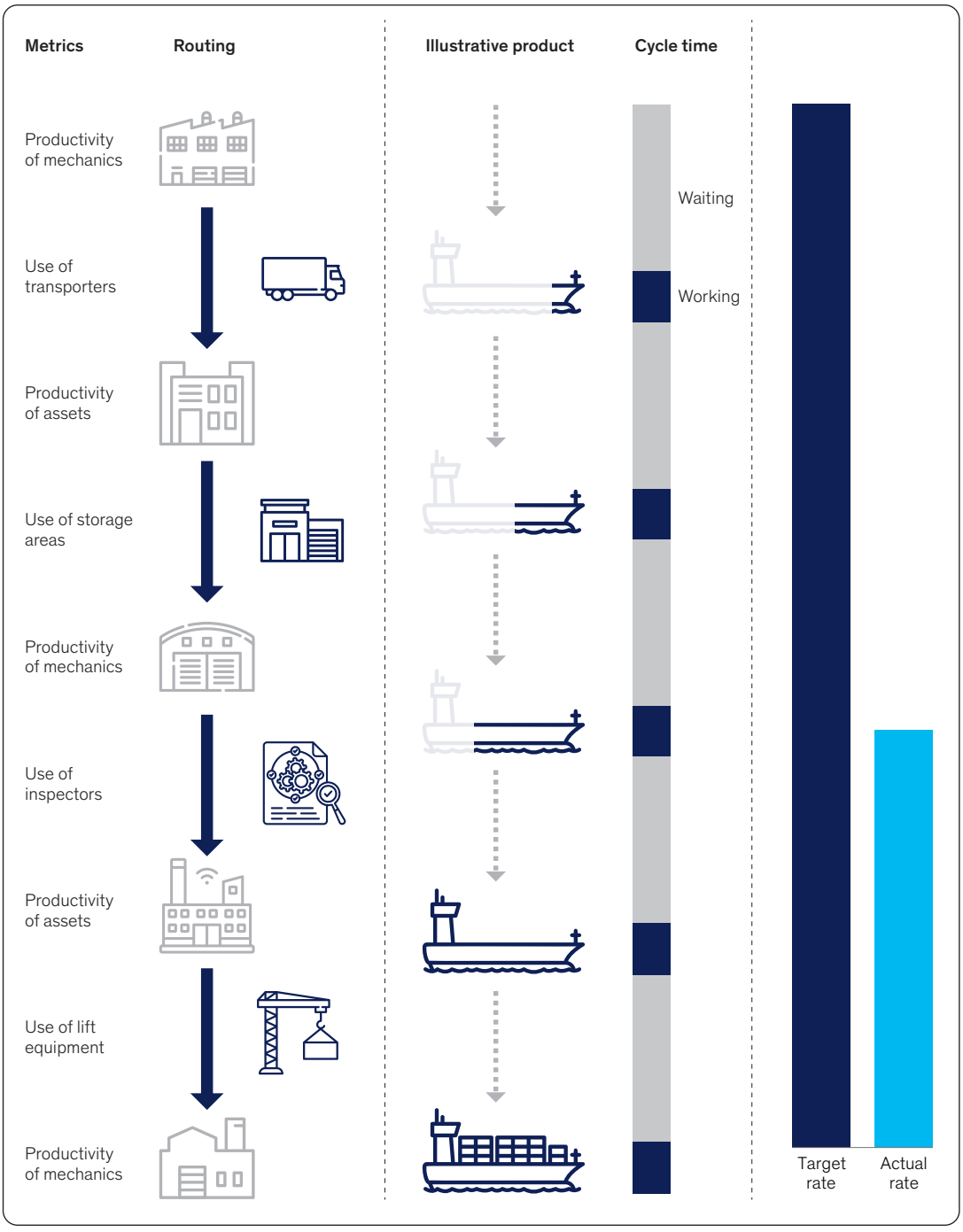
Product-focused management systems

In product-focused management systems, the primary goal is to optimize end-product output rather than functional performance. In addition to better illuminating bottlenecks across the value stream, these systems facilitate decision making and problem resolution, allowing maritime producers to maximize value stream efficiency (instead of local, functional efficiencies).

Central to every product-focused management system is a multidisciplinary team comprising stakeholders from relevant functional shops and support organizations such as quality, material handling, procurement, and facilities. The teams, which are empowered to break down organizational barriers, work toward a common goal and create a sense of shared purpose (in contrast to process-driven operations, in which numerous individuals in separate organizations work toward different targets).

Exhibit 1

Process-focused production slows velocity.



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The multidisciplinary product teams oversee both daily production and continuous-improvement activities. The most effective teams emphasize the following:

— *Speed and visibility.* High-performing teams hold daily stand-up meetings with daily progress plans to ensure that tactical constraints are quickly identified, tracked, and resolved. Ideally, meetings occur in a central command center, furnished with visual management tools to build shared situational awareness, and have strictly defined issue escalation criteria to ensure no constraint festers without resolution.

— *Shipyard-level success.* Product-focused teams replace function-specific KPIs with new metrics related to tangible end-product throughput—such as the number of units completed—and incremental, lower-level metrics, such as milestone progress and bottleneck utilization. In addition to increasing product throughput, this shift helps teams create greater transparency into the flow of critical WIP from one step to the next.[2]

— *Enhanced product flow.* Product-focused teams avoid WIP accumulation and enhance flow by creating dedicated storage and queuing lanes for parts and by strictly enforcing footprint capacity limits. If inventory reaches its limit, stop-work signals can automatically flow to upstream stations. In addition to freeing up space, controlling the amount of WIP in the system enables faster, more accurate diagnoses of often-moving bottlenecks.

One leading shipbuilder's recent experience illustrates the benefits of product-focused management systems. One particularly complex product, requiring numerous jobs to be completed in sequence by multiple functions, was falling behind as demand grew. The builder had historically concentrated on functional metrics and measured "job counts," often numbering dozens, at the shop level. When job counts fell below the target, efforts to increase completion rate proved counterproductive; inventory soared, creating gridlock within the facility and slowing throughput. Moreover, overcoming roadblocks was challenged by low visibility into bottlenecks that were slowing downstream production and a strong focus on disconnected functional metrics.

To improve operations, the shipbuilder began measuring end-product throughput rather than focusing on the volume of jobs completed for each function. It empowered a cross-functional team, which created a command center adjacent to the shop floor to manage all production tasks, including material controls, WIP monitoring, and bottleneck mitigation. In addition to deploying simple but effective performance management tools, the team introduced standard work protocols to create and sustain consistent processes, regardless of shift change or personnel turnover. The result: throughput doubled without any capital expense while freeing up 20 percent more floor space by reducing idle inventory.

