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Editorial Note

Transforming Engineering Systems: The Evolution of AI from Tools to Autonomous Agents

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Until very recently, AI in engineering functioned primarily as a highly specialized, responsive tool. An engineer provided a set of instructions or boundary conditions, the system executed the calculation, and it quietly waited for the next command. Generative AI expanded this dynamic by producing complex code, technical documents, and preliminary analysis. However, it remained bound to a fundamental prompt-and-response architecture.

Agentic AI represents a distinct departure from this passive framework. Rather than waiting for step-by-step instructions, agentic systems are designed as autonomous entities capable of pursuing complex objectives with minimal human intervention. These architectures exhibit proactive planning, long-term contextual memory, integration of external tools, and dynamic behavioral adaptation within unpredictable environments (Abou-Ali et al., 2025; Acharya et al., 2025). Instead of merely answering inquiries, an agentic system makes multi-step action sequences, directly interfaces with external sensors, databases, and actuators, and autonomously modifies its strategy based on operational feedback.

The shift from static software tools to goal-driven agents is rapidly reshaping the enterprise and industrial landscape. Gartner identified agentic AI as its top strategic technology trend for 2025, projecting that by 2028, at least 15% of daily workplace decisions will be made autonomously—up from nearly zero in 2024—and that 33% of enterprise software applications will embed agentic capabilities (Coshow et al., 2024). Technical benchmarks reflect a similar trajectory; performance on OSWorld, a standard benchmark assessing AI agents on real computer tasks, surged from approximately 12% accuracy in early 2024 to 66.3% by the end of 2025, approaching average human performance (Hostinger Research, 2025).

Furthermore, the industrial sector is projected to achieve the highest compound annual growth rate in AI deployment through 2033 (Grand View Research, 2025). These figures underline an important reality: autonomous decision-making components are increasingly incorporated into the design, validation, and governance structures of modern engineering systems.

Key Characteristics and the Concept of "Agenticness"

No agentic system is simply defined by the size of its underlying language model but by the architecture within which that model operates. Agentic AI is characterized by four core dimensions: multi-step goal-directed planning, persistent contextual memory across interactions,

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the ability to invoke and coordinate external tools, and behavioral adaptation in response to environmental feedback (Abou-Ali et al., 2025; Acharya et al., 2025).

For example, an agentic architecture can be exemplified by a system that independently queries a sensor network, identifies an anomaly, generates a maintenance recommendation, and logs corrective actions without human prompting at each stage. Unlike traditional automation, which follows fixed logic rules, an agentic system dynamically selects and sequences actions to solve problems whose exact conditions were not fully specified in advance.

Recent academic literature formalizes this capability through the concept of "agenticness"—defined as the degree to which a system adaptably achieves complex goals in dynamic environments with limited direct supervision (Abou-Ali et al., 2025). This concept evaluates autonomy in terms of goal complexity, environmental variability, adaptability, and action scope (Abou-Ali et al., 2025). This formalization offers a rigorous foundation for evaluating autonomy levels during system procurement, deployment, and safety auditing for engineering practitioners.

Sector-specific engineering applications

Agentic architectures are already driving breakthroughs across engineering sectors in real-world applications. Major manufacturers are deploying artificial intelligence (AI)-driven factory operations where autonomous agents coordinate across production lines, anticipate supply chain disruptions, and flag quality anomalies in real time (Chen, 2026). In civil and structural engineering, multi-agent frameworks monitor critical infrastructure assets, processing sensor stream data across bridges, tunnels, and water networks to estimate the remaining useful life and autonomously initiate inspection routines.

The energy and natural resources sector is equally well-suited for agentic deployment. Upstream oil and gas operations require the integration of seismic interpretation, production monitoring, reservoir simulation, and economic evaluation across distributed assets within data-intensive, multidisciplinary workflows (Al-Rawahi et al., 2025). Conventional tools require significant manual intervention during calibration and model updates. Agentic systems streamline these processes by dynamically managing workflows, detecting model misalignments, and adjusting simulation parameters in real time, compressing analysis cycles that previously required lengthy manual iteration (Al-Rawahi et al., 2025).

