

Building the Systems Workforce of the Future

Guidance for Development, Education and Training of the Systems-Competent Workforce

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Prof. Dipl.-Ing Heinz Stoewer M.Sc | Delft University of Technology
David Nichols | JPL/Caltech

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This white paper responds to a recognized and growing shortage of experienced, multidisciplinary systems professionals capable of coping with growing complexity in society and industry. Its intention is to promote the application of its guiding principles by professional organizations, industry, academia, governments, and their agencies.

The guidance is applicable across all application domains, including:

- Energy
- Business information
- Financial systems
- Global change and climate assessment
- Aerospace and defense
- Natural resources and chemical processing
- Biological systems
- Social and economic systems
- Government policy
- Medicine and public health
- Education
- Infrastructure
- Smart cities and smart agriculture
- Sustainability
- Transportation systems



It is equally applicable to all system types:

- Hardware-intensive systems
- Software-intensive systems
- Cyber-physical systems
- Data and IT systems
- Autonomous systems
- Systems of all scales (small and large)
- Social systems
- Verification and test systems
- Production systems
- Maintenance and support systems
- Mechatronic and robotic systems
- Logistics systems
- Operations systems
- System of Systems (SoS)



Building the Systems Workforce of the Future

Societal and industrial transformations — spanning energy, mobility, space, agriculture, healthcare, security, and critical infrastructure — are being realized through increasingly complex, software-defined System of Systems. These systems are interdependent, AI-enabled, data-driven, and life-cycle intensive, extending from large-scale strategic programs down to the complex products and components of everyday life. Their success depends not only on technological innovation, but on the availability of a highly capable, multidisciplinary systems workforce.

That workforce is in critically short supply. The first-ever worldwide Systems Workforce Summit, convened in Delft in October 2024, formally recognized this gap and issued a coordinated Call for Action. Addressing it requires a

paradigm shift in how systems talent is cultivated and sustained—across educational institutions, industry, government, and professional organizations. This white paper sets out the strategic context, defines what a systems-competent workforce does and where it is needed, and provides practical guidance for the institutions and leaders who must act.

The realization of societal transformation depends on a scarce but indispensable systems-competent workforce capable of integrating technology, management, business, sustainability, risk, and AI across entire life cycles. Strengthening this workforce is not a sectoral concern—it is a matter of strategic policy, economic resilience, and societal trust.



The Systems Workforce

- ▶ **Evaluates** stakeholder needs for transformational initiatives or market opportunities, develops system requirements, architectures, and incremental implementation plans with performance, cost, risk, and schedule estimates and iterates with stakeholders to confirm readiness to proceed
- ▶ **Integrates** skills across disciplines, selecting suitable technologies, generating design solutions, developing digital twins and prototypes, and coordinating the manufacturing, testing, verification, marketing and services for life-long updates.
- ▶ **Leads** cross-disciplinary assessments to understand risk and consequences of regulatory policy options and programmatic analyses of alternatives.

The Imperative

Modern systems — from power grids and autonomous vehicles to satellite constellations and smart-city infrastructure — are no longer designed by single disciplines. They are realized through networked, software-defined architectures in which engineering, business, cybersecurity, supply chain, and regulatory considerations must be integrated from the outset. The boundaries between systems engineering, project management, and business management are

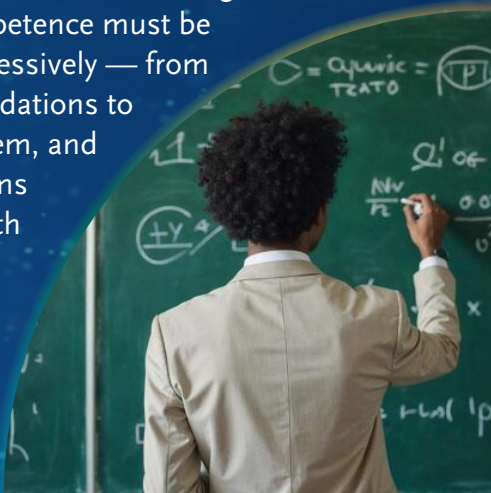
increasingly fluid. Decisions made in one domain routinely reshape the viability of another.

Yet most organizations continue to invest primarily in deep disciplinary specialists. The integrating perspective — the ability to hold the whole system in view while managing its parts — is precisely what is hardest to develop, hardest to retain, and most consequential when absent.

Four Domains of Response

Educational Institutions

Curricula must embed systems thinking, model-based approaches, AI literacy, and multidisciplinary capstone projects as standard elements of engineering, business, and management education. Competence must be developed progressively — from disciplinary foundations to subsystem, system, and System of Systems integration — with lifelong learning treated as an institutional commitment.



Government

Governments bear strategic responsibility for ensuring systems competencies in national infrastructure, defense, energy transition, and public services. Investment in systems workforce development should be treated as critical national infrastructure.



Industry

Employers must invest in structured continuous learning to keep pace with digital engineering, cybersecurity, AI integration, and evolving supply chains. Career pathways should reward systems integration competence alongside deep specialization, and structured rotation through integrative roles — validation, integration and test, operations — should become a deliberate part of career development.



Professional Organizations

Professional bodies must align standards, frameworks, and incentivize digital tool interoperability across disciplines and sectors. They serve as custodians of the discipline's future, advisers to governments, and catalysts for incorporating new technologies into practice.



Building the Systems Workforce of the Future

1. Global Needs and Influences

The need for systems-competent workforces does not arise in isolation. It is shaped by a convergence of transformations that are simultaneously expanding system complexity, accelerating technological change, and raising the stakes of integration failure.



1.1 Global Transformations

Several intersecting forces are reshaping the systems challenge:

- Digital and technological change: AI, automation, and digital platforms are fundamentally restructuring how decisions are made, work is organized, and systems are operated.
- Economic globalization and supply chain shift: Integrated global markets and geopolitical pressures on supply chain sovereignty create new trade-off imperatives for