Throughput maximization via changing physical layouts

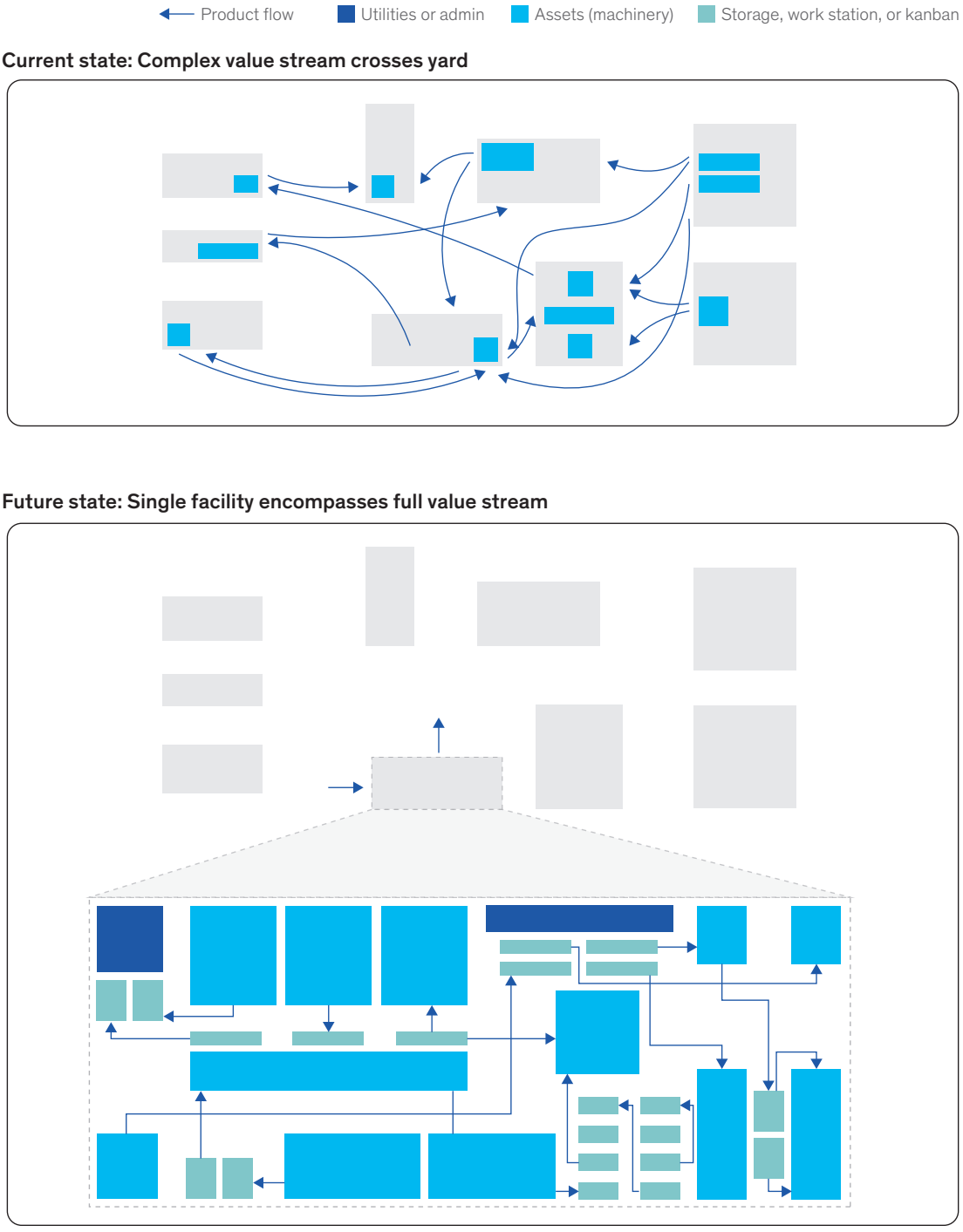
For some in the global commercial and defense maritime industries, deploying product-driven management systems for critical components may be enough to reach target throughput levels. Others, however, may also require physical layout changes to their facilities to eliminate structural problems that hamper productivity and coordination. For instance, workers may need to transport products between two facilities that are far apart, slowing production, or WIP may require excessive routings between work cells for iterative processes.

When making layout changes, maritime players can look first to create a single location, staffed with a dedicated team and containing all necessary equipment, focused on production of a single critical product or product group (Exhibit 2). Consolidating all product-related activities under one roof—"factories within factories"—can create better transparency and facilitate coordination among functions. Highly complex producers, such as shipyards, should make layout changes only for select products; this will allow them to address targeted constraints without affecting operations in the rest of the production system.

[2] "Why flow matters most in highly complex manufacturing," McKinsey, May 3, 2024.

Exhibit 2

Product-focused design reduces the complexity of core value streams.



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Optimizing physical layouts typically takes more time than implementing product-focused management systems. It also requires a change in mindset. Many in the global shipbuilding industry focus on one-for-one replacement of select equipment or concentrate on footprint expansion to solve capacity challenges. Instead, they should undertake a more targeted optimization of selected product value streams. While additional space and more equipment are sometimes helpful, maritime players can often achieve greater gains by building in a product focus to the layout changes they make—for instance, explicitly simplifying product routings instead of reinforcing existing process centers.

Product-focused layout optimizations succeed only when accompanied by management system changes. Otherwise, managers and employees retain process-focused mindsets and incentives that tend to diminish efficiency in a system designed for throughput. For example, in a process-focused system, it's easy for employees to let other work "creep" into assets that are supposed to be dedicated to certain products. Although this would increase equipment utilization, it could also cause critical components to wait in queues. The cost of time lost to queuing for a shared asset can very quickly exceed the purchase price of the machine itself.

To ensure a product-focused layout change achieves its intended goals, maritime players can observe three important design principles. End-to-end visibility along the value stream is important, and most yards and suppliers will achieve it if they reach their goal of housing all product-related activities under one roof. (Even if cohousing is not feasible, product-focused management systems still produce some improvement.) Maritime players should also attempt to compress cycle times by relying on a simple, single-piece flow. This practice can involve creating separate production lines for individual components, putting commonly used assets close to each other, or creating dedicated space for inventory and WIP. Single-piece flow reduces batching and movement losses while improving quality, repeatability, and rate. Last, any layout changes should focus on optimizing product throughput rather than on increasing asset utilization.

Product-focused physical layout changes can have a dramatic effect on throughput. One leading shipbuilder, facing a significant increase in demand, adopted a product-focused approach for its most challenging product group. The manufacturing process for the product involved more than 15 functional teams and routings across a dozen facilities. Without accountability or transparency, these products spent more than 90 percent of their time in production waiting in queues for shared assets or teams.

To improve performance, the shipbuilder implemented a product-focused operating system and changed its physical layout. The new layouts embodied the design principles discussed above: single-piece flow, end-to-end visibility, and a focus on product throughput. Among other benefits, the physical-layout changes alone

Maritime players can often achieve greater gains by building in a product focus to the layout changes they make.

reduced the number of routings by 50 percent and the distance traveled by 95 percent, creating an accelerated path to meet demand.

Across the global commercial and defense shipbuilding industry, today's modern ships contain more sophisticated technologies and components than their predecessors, but many of the processes and approaches to building them have remained relatively unchanged for decades. With increasing order backlogs and a tidal wave of growing demand, the industry must make bold changes to stay on track. By using a product-focused production model for the most challenging and important components of critical products, the global maritime industry can accelerate production velocity and increase throughput with minimal time and cost. Companies in other high-complexity, low-volume industries have already found success with this approach, and maritime players that emulate them may be the first to resolve the mismatch between demand and delivery that is now challenging the industry.

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Redeveloping legacy sites to boost global maritime industry capacity

How can the global commercial and defense maritime industry meet the recent spike in demand while saving time and costs? With a strategic process to redevelop their existing legacy sites and assets.

This article is a collaborative effort by Brooke Weddle, Nick Mellors, and Ryan Brukardt, with Andy Voelker, Benjamin Plum, and Sean Cassady, representing a private sector perspective from McKinsey's Aerospace & Defense Practice. Our A&D Practice focuses on helping executives improve outcomes for companies in the Aerospace & Defense sector.

The global commercial and defense maritime industry is on the cusp of a new era amid rising demand. With 20 percent growth forecast by 2030, the industry has an opportunity to refocus on shipbuilders, suppliers, and repair yards in the United States and Europe.[1] But decades of underinvestment, long-standing reliance on institutional knowledge, and an ongoing gray-to-green workforce transition[2] have contributed to diminished capacity.[3] And the engineering, design, and production complexities of today's ships would likely have challenged the infrastructure of leading yards even in their primes. Global commercial and defense maritime players must not only replace legacy assets to bolster baseline capacity but also find ways to incorporate new capabilities, such as additive manufacturing and automation, into their yards. At the same time, they need to move quickly to recover from worsening production delays.

To address this array of challenges, many producers are choosing to revitalize and redevelop existing or legacy facilities to create cost-effective capacity quickly. This article explores how they can avoid common pitfalls in redeveloping legacy sites and assets, successfully deploy a tested five-part redevelopment strategy, and emerge better equipped to meet growing demands within their existing yards (see sidebar, "Legacy site redevelopment: Real-world gains").

A five-part strategy for legacy site redevelopment

It is strategically savvy for commercial and defense shipbuilders, suppliers, and repair yards around the world to revamp and repurpose legacy sites and assets within their existing yards rather than incur the costs of locating, securing, and building new greenfield sites. Nevertheless, efforts to repurpose existing resources can go awry in the absence of appropriately focused and detailed advanced planning, leading to cost overruns, capacity loss during retrofitting, underuse of newfound capacity, and suboptimal performance. Five common pitfalls could prevent companies from fully realizing the benefits of reconfiguring their legacy assets (Exhibit 1).