In engineering design, agentic systems act as proactive collaborators capable of generating design candidates, evaluating performance against structural criteria, identifying failure modes, and iterating toward optimal configurations. This builds upon the materials informatics framework discussed in the January 2024 IJTech editorial, which positioned AI as an accelerator for material discovery (Whulanza & Kusrini, 2024). Agentic AI expands this paradigm by enabling the pursuit of autonomous goals across design solution spaces, thereby reducing the need for explicit human direction at every phase.

Governance, Accountability, and Safety Engineering

However, integrating autonomous decision-making into engineering systems introduces governance challenges that cannot be resolved by standard performance metrics. When an autonomous agent contributes to a structural failure or operational outage, the decision pathway must remain traceable, auditable, and interpretable. Recognizing this, Siemens Energy mandated in early 2026 that all industrial AI decisions in critical infrastructure must be verifiable, auditable, and subject to final human authority (Evolance Market Research, 2026).

The IEEE Standard for Fail-Safe Design of Autonomous and Semi-Autonomous Systems (IEEE, 2024) offers a formal framework to address these requirements, defining criteria for fail-safe behavior, autonomy levels, human approval checkpoints, and emergency shutdowns. Compliance requires embedding classical systems engineering practices—such as functional decomposition, fault-mode analysis, and lifecycle governance—directly into AI system architectures. Evaluating these architectures also requires reproducible and explainable benchmarks tailored to domain-specific tasks (Li & Storhaug, 2026).

Moving forward, agentic AI opens up a rich research area. The critical topics include developing robust control architectures for industrial environments, establishing formal verification methods for non-deterministic agent decisions, and integrating multi-agent systems with digital twins and SCADA networks. Additionally, defining clear boundaries for human-agent collaboration and establishing ethical governance frameworks remain vital research priorities.

This issue

IJTech welcomes interdisciplinary submissions that address these challenges across mechanical, civil, chemical, electrical, and industrial engineering disciplines. Research on autonomous system safety, verification frameworks, and governance models will be essential as our engineering community shapes goal-directed intelligence's future.

(Nga & Tam, 2026) first study examines the continued use of generative AI assistants in Vietnamese digital banking through a trustworthy-AI framework. This study applies PLS-SEM to 845 users to evaluate explainability, service quality, cybersecurity, accuracy, privacy, trust, and digital financial literacy. AI service quality is the strongest predictor, whereas trust mediates continuance intention and digital financial literacy strengthens this relationship (Nga & Tam, 2026).

(Alenezi et al., 2026) developed and validated a governance-oriented framework for integrating agentic AI across the software development lifecycle. This study combines a systematic literature review with a quasi-experimental evaluation of DORA, quality, and compliance metrics for four enterprise projects. It shows substantial reductions in cycle time and MTTR, increased test coverage, and fewer change failures without compliance breaches (Alenezi et al., 2026).

(Lubis et al., 2026) developed DTFarming, a Kubernetes-orchestrated digital twin platform for scalable indoor-farm monitoring and control. This study validates an analytical performance model under 4-, 20-, and 100-sensor workloads. It shows linear telemetry scaling with low CPU use, while memory limits capacity to approximately 110 pods and increases scheduling latency near saturation, closely matching model predictions (Lubis et al., 2026).

(Wang et al., 2026) optimized multimodal CNN models for UAV-assisted crop health monitoring using leaf images and environmental sensor data. This study compares Bayesian optimization, PSO, baseline CNNs, and conventional classifiers. The PSO-tuned model performed best, achieving 90.59% validation accuracy and a 0.8675 F1-scoreWith smoother convergence and improved robustness under noisy conditions (Wang et al., 2026).

