

# THE FUTURE OF SKILLED LABOR AND TRADES: 2045



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*Image Source: Caterpillar Inc.*



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## CLIENT

Caterpillar Inc.

## INTRODUCTION:

Skilled trades and labor industries stand at a critical inflection point across North America. Historically, trades were held in high regard, offering reliable career paths and strong middle-class livelihoods.

However, over the last several decades, a combination of societal shifts, like cultural prioritization of four-year college degrees, the decline of vocational training programs and changing perceptions around manual labor, has led to a steady reduction in the number of individuals pursuing careers in trades.

Adding to this pressure are broader global forces that introduce greater complexity into the system. Sustainability imperatives and environmental policy are reshaping the materials, methods, and expectations surrounding construction and trades, demanding greener practices and new skillsets that few longtime tradespeople have been trained for.

Technological advancements, including autonomy and AI and project management, are transforming the nature of work, potentially displacing some traditional roles while creating demand for new hybrid skills.

This project explores urgent questions about the industry's future resilience, adaptability and workforce sustainability using Caterpillar Inc. as a model client.

## GEOGRAPHIC SCOPE:

North America with a strong focus on the United States

## TIME HORIZONS:

We considered three different time horizons in our exploration of the domain:

**Horizon 1:** 2025-2035

**Horizon 2:** 2030-2045

**Horizon 3:** 2045 and beyond

## KEY QUESTION

What are the plausible futures for skilled labor and the trades (construction, manufacturing, plumbing, electrical, and other manual professions) by 2045, given accelerating technological disruption, demographic shifts, and evolving cultural attitudes toward labor and manufacturing work?

## FRAMING: CURRENT ASSESSMENT

Even a brief glimpse at today's headlines paints a picture of turmoil and change in skilled labor and trades. The shortages are no longer cyclical. They're structural. Generational preferences for work-life balance, immigration volatility, climate regulation and automation are reshaping workforce availability and skills.

A host of drivers are pushing the future of the trades and skilled labor to a tipping point with two paths:

- A tech-led future with minimal human labor
- A tech-human partnership

One thing is for certain, for Caterpillar, the question is no longer how to sell equipment, but how to shape the future workforce ecosystems that equipment must operate in.

This research highlights the drivers, potential futures and potential paths for Caterpillar's role in the future of Skilled Trades and Labor.



# STAKEHOLDERS & DOMAIN MAP

## Lawmakers/Regulators:

Enact policies on training programs, licensing, labor protections, and safety standards.

**Construction Firms:** Directly impacted by labor supply, cost structures and new technology.

## Unions & Vocational Schools:

Gatekeepers for training pipelines, certification and bargaining for workforce rights.

## Immigrant Worker Communities:

A large share of the workforce in many regions, especially in construction and agriculture-related trades.

## Public Sector &

**Infrastructure:** Rely on skilled trades for critical national and local projects.

**Students:** Those considering future career paths amidst exponential changes across industries and education

**Tech Bros:** Large scale tech providers including AI companies shifting the future of workforce tools.

## Manufacturers and

**Startups:** Develop automation, telematics and productivity tools that shift workforce requirements.



# SKILLED LABOR AND TRADE HISTORY (1945 - 1980)

Following the end of World War II in 1945, construction industries and skilled trades entered a period of significant global stability and growth. Massive reconstruction efforts in Europe under the Marshall Plan, booming suburban development in the US, and rapid industrialization in parts of Asia created a sustained and urgent demand for skilled labor.

Vocational training programs were robust and publicly supported, unions protected workers' rights and wages, and construction work was seen as an essential pillar of national economic recovery and growth.

Skilled trades offered a direct path to middle-class prosperity without the need for a college degree, and craftsmanship, manual expertise, and technical know-how were highly respected in society.

Public infrastructure projects — highways, schools, ports, and utilities — flourished under government investment, reinforcing construction as both a stable career choice and a national economic backbone.

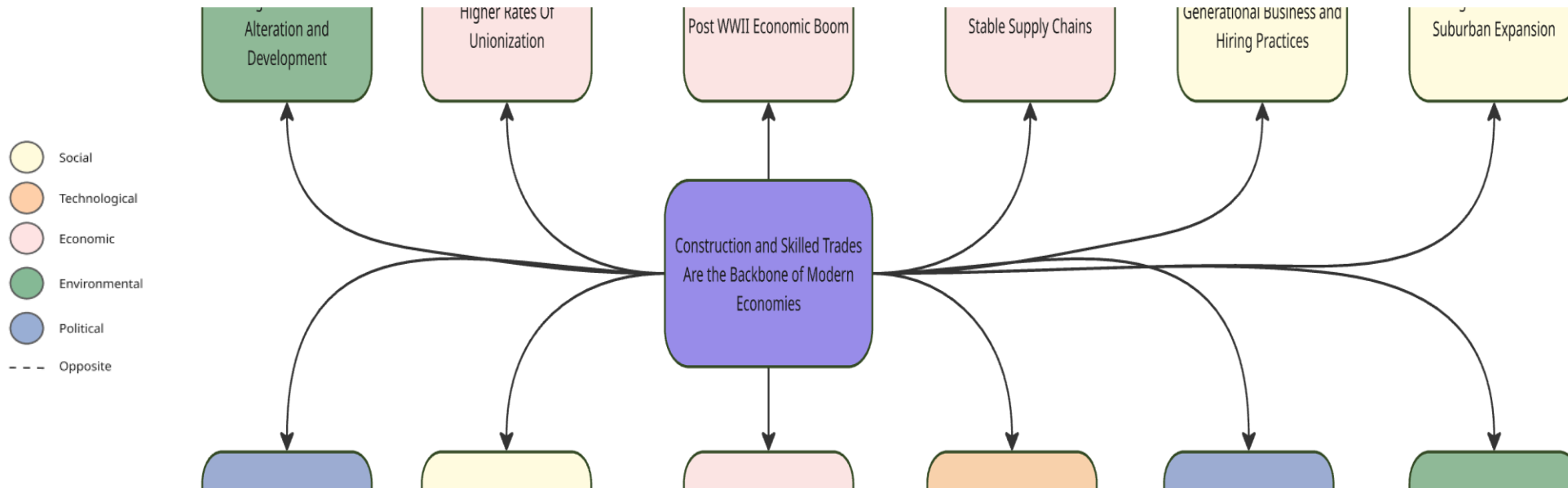


Figure 1 –Historical Influence Map



## HISTORY (1980 - PRESENT)

This period of relative stability began to shift in the late 20th century, particularly from the 1980s onward, as globalization, technological innovation, and policy changes began to reshape labor markets.

Deindustrialization in Western economies reduced traditional demand for skilled labor at home, while emerging markets increasingly competed on lower labor costs.

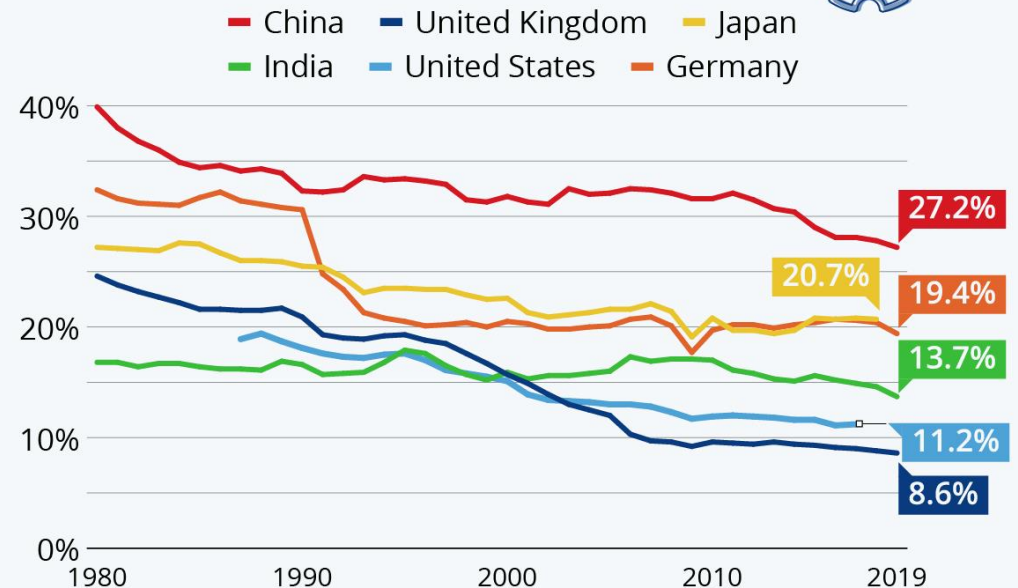
At the same time, cultural shifts prioritized university education over vocational training, eroding the social prestige of trades.

Automation and mechanization began to displace certain manual roles, while the rise of neoliberal economic policies in many countries weakened union protections and public investment in infrastructure.

Together, these forces marked the beginning of a profound transformation of the construction sector, destabilizing the steady ecosystem that had supported skilled trades for decades and setting the stage for the complex, adaptive challenges the industry faces today.