[1] *Shipbuilding market size, share, growth, and industry analysis, by type (bulkers, tankers, containers and other ships), by application (goods transportation, passenger transportation and others), regional insights and forecast to 2032*, Business Research Insights, updated September 30, 2024.
[2] Varun Marya, Michael Park, Andy Voelker, and Brooke Weddle, "Navigating the gray-to-green transition in aerospace and defense," McKinsey, March 16, 2023.
[3] David Sharp, "The US Navy's warship production is in its worst state in 25 years. What's behind it?," Associated Press, August 11, 2024; Megan Eckstein, "US Navy ship programs face years-long delays amid labor, supply woes," Defense News, April 2, 2024; *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and issues for Congress*, Congressional Research Service, August 5, 2024.

Exhibit 1

Maritime players commonly encounter five pitfalls when redeveloping legacy sites.

Point replacement of aging assets

Replacing each worn-out or malfunctioning asset with a new but nearly identical asset, ultimately creating a duplicate of a site that is not equipped to deliver the needed output

Treating legacy sites as overflow areas

Using legacy sites as extensions of a central shop or yard, turning them into disadvantageous amalgamations of assets that no longer fit within the existing footprint

Replicating existing management systems in new facilities

Copying legacy ways of working in new facilities without first assessing operating systems to determine potential improvements, leaving inefficiencies and impediments unaddressed and potentially compounded

Filling legacy spaces with new technology without addressing bottlenecks

Assembling an array of new technologies in a legacy space rather than using the space to solve existing yard constraints, potentially heightening existing production constraints

Pursuing the path of least resistance

Making decisions based on decades of institutional knowledge or opinions of knowledgeable employees and potentially missing out on valuable opportunities, rather than fully considering alternatives from first principles or other industries

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Legacy site redevelopment: Real-world gains

Some global commercial and defense maritime players that employed the approaches and processes outlined in this article to redevelop their legacy sites and assets for increased capacity realized a number of benefits.

Substantial savings in capital project time and cost. One shipyard expects to save more than 85 percent in capital expenditures on a new fabrication and assembly facility while reducing the time to launch by more than three months by pursuing legacy site redevelopment over greenfield construction and finding creative ways to repurpose and retool assets.

Process and footprint optimization. One leading shipbuilder removed a major asset from its main production line after identifying an opportunity to consolidate production capabilities on other assets using additional tooling attachments. In addition to enabling cost savings, removing this asset created new footprint capacity and reduced material movement by approximately 10 percent.

How can producers sidestep these pitfalls? With strategic actions that, together, make up a tested, five-part approach to redeveloping legacy sites (Exhibit 2).

The following sections of this article discuss the five-part strategy producers can use to maximize the impact of extensive legacy site redevelopment.

1. Rigorously prioritizing constraints on throughput
Most environments in the global commercial and defense maritime industry encompass high-complexity production and construction, which makes identifying and managing dynamic constraints in real time a complicated undertaking. Product value streams are complex and intersecting, constraints can be numerous and

Exhibit 2

A five-part strategy can help commercial and defense maritime players avoid common pitfalls and maximize throughput in redeveloped sites.

1	**Rigorously prioritizing constraints on throughput**	– Define specific objectives (eg, debottlenecking a specific program) – Share objectives widely across the organization – Use objectives as a North Star to guide informed trade-offs throughout the process
2	**Adhering to objective principles for site design**	– Set up core design principles and evaluative principles in advance – Create at least three different designs that range from aspirational to the minimal viable solution as a check against potential biases in decision making based on the status quo or historic and outdated criteria
3	**Incorporating people-centric design elements**	– Cultivate a people-centric company culture with open spaces for gathering and relaxing as well as convenient on-site facilities to foster better work–life balance, retain talent, and mitigate workforce shortages
4	**Building a strong digital backbone**	– Ensure that information technology (IT) and operational technology (OT) can provide transparent, real-time data on the status of work in progress, assets, staffing, demand, and supply to maximize ROI, capacity, and throughput
5	**Finding creative ways to reduce project risks and costs**	– Once designs are complete, assess existing assets, resources, and in-flight initiatives to identify potential opportunities to realize efficiencies

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variable, and data systems are often not equipped to illuminate and prioritize constraints to inform real-time decisions and maximize throughput while ensuring uncompromised safety and quality.

In such environments, choosing how best to repurpose and redevelop a legacy site to expand capacity and boost performance—or making any strategic decision—can be fraught. Companies that make decisions informed by conventional wisdom, the loudest voice in the room, the wrong indicators, or noisy data run the risk of prioritizing bottlenecks incorrectly or suboptimally. And getting it wrong is almost always costly: more than one company has spent millions of dollars and many years on redevelopment projects that result in no net change in costs or schedule performance when unidentified or deprioritized bottlenecks prove to be rate limiting.

In our experience, companies that successfully address their most limiting, highest-priority constraints with site redevelopment tend to conduct detailed critical-path analyses regularly, identify and prioritize constraints, and understand the root causes of those constraints sufficiently to address them effectively.

Conducting regular critical-path analyses. Analysis should be detailed enough to describe any single component, asset, or process and estimate its impact on production timelines, enabling teams to identify and prioritize constraints in all major value streams (Exhibit 3).

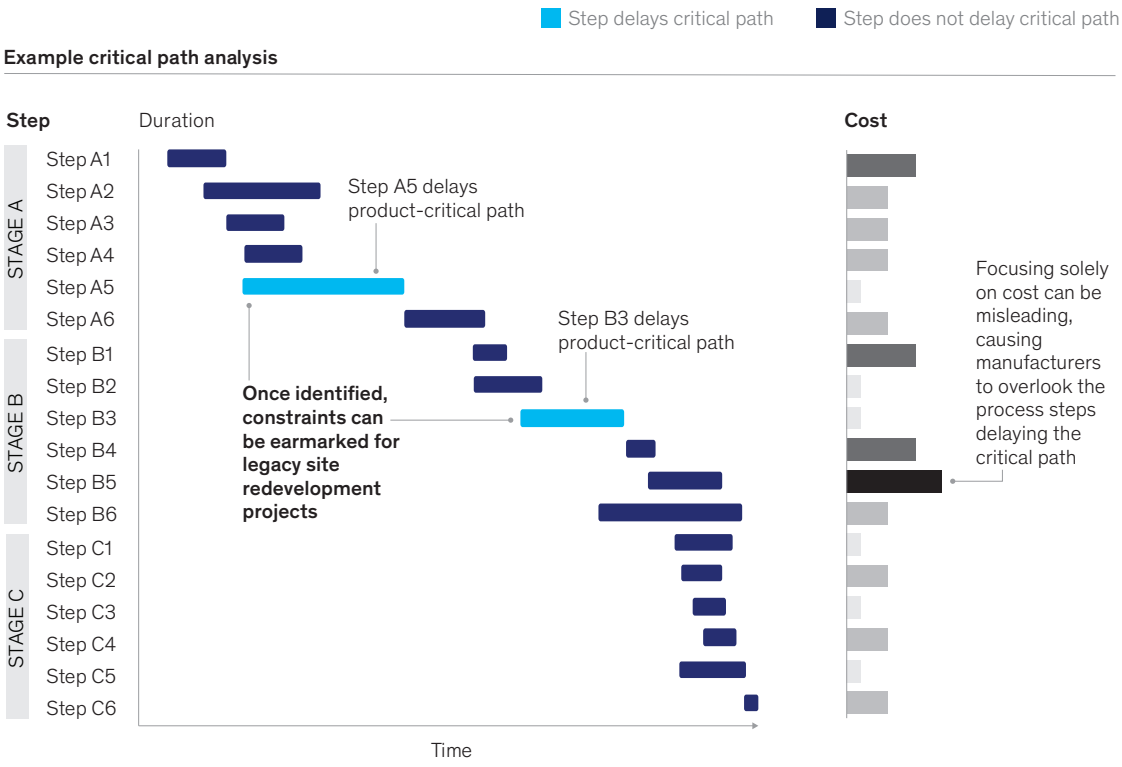
Understanding the root causes of priority constraints. The level of understanding should be sufficiently granular to support and guide design efforts to remove prioritized constraints from the operating system during facility redevelopment.