(Abtan et al., 2026) developed a cost-effective 28-GHz Class-AB power amplifier in 180-nm CMOS for industrial 5G applications. T-type matching, reverse body biasing, ADS simulations, and cost-performance benchmarking are used in this study. It achieves 13.43-dBm saturated power, 19.35% peak efficiency, 4-GHz bandwidth, and 5G-compliant linearity while reducing the estimated die cost by 60% compared with 65-nm technology (Abtan et al., 2026).

The sixth study, written by (Ahmed & Alqahtani, 2026), develops an AI-enhanced intrusion detection framework that combines ant colony optimization with a CNN–BiLSTM architecture. This study evaluates the model using the CICIDS2017, UNSW-NB15, and CSE-CIC-IDS2018 datasets. It achieves 98.39% accuracy, 96.90% precision, 95.00% recall, and a 98.43% F1-score, demonstrating robust and scalable detection of evolving cyber threats (Ahmed & Alqahtani, 2026).

The seventh study, written by (Qassim et al., 2026) introduces Adaptive Gradient Shielding to improve deep-learning robustness against adversarial attacks. This study combines perturbation-aware feature smoothing with dynamic gradient modulation and evaluates the method on CIFAR-10 and ImageNet subsets. It increases CIFAR-10 PGD-20 accuracy from 42.8% to 71.4% while preserving clean accuracy and adding only 3.2% computational overhead ((Qassim et al., 2026)).

(Manova et al., 2026) developed an automated forensic framework for diagnosing mobile banking reliability failures in Indonesia and Thailand. This study analyzed 200,000 Google

Play reviews using LDA, VADER-based weak supervision, TF-IDF, and SVM classification. It achieves weighted F1-scores above 92% and reveals distinct failure patterns: authentication and post-update access issues in Indonesia versus runtime instability and crashes in Thailand (Manova et al., 2026).

(Setiawan et al., 2026) developed a zero-waste framework for large-scale crude palm oil production using system thinking and system dynamics. This study couples producer and consumer sub-models to simulate biomass-residue generation, processing, and use. This shows that balancing palm kernel shell consumption with processed empty fruit bunches and external interventions can accelerate the adoption of waste-to-energy toward complete biomass utilization (Setiawan et al., 2026).

The tenth study, written by (Whasphuttisit & Jitsakul, 2026), compares 12 deep-learning architectures for one-hour-ahead $PM_{2.5}$ forecasting in Bangkok. This study uses 24,840 hourly observations and evaluates recurrent, hybrid, attention, transformer, statistical, and ML models. Bidirectional recurrent models perform best, with Bi-RNN achieving 5.712 $\mu g/m^3$ RMSE, while attention and transformer models offer no advantage at this data scale (Whasphuttisit & Jitsakul, 2026).

Imasheva et al., 2026 developed an integrated UAV-swarm and distributed-antenna architecture for GNSS-denied smart warehouses. This study applies reinforcement learning to optimize UAV relay positioning while supporting inventory, monitoring, and delivery tasks. Simulations show improved signal quality, coverage, throughput, latency, and logistics-task success, demonstrating the feasibility of multifunctional UAV swarms as adaptive extensions of fixed indoor communication infrastructure (Imasheva et al., 2026).

Marko et al., 2026 developed a vegetation-based watershed health assessment using long-term MODIS NDVI within a Reliability–Resilience–Vulnerability framework. This study analyzed dry-season observations from 2000 to 2020 across six Upper Citarum sub-watersheds. The highest health index was found in Ciwidey and the lowest in Cikapundung, confirming that forest cover improves persistence and recovery, whereas built-up areas reduce watershed health (Marko et al., 2026).

Rodionov et al., 2026's thirteenth study develops a six-dimensional GAP-analysis framework for sustainable regional development. This study uses regression and scenario modeling to evaluate 15 Russian regions across informational, technological, financial, human, organizational, and marketing dimensions. It shows that diversification, institutional quality, and sectoral structure strongly shape strategic gaps, while integrated policies could reduce these gaps by 25%–35% within five to seven years (Rodionov et al., 2026).

