© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719972

Productivity Systems for Engineering Teams and Frontline Managers: A High-Impact Framework for Strategy Execution, Flow, Learning, and Sustainable Operational Performance

EKERETE USAK
Mechanical Engineering Department, Federal University of Technology, Owerri, Imo State, Nigeria

Abstract-* *Productivity in engineering organizations is often treated as a matter of individual effort, technical competence, software adoption, or cost control. This article argues that sustainable productivity is instead an integrated management system: a disciplined architecture through which strategy is translated into executable work, work is made visible and measurable, constraints are escalated rapidly, frontline learning is institutionalized, and technology is deployed to augment human capability. Recent evidence from operational excellence, construction productivity, software delivery performance, artificial intelligence adoption, and workforce transformation shows that productivity gains rarely persist when organizations rely on tools alone; durable improvement requires coordinated changes in management routines, technical systems, leadership behavior, data visibility, and capability building 123. The article proposes a Productivity Systems Framework for Engineering Teams and Frontline Managers, structured around eight mutually reinforcing elements: strategic alignment, flow and work-in-progress control, tiered daily management, visual performance systems, standard work, capability development, root-cause learning, and digital/AI augmentation. It further introduces a practical operating rhythm, maturity model, productivity scorecard, and implementation roadmap for engineering teams in manufacturing, oil and gas, construction, utilities, infrastructure, maintenance, and technology-enabled operations. The central thesis is that productivity becomes sustainable when leadership builds a repeatable operating rhythm: strategy is converted into work, work is measured, problems are escalated, and learning continuously improves the system.

Keywords:* *Engineering Productivity, Frontline Managers, Operational Excellence, Daily Management System; Visual Management; Standard Work, Artificial Intelligence, Lean, Industry 4.0, Work-In-Progress, Engineering Leadership, Continuous Improvement.

I. INTRODUCTION

Engineering organizations are under increasing pressure to deliver more value with constrained labor, tighter capital, higher safety expectations, accelerated digital transformation, and growing project complexity. The challenge is especially acute in engineering-intensive sectors such as construction, manufacturing, energy, process industries, utilities, and infrastructure. McKinsey's 2024 construction productivity analysis reported that global construction output was approximately US$13 trillion in 2023, representing about 7% of global gross output, yet productivity growth in construction has remained structurally weak for decades 2. The same analysis warned that, under current productivity and workforce trajectories, cumulative construction output could fall short of demand by up to US$40 trillion by 2040 2.

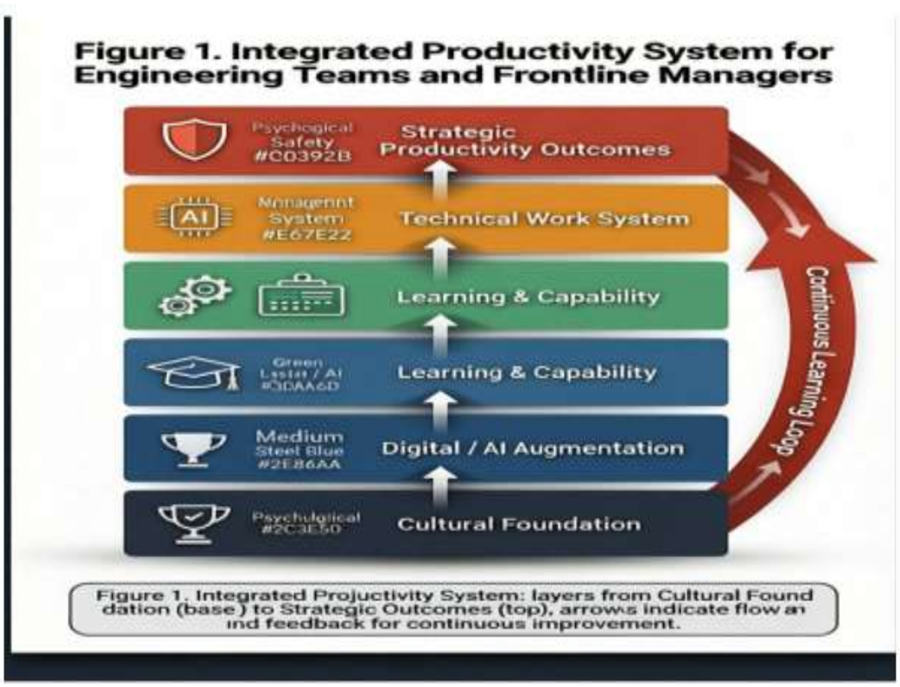
This productivity challenge is not limited to construction. Across engineering organizations, leaders frequently adopt new digital tools, dashboards, enterprise systems, artificial intelligence applications, or automation platforms without redesigning the underlying work system. McKinsey's next-generation operational excellence research emphasizes that technology alone does not create lasting productivity; high-performing organizations align purpose, behaviors, management systems, technical systems, and technology into one operating model 1. Similarly, Deloitte argues that generative AI changes work by reshaping tasks, roles, skills, and workflows—not by simply replacing people or automating isolated activities 3.

The implication for engineering leaders is clear: productivity is not a slogan, campaign, or software implementation. It is a system. It must be designed, operated, measured, learned from, and continuously improved.

II. CONCEPTUAL THESIS: PRODUCTIVITY AS A SYSTEM

The central argument of this article is that productivity becomes sustainable when leadership builds a repeatable operating rhythm. In such a rhythm:

1. Strategy is translated into measurable engineering and frontline work.
2. Work is planned, sequenced, and made visible.
3. Performance is measured through balanced leading and lagging indicators.
4. Problems are escalated quickly through tiered management.
5. Root causes are addressed instead of symptoms.
6. Learning is converted into standard work and capability development.
7. Digital tools and AI augment human decision-making.
8. Leadership behavior reinforces discipline, psychological safety, and continuous improvement.



This systems view reflects the shift from isolated productivity initiatives toward integrated operational excellence. McKinsey identifies five core elements of modern operational excellence: purpose and strategy, behaviors and principles, management systems, technical systems, and technology 1. DORA's software delivery research similarly shows that engineering productivity is multidimensional, combining throughput, stability, reliability, and team well-being rather than relying on single output metrics 4.