### The Global Decline of Manufacturing

Manufacturing value added as a percentage of GDP in selected countries (1980-2019)



Sources: United Nations and World Bank



statista



# RECENT HISTORY

## Covid Disrupts Labor Pipelines

The COVID-19 pandemic halted construction, closed trade schools, and disrupted apprenticeship pipelines across North America. Many older workers exited the labor force permanently, while training backlogs created a delayed but compounding skills shortage that continues to affect project delivery today. [\[LINK\]](#)

## Rapid Commercialization of Autonomous Construction Equipment

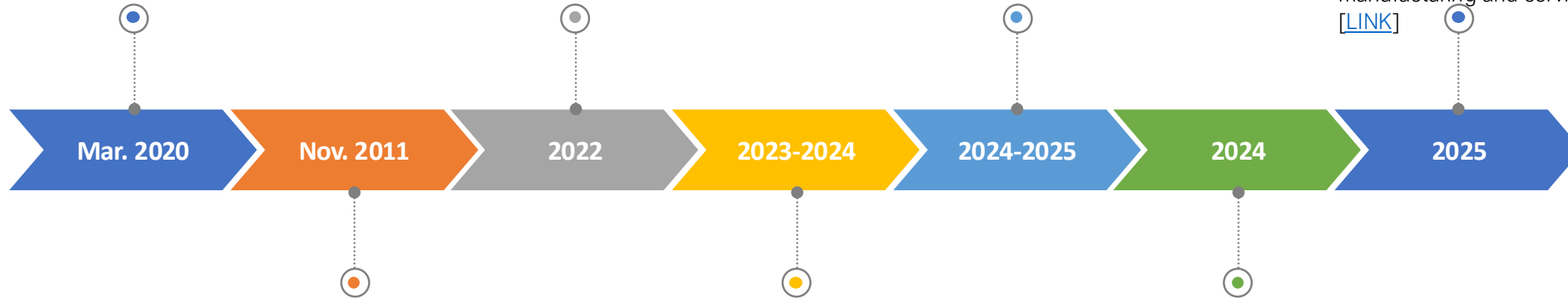
Manufacturers accelerated deployment of semi-autonomous and operator-assist systems to offset labor shortages. While productivity gains were realized, uneven training, unclear accountability, and inconsistent safety standards highlighted governance gaps between human operators and intelligent machines. [\[LINK\]](#)

## Heightened Immigration Enforcement and Policy Volatility

Renewed enforcement actions and stalled immigration reform increased uncertainty for industries heavily reliant on immigrant labor. Construction and agricultural sectors experienced regional workforce shocks, reinforcing automation adoption as a risk-mitigation strategy rather than a planned transition. [\[LINK\]](#)

## Ford CEO Jim Farley Warns of Labor Crisis

In late 2025 and early 2026, Ford CEO Jim Farley publicly warned that America is facing a skilled worker shortage, noting the company cannot fill thousands of auto technician and mechanic roles (even six figure salaries) because the training pipeline is insufficient. Farley has framed this as a national labor crisis that threatens basic manufacturing and service capacity. [\[LINK\]](#)



## Infrastructure Investment & Jobs Act Passed

The \$1.2 trillion federal infrastructure bill dramatically increased demand for skilled labor across transportation, energy, and public works—at the exact moment workforce capacity was constrained. The mismatch between funding and available labor intensified competition for workers and exposed systemic weaknesses in training and credentialing pipelines. [\[LINK\]](#)

## Expansion of Micro-Credentialing and Nontraditional Training Models

Employers, unions, and technology providers increasingly turned to short-cycle credentials, VR-based training, and competency-based certification to accelerate workforce readiness. These models challenged traditional trade schools and raised questions about credential portability, verification and quality assurance. [\[LINK\]](#)

## Growing Scrutiny Over Algorithmic Management and AI

Labor groups and regulators began questioning the role of algorithmic decision-making in scheduling, safety monitoring, and performance evaluation. Early debates around transparency, bias, and accountability signaled that governance and not just technology, would shape the future of automation in the trades. [\[LINK\]](#)



# CURRENT CONDITIONS

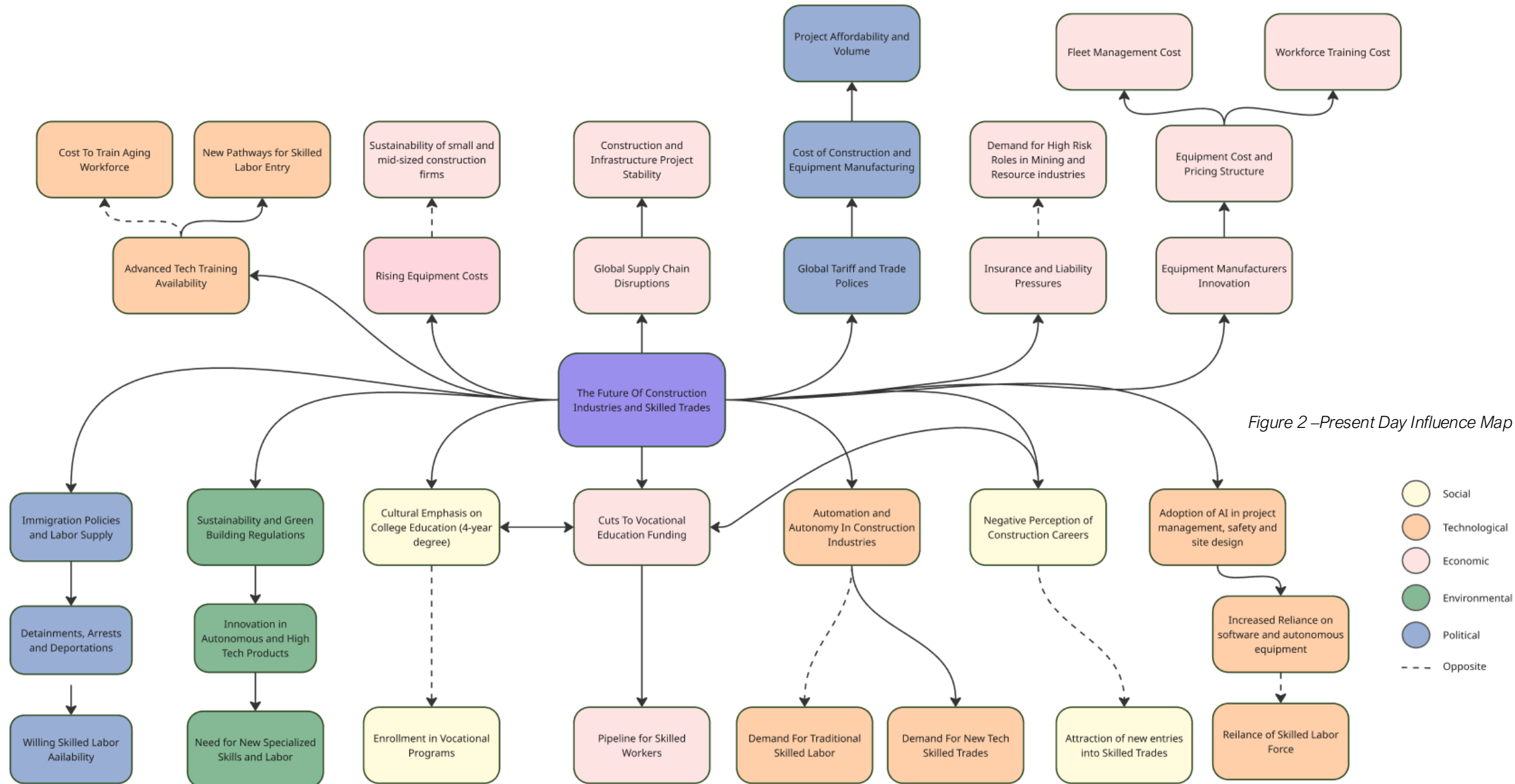


Figure 2 –Present Day Influence Map

# SIGNALS OF THE FUTURE OF SKILLED LABOR AND TRADES

During the project we collected more than 150 scan hits across three horizons and every category defined in our domain map. Based on horizon scanning, the most immediate and chaotic change facing the skilled labor pool and construction industries is growing political volatility around workforce policy, combined with the rapid cultural shift toward automation and deregulation. It is currently unraveling the institutional support structures for skilled labor, while aging workers are not being replaced nearly fast enough.

## HORIZON 1 – NEAR TERM / CONFIRMING

- Operator-assist and semi-autonomous features are becoming standard equipment rather than premium add-ons, signaling that automation is now a baseline expectation in heavy machinery. [\[link\]](#)
- Federal and state workforce funding is expanding toward skills training and digital credentials, but largely without reforming credential portability or cross-employer coordination. [\[link\]](#)

## HORIZON 2 – MID TERM / TRANSITIONAL

- Unions and employers are beginning to negotiate formal agreements governing the use of AI, automation, and data in the workplace, signaling early moves toward shared human–machine governance. [\[link\]](#)
- Construction and manufacturing firms are piloting AI-enabled safety monitoring systems that blur the line between human supervision and algorithmic enforcement, raising new accountability questions. [\[link\]](#)
- Industry groups are working to standardize AI safety, transparency, and accountability frameworks, suggesting that governance of intelligent machines is becoming an industry concern, not just a regulatory one. [\[link\]](#)

## HORIZON 3 – LONG TERM / TRANSFORMATIVE

- Verifiable digital credential wallets are emerging as foundational labor-market infrastructure, enabling portable and interoperable skill verification across employers and regions. [\[link\]](#)
- U.S. policymakers and workforce organizations are increasingly exploring Learning and Employment Records (LERs) as a mechanism for governing skills data at an ecosystem level. [\[link\]](#)



# TRENDS (TIPPOS)

Skilled labor and trades are being reshaped by the convergence of **automation**, **demographic pressure**, **sustainability mandates**, and **changing cultural attitudes toward work**. Automation is increasingly positioned as assistive rather than being a substitute, while education systems pivot toward apprenticeships, micro-credentials, and competency-based learning. Together, these trends signal a system adapting incrementally to strain rather than undergoing full structural transformation.