There are typically two types of root causes for bottlenecks in a complex value stream:

— capacity limitations, caused by overloaded assets and teams, or inadequate first-pass quality, creating rework

Exhibit 3

Identifying the true constraints underlying production delays helps leaders determine what to address during legacy site redesign.



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— flow-related slowdowns caused by breakdowns in coordination and sequencing between process steps

By gaining a full understanding of the root causes of priority constraints, companies can proceed knowing exactly what needs to change in the future site to ensure that issues are addressed safely, sustainably, and with the utmost quality.

2. Adhering to objective principles for site design

In the design phase of a legacy site redevelopment project, it is often tempting to rely on past experience to guide design efforts. However, we have observed that redesigning facilities around objective principles tends to lead to better outcomes—that is, improved throughput at lower cost. Four such principles can be used nearly universally to guide legacy site redevelopment, design, and planning: promoting end-to-end visibility into the value stream; employing simple, efficient flows; prioritizing product throughput over asset utilization; and adopting an iterative design approach.

— *Promoting end-to-end visibility into the value stream.* When it comes to maximizing visibility, housing the full value stream under one roof is ideal. Products can be seen, routings can be walked, and waste has fewer places to hide. Visibility can be enhanced easily by adding standard material laydown areas and kanban to see progress along the value stream and instituting "stop work" criteria to help prevent job buildups and illuminate bottlenecks. Teams can gain additional control of their supply chain destinies by ceasing to source problematic components or manufacturing processes from external third parties and instead creating them in-house.

— *Employing simple, efficient flows.* In complex manufacturing, focusing on optimizing the flow of each component can help pinpoint wasted steps to reduce batching, cycle times, and movement to improve quality, repeatability, and rate.[4]

— *Prioritizing throughput over asset utilization.* Many complex operations employ process-focused systems that prioritize groupings of similar capabilities to optimize costs within a constrained footprint. When redeveloping legacy sites, however, this approach can often lead to underused capacity. Instead, it is helpful to base site design and production system layout decisions on throughput, the primary objective for expanding capacity. In some cases, such an approach may favor product-focused operating systems over traditional process-focused production.

— *Adopting an iterative approach to site design.* Adhering to the principles noted above can be challenging, and it is unlikely that the best design will be achieved on the first try. Rather, the best design typically emerges after following an explicitly iterative and cross-functional approach, beginning with at least three designs: one aspirational, one incremental, and one a middle ground between aspirational and incremental. Exploring the full range of possible designs yields a common understanding of realistic constraints and opportunities, and often spurs further creativity.

Companies can maximize throughput by keeping these four principles at the heart of key decisions about site selection and layout design. Although implementing these actions may prove challenging for global shipyards and repair yards with deeply entrenched ways of working, ultimately they create the conditions to maximize performance of nearly any revitalized legacy site (Exhibit 4).

3. Incorporating people-centric design elements

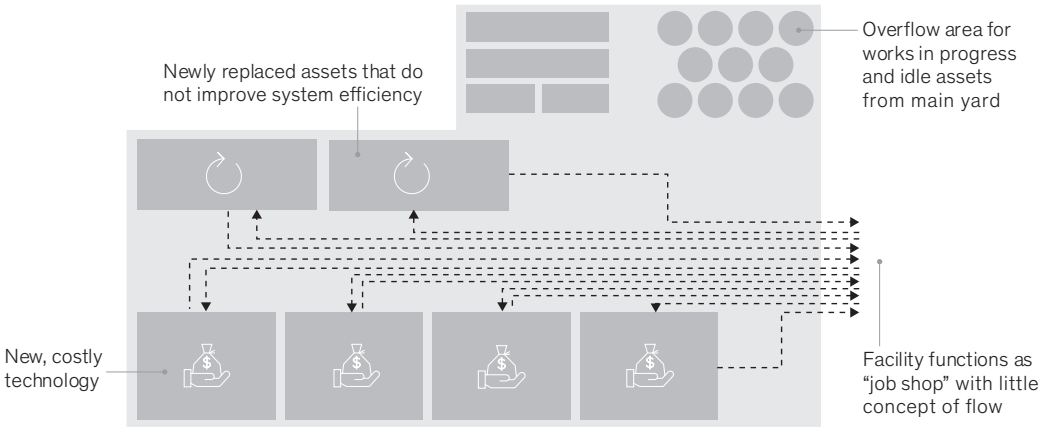
Many players in the global commercial and defense maritime industries (yards and their suppliers) face mounting workforce challenges.[5] Plagued by a rapidly aging workforce, rising attrition levels, and a difficult hiring environment, employers are finding it increasingly tough to maintain the right labor supply to meet growing demand.[6] McKinsey research shows that in the United States alone,

[4] "Why flow matters most in highly complex manufacturing," McKinsey, May 3, 2024.
[5] "Navigating the gray-to-green transition," March 16, 2023.
[6] Ibid.

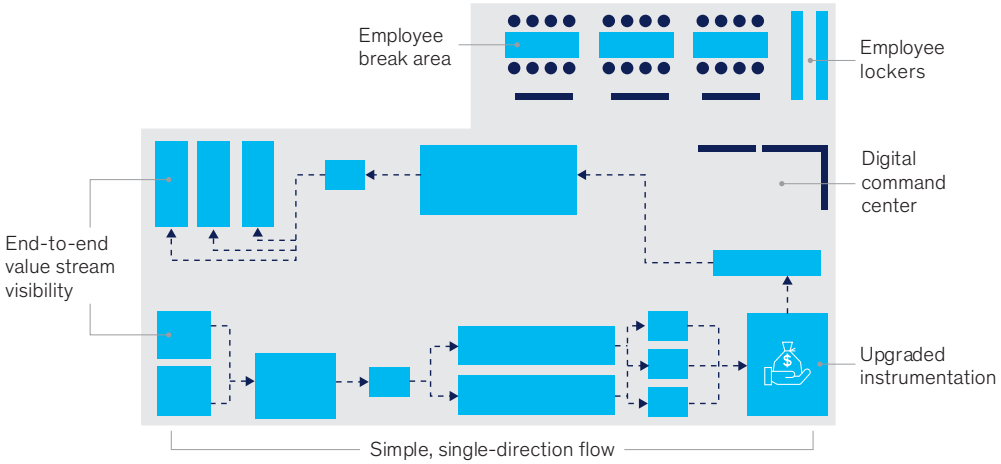
Exhibit 4

Strategically redesigning legacy facilities can unlock throughput by enhancing capabilities and flow.

Example legacy site



Example strategically redesigned legacy site



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employers expect annual hiring to be more than 22 times the projected annual increase in net new jobs due to churn. One significant contributing factor? Skilled-trades jobs in global commercial and defense maritime are physically quite demanding. Meanwhile, the barriers to entering new career paths (gig work, for example) are declining along with the cost of switching jobs. And there are many new jobs available—with fewer physical demands in newer facilities and at comparable wages—that pose a significant threat of diverting employees who might otherwise have pursued maritime skilled trades.

Indeed, employees' expectations for when, where, and how they work have evolved. While other sectors have raced to keep up, most legacy sites are not equipped to accommodate employees' new priorities. Legacy layouts and aesthetics tend to favor efficiency above all else, for example, so welcoming, comfortable spaces for employees to gather, eat, exercise,

or relax are limited or nonexistent. In advanced industrial manufacturing, the presence or absence of workplace flexibility (related to physical work settings for those in skilled trades) is a top reason why employees decide to join, remain at, or leave a company.[7] Thus, the ROI on architectural design is clear, and companies can capture it by incorporating people-centric architectural elements into legacy site redevelopment, elevating the appeal of their entire site with targeted capital deployment.