Figure 1. Integrated Productivity System for Engineering Teams and Frontline Managers. Layers run from Cultural Foundation (base) through Digital/AI Augmentation, Learning & Capability, Technical Work System, Management System Layer, to Strategic Productivity Outcomes (top). Upward arrows between layers indicate value flow; the right-side curved arrow labeled "Continuous Learning Loop" indicates feedback that converts lessons into updated standards, training, and system improvements.

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719972

The diagram shows the layered system required for sustainable productivity: foundational culture, digital/AI augmentation and learning, a disciplined technical work system and management system, leading to strategic productivity outcomes; continuous learning converts outcomes into updates to standards and capability.

III. WHY ENGINEERING PRODUCTIVITY FAILS TO SUSTAIN

Engineering productivity initiatives often fail for five recurring reasons.

3.1 Tool-led transformation without work-system redesign

Many organizations introduce dashboards, AI tools, mobile apps, or planning platforms without redesigning decision rights, handovers, standard work, escalation pathways, and frontline routines. McKinsey warns that operational technology frequently underdelivers when leaders use technology as an add-on rather than as part of a redesigned operating model 1. Deloitte similarly argues that generative AI requires leaders to rethink tasks, skills, workflows, and human capability 3.

3.2 Activity metrics mistaken for productivity

Engineering teams may produce more drawings, reports, maintenance orders, inspections, or software commits while generating less usable value. The SPACE framework emphasizes that developer productivity must be measured across satisfaction, performance, activity, communication/collaboration, and efficiency/flow rather than activity alone 5. DORA also warns against using metrics as targets in ways that encourage gaming rather than improvement 4.

3.3 Poor flow and excessive work-in-progress

Many engineering environments suffer from excessive open work, unclear priorities, approval delays, rework loops, late scope changes, and unresolved constraints. In construction and capital projects, weak workflow reliability and poor planning discipline contribute directly to productivity loss 2. Lean construction research and Last Planner System literature emphasize that reliable planning and constraint removal are central to project productivity 67.

3.4 Weak frontline management routines

Frontline managers are often expected to deliver safety, quality, schedule, cost, morale, compliance, and continuous improvement with limited management-system support. Without leader standard work, visual management, daily huddles, escalation rules, and coaching routines, managers drift into reactive firefighting.

3.5 Learning not institutionalized

Organizations often investigate incidents, defects, or project delays but fail to convert lessons into standards, training, design rules, maintenance practices, and leadership routines. In high-risk engineering sectors, this is a critical weakness because repeated problems consume capacity and increase operational risk.

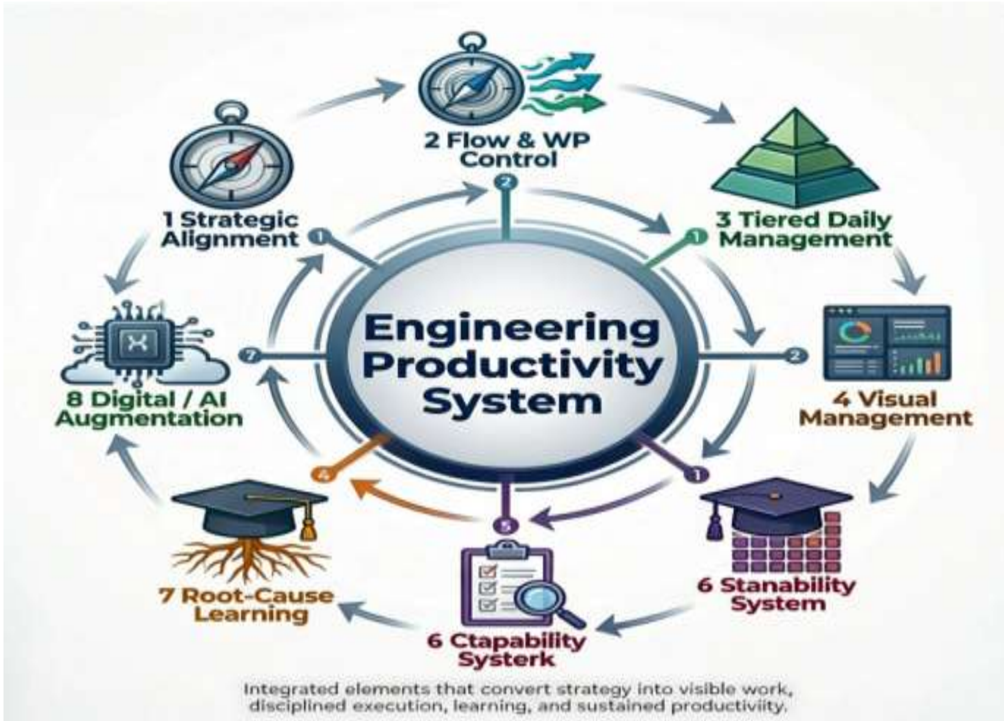
IV. PROPOSED FRAMEWORK: THE ENGINEERING PRODUCTIVITY SYSTEM

This article proposes an eight-element productivity system for engineering teams and frontline managers.

Figure 2. The Eight Elements of the Engineering Productivity System. Each numbered node represents a necessary element for sustainable productivity; arrows show the continuous clockwise learning and improvement loop that refreshes standards, capability, and work design.

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719972

Figure 2. Eight Elements of the Engineering Productivity System



The central hub ("Engineering Productivity System") is surrounded by eight interlocking elements that form a continuous improvement cycle: 1) Strategic Alignment; 2) Flow & WIP Control; 3) Tiered Daily Management; 4) Visual Management; 5) Standard Work; 6) Capability System; 7) Root-Cause Learning; 8) Digital / AI Augmentation. Arrows indicate clockwise learning and improvement flow; concentric rings suggest depth and dependencies.

4.1 Strategic Alignment: Translating Strategy into Work

Engineering productivity starts with strategic clarity. Leaders must convert organizational objectives into team-level priorities, measurable outcomes, and executable work packages. Objectives and Key Results (OKRs) can create strategic focus, while Key Performance Indicators (KPIs) monitor operational health. Recent research and professional practice literature on OKRs emphasizes transparency, alignment, collaboration, and outcome orientation 89.