## AUTOMATION

- + **Human-robot collaboration & adaptive robotics in trades:** newer systems are being designed to assist rather than replace workers – [Link](#) (PDF)
- + **Reshoring and investment in autonomy:** In this new economic and autonomous environment, moving some production and distribution processes from abroad back to the US despite a shallow skilled labor pool becomes attractive to companies in manufacturing, construction and skilled trades. – [Link](#)

## EDUCATION

- + **Renewed interest and investment in apprenticeships and trade-school/skills pathways:**
- + Young people, veterans, and minority groups are being encouraged to enter the trades, with support or paid programs.– [Link](#)
- + **Flexible and competency-based learning, including use of immersive tech (VR):** micro-credentials, and education models emphasizing skill acquisition over formal degree. - [Link](#)
- + **Decline in union participation is seen as negative to the future of the trades and work in America** - [Link](#)

## SUSTAINABILITY

- + **Stricter building codes and performance standards focused on energy, emissions, resilience.** States are updating codes to require higher efficiency, lower carbon intensity, resilient design (fire, wind, climate changes requiring different skillsets, innovation and process - [Link](#)
- + **Sustainability skills gap in the workforce.** Employers across industries, including construction and trades are reporting difficulty hiring workers trained in sustainable practices. This trend will push for new certifications, retraining, and integration of green skills into vocational education - [Link](#)



# TRENDS CONTINUED (TIPPOS)

Skilled labor and trades are being reshaped by the convergence of **automation**, **demographic pressure**, **sustainability mandates**, and **changing cultural attitudes toward work**. Automation is increasingly positioned as assistive rather than being a substitute, while education systems pivot toward apprenticeships, micro-credentials, and competency-based learning. Together, these trends signal a system adapting incrementally to strain rather than undergoing full structural transformation.

## CULTURE

- + **Trade work is becoming more socially valued again:** Partly due to concerns about white-collar job stability & cost of college, Gen Z is showing a pivot toward trade jobs – [Link](#)
- + **Shifting Expectations of Job Value, Meaning & Alignment:** Longstanding bias toward white-collar, degree-based jobs is under pressure. There's more respect being given to skilled trades: stability, tangible results, autonomy, hands-on work. - [Link](#)

## LABOR INDUSTRIES

- + **Labor industries are under significant stress:** Persistent labor shortages in skilled trades, especially technicians, electricians, HVAC, etc. With retiring workforce and not enough entrants, many industries are under stress. – [Link](#)
- + **Growth in renewable and Green Infrastructures:** Solar, wind, energy retrofit are requiring different or new trade roles. The labor demand is shifting not just volume, but skill type - [Link](#)

## POLICY & REGULATION

- + **Regulatory rule changes (e.g. environmental, energy):** Policy and incentives are being used to guide industry behavior. – [Link](#)
- + **Policy changes are pushing construction/trades to adapt to new minimums:** State and local government are increasingly active in updating building energy and performance codes, emission standards, and other sustainability-oriented regulations. - [Link](#)



# ISSUES (TIPPOS)

The skilled labor system is marked by unresolved tensions between speed, equity, cost and coordination. Labor shortages persist amid volatile immigration policy, while automation adoption outpaces training and governance frameworks. Climate compliance, data fragmentation and uneven workforce capability further complicate delivery, exposing gaps between ambition and execution.

- + **Automation gains vs. job displacement.** Safety and throughput gain from autonomy/AI vs. risks of displacing skilled operators without adequate reskilling pathways.
- + **Climate compliance vs. cost/schedule.** Stricter building-sector decarbonization targets vs. higher CAPEX/OPEX for low-carbon materials, methods, workflows and reporting.
- + **Immigration dependence vs. policy volatility.** Construction's heavy reliance on immigrant labor vs. shifting enforcement and legal uncertainty, which can tighten labor supply.
- + **Data/AI adoption vs. fragmentation and capability gaps.** Owners and contractors want connected data and AI planning, mass automation and operational improvements yet many firms lack the data analysis and skills to benefit.
- + **Federal funding windows vs. delivery capacity.** IIJA dollars are substantial but time-bound; obligation deadlines and shifting program criteria raise risk of forfeited funds if projects stall.



# PLANS (TIPPOS)

The current plans to address skilled labor shortages reveal a split strategy. Public-sector efforts focus on expanding apprenticeships and workforce access through near-term funding, while private-sector actors increasingly pursue automation and AI-driven substitutes for labor. These parallel approaches reflect uncertainty about whether the future of work will be rebuilt around people, technology, or both. See examples below.

- + **U.S. Department of Labor | Apprenticeship expansion:** ~\$84M in 2025 formula grants to states to grow Registered Apprenticeships; additional targeted grants (e.g., WANTO; state awards) to widen construction pipelines. 2025–2026. – [Link](#)
- + **Ric Robotics introduced Zyrex, the world's first giant AI-powered construction robot designed for large-scale infrastructure projects:** The robot, powered by advanced AI and reported by RIC (the company releasing the robot) to be the first of its kind. It will address workforce and labor shortages in the building and construction industry and require fewer workers to operate, with future versions requiring no human input to launch in 2026 - [Link](#)



Image Source: RIX Robotics – Zyrex Robot



# PROJECTIONS (TIPPOS)

Projections indicate that skilled trades will remain essential through 2030 and beyond, but the composition of work will shift toward digitally enabled, sustainability-oriented roles. Human-machine collaboration, continuous reskilling, and interoperability across systems are expected to define workforce competitiveness. Demand will favor adaptability over headcount alone.

- + **WEF, Future of Jobs Report 2025** — 2025–2030: trades remain essential but upskilled; demand rises for digital/green capabilities and human-machine collaboration; employers plan reskilling at scale – [Link](#)
- + **UNEP, Global Status Report for Buildings & Construction 2024/2025:** 2025-2030+: sector must accelerate low-carbon materials/methods to hit climate pathways, implying rapid diffusion of new techniques and credentials. - [Link](#)

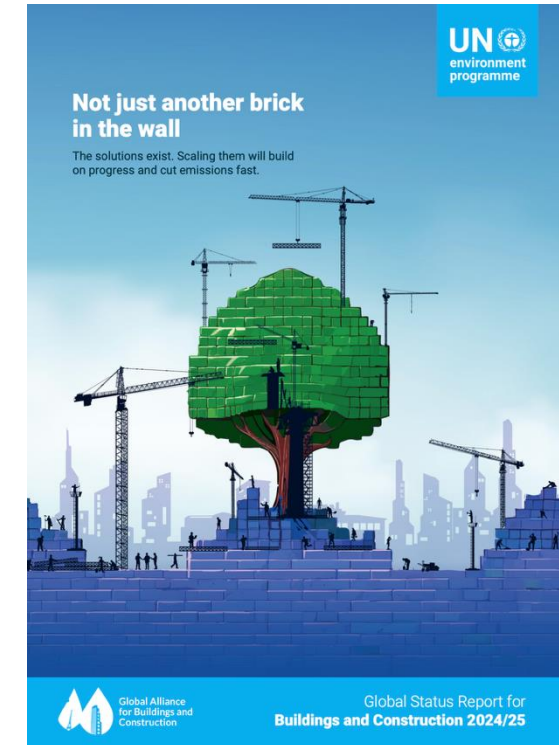
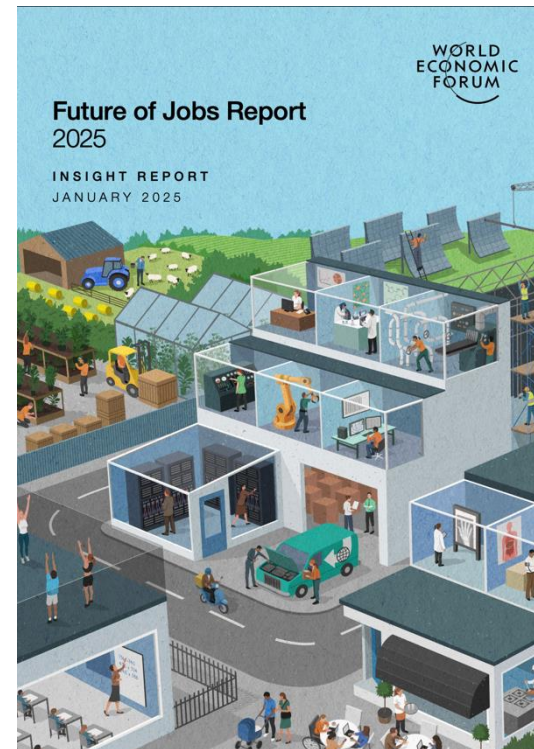


Image Sources: (Left) World Economic Forum (Right) United Nations Environment Programme



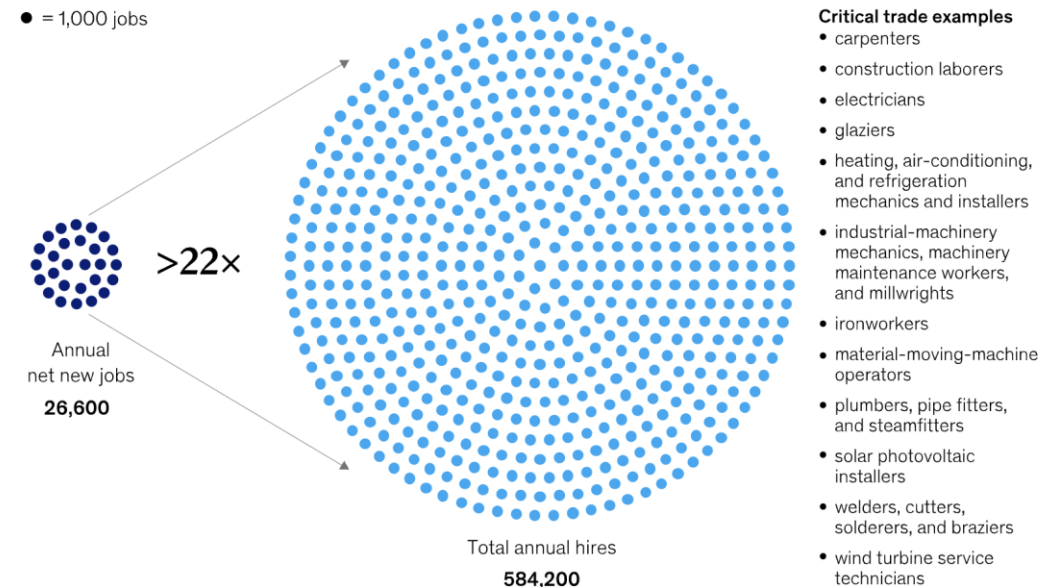
# OBSTACLES (TIPPOS)

Despite clear signals and stated intentions, structural obstacles continue to slow progress. Policy instability, rigid program requirements, and a looming retirement cliff undermine long-term workforce planning. Without coordinated governance and faster pathways into the trades, current interventions risk delaying rather than reversing systemic decline.