No-regrets people-centric architectural elements can include the following:

- comfortable, open spaces for recreation, socializing, and relaxation
- ample parking and transportation options for commuting employees
- timely, engaging, and relevant visual communication aids
- dedicated and comfortable communal eating spaces
- quiet break rooms where employees can rest before and after shifts

Larger investments in people-centric elements could include the following:

- on-site childcare facilities
- on-site exercise and shower facilities to help employees maximize their personal time and health

In our experience, many of these elements can be incorporated with only minor adaptations to design, marginal floor space, and little cost relative to the full redevelopment effort. They can also have an outsize impact on productivity.[8]

4. Building a strong digital backbone

Legacy sites often predate the digital age; consequently, they may contain a hodgepodge of digitally enabled and non-digitally enabled assets. Few legacy sites have a strong digital backbone with an information technology (IT) and operational technology (OT) stack capable of providing transparent, real-time data on the status of work in process, assets, staffing, demand, and supply. Unless companies include investments in technology upgrades as part of their legacy site redevelopment, they can fall short when it comes to maximizing capacity and miss an opportunity to use the site as a digital testing ground to accelerate innovation across the organization.

Thus, developing a digital backbone design for a legacy site alongside the physical layout design is imperative to maximize the new site's capacity, efficiency, and ROI. A strong digital backbone gives operating leaders the ability to see and prioritize constraints to make informed decisions in real time. Such a system requires, at a minimum, four basic components:

- instrumentation on assets to measure overall equipment effectiveness in real time
- transparent, real-time signals for supply and demand
- dynamic planning and scheduling systems to guide production
- tracking and daily progress measurements for work in process, inventory, and individual operator performance

In addition to unlocking the ability to quickly pilot different technologies before scaling them across the network, companies that design and implement a strong digital backbone can build new digital deployment capabilities in their organization that may have been unattainable otherwise.

5. Finding creative ways to reduce project risks and costs

Once the site and layout have been selected for redevelopment, it is important to relaunch the legacy site as quickly and cost-effectively as

[7] Brooke Weddle, Giulietta Poltronieri, Hugues Lavandier, and Andy Voelker, "The talent gap: The value at stake for global aerospace and defense," McKinsey, July 17, 2024.
[8] Ibid.

possible. In many cases, the site must remain operable during design and refitting, further complicating redevelopment and adding constraints. At this stage, companies often make two potentially costly mistakes:

— compromising their objective design principles to accommodate existing assets and then designing around self-imposed constraints

— creating prohibitively complicated and expensive plans that cause construction and ramp-up delays and ultimately diminish the benefits of redevelopment

To avoid these pitfalls, manufacturers can deploy several levers to keep costs low and compress the time it takes to launch a newly redeveloped and fully operational facility:

Repurposing existing assets without compromising design principles. Only after facility designs have been created can teams examine the new layout for minor modifications to incorporate existing assets, fixtures, or other capital equipment. In so doing, it is important to ensure that the modifications still achieve the underlying design principles as well as the throughput and reliability demands of the envisioned facility.

Rigorously managing five key milestones. Five milestones in the redevelopment cycle are especially important to maintaining the scheduled timeline: engineering and design, procurement, site preparation, asset commission, and production ramp-up. Project plans should be scrupulously detailed and rigorously managed. For example, one rigorous site redevelopment plan encompassed more than 30 individual initiatives, and project teams met daily to address constraints and risks.

Engaging in strategic partnerships. Complex advanced industrials can derisk legacy site launches and reduce costs through strategic public and private partnerships. Collaborations with local governments can help clarify site permitting requirements, for example, while private partnerships can provide essential capital. Potential partners include local economic development groups, private equity firms, government entities, and universities.

Redeveloping legacy assets and sites offers many industries, including the global commercial and defense maritime industry, an opportunity to physically expand capacity to meet higher throughput demands at a fraction of the time and expense required for equivalent greenfield construction. The model for success is evident: clearly defining and prioritizing constraints on throughput, adhering to objective principles to guide site selection and design, incorporating people-centric elements and a strong digital backbone, and using creative means to lower project risks as well as costs.

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The authors wish to thank George Naughton, Jon Blashford, and Sarah Parkes for their contributions to this article.

Shifting currents: The role of shipbuilders in enhancing naval fleets

As the global security context changes, government defense budgets are shifting. Shipbuilders could adjust their offerings in response to navies seeking to improve fleet capabilities and readiness.

This article is a collaborative effort by Björn Hagemann and Ryan Brukardt, with Katharina Wagner and Tobias Otto, representing a private sector perspective from McKinsey's Aerospace & Defense Practice. Our A&D Practice focuses on helping executives improve outcomes for companies in the Aerospace & Defense sector.

With an evolving security environment across the globe, public spending for defense and security has been prioritized by governments. For 2024, NATO (the North Atlantic Treaty Organization) expects 23 member states to achieve NATO's defense spending goal of 2 percent—up from only three member states in 2014.[1] In the Asia–Pacific (APAC) region, Japan increased its defense budget by 27 percent from 2022 to 2023 after a revision of its national security strategy, which now aims to spend 2 percent of its GDP on defense by 2027.[2] South Korea plans to increase its defense spending by approximately 7 percent annually from 2024 to 2028.[3]

After decades of reduced defense spending,[4] the recent shift in defense budgets includes funding for navies to bolster their capabilities and fleet readiness. McKinsey analysis shows that the naval market could grow from approximately €78 billion in 2024 to more than €100 billion in 2033. APAC is projected to have the strongest growth, reaching a market volume of almost €21 billion by 2033.

The shift presents global military shipbuilders with an opportunity to seek ways to efficiently and effectively meet customer demand. However, to stay ahead of competitors, they will need to assess how to make their products more affordable, flexible, and responsive to customer needs. In addition, both the naval industry and navies could work hand in hand to adapt to evolving needs. As both stakeholders face other challenges, such as significant talent shortages, collaborative efforts may more effectively address these problems.

The unfolding security environment and new technological developments will affect navies and shape the outlook for the naval shipbuilding market over the next decade (see sidebar "Methodology"). We analyze the potential implications for industry participants to help better serve their customers while supporting the renewed imperative of security.

Key developments shaping the global naval market

Today's navies need to be ready for a broad set of missions, from protecting maritime trade and critical infrastructure to maintaining submarine capabilities. As active conflicts shape the population's perception of global threats, governments around the world have announced plans to increase their defense and security budgets. At the same time, mission readiness—the ability to deploy assets for their intended purposes—and the mastery of evolving technology are becoming increasingly relevant for navies. These converging trends are expected to shape the naval market in the next decade.

[1] "Funding NATO," NATO, updated July 26, 2024.
[2] "Japan's defense budget rising toward NATO target of 2% of GDP," Nippon.com, September 26, 2024.
[3] "S. Korea seeks to spend nearly $265 bil. in defense over next 5 years," *The Korea Times*, updated December 13, 2023.
[4] "Innovation and efficiency: Increasing Europe's defense capabilities," McKinsey, February 28, 2024.

Methodology

This analysis examines the value of newly constructed military ships between 2024 and 2033. Included in the scope of the market analysis are all countries that operate a navy of at least 500 personnel. This forecast excludes countries that are subject to certain prohibitions under US or European law, including China, Cuba, Iran, Libya, Syria, North Korea, and Russia. It focuses on major naval combat assets, including naval surface combatants and submarines, but excludes auxiliaries and some categories of smaller boats and craft.

The analysis excludes an extended assessment for unmanned naval systems because the current adoption rate and value compared to the existing market of traditional manned naval platforms remains uncertain.

Changing global threat perceptions
In 2011, after multiple years of relative peace, the global security environment began shifting. Between 2010 and 2022, the number of active conflicts more than doubled (Exhibit 1). There was an especially steep increase in international conflicts from 2010 to 2015, including the Russian invasion and annexation of Crimea.

The way the general population perceives global threats mirrors this shift. Data from the Munich Security Index, which measures how the public perceives different risks (such as overall security), shows that the public's perception of risk related to security has significantly increased since 2021 (Exhibit 2).

Challenges for naval mission readiness
Many navies face challenges to their mission readiness. One such challenge is sustaining aging fleets, with 41 percent of the in-service classes of submarines and surface vessels having been introduced in the 1980s or earlier and with some vessels even operating beyond the end of their intended service life.[5] Another challenge is recruiting and training personnel to properly staff and maintain assets, with shortfalls of 20 percent or more being common, according to McKinsey analysis. These missing personnel may result in fewer ships and submarines that are ready for deployment in open waters.

Technological developments' impact on navies
Navies are grappling with technological advancements such as more capable electronics, new sensor and communication technology, increased automation, and AI—all of which present both potential benefits as well as risks.