Acosta-Vega et al., 2026's fourteenth study develops a fair allocation framework for scarce logistics resources using multi-issue bankruptcy with cross-claims. This study adapts the constrained equal awards rule through iterative linear programming and compares it with proportional and CEL-inspired benchmarks. This shows that the approach produces feasible and equitable allocations and supports more collaborative logistics decision-making under interdependent resource constraints (Acosta-Vega et al., 2026).

The fifteenth study, written by (Kim & Ho, 2026), develops and validates a multidimensional scale for assessing factors influencing the night-time economy of Ho Chi Minh City. This study employs a sequential exploratory mixed-methods design that integrates qualitative inquiry and quantitative validation. The study identified governance, infrastructure, community awareness, safety, service diversity, and digital technology as key factors, with safety and product diversity exerting the strongest influence (Kim & Ho, 2026).

(Aleksanyan et al., 2026)'s sixteenth study examines how trust and system usability shape digital banking adoption and socio-economic sustainability in Armenia. This study applies PLS-SEM to assess factors of technology acceptance and perceived outcomes in financial inclusion, economic benefit, business enablement, and participation. This shows that institutional trust strongly drives adoption, which subsequently improves all four sustainability outcomes, whereas usefulness, ease of use, and perceived risk are insignificant (Aleksanyan et al., 2026).

Ulum et al., 2026 developed a Venturi flotation column using corn starch as a biodegradable depressant for selective Pb and Zn recovery from pyrite. This study combines computational fluid dynamics (CFD) optimization with flotation tests across different pH and starch dosages. The best Pb–Fe selectivity was observed at pH 10 with 12.5 ppm starch, while Zn–Fe separation performed best at pH 4 (Ulum et al., 2026).

Kuklin et al., 2026 modified PET track-etched membranes with TiO coatings using vacuum-arc physical vapor deposition. This study evaluates the effects of deposition time on pore geometry, morphology, crystallinity, mechanics, wettability, and photocatalysis. It achieves 70%–73% hydroquinone degradation after 14 h, with the 120-s coating showing the highest activity, supporting antifouling, self-cleaning, and advanced water purification applications (Kuklin et al., 2026).

Arystan et al., 2026 developed crosslinked polyurethane–acrylate hybrid coatings using a high NCO/OH ratio and mixed polyols. This study evaluates network formation, rheology, mechanical performance, adhesion, hydrophobicity, and chemical resistance of aqueous solution. It achieves a tensile strength of 205 MPa, an adhesion strength of 10.5 MPa, and a contact angle of 153°, demonstrating that it is a durable coating for demanding industrial applications (Arystan et al., 2026).

Zaldívar et al., 2026 assessed heat-affected-zone fracture toughness in FCAW-welded AISI 1015 steel. This study integrates Charpy V-notch testing, metallography-guided notch placement, analytical energy conversion, uncertainty analysis, and finite-element simulation. It estimates experimental toughness at 62.19 ± 1.6 MPa·m$^{1/2}$, about 10% below the base material, confirming that the HAZ is the fracture-controlling region (Zaldívar et al., 2026).

Galym et al., 2026 study reviews epoxy–acrylic hybrid resins for advanced anticorrosion coatings. This study examines synthesis routes, hybrid architectures, corrosion mechanisms, standardized testing, and emerging waterborne, nanocomposite, and self-healing systems. Hybridization combines epoxy adhesion and barrier strength with acrylic flexibility and UV resistance, offering durable, low-VOC coatings while overcoming the challenges of phase compatibility, processing, and long-term stability (Galym et al., 2026).

Research practices' role in driving collaboration and accessibility within frontier technologies remains a vital area of inquiry. IJTech welcomes original manuscripts that explore these dimensions. Authors are kindly invited to submit their work for consideration.

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