A strong engineering productivity system distinguishes between:

Measurement Type	Purpose	Example
Strategic objectives	Define what must improve	Improve engineering delivery reliability
Key results	Define measurable progress	Reduce design cycle time by 25%
KPIs	Monitor operational health	Schedule adherence, rework hours
KRIs	Monitor risk exposure	Overdue safety actions, unresolved constraints
Leading indicators	Predict future performance	% constraints cleared before execution
Lagging indicators	Confirm results	Cost variance, downtime, incidents

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719972

4.2 Flow and Work-in-Progress Control

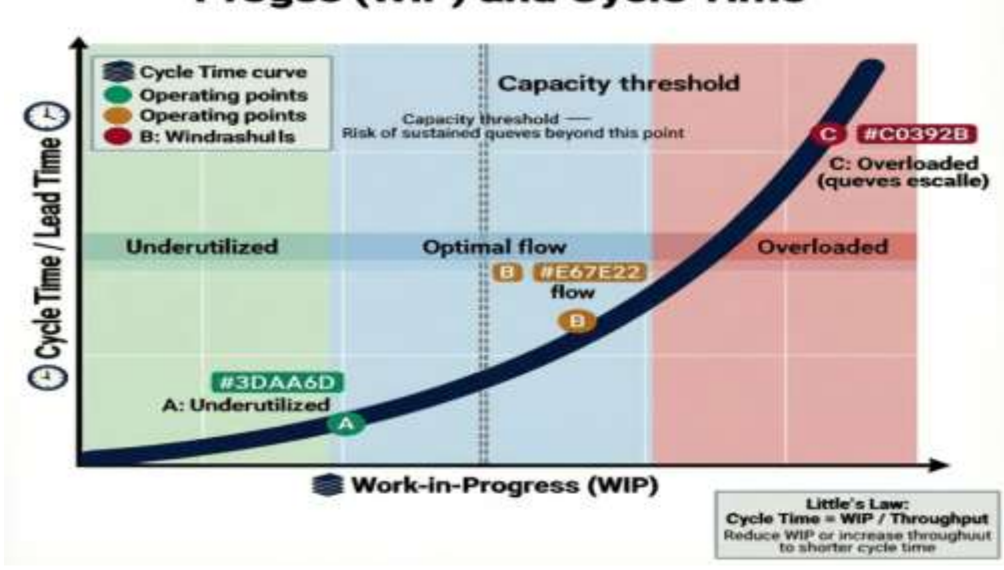
Flow is the movement of work through the engineering system. In engineering environments, productivity losses often hide in queues, handovers, approvals, change requests, rework, and waiting time. The productivity question is therefore not simply "How busy are people?" but "How smoothly does value move through the system?"

Work-in-progress control is central. Excessive WIP increases cognitive load, multitasking, cycle time, and error probability. Engineering leaders should limit active work, manage constraints, reduce batch sizes, standardize handovers, and track aging work.
Work-in-Progress and Cycle Time. The convex curve demonstrates the non-linear increase in lead time as WIP grows. Operating points illustrate typical regimes: A = Underutilized; B = Optimal flow; C = Overloaded. Vertical dashed line denotes a capacity threshold beyond which queues escalate rapidly. Inset: Little's Law and practical levers.

Figure 3 illustrates the relationship between work-in-process (WIP) and cycle time, emphasizing that as the number of active tasks in a system increases, the time required to complete each task also tends to rise. This relationship reflects a core principle of flow management: excessive WIP creates congestion, increases waiting time, and reduces predictability. By visualizing this association, the figure highlights why limiting WIP is essential for improving throughput, reducing delays, and maintaining stable operational performance.

As shown in Figure 3, cycle time is closely influenced by the amount of work simultaneously moving through a process. When WIP remains controlled, teams are better able to maintain flow, identify bottlenecks, and complete work within predictable timeframes. Conversely, when WIP exceeds system capacity, queues accumulate, handoffs become delayed, and cycle time increases. The figure therefore provides a practical foundation for understanding why disciplined WIP management is central to operational reliability and continuous improvement.

Figure 3. Relationship Between Work-in-Progss (WIP) and Cycle Time



The figure visualizes why limiting WIP is a foundational control for engineering productivity: beyond the "optimal flow" region, adding more concurrent work creates disproportionate increases in cycle time (waiting, handover delays, rework). Little's Law clarifies the trade-off: either reduce WIP or increase sustained throughput to shorten cycle time. The capacity threshold signals the approximate

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719972

point where queues begin to escalate and velocity declines.

Interpretation: As work-in-progress increases beyond team capacity, queue time and cycle time rise disproportionately.

In summary, Figure 3 reinforces that cycle time is not only a function of task complexity but also of system load. Managing WIP creates the conditions for smoother flow, faster completion, and greater process stability. By making the WIP–cycle time relationship explicit, the figure supports a central operational lesson: reducing overload is a prerequisite for improving speed, quality, and predictability

4.3 Tiered Daily Management

Tiered daily management connects strategy to frontline execution through structured daily and weekly routines. It enables rapid escalation, disciplined accountability, and faster decision-making.

As shown in Figure 4, the Tiered Daily Management Escalation Model provides a practical architecture for converting frontline signals into timely organizational action. The model links daily problem identification at the point of work with progressively higher levels of review, support, and decision-making. By distinguishing issues that can be resolved locally from those requiring cross-functional coordination or executive intervention, the escalation structure reduces ambiguity, accelerates response time, and strengthens accountability across the management system. Importantly, the downward feedback pathway ensures that escalated issues do not disappear into higher-level forums but return to frontline teams as decisions, resources, or clarified expectations.