- + **Policy/program instability.** Changing federal criteria (e.g., DEI/climate requirements removed in some grants) and legal challenges inject uncertainty into workforce and infrastructure programs, complicating planning. – [Link](#)
- + **Retirement Cliff:** By 2031, nearly 40% of U.S. construction managers and 30% of skilled trade workers are projected to retire, creating persistent labor shortages. A large share of the skilled trades workforce is nearing retirement, with too few new entrants to replace them. – [Link](#)

**Annual hiring in the United States for critical skilled roles could be more than 20 times the projected annual increase in net new jobs from 2022 to 2032.**

Annual job creation in critical trade categories,<sup>1</sup> number of jobs (average flows per year, 2022–32)



<sup>1</sup>Identified based on 3 criteria: frequent migration to other jobs (or significant portions of workforce entering retirement), extensive training requirements, and criticality to public and private infrastructure, clean-energy projects, and advanced manufacturing.



# EMERGING CHANGE: DISRUPTORS AND LABOR SYSTEM IMPACTS

Where the Future Hits the Present: Disruption Points in the Skilled Trades and Labor Systems

## CHANGE

Modular and Prefabricated Construction Practices

Autonomous and AI Driven Job Sites

AI-Integrated Planning and Scheduling Tools

Generational Shifts in Career Values

Volatility in Immigration Laws and Labor Policies

Climate Regulation and Green Policy

Growth of Safety & Productivity Tech Startups

## IMPACTS

Undermines on-site trade labor demand & bypasses apprenticeship environments

Deepens dependency on technology; widens skill mismatch gaps

Displaces mid-tier project roles; centralizes tech oversight functions

Weakens recruitment into trades, union and disrupts traditional training incentives

Reduces available workforces; destabilizes regional construction markets

Renders old methods, materials and equipment obsolete; accelerates pressures on reskilling and retraining

Disrupts OEM innovation dominance; fragments training, adoption and tech programs to labor



# DRIVERS OF CHANGE

## 1. Human-Tech Synergy

AI, robotics, and autonomy are actively redefining the role of human labor in construction and manufacturing.

## 2. Generational Shifts

Trades will either fragment into smaller, tech-enabled, flexible pathways—or transform entirely as Gen Z and Millennials reshape what counts as a “good job.”

## 3. Union and Organizational Shift

Union density continues to erode with advances in tech while the workers reorganize through sectoral/coalition bargaining, project-based agreements and regulation of algorithmic management.

## 4. Immigration Impacts Labor Supply

Shifting American attitudes towards immigration, undocumented workers conflict with skilled trades heavy reliance on immigrant labor.

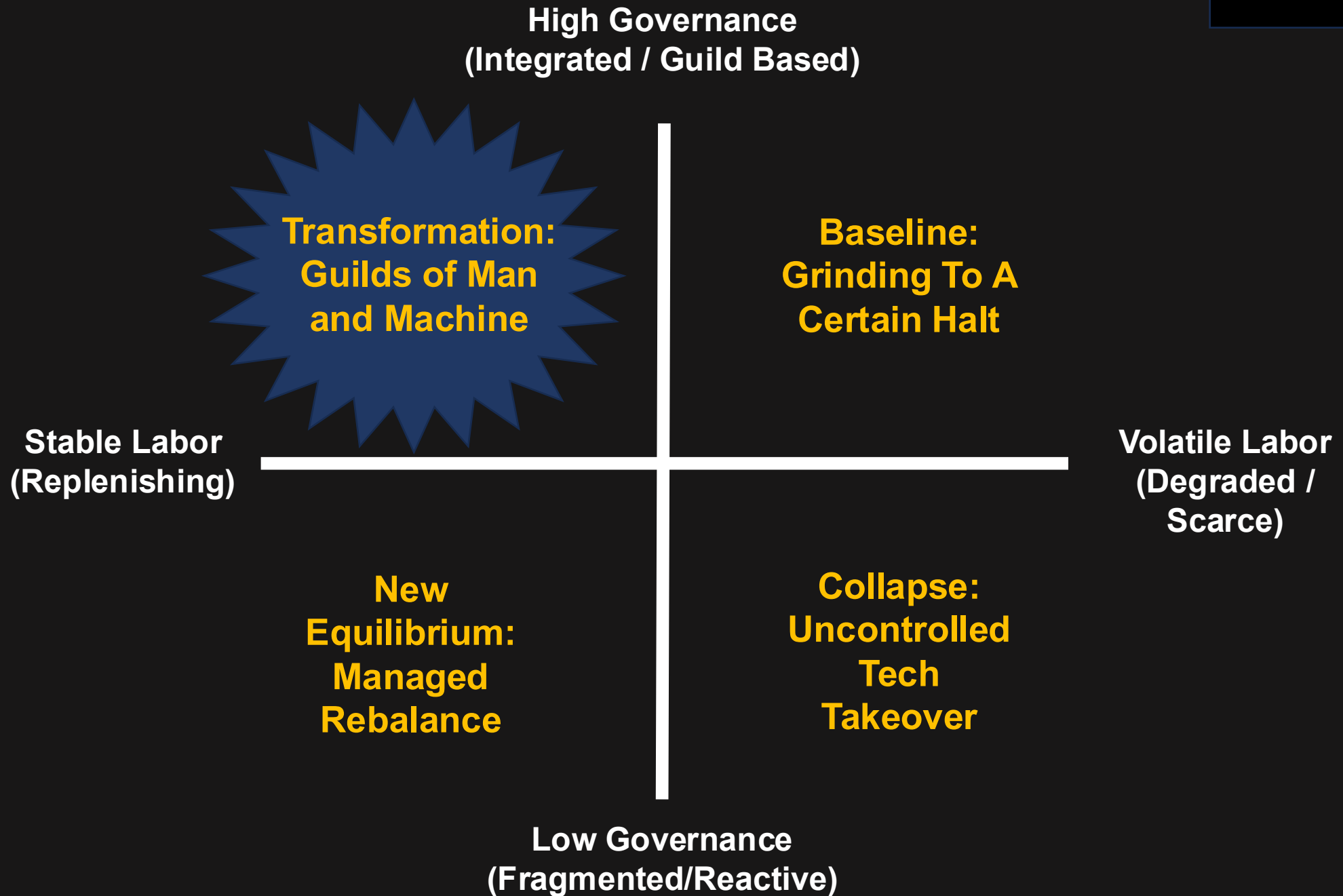
## 5. Micro Credentials Changing Training

Traditional trade schools give way to competency-based models: apprenticeships & micro-credentials. Flexible career pathways are expanding as industry demands evolve faster than trade schools can adapt.

## 6. Climate Demands Innovation

Urbanization and climate change will drive the development of the future. Construction, agriculture and heavy industries must plan and evolve their thinking considerably.

## SCENARIO DEVELOPMENT



# BASELINE: GRINDING TO A CERTAIN HALT

As skilled labor shortages deepen and traditional training systems fail to keep pace, the construction and trades ecosystem drifts into a slow, grinding stagnation.

Human-led standards remain intact, but every year they feel slightly more outdated as semi-autonomous equipment, new safety requirements, and advanced materials exceed workforce capacity. Immigration volatility and retirement waves continually undermine workforce stability, forcing companies into reactive hiring practices and short-term fixes.

Projects take longer, costs increase, and productivity erodes, not through sudden collapse, but through a steady accumulation of delays, mismatches, and unmet expectations that quietly reshape what “normal” looks like on the jobsite.



# TRANSFORMATION: GUILDS OF MAN AND MACHINE

Human-machine collaboration becomes the backbone of skilled labor. Smart equipment, real-time safety analytics, and interoperable credentialing platforms converge to form new guild-like ecosystems where workers, companies, unions, and AI systems co-govern the standards of work.

Skills are continuously updated through micro-credentials, augmented reality training, and adaptive learning modules that travel with the worker from site to site, region to region and country to country.

Automation doesn't replace labor, it elevates it, giving operators the ability to direct powerful machine counterparts with greater precision and intelligence. Trust, transparency, and shared governance allow the sector to reinvent itself as a coordinated, ethical and highly efficient workforce system.



# NEW EQUILIBRIUM: MANAGED REBALANCE

After years of disruption, the industry reaches a fragile but workable balance. Labor shortages remain, but are partially offset by localized training pipelines, practical immigration policies, and employer-driven upskilling initiatives.

Human-led standards persist, yet they evolve more quickly as regulators, unions, and manufacturers collaborate to update certification pathways and safety guidelines.

Automation takes on targeted roles, augmenting and in some cases replacing. Predictable workflows allow for hybrid human-machine teams or fully autonomous sites. The result is neither transformation nor decline, but a pragmatic recalibration: a future where the system stabilizes through continuous adjustment, compromise, and incremental modernization across the industry.