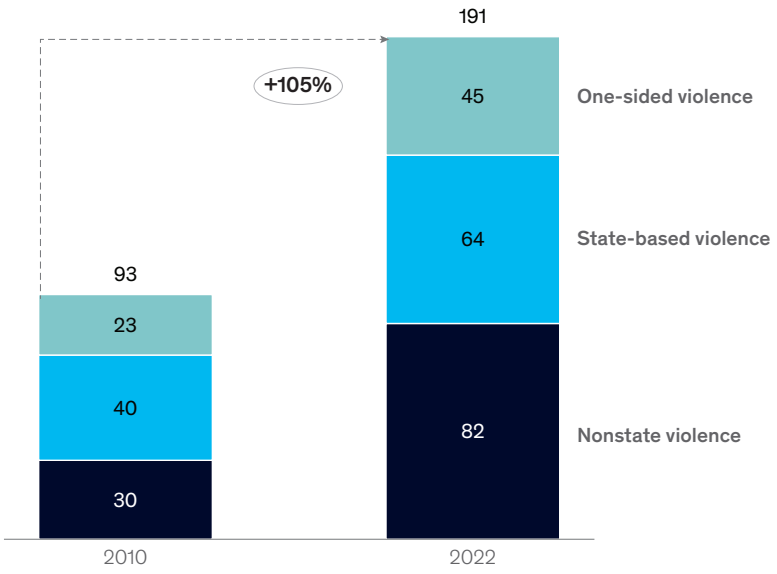
For instance, increased automation could help reduce crew sizes and mitigate challenges with crewing vessels. Technology in the hands of groups such as nonstate actors can have severe impacts on security, as demonstrated by, for example, the 2024 attacks on merchant shipping in the Red Sea. New sensor and communication

[5] The assessed sample includes 70 different submarine classes and ~420 surface ship classes in service globally. Analysis was based on data taken from *The Military Balance 2024*, published by The International Institute for Strategic Studies; *Seaforth World Naval Reviews*, published by Seaforth Publishing; and *Weyers Flottentaschenbuch 2020/22*.

Exhibit 1

Between 2010 and 2022, the number of global conflicts significantly increased.

Number of active conflicts



Source: Shawn Davies, Magnus Öberg, and Therése Pettersson, "Organized violence 1989–2022, and the return of conflict between states," *Journal of Peace Research*, July 2023, Volume 60, Number 4

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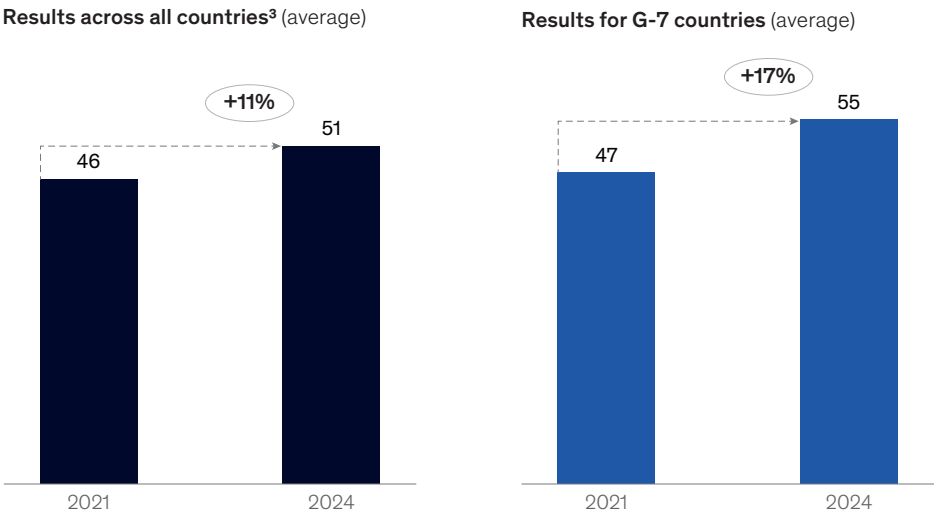
Exhibit 2

Compared with 2021, the public's perception of risk is still signficantly higher, especially in the G-7.

Security overall (internal and external), selected risks from the Munich Security Index,[1] comparison of 2021 and 2024 risk index scores[2]

xx % increase from 2021 to 2024



[1]The sixteen selected risk dimensions from the Munich Security Index include, among others, the following: cyberattacks on own country; mass migration as a result of war or climate change; radical Islamic terrorism; disinformation campaigns from enemies; and the use of chemical, biological, or nuclear weapons. Excluded were risks that are not directly affecting internal and external security, racism or discrimination, rapid change in a country's culture, or rising inequality.
[2]The Munich Security Index risk index score is an absolute figure (with 100 being the highest and 0 the lowest possible).
[3]The G-7 countries plus Brazil, China, India, and South Africa.

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technology can improve navies' situational awareness, but it can also increase the likelihood of being detected by adversaries. AI could generate better insights into data, but it could also be a weakness if adversaries were to hack it or feed it incorrect data.

Driven by these technological advancements, naval electronics such as sonar, radar, communication, or electronic warfare equipment are becoming increasingly important components for building fleets that are more advanced. Additionally, warships and submarines rely more heavily on software to function effectively. As both fields develop, naval players have more competitors to contend with.

Outlook for the naval market to 2033

As previously discussed, naval forces are being allocated increases via defense budgets. Part of these funds are then available for acquiring and sustaining naval equipment, and the market segments for naval ships and submarines are expected to experience an upward trend in military spending. Naval shipbuilders and their suppliers can use the assessment of spending trends over the next ten years to more effectively validate and, if needed, adjust their product portfolios and go-to-market approaches.

Demand shifting toward the APAC market

Our modeling shows an estimated average annual growth rate for the global naval market of 2.8 percent

(real terms), which is unevenly distributed. Europe and APAC are expected to show the strongest growth, while other regions, including North America, will see slower-than-average growth (Exhibit 3). Submarines account for roughly 30 percent of the market value, while the remaining 70 percent is invested in surface ships, a split that is projected to remain stable from 2024 to 2033.

Conventional submarines showing stronger growth than nuclear submarines

Looking one level deeper into the submarine market group, conventional submarines are expected to see growth of 3.6 percent per annum and will reach a market volume of more than €10 billion by 2033 (Exhibit 4). The growth for nuclear submarines is modeled to be significantly lower, with around 2.6 percent per annum until 2033.

Frigates and corvettes are the largest submarket in the surface vessel segment

In the surface ship market, the smallest segment—consisting of offshore patrol and mine warfare vessels—has the highest growth rate, with 3.2 percent per annum until 2033. The largest segment, frigates and corvettes, making up 44 percent of the surface ship market, is also growing faster than average, with 2.8 percent per annum—a similar growth rate as the "flat-top"[6] and amphibious segment (Exhibit 5). This development is in line with the APAC market—in which these vessels are highly relevant—leading in overall growth.

Implications for the naval industry

The naval industry has an opportunity to serve evolving customer needs. With new opportunity, however, comes new competition and changes to market dynamics. Shipbuilders could consider these implications as they chart their course for the next decade and beyond.

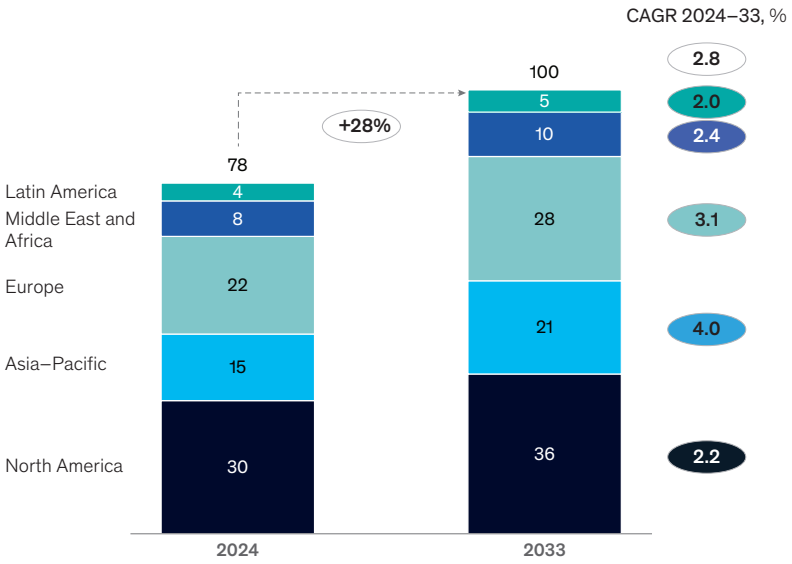
The following considerations are mainly relevant for top management of naval shipbuilders and naval suppliers, from market and product portfolio decisions (CEOs, the strategy team, and product

[6] Aircraft and helicopter carriers, as well as large amphibious assault ships and landing platform docks.