The figure illustrates how tiered daily management creates a closed-loop escalation system in which frontline concerns are rapidly surfaced, appropriately elevated, resolved at the right level, and communicated back to the teams closest to the work

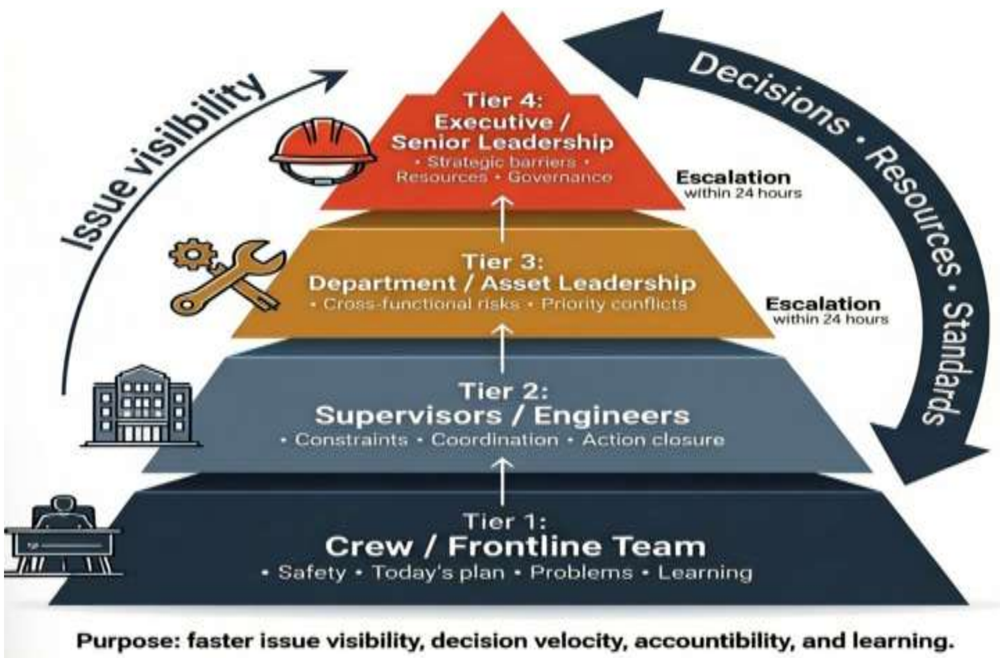


Figure 4. Tiered Daily Management Escalation Model

The Tiered Daily Management Escalation Model reinforces the principle that reliable organizational performance depends on more than identifying problems; it requires a disciplined mechanism for moving information, authority, and resources to the level where action can occur. When escalation pathways are clearly defined, frontline teams gain confidence that concerns will be heard and addressed, while leaders gain visibility into recurring barriers that require system-level intervention. In this way,

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719972

tiered daily management functions as both an operational control system and a learning infrastructure, enabling organizations to respond to immediate disruptions while also detecting patterns that inform longer-term improvement. Properly implemented, the model closes the gap between daily work and strategic oversight, ensuring that management routines translate observation into action, action into learning, and learning into sustained performance improvement.

Figure 4. Tiered Daily Management Escalation Model. The model shows how daily frontline huddles (Tier 1) escalate unresolved constraints and safety or delivery issues through supervisory and departmental tiers to executive leadership. Rules: escalation within 24 hours, short visual huddles, and owner + due date for each action.

A good tiered management system is short, visual, fact-based, and action-oriented. It should reduce unnecessary meetings by ensuring the right problems reach the right decision level quickly.

4.4 Visual Management

Visual management makes work, risk, and performance visible. In engineering and frontline settings, a visual board should show plan versus actual, safety-critical tasks, constraints, backlog, defects, skill gaps, open actions, and escalation status.

Table 1. Recommended Visual Board Structure

Board Zone	Core Question	Example Indicator
Safety	Are we safe to work today?	Critical control verification
Delivery	Are we on plan?	Plan completion rate
Quality	Are we producing right-first-time work?	Rework hours
Flow	Where is work stuck?	WIP age / queue time
People	Do we have capability and coverage?	Skills matrix coverage
Actions	Are problems being closed?	Overdue corrective actions
Learning	What did we learn this week?	Lessons implemented

4.5 Standard Work for Frontline Managers

Standard work stabilizes performance by defining the best-known method for recurring leadership and technical tasks. For frontline managers, standard work should include start-of-shift briefings, field walks, coaching, constraint reviews, visual board reviews, and problem-solving routines.

Table 2. Frontline Manager Standard Work

Routine	Frequency	Purpose
Start-of-shift safety and productivity briefing	Daily	Align the team on hazards, priorities, and constraints
Gemba / field walk	Daily	Observe real work and remove blockers
Visual board review	Daily	Compare plan versus actual and assign actions
Constraint log review	Daily	Escalate unresolved barriers
Coaching conversation	Weekly	Build capability and accountability
Root-cause review	Weekly	Verify corrective action quality
Skills matrix review	Monthly	Close capability gaps
KPI review	Monthly	Link work to strategic outcomes

4.6 Capability System: Skills, Coaching, and Certification

Productivity depends on capability. Engineering organizations need role-based competency matrices, structured onboarding, coaching routines, certification pathways, and learning systems that convert experience into transferable knowledge. This is increasingly important as labor shortages, retirement, new technologies, AI adoption, and rapid skill shifts affect engineering workforces 210.

The World Economic Forum's Future of Jobs work emphasizes that AI, digitalization, green transition,

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719972

and changing work models are reshaping skills demand globally 10. Deloitte's generative AI work similarly highlights the need to understand tasks and skills as work changes 3.

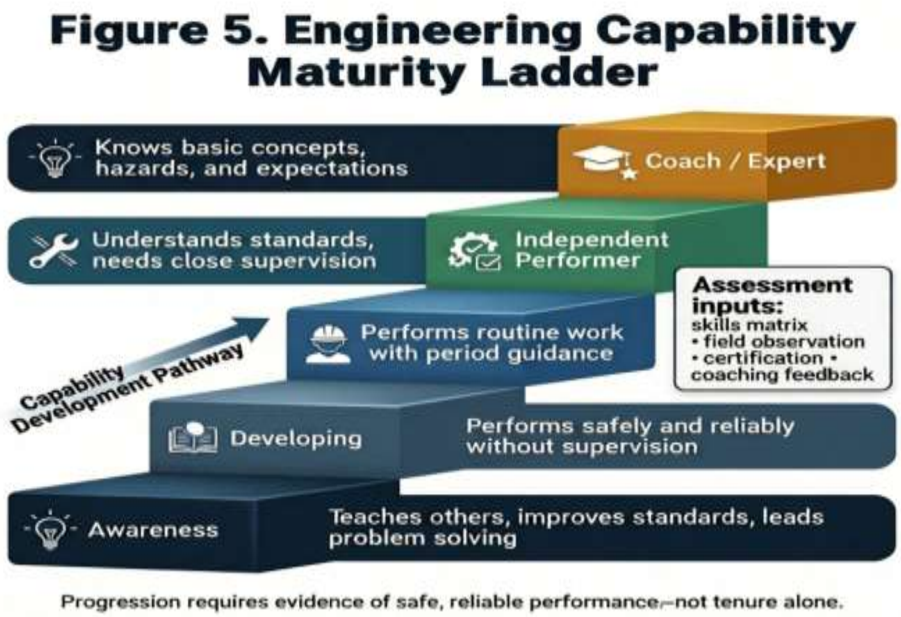


Figure 5 visualizes the five-level Engineering Capability Maturity Ladder. It provides a simple rubric to align role expectations, training curricula, and certification decisions with frontline productivity objectives."