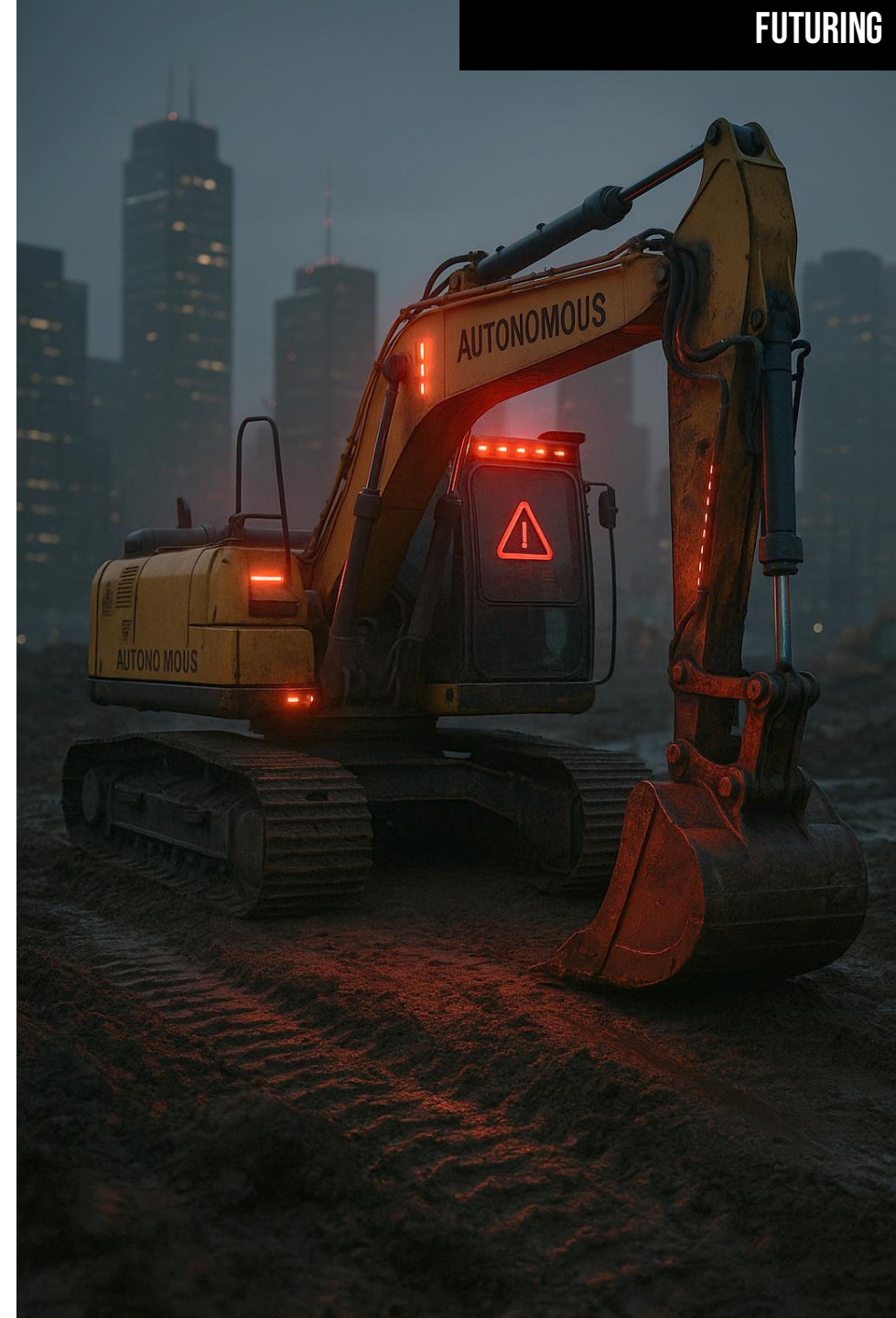
# COLLAPSE: UNCONTROLLED TECH TAKEOVER

Rapid, uneven deployment of autonomous equipment and algorithmic oversight creates a chaotic and unstable workforce environment.

With labor supply volatile and governance frameworks lagging years behind, companies lean heavily on automation to fill gaps, but without consistent standards or coordinated training, jobsite safety becomes unpredictable and trust erodes.

Workers struggle to keep up with opaque machine behaviors, while credentialing systems fracture into incompatible platforms that fail to validate competence.

Project performance swings wildly, regulatory systems buckle under the speed of technological change, and a growing divide emerges between firms that can manage the chaos and those that cannot.



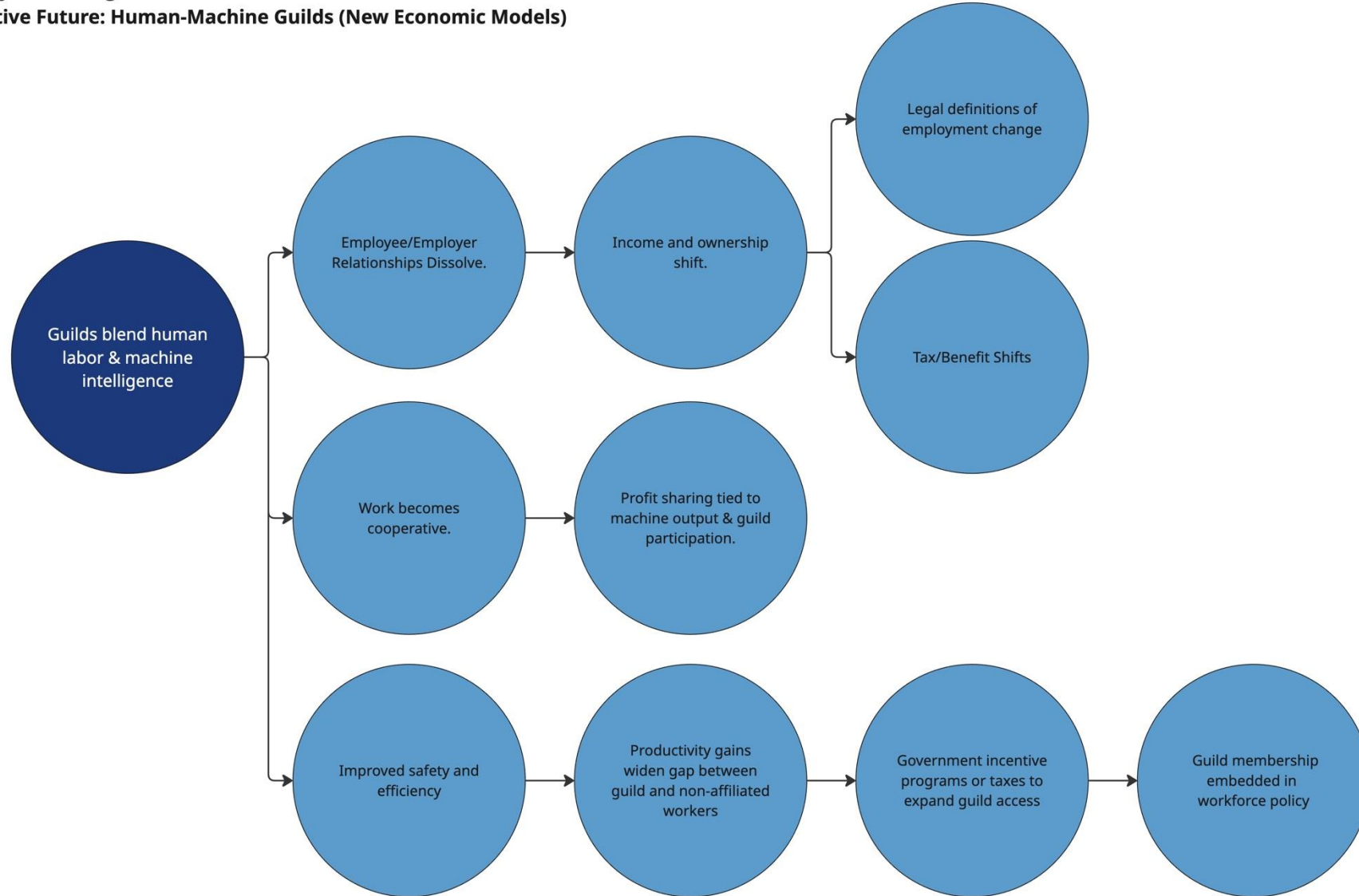
# IMPLICATIONS FOR CATERPILLAR

Domain	Key Change	Impacts On The Industry
<b>Social</b>	Guild-based collaboration between humans and intelligent machines	Workers operate inside digitally mediated guild networks that coordinate tasks, standards, and shared learning.
<b>Tech</b>	Algorithmic governance establishes unified safety and performance standards	Jobsite operations are continuously monitored by AI systems enforcing compliance and guiding dynamic conditions.
<b>Economic</b>	Skills become portable through open credentialing and verified reputation systems	Workers present digital portfolios with live capability data, enabling mobility across sectors & shifting value toward verified skill.
<b>Environmental</b>	Sustainability becomes embedded into trade activity as a default guild requirement	Equipment and workflows benchmark against ecological metrics, prioritizing regenerative and low-impact practices.
<b>Political</b>	Digital guilds co-govern ethical automation and labor policy	Unions, coalitions, and machine governance bodies jointly influence regulation and automation deployment standards.