Exhibit 3

Asia–Pacific shows above-average market growth, followed by Europe.

Global[1] market volume (revenue) by region in 2024 and 2033, projected, € billion[2]



Note: Figures may not sum to totals, because of rounding.
[1]Excluding countries that are subject to certain prohibitions under US or European law, including China, Cuba, Iran, Libya, North Korea, and Russia.
[2]Naval procurement spend.
Source: McKinsey 2024–33 global naval market model

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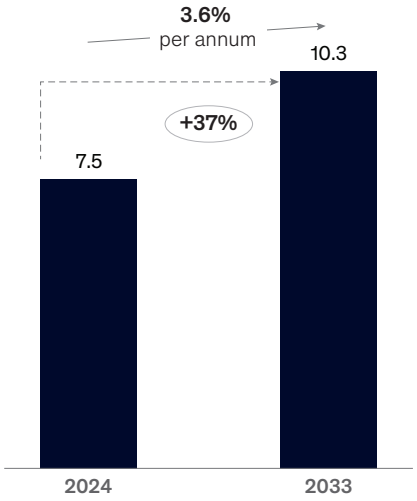
Exhibit 4

Conventional submarines will reach a market volume of €10 billion in 2033.

Global[1] conventional submarine market volume (revenue) in 2024 and 2033, projected, € billion[2]



[1]Excluding countries that are subject to certain prohibitions under US or European law, including China, Cuba, Iran, Libya, North Korea, and Russia.
[2]Naval procurement spend.
Source: McKinsey 2024–33 global naval market model

McKinsey & Company

development team) to opportunities to address operational challenges (COOs and their team) to the financial implications of such choices (CFOs and their team). Moreover, some considerations may also be of interest for navies and procurement agencies handling the acquisition of naval equipment.

Rethinking product portfolio and go-to-market approach for the APAC market

The shift of demand toward APAC raises the question of how this development can best be addressed by the global shipbuilding industry. For shipbuilders, the priority may be to assess the current product portfolio and validate whether it matches shifting demand. Second, shipbuilders and suppliers may need to reevaluate their go-to-market strategies and adjust them to the needs of potential customers in APAC.

Key for market success will be the ability to offer modular designs that can be readily adjusted to local requirements without driving up costs for additional R&D. Moreover, players that want to win contracts within the APAC region must master offset obligations and industrial participation. The challenge here will be to find suitable local partners that can be integrated into their own supply chain or can absorb the required transfer of technology.

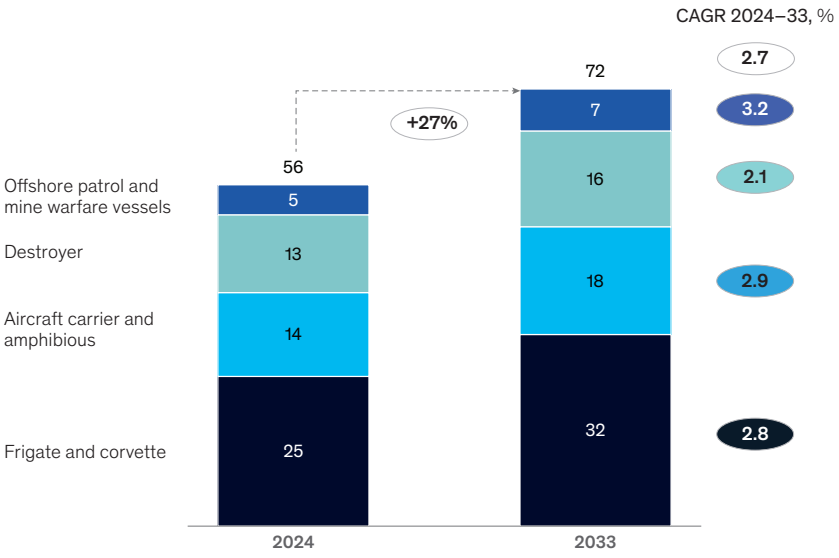
Offering affordable solutions in response to funding pressure in naval acquisition

Despite growing budgets overall, navies will still need to balance competing priorities, such as acquiring new equipment for replacement instead of for fleet expansion, investing in upgrades and modernization of the existing fleet, increasing wages to attract more talent, or purchasing consumables, particularly ammunition. Consequently, cost per unit is likely to remain an important decision factor for naval customers. While some might order smaller fleets, others might choose to emphasize upgrades over new acquisitions or to deprioritize some requirements (for example, a more limited capability profile for an asset or reducing class size for a new ship) to maximize the impact of additional spending on naval mission readiness. In this context, the naval industry has an opportunity to address customers' needs and constraints by offering more-affordable options for acquiring and modernizing their platforms.[7]

Exhibit 5

Frigates and corvettes are the largest sub segment within the surface market.

Global[1] surface vessel market volume (revenue) by subsegment in 2024 and 2033, projected, € billion[2]



Note: Figures may not sum to totals, because of rounding.
[1]Excluding countries that are subject to certain prohibitions under US or European law, including China, Cuba, Iran, Libya, North Korea, and Russia.
[2]Naval procurement spend.
Source: McKinsey 2024–33 global naval market model

McKinsey & Company

What does this look like practically for the industry? Beyond typical efficiency levers (such as improving shipyard productivity, optimizing purchasing conditions, or reducing overhead costs), players could pursue several avenues specific to the naval context:

Modular solutions include predesigned modules that provide a foundation for manufacturers to build new platforms and vessels. They also include open designs that allow customers to combine a variety of components, subsystems, and systems in the design of a new platform to meet their specific need. By using key standardized protocols, data and messaging formats, form factors, interfaces, or connectors—such as under the Modular Open Systems Approach (MOSA)—shipbuilders can better control nonrecurring design and engineering costs, as compared with a fully custom design approach.

Joint procurement of naval assets by multiple countries could also reduce the cost per asset because one-off development costs can be distributed across a larger class of (more or less identical) ships. Bundling procurement power for inputs (for example, raw materials or subsystems) could result in more-attractive price structures. While countries have pursued multinational procurement efforts in the past, few attempts were successfully completed[8] because the customer group struggled to compromise on common specifications. This challenge could be addressed by ensuring sufficient economies of scale.

Ultimately, reducing costs and keeping the acquisition of naval assets affordable for the domestic customer will also strengthen the industry's position within the export market, where affordable products are a key criterion in light of competing priorities and continuing funding pressure.

[7] "NATO, industry leaders discuss the future of defence and security at the NATO-Industry Forum," NATO, October 24, 2023.
[8] For more, see "NATO frigate replacement for the 1990s [NFR-90]," GlobalSecurity.org, updated January 25, 2013.

Staying competitive amid new players in the international naval export market

In the international export market, incumbents encounter three new types of competitors:

Local players that start supplying the domestic market, thus reducing the need for imports, and then add exports. For example, in Türkiye—which had historically imported ships—players began building ships for the domestic market and then also became exporters. In this approach, shipbuilders often start by building locally and absorbing foreign production technology while still using imported designs.

Next-generation global players that pivoted from importing or focusing solely on domestic production to exporting. For example, companies in South Korea have shifted from competing regionally to expanding internationally to regions such as North America, South America, and Europe. The industry saw an early sign of South Korea's expansion when some European countries selected their designs for their replenishment ship requirements.[9]

Established players that have expanded their product portfolio and now compete in new segments of the international market. For example, Babcock entered the surface ship new-build market with the acquisition of Rosyth shipyard in the 1990s. It also supplies to the Royal Navy and has recently been successful in the export market.