The ladder illustrates a practical five-level capability framework for frontline engineering roles. Use it to (1) map role expectations to training and certification, (2) create role-based competency matrices for staffing and deployment, (3) define progression criteria for supervisor academies, and (4) link assessment outcomes to targeted coaching interventions. The visual emphasizes that moving people upward requires deliberate training, coaching, standards, and verification.

4.7 Root-Cause Learning and Continuous Improvement

Engineering productivity is repeatedly lost through recurring defects, rework, incident recurrence, equipment failures, planning errors, and late changes. A productivity system must therefore include structured problem-solving.

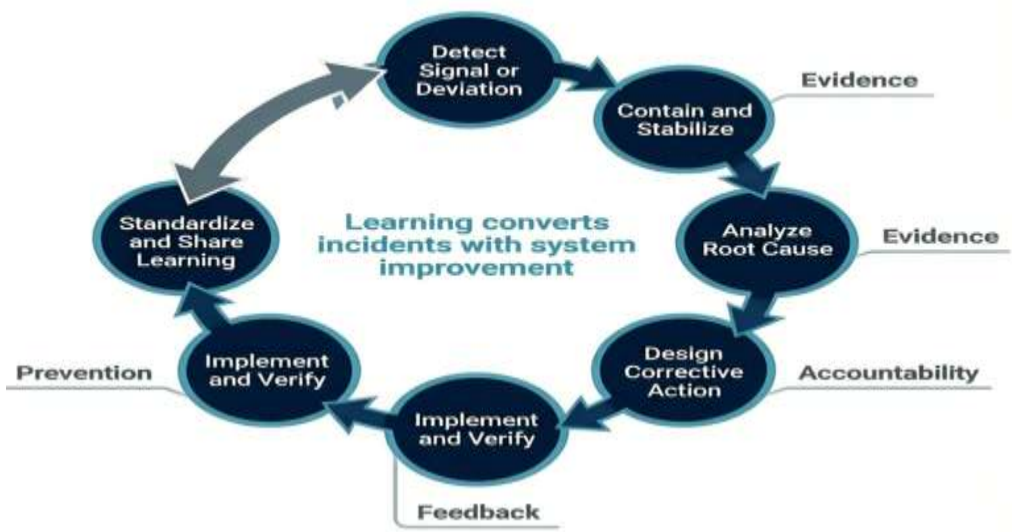
Recommended root-cause sequence:

1. Define the problem precisely.
2. Confirm the expected standard.
3. Go to the work location.
4. Collect facts and data.
5. Identify contributing factors.
6. Determine root causes.
7. Develop countermeasures.
8. Assign owners and due dates.
9. Verify effectiveness.
10. Update standard work and training.

This learning loop transforms incidents and performance gaps into organizational knowledge.

As depicted in Figure 6, sustainable improvement requires closing the loop from detection through systematic root cause diagnosis into monitored implementation and iterative learning."

Figure 6. Root-Cause Learning Loop



The Root Cause Learning Loop synthesizes detection, disciplined diagnosis, and iterative implementation into a continuous improvement engine. Crucially, it shows that detection alone does not produce durable change — rigorous root cause work and short cycle experimentation are necessary to translate signals into effective interventions. Moreover, data systems, governance, and workplace culture must be developed in tandem with analytic capability; without these supporting layers, efforts stall at implementation or fail to scale. Framing improvement as an integrated loop directs leaders to pair technical fixes with decision rights and investment in learning capacity, thereby increasing the likelihood that interventions lead to sustained system improvement rather than temporary gains.

4.8 Digital and AI Augmentation

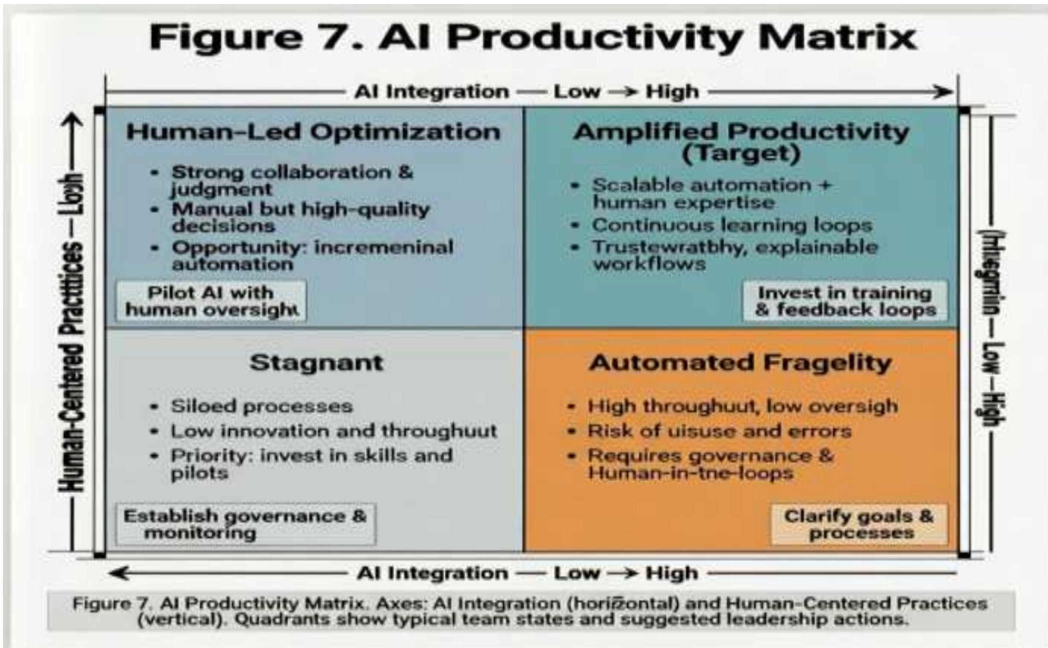
Artificial intelligence, digital twins, predictive analytics, mobile work management, digital dashboards, and knowledge systems can significantly improve engineering productivity—but only when embedded in redesigned workflows. Stanford's 2025 AI Index reported that 78% of organizations used AI in 2024, up from 55% the previous year, and that research increasingly confirms AI's productivity impact 11. GitHub research reported that Copilot users experienced faster task completion and reduced cognitive burden in software development contexts 1213.