# TRANSFORMATION: LABOR ORGANIZATION IMPACTS

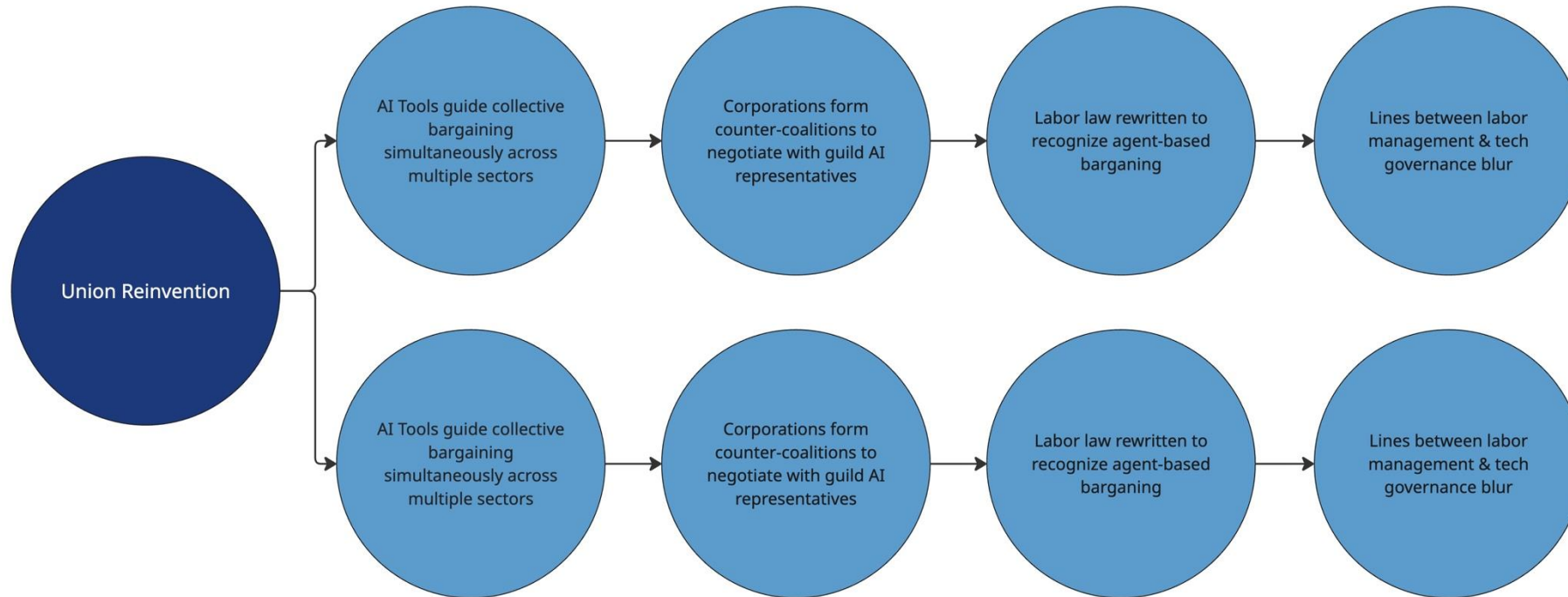
Category: Labor Organizations  
 Alternative Future: Human-Machine Guilds (New Economic Models)



# TRANSFORMATION: LABOR ORGANIZATION IMPACTS

Category: Labor Organizations

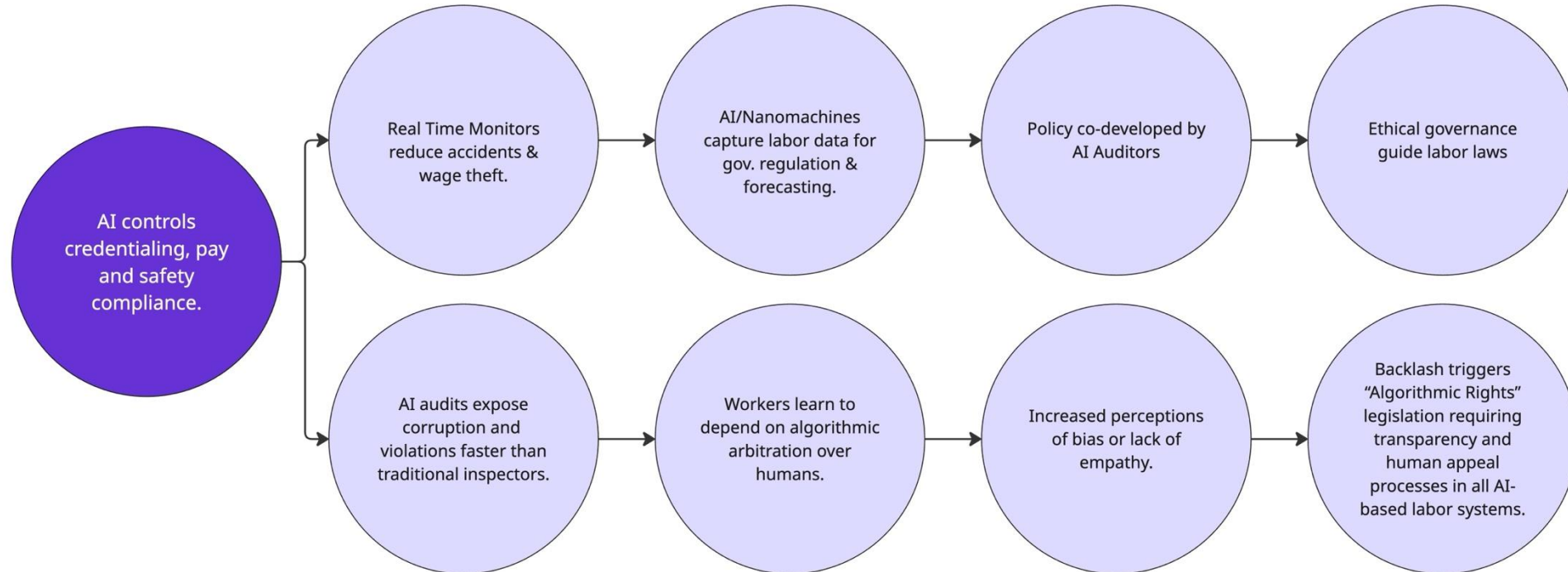
Alternative Future: Unions Reinvented by AI



# TRANSFORMATION: POLICY IMPACTS

Category: Policy

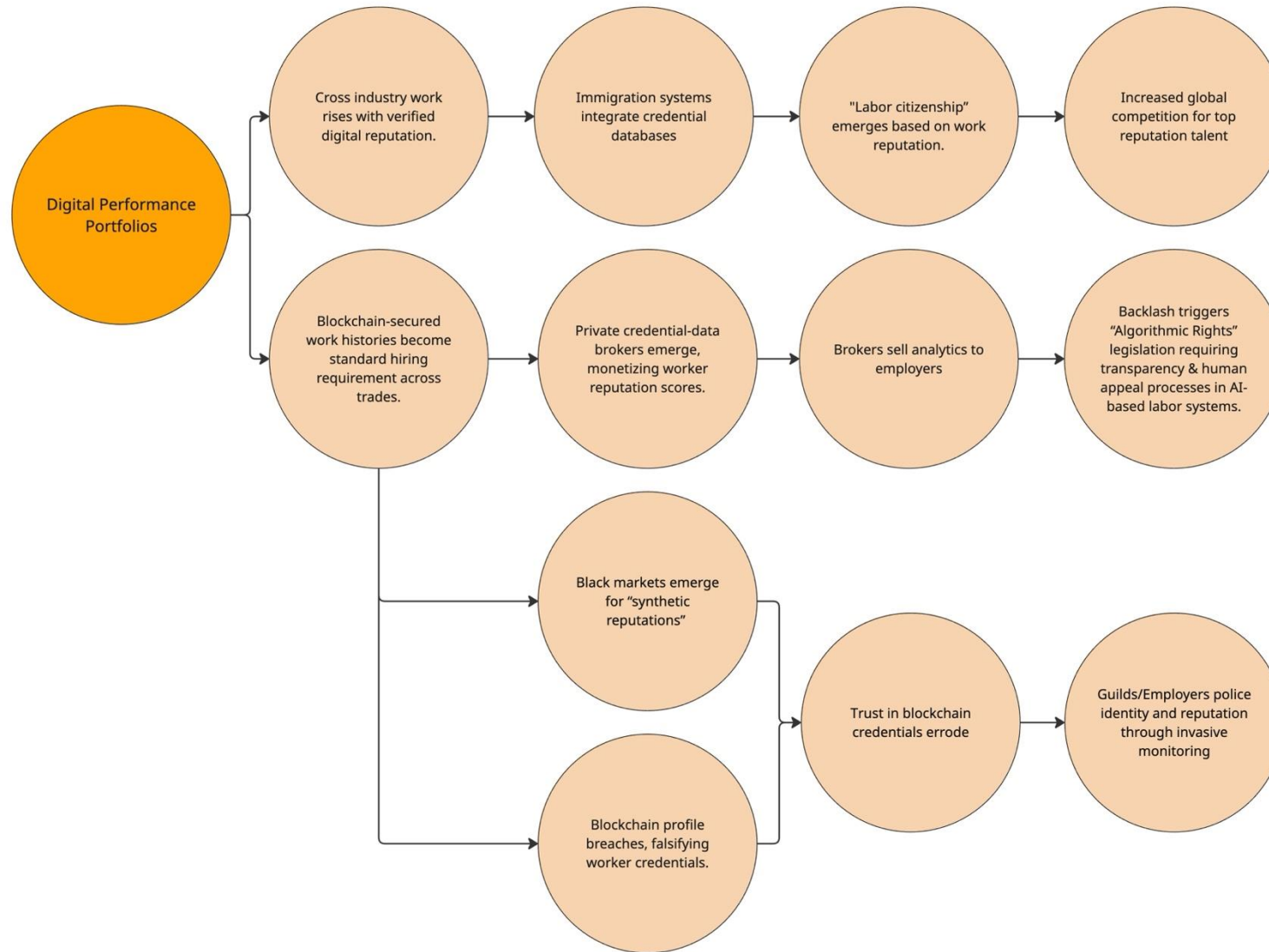
Alternative Future: Algorithms Drive Labor Reform