Except for smaller vessels or the sale of secondhand warships, US players have not competed broadly in the international market in recent decades. At the same time, US companies lower in the supply chain (such as naval electronics and weapons) will continue to have a prominent role in the international market.

Incumbents could face this new competition in several ways. Shipbuilders around the globe that are highly dependent on exports could deploy lean principles in ship design, engineering departments, and construction to make their cost base more flexible and efficient. They could also forge partnerships with emerging local players to present combined offerings to potential customers and leverage local engineering know-how and technology for dedicated product development—for example, a combat management or integrated platform management system.[10] Another potential strategy could be acquiring shipyards in export markets. Companies could then strategically tap into labor markets to meet the export markets' cost levels and use the yards as hubs for exporting within the region; however, this strategy would be on a case-by-case basis and might not be the right model for every company.

Providing new capabilities in electronics and unmanned technology

Keeping electronics and mission systems up to date with rapid advances in technology is a top priority for navies. Companies can distinguish themselves by designing electronics that are easily and quickly upgraded. Established shipyards could partner with players from the electronics supply base to offer a full-service package to customers. Additional moves could include vertical integration (see sidebar "Vertical integration: An alternative approach to capturing value"), investing in relevant R&D efforts, and building an ecosystem of innovative electronics players whose products can complement the shipbuilder's platform.

The next innovation powered by advanced technology lies in the field of uncrewed naval technology.[11] In the past two years, this market segment has seen a rise in the number of new players because it offers a competitive entry point with products that are much smaller than manned warships and submarines. The in-service fleet of unmanned naval systems is growing rapidly.

Improving shipyard operations through digitalization

Delays, cost overruns, or quality issues in both naval new-build project and sustainment or

[9] "Norway's new support ship HNoMS Maud starts journey home," Naval Today, February 5, 2019; "Tidespring, the first tide class (MARS) Royal Fleet Auxiliary tanker started sea trials," Army Recognition Group, June 29, 2016.

[10] "Thyssenkrupp Marine Systems, Embraer and Atech sign a contract to build Brazilian navy's Tamandaré class ships," Atlas Elektronik, March 5, 2020.

[11] Includes not only uncrewed surface vessels and uncrewed underwater vessels but also naval uncrewed aerial systems.

Vertical integration: An alternative approach to capturing value

Vertical integration—that is, expanding operations to have direct control over multiple stages or processes involved in producing a good or service—may be a promising strategy for shipyards that face challenges in balancing capacity. Either moving higher-margin electronics in-house or expanding into services that keep ships ready and afloat could increase shipbuilders' value capture and offer cost efficiencies through consolidating operations.

Integration capabilities are crucial for shipbuilders considering such a holistic offering. Players who manage to build or acquire strong integration capabilities could then also deploy them to meet the increasing demand for connectivity and integration of the growing number of uncrewed systems in naval warfare.

overhaul projects affect force readiness and ship availability. While there may be several root causes, some of these issues can be overcome by improving shipyard processes and modernizing shipbuilding facilities and shipyards. Concrete measures could include the following:

Deploying a digital operating model allows shipyards to manage the shipbuilding process quickly and seamlessly while avoiding costly errors that stem from poor links between legacy systems. Shipyard digitalization is even more powerful if the supply chain is equally equipped with advanced digital technology such as Internet of Things capabilities, analytics, automation, and cloud computing. These technologies could help ensure a secure exchange of data and information between design and engineering providers, shipbuilders and suppliers, and eventually customers. With more transparency into the supply chain, shipbuilders can address problems early, such as locating missing parts and avoiding inconsistent data, drawings, and plans across the shipbuilding project.

Using digital twins for ship design, upgrades, and sustainment can offer benefits in terms of cost and saving time. For example, digital twins enable full digital representations of each ship to be updated before the actual ship is modified. Testing and certifying new software releases or new hardware components can then happen in a secure environment and under simulated operational conditions without harming the functioning of a warship. In the future, digital twins could be used to predict faults in ship systems (for example, in a gas turbine or an engine) before they occur by running the digital twin in parallel to the operational equipment. Similar efforts are ongoing in industrial turbines. Products starting out as digital twins may have up to 25 percent fewer quality issues when they enter production, and development times could be cut by 20 percent.[12] Although industries differ, these findings are promising and may encourage naval shipbuilders and their suppliers to explore the potential benefits of digital twins.

Digitalizing and automating general and administrative functions, such as procurement, supply chain, human resources, or finance can help drive down cost. McKinsey research suggests that tasks across industries could be automated with technology such as process automation, machine learning, or natural language processing. In human resources, for example, 38 percent of tasks could be automated; in finance, automation is estimated at 41 percent; supply chain management could be automated at 37 percent; and 29 percent of procurement could be automated. Given the often considerable administrative work related to naval programs, efficiency gains in shipbuilders' general and administrative functions can both accelerate

[12] Roberto Argolini, Federico Bonalumi, Johannes Deichmann, and Stefania Pellegrinelli, "Digital twins: The key to smart product development," McKinsey, July 31, 2023.

processing times and lower the indirect costs associated with the program.

Collaborating with industry stakeholders to address naval asset shortages

Amid heightened global tensions, navies could benefit from collaborating with industry to overcome the challenge of asset shortages. Given that fleet readiness can be significantly affected by sustainment turnaround times, shipbuilders have an opportunity to embrace alternative, innovative solutions. For instance, yard time can be reduced by shifting maintenance routines from strict calendar-based schedules to condition-based ones and by intelligently grouping maintenance activities.

Several solutions either have already had a positive impact in the field or hold promise:

Performance-based logistic (PBL) contracts in which the customer pays for an agreed-upon level of service have, in various setups, been an effective way for navies and industry to form a government–industry partnership. However, PBL contracts are not a universal remedy for all availability challenges. Additionally, while PBL contracts seek to fairly distribute risk between customer and supplier, customers ultimately will still carry the operational risk of not having military platforms available when needed, independent of the financial penalties borne by the supplier.

Digital solutions have already proved effective in improving the sustainment processes and increasing naval asset uptime.[13] As discussed previously, using digital twins could potentially improve the likelihood of assets staying at sea longer. Analytics of operational ship data can help to improve operational availability by refining maintenance and tailoring preventive maintenance schedules based on analytical insights, especially with advances in machine learning.

3D printing at sea could also present an opportunity for collaboration. Industry players (tier-one or tier-two OEMs) could, where technically feasible, design qualified spare parts and then send printing instructions to ships at sea that are equipped with the necessary printers.

Remote maintenance support could be another potential area for partnership, in which industry provides augmented reality tools to help navies keep assets at sea. Remote maintenance support is cost-effective in enabling specialists to solve problems and support crews remotely as opposed to traveling to the location for repairs.

Addressing critical skills shortages in both the naval industry and navies

Given that the workforce challenge is industry-wide in addition to affecting navies, solutions beyond the company level should also be considered. The global naval shipbuilding industry could help navies cope with the crewing challenge—especially by offering solutions that help reduce the crew size of warships, such as ship digitalization, automation, and AI. Automation of relevant

[13] For example, see "Fact sheet: Enhancing operational readiness of the RSN," Ministry of Defence of Singapore, June 30, 2021.

The global naval market is undergoing significant transformation, driven by expanding budgets and increasing demand for advanced vessels.

functions of a warship has already helped in several cases to reduce crew sizes significantly in new generations of warships.

At the same time, there are tasks for which automation isn't available, such as maintenance. In these areas, navies and industry are interested in the same limited pool of labor. To increase this labor pool (rather than competing against each other), industry could consider the following measures:

— cohort-based capability building, skilling initiatives, and educational support, including high-quality vocational training

— retention efforts to keep experienced staff longer or bring retired personnel back

The global naval market is undergoing significant transformation, driven by expanding budgets and increasing demand for advanced vessels. This period of change presents an opportunity for shipbuilders who can adapt and innovate. By leveraging technologies such as digitalization and automation as well as partnerships, shipyards can help navies respond more efficiently and effectively to their evolving needs. Moreover, the integration of proven concepts from other industries into shipbuilding processes could be a game changer, potentially revolutionizing productivity and capabilities in the naval sector. Those who successfully capture these opportunities and lead in innovation are likely to thrive in this dynamic and growing market.

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