However, AI should be treated as an augmentation layer, not a substitute for management discipline. Deloitte emphasizes that generative AI changes tasks and skills, requiring leaders to redesign work around human-machine collaboration 3.

Table 3. AI-Enabled Productivity Use Cases for Engineering Teams

Use Case	Productivity Benefit	Risk Control
Technical document search	Faster retrieval of standards and prior decisions	Source validation
Maintenance troubleshooting assistant	Faster diagnosis	Engineer review
Design review assistant	Earlier detection of inconsistencies	Human approval
Permit/procedure drafting	Lower administrative burden	HSE verification
Lessons-learned retrieval	Reduces repeated failures	Curated knowledge base
Project risk summarization	Faster decision preparation	Traceable assumptions
Training personalization	Faster capability development	Competency validation

Figure 7. AI Productivity Matrix. Axes: AI Integration (horizontal, Low → High) and Human Centered Practices (vertical, Low → High). Quadrants summarize typical team states and recommended leadership actions to improve reliable, scalable productivity.



The AI Productivity Matrix highlights that maximizing the benefits of AI is not a purely technical exercise but an organizational one: durable productivity gains arise when technical capability and human practices are developed together. Framing diagnostic and change efforts across these two dimensions directs leaders to pair investments in governance, measurement, and human skills with targeted automation — a dual approach that reduces risk, increases adoption, and converts AI-driven insights into repeatable value.

V. PRODUCTIVITY SCORECARD FOR ENGINEERING TEAMS

A balanced productivity scorecard prevents overemphasis on speed or output volume at the expense of safety, quality, learning, or resilience. DORA's guidance is instructive: high-performing technology teams measure both throughput and stability, and avoid turning metrics into rigid targets that can distort behavior 4.

Table 4. Balanced Productivity Scorecard

Dimension	Leading Indicators	Lagging Indicators
Safety	Critical control checks, permit quality	Recordable incidents, high-potential events
Quality	First-time-right reviews, inspection readiness	Rework hours, defect escape rate
Delivery	Constraint removal, plan reliability	Schedule adherence, milestone slippage
Flow	WIP age, queue time, decision turnaround	Cycle time, backlog growth
Cost	Productivity variance, resource	Cost variance, overtime cost

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719972

	utilization	
People	Skills coverage, coaching frequency	Turnover, absenteeism
Learning	Corrective action closure, lessons applied	Repeat incident rate
Innovation	Improvement ideas tested	Verified benefits realized

VI. PSYCHOLOGICAL SAFETY AND PERFORMANCE DISCIPLINE

Sustainable productivity requires both psychological safety and execution discipline. Psychological safety enables people to speak up, report errors, escalate risks, and challenge unsafe assumptions. Performance discipline ensures standards are followed, commitments are met, and deviations are corrected. ISO 45003:2021 provides guidance for managing psychosocial risk and promoting worker well-being within occupational health and safety systems 14. Research and professional evidence also link psychological safety to engineering team effectiveness and communication quality 1516.

As shown in Figure 8, teams that combine high psychological safety with high performance discipline achieve the most reliable innovation and delivery; movement into this quadrant requires concurrent interventions to strengthen shared goals, clear processes, and leader behaviors that invite voice.

This matrix synthesizes how two complementary dimensions — psychological safety and performance discipline — jointly determine team capability. It emphasizes that neither dimension alone is sufficient: high safety without discipline produces creative but unreliable outcomes, while high discipline without safety produces reliable but unadaptive systems. Practical change therefore requires dual-track interventions that (1) create the interpersonal conditions for speaking up and learning, and (2) put in place clear goals, metrics, and processes that convert insight into consistent delivery. Framing

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719972

diagnosis and action in this two-dimensional way helps leaders prioritize paired behavioral and structural investments and provides a pragmatic roadmap for moving teams toward sustainable high performance.

The high-performance zone is created when managers treat problems as process signals while still holding teams accountable for standards and commitments.

VII. IMPLEMENTATION ROADMAP

The productivity system should be deployed in phases, beginning with diagnosis and stabilization before digital scaling.

Table 5. Twelve-Month Engineering Productivity Deployment Roadmap

Phase	Period	Focus	Key Deliverables
Phase 1	Months 0–3	Diagnose and align	Baseline assessment, stakeholder map, productivity charter
Phase 2	Months 3–6	Build core routines	Tiered meetings, visual boards, manager standard work
Phase 3	Months 6–9	Build capability	Skills matrix, supervisor academy, root-cause program
Phase 4	Months 9–12	Digitize and scale	Dashboard, AI pilots, standard work library
Phase 5	12+ months	Optimize	Benchmarking, automation, advanced analytics

VIII. PRODUCTIVITY MATURITY MODEL

Table 6. Engineering Productivity Maturity Model

Level	Description	Leadership Signature	Typical Metrics
Level 1 — Reactive	Work managed by urgency	Firefighting	High rework, high overdue actions
Level 2 — Visible	Work and problems are visible	Basic control	Visual boards, issue logs
Level 3 — Standardized	Routines and standards followed	Discipline	Standard work adherence
Level 4 — Learning	Teams solve root causes	Coaching	Repeat issue reduction
Level 5 — Predictive	Data and AI prevent problems	Strategic agility	Predictive risk, optimized flow

IX. MANAGERIAL IMPLICATIONS

For engineering executives, productivity improvement should be governed as an enterprise capability, not a temporary initiative. The practical implications are:

1. Build the management system before scaling technology. Digital tools should reinforce work routines, not compensate for their absence.
2. Measure productivity as a balanced system. Safety, quality, flow, delivery, people, and learning must be measured together.
3. Make frontline managers system owners. Productivity is won or lost at the point where work is planned, supervised, executed, and learned from.
4. Reduce WIP before demanding speed. Overloaded systems cannot become productive through pressure alone.
5. Institutionalize learning. Every incident, defect, delay, and constraint should improve standards, training, and future decision-making.
6. Use AI to augment judgment. AI should accelerate information retrieval, diagnosis, planning, and learning while preserving engineering accountability.
7. Create psychological safety with discipline. Teams must be able to speak up while still respecting standards and commitments.