# TRANSFORMATION: EDUCATION IMPACTS

Category: Education

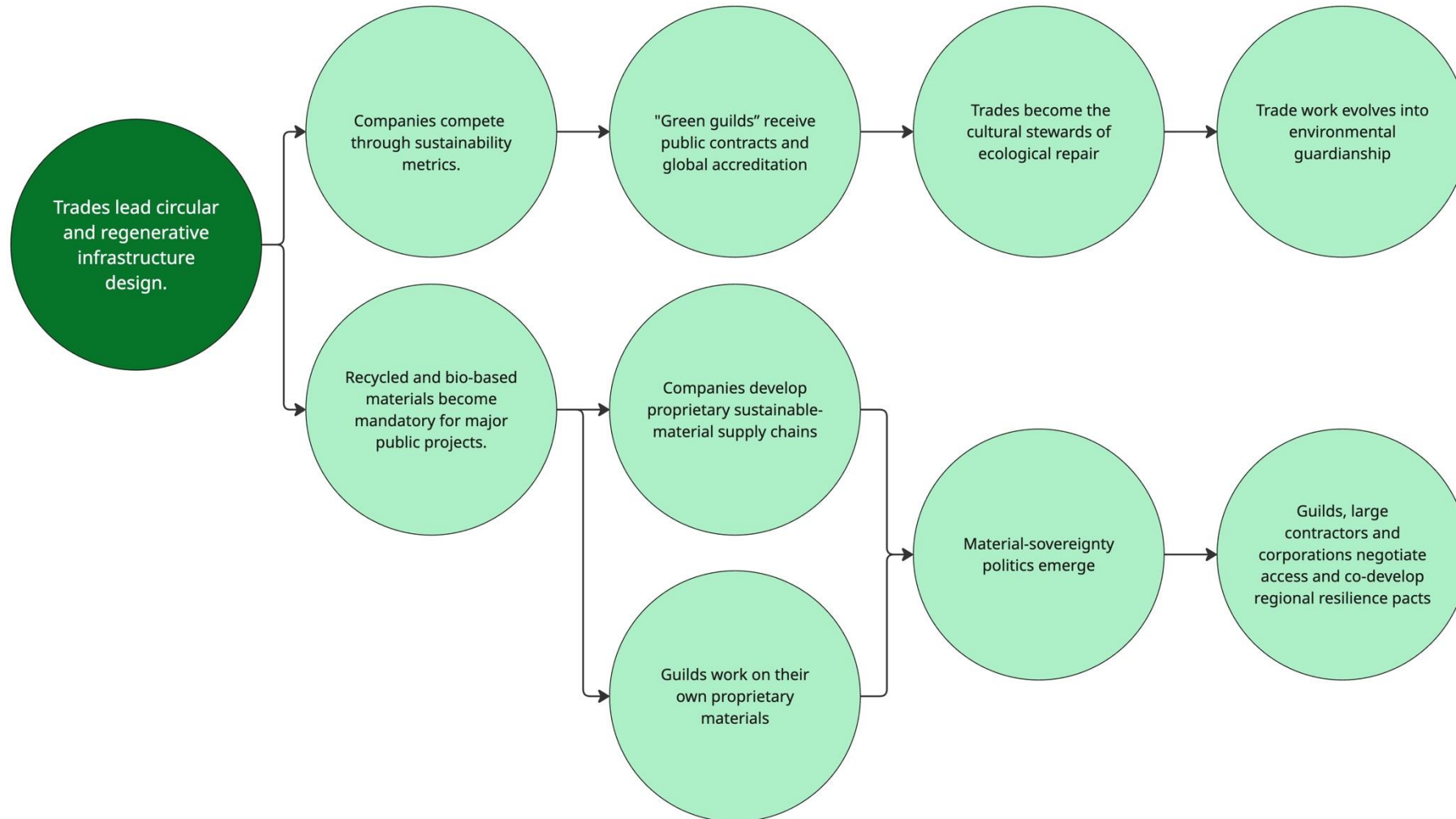
Alternative Future: Reputation Based Credentialing To Workforce Fluidity



# TRANSFORMATION: CLIMATE & SUSTAINABILITY IMPACTS

Category: Climate & Sustainability

Alternative Future: Trades Lead Ecological Transformation





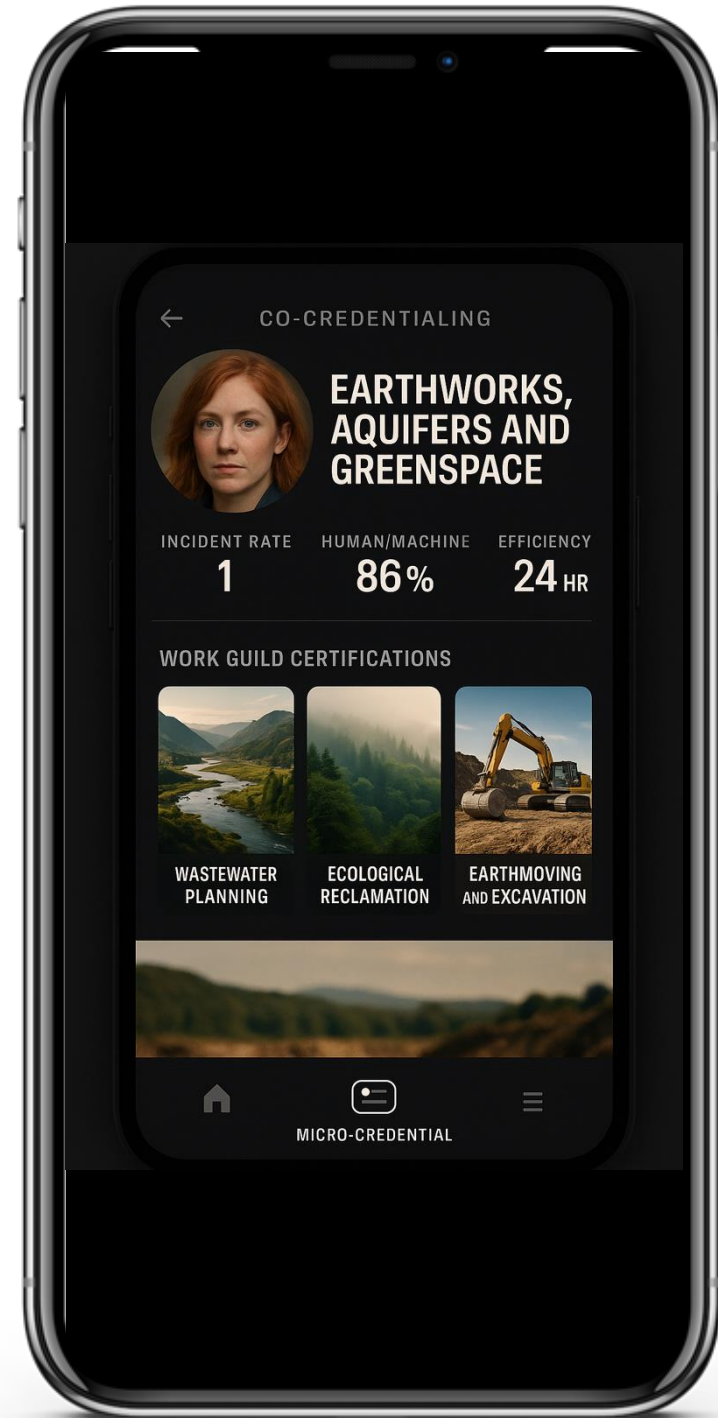
**How should Caterpillar position itself within emerging human–machine guild ecosystems to remain trusted and essential to skilled trades, labor and its core customers?**


# OPTION 1: THE GUILD STEWARDSHIP INITIATIVE

**What it is:** A co-developed, cooperative labor tracking system that could work with guilds, trade unions or employers looking for specific skill requirements.

**How Cat Can Support It:** By extending its VisionLink, Cat Command, Cat AI Assistant and Cat Detect platforms into an interoperability standard that records event-level machine behavior, sensor activations, operator inputs, and safety interventions. Cat can co-develop shared protocols with unions, guilds, and regulators to ensure data integrity, create tamper-resistant machine logs and pilot AI-auditable safety systems for cross industry adoption.

**What Success Looks Like:** Caterpillar becomes the global benchmark for transparent automation, trusted by guilds, governments, and workers. By helping develop the credentials (see example at right) Caterpillar can steward trade work into the future and create tradesperson passports.



A yellow Caterpillar excavator is shown in a construction setting, actively digging a trench in the earth. The machine's arm and bucket are extended, and it is positioned on a dirt mound. The background features a line of green trees under a blue sky with scattered white clouds. The overall scene is brightly lit, suggesting a clear day.

**If AI and automation gain co-governance roles in labor guilds, what new forms of accountability and partnership must Caterpillar establish to ensure ethical alignment, shared responsibility, and sustained legitimacy in this new governance environment?**

## OPTION 2: ACCOUNTABILITY BY DESIGN

**What it is:** A next-generation framework for shared accountability between humans, AI systems, and corporate partners through transparent data ethics, auditable decision-making, and guild-verified oversight mechanisms aimed at thwarting manipulation.

**How Cat Can Support It:** By fast tracking the extension of its VisionLink and Cat Detect systems, Caterpillar can co-work with employers and work guilds to transfer machine and operator data to a verified profile and work history that helps empower operators and guilds alike

**What Success Looks Like:** Caterpillar becomes a global reference model for "ethical automation," and begins collaborative work with emerging guilds and governments across the globe based on pilot results



# SUGGESTED NEXT STEPS FOR CATERPILLAR

**The Opportunity:** While every scenario deserves attention, Caterpillar has the unique opportunity to address many of these potential futures head on, securing its business and leadership position through thoughtful, intentional attempts to make the future a more equitable whether it's human led, tech led, or co-led. We believe the following next steps are essential to consider first:

1. Launch Ethical Automation & Workforce Futures Taskforce
2. Engage unions and training networks
3. Pilot guild-integrated training ecosystems internally

# CONCLUSION

## **Shaping The Workforce Systems Of The Future:**

The future of skilled labor and trades is not predetermined by automation alone, but by how effectively human, technological and institutional systems are governed together. Across all scenarios, Caterpillar's role expands beyond equipment manufacturing into stewardship of the workforce ecosystems its machines and partners depend on.

Whether the industry drifts, stabilizes, transforms, or fractures will depend on decisions made now and in the near term around accountability, training and shared standards. By engaging early in ethical automation, credentialing and guild-based governance models, Caterpillar can help shape a future where productivity, trust and human expertise evolve together, rather than in conflict.