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719972

X. DISCUSSION

The framework presented in this article integrates insights from Lean, operational excellence, engineering management, software delivery, project management, Industry 4.0/5.0, and human-centered digital transformation. The evidence suggests that productivity is not achieved by optimizing isolated components; it emerges from the interaction of work design, leadership behavior, data visibility, capability development, and learning discipline.

Industry 5.0 discussions reinforce this point by emphasizing human-centric, resilient, and sustainable production systems rather than purely technology-driven automation 17. Digital twin and predictive maintenance literature similarly suggests that real-time monitoring and analytics become valuable when connected to maintenance decisions, reliability workflows, and frontline action 1819.

For engineering journals, the proposed framework contributes a practice-oriented systems model that can be tested empirically across sectors. Future research should examine which combinations of system elements produce the strongest productivity gains, how productivity systems differ between capital projects and steady-state operations, and how AI-enabled decision support affects frontline management effectiveness.

XI. CONCLUSION

Productivity systems for engineering teams and frontline managers must move beyond slogans, dashboards, and isolated improvement projects. Sustainable productivity is created through a disciplined operating rhythm: strategy is translated into work, work is made visible, flow is controlled, performance is measured, problems are escalated, root causes are eliminated, capability is built, and learning improves the system.

The future-ready engineering organization will not be defined by the number of technologies it owns, but by the strength of its productivity system. Technology will matter; AI will matter; data will matter. But the decisive advantage will belong to organizations that combine human judgment, frontline discipline, systems thinking, and continuous learning into one repeatable management architecture.

REFERENCES

[1] Adobe. (2024). Digital trends 2024. Adobe Experience Cloud. https://business.adobe.com/resources/digital-trends-report.html

[2] American Psychological Association. (2024). Psychological safety in the changing workplace: Work in America 2024. https://www.apa.org/pubs/reports/work-in-america/2024

[3] Bick, A., Blandin, A., & Deming, D. J. (2025). The impact of generative AI on work productivity. Federal Reserve Bank of St. Louis. https://www.stlouisfed.org/on-the-economy/2025/feb/impact-generative-ai-work-productivity

[4] Brynjolfsson, E., Li, D., & Raymond, L. R. (2023). Generative AI at work (NBER Working Paper No. 31161). National Bureau of Economic Research. https://doi.org/10.3386/w31161

[5] Colotla, I., Fookes, W., Iverson, T., Schaefer, E., Sellschop, R., & Wijpkema, J. (2024). Today's good to great: Next-generation operational excellence. McKinsey & Company. https://www.mckinsey.com/capabilities/operations/our-insights/todays-good-to-great-next-generation-operational-excellence

[6] Criado, J. M., Gutierrez, G., Garzas, J., Cano, E. L., de Lena, M. T. G., & Moguerza, J. M. (2024). Exploring the effectiveness of OKRs in enhancing company objectives: A comparative study. IEEE Engineering Management Review, 53(2), 110–121. https://doi.org/10.1109/EMR.2024.3426327

[7] Deloitte. (2024). Generative AI and the future of work. Deloitte AI Institute. https://www.deloitte.com/us/en/what-we-do/capabilities/applied-artificial-

intelligence/articles/generative-ai-and-the-future-of-work.html

[8] Deloitte. (2024). 2024 global human capital trends. Deloitte Insights. https://www.deloitte.com/insights

[9] Deloitte. (2025). 2025 engineering and construction industry outlook. Deloitte Insights. https://www.deloitte.com/insights

[10] Deloitte. (2025). 2025 global human capital trends. Deloitte Insights. https://www.deloitte.com/insights

[11] Deloitte. (2026). 2026 engineering and construction industry outlook. Deloitte Insights. https://www.deloitte.com/insights

[12] Deloitte. (2026). 2026 global human capital trends. Deloitte Insights. https://www.deloitte.com/insights

[13] Digital.ai. (2021). 15th annual state of agile report. https://digital.ai/resource-center/analyst-reports/state-of-agile-report

[14] Digital.ai. (2022). 16th annual state of agile report. https://digital.ai/resource-center/analyst-reports/state-of-agile-report

[15] Digital.ai. (2023). 17th annual state of agile report. https://digital.ai/resource-center/analyst-reports/state-of-agile-report

[16] Digital.ai. (2024). 18th annual state of agile report. https://digital.ai/resource-center/analyst-reports/state-of-agile-report

[17] DORA. (2021). Accelerate state of DevOps report 2021. Google Cloud. https://dora.dev/research/2021/dora-report/

[18] DORA. (2022). Accelerate state of DevOps report 2022. Google Cloud. https://dora.dev/research/2022/dora-report/

[19] DORA. (2023). Accelerate state of DevOps report 2023. Google Cloud. https://dora.dev/research/2023/dora-report/

[20] DORA. (2024). Accelerate state of DevOps report 2024. Google Cloud. https://dora.dev/research/2024/dora-report/

[21] DORA. (2026). DORA's software delivery performance metrics. Google Cloud. https://dora.dev/guides/dora-metrics/

[22] European Commission. (2021). Industry 5.0: Towards a sustainable, human-centric and resilient European industry. Publications Office of the European Union. https://research-and-innovation.ec.europa.eu

[23] Farley, D. (2021). Modern software engineering: Doing what works to build better software faster. Addison-Wesley.