**THANK YOU**



# APPENDIX

Reference, Related Scan Hits From Systems Thinking, Flotsam and Jetsam

# RESOURCES

## Skilled Labor Shortages & Vocational Education

- National Bureau of Economic Research: Applying AI to Rebuild Middle Class Jobs – <https://www.nber.org/papers/w32140> (Accessed April 28, 2025)
- National Center for Construction Education and Research (2024) – Future Proofing the Construction Workforce: The Value of Training and Credentials - <https://www.nccer.org/research/future-proofing-the-construction-workforce-the-value-of-training-and-credentials> (Accessed April 17, 2025)
- National Center for Construction Education and Research (2023) – Construction Company Sizes and Employment - <https://www.nccer.org/media/2023/03/construction-company-size-and-employment.pdf> (Accessed April 17, 2025)

## AI and Tech

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## Cross Impact Analysis

...the impact on this driver is...

DRIVERS	1.	2.	3.	4.	5.	6.
1. Human Tech Synergy		+	0	++	++	++
2. Generational Shifts	+		0	++	+	0
3. Immigration Policy Impacts Labor Supply	0	-		++	0	0
4. Union/Labor Organization Shifts	+	++	0		-	0
5. Micro-credentials Changing Training	+	++	0	+		+
6. Climate Demanding Innovation	++	0	0	+	+	

++ Strongly Reinforces    + Reinforces    0 Neutral    - Contradicts    -- Strongly Contradicts



# Option Elevator Speech


Fill out the right column(s) according to the instructions in the left column.

<p><b>STRATEGIC QUESTION 1</b></p> <p><i>What is the issue or opportunity?</i></p>	<p>How should Caterpillar position itself within emerging human-machine guild ecosystems to remain trusted, interoperable, and essential to skilled trades, labor and its core customer base?</p>		
<p><b>OPTION</b></p> <p><i>Response: How should client respond Include a memorable name and one-line description</i></p>	<p><b>The Guild Stewardship Initiative</b></p> <p>Caterpillar should reposition itself as an "ecosystem partner" through co-developing ethical automation frameworks, credentialing tracking standards and open, secure data architectures that align with governance structures of emerging human/machine guilds</p>		
<p><b>WHY IS IT IMPORTANT?</b></p> <p><i>Rationale: Describe why the strategic question is worth responding to</i></p>	<p>Guild-based labor systems in transformation are reshaping the rules of trade work and labor, certification and the integration of advanced technology and automation.</p> <p>Caterpillar's long-term success in this future depends on being recognized not just for its innovative equipment, automation and telematics processing but for how these will uphold fairness, transparency and climate standards in a new cooperative labor system. By taking early action while guilds are forming, Caterpillar could preserve its leadership position, brand relevance and secure access to changing work infrastructures, while building trust with guild-led regulatory bodies and their government counterparts.</p>		
<p><b>WHAT SHOULD WE DO ABOUT IT?</b></p> <p><i>Strategic response: List the key components of your long-term strategy across the timeframe of your project</i></p>	<p><b>PHASE 1 (Now To 2030) Startup</b></p> <ul style="list-style-type: none"> <li>Launch an agile, cross-functional "Ethical Automation Taskforce" with representatives from product R&amp;D, HR, sustainability, and legal.</li> <li>Map guild-aligned training and credentialing systems to identify integration points across the Caterpillar product and technology roadmap.</li> <li>Partner with trade unions, vocational schools and emerging AI governance organizations to co-design training modules and credentialing standards.</li> </ul>	<p><b>PHASE 2 (2030-2035) The Work</b></p> <ul style="list-style-type: none"> <li>Pilot "Guild Certification Partnerships" across key markets where automation and labor policy are advancing (US, Europe, Asia Pacific)</li> <li>Integrate Caterpillar's VisionLink (telematics) platform, operator-assist, and safety data streams into guild-standard reporting frameworks.</li> <li>Create an open-access API library for sharing guild-required data transparency on emissions, operator safety, operator performance and AI/machine collaboration metrics.</li> </ul>	<p><b>PHASE 3 (2035-2045) Success</b></p> <ul style="list-style-type: none"> <li>Caterpillar becomes a global reference model for "ethical automation," and begins collaborative work with emerging guilds and governments across the globe based on pilot results</li> <li>Guilds, governments, and industry organizations adopt Caterpillar's standards as part of required certification.</li> <li>Market perception shifts from equipment manufacturer to "trusted co-steward of intelligent work platforms."</li> <li>Operators and companies align and adopt Caterpillar standards as a model for excellence</li> </ul>
<p><b>WHO "OWNS" IT?</b></p> <p><i>Responsibility: Identify the long-term internal champion for the issue and option (person and/or function)</i></p>	<p>Chief Technology Officer (Jamie Meinart) and Vice President of Sustainability &amp; Global Partnerships (George Moubayed) and regional VP Leaders. These roles are accountable for integration of technology ethics, interoperability, and guild-aligned partnerships on a global scale.</p>		

<p><b>STRATEGIC QUESTION 2</b></p> <p><i>What is the issue or opportunity?</i></p>	<p>If AI and automation gain co-governance roles in labor guilds, what new forms of accountability and partnership must Caterpillar establish to ensure ethical alignment, shared responsibility, and sustained legitimacy in this new governance environment?</p>		
<p><b>OPTION</b></p> <p><i>Response: How should client respond Include a memorable name and one-line description</i></p>	<p><b>Accountability By Design</b></p> <p>Develop a next-generation framework for shared accountability between humans, AI systems, and corporate partners through transparent data ethics, auditable decision-making, and guild-verified oversight mechanisms aimed at thwarting cyber-attacks and manipulation.</p>		
<p><b>WHY IS IT IMPORTANT?</b></p> <p><i>Rationale: Describe why the strategic question is worth responding to</i></p>	<p>In this transformed world, algorithmic decision systems now shape how labor, safety, and sustainability are governed. If this system is adopted by guilds, governments and the humans and technology that are managed by it, accountability will become the new currency of trust.</p> <p>Caterpillar's technologies must operate in co-managed environments where responsibility for outcomes (accidents, emissions, errors or even performance standards) must be verifiable and shared between human operators, their tech counterparts, labor guilds and governing bodies. Building accountability into system design prevents regulatory risk, strengthens trust with guilds and governments, and reinforces Caterpillar's leadership in responsible automation and as a key component to the future of trades and skilled labor in this new world.</p>		
<p><b>WHAT SHOULD WE DO ABOUT IT?</b></p> <p><i>Strategic response: List the key components of your long-term strategy across the timeframe of your project</i></p> <p><i>Hint: Phases may be the same as your Horizon years</i></p>	<p><b>PHASE 1 (Now To 2030)</b></p> <ul style="list-style-type: none"> <li>Conduct an AI Accountability Audit to identify risk points in machine autonomy, safety systems, and data management.</li> <li>Form a Guild Accountability Council with labor representatives, AI ethicists, and policy experts.</li> <li>Draft a transparent "accountability charter" defining shared responsibility between Caterpillar, operators, guilds and AI, fully autonomous and semi-autonomous automation systems.</li> </ul>	<p><b>PHASE 2 (2030-2035)</b></p> <ul style="list-style-type: none"> <li>Implement "traceable AI" protocols across product lines (VisionLink dashboards, machine decision logs or ethical black boxes)</li> <li>Create an open digital reporting platform for guild oversight, allowing third-party verification of Caterpillar's automation and operator data tied to biometric chips or other "hard-to-hack" authentication protocols.</li> <li>Develop human training programs to reinforce shared responsibility and decision clarity on automated worksites.</li> </ul>	<p><b>PHASE 3 (2035-2045)</b></p> <ul style="list-style-type: none"> <li>Caterpillar becomes a global model for "responsibly automation" and accountability.</li> <li>Industry standards adopt Caterpillar's accountability charter as a requirement for co-managed guild operations.</li> <li>Trust in Caterpillar systems anchors its leadership in future human-machine governance frameworks.</li> <li>Model moves beyond construction and resource industries to be adopted by other manufacturing sectors powered by humans and machines.</li> </ul>
<p><b>WHO "OWNS" IT?</b></p> <p><i>Responsibility: Identify the long-term internal champion for the issue and option (person and/or function)</i></p>	<p>This feels like a combination of a role that doesn't currently exist at Caterpillar (a chief ethics/AI officer), the Chief Information Officer and Legal. All these roles would be accountable for embedding auditing and human-aligned AI across products and establishing the governance and privacy models necessary for data sharing.</p>		



# CONCEPTING








INCIDENT RATE **0,6**

HUMAN/MACHINE **92%**

EFFICIENCY **45,7**  
hour worked

### WORK GUILD CERTIFICATIONS

-  EARTHMOVING OPERATIONS
-  MECHANICAL MAINTENANCE
- 
- 



WORK GUILD CERTIFICATIONS

Earrhimming Proficiency **0,4** ▼

Incidents Rate **0,4** ▲

Human/Machine Performance **87%** ▲

Efficiency per Hour Worked **75** ▲

Precision Automation  
Guild of Heavy Equipment Operators

Efficiency per Hour Worked  
Guild of Heavy Equipment Operators

Green Building Fundamentals



CAT

### EVENT LOG

MACHINE DATA TRAIL

ERROR

- OBSTACLE DETECTED 041818322  
MANUAL MODE CANCELLED 00:02:37
- AUTONOMOUS MODE OVERRIDE 041818322  
VDWIBRIM, MOL 07:09:01
- SENSOR CALIBRATION FAILURE: 041818332  
VDWIBRIM EQ TOOL STRAIGHTENED 07:07:43
- EQUIPMENT: MATERIALS RATE: 001  
A4 18 000809 AZOR DATA 03:01:32

**ALERT**

Credentials Overview Screen

Credentials Certifications Screen

Autonomous Operation Log