[24] Forsgren, N., Storey, M.-A., Maddila, C., Zimmermann, T., Houck, B., & Butler, J. (2021). The SPACE of developer productivity: There's more to it than you think. ACM Queue, 19(1), 20–48. https://queue.acm.org/detail.cfm?id=3454124

[25] Gartner. (2023). Top strategic technology trends for 2024. Gartner. https://www.gartner.com/en/articles/gartner-top-10-strategic-technology-trends-for-2024

[26] Gartner. (2024). Top strategic technology trends for 2025. Gartner. https://www.gartner.com/en/articles/top-technology-trends-2025

[27] GitHub. (2022). The impact of AI on developer productivity: Evidence from GitHub Copilot. GitHub Blog. https://github.blog

[28] GitHub. (2023). Quantifying GitHub Copilot's impact on developer productivity and happiness. GitHub Blog. https://github.blog

[29] GitLab. (2023). Global DevSecOps report 2023. GitLab. https://about.gitlab.com/developer-survey/

[30] GitLab. (2024). Global DevSecOps report 2024. GitLab. https://about.gitlab.com/developer-survey/

[31] International Labour Organization. (2023). Generative AI and jobs: A global analysis of potential effects on job quantity and quality. ILO. https://www.ilo.org

[32] International Organization for Standardization. (2021). ISO 45003:2021: Occupational health and safety management—Psychological health and safety at work—Guidelines for managing psychosocial risks. ISO. https://www.iso.org/standard/64283.html

[33] Jiang, F., Ma, L., Broyd, T., & Chen, K. (2021). Digital twin and its implementations in the civil engineering sector. Automation in Construction, 130, Article 103838. https://doi.org/10.1016/j.autcon.2021.103838

[34] Lean Construction Institute. (2022). Last Planner System: Transforming project planning and control. Lean Construction Institute. https://leanconstruction.org

[35] Mayer, H., Yee, L., Chui, M., & Roberts, R. (2025). Superagency in the workplace: Empowering people to unlock AI's full potential at work. McKinsey & Company. https://www.mckinsey.com

[36] McKinsey & Company. (2022). How to implement transformations for long-term impact. McKinsey & Company. https://www.mckinsey.com/capabilities/transformation/our-insights

[37] McKinsey & Company. (2023). The economic potential of generative AI: The next productivity frontier. McKinsey Global Institute. https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-economic-potential-of-generative-ai-the-next-productivity-frontier

[38] McKinsey & Company. (2023). The state of AI in 2023: Generative AI's breakout year. McKinsey & Company. https://www.mckinsey.com/capabilities/quantumblack/our-insights/the-state-of-ai-in-2023-generative-ais-breakout-year

[39] McKinsey & Company. (2023). The state of organizations 2023: Ten shifts transforming organizations. McKinsey & Company. https://www.mckinsey.com/capabilities/people-and-organizational-performance/our-insights/the-state-of-organizations-2023

[40] McKinsey & Company. (2024). The state of AI in early 2024: Gen AI adoption spikes and starts to generate value. McKinsey & Company. https://www.mckinsey.com/capabilities/quantumblack/our-insights/the-state-of-ai

[41] Microsoft. (2021). The next great disruption is hybrid work—Are we ready? Work Trend Index annual report. Microsoft WorkLab. https://www.microsoft.com/worklab/work-trend-index

[42] Microsoft. (2022). Great expectations: Making hybrid work work. Work Trend Index annual report. Microsoft WorkLab. https://www.microsoft.com/worklab/work-trend-index

[43] Microsoft. (2023). Will AI fix work? Work Trend Index annual report. Microsoft WorkLab. https://www.microsoft.com/worklab/work-trend-index

[44] Microsoft. (2024). AI at work is here. Now comes the hard part. Work Trend Index annual report. Microsoft WorkLab. https://www.microsoft.com/worklab/work-trend-index

[45] Mischke, J., Stokvis, K., & Vermeltfoort, K. (2024). Delivering on construction productivity is no longer optional. McKinsey & Company. https://www.mckinsey.com/capabilities/operations/our-insights/delivering-on-construction-productivity-is-no-longer-optional

[46] National Academies of Sciences, Engineering, and Medicine. (2022). Human-AI teaming: State-of-the-art and research needs. The National Academies Press. https://nap.nationalacademies.org

[47] Noda, A., Storey, M.-A., Forsgren, N., & Greiler, M. (2023). DevEx: What actually drives productivity. ACM Queue, 21(4), 1–18. https://queue.acm.org

[48] Organisation for Economic Co-operation and Development. (2023). OECD employment outlook 2023: Artificial intelligence and the labour market. OECD Publishing. https://doi.org/10.1787/08785bba-en

[49] Project Management Institute. (2021). Pulse of the profession 2021: Beyond agility. PMI. https://www.pmi.org/learning/thought-leadership/pulse

[50] Project Management Institute. (2023). Pulse of the profession 2023: Power skills, redefining project success. PMI. https://www.pmi.org/learning/thought-leadership/pulse

[51] Project Management Institute. (2024). Pulse of the profession 2024: The future of project work. PMI. https://www.pmi.org/learning/thought-leadership/pulse

[52] Project Management Institute. (2025). Pulse of the profession 2025: Boosting business acumen. PMI. https://www.pmi.org/learning/thought-leadership/pulse

[53] Rompho, N., & Truktrong, S. (2024). Do OKRs help employees collaborate and innovate? Measuring Business Excellence, 28(3/4), 293–310. https://doi.org/10.1108/MBE-02-2023-0018

[54] Stanford Institute for Human-Centered Artificial Intelligence. (2024). The AI Index 2024 annual report. Stanford University. https://hai.stanford.edu/ai-index

[55] Stanford Institute for Human-Centered Artificial Intelligence. (2025). The AI Index 2025 annual report. Stanford University. https://hai.stanford.edu/ai-index/2025-ai-index-report

[56] Tetik, M., Peltokorpi, A., Seppänen, O., & Holmström, J. (2021). Direct digital construction: Technology-based operations management practice for continuous improvement of construction productivity. Automation in Construction, 127, Article 103707. https://doi.org/10.1016/j.autcon.2021.103707

[57] World Economic Forum. (2023). The future of jobs report 2023. World Economic Forum. https://www.weforum.org/publications/the-future-of-jobs-report-2023/

[58] World Economic Forum. (2025). The future of jobs report 2025. World Economic Forum. https://www.weforum.org/publications/the-future-of-jobs-report-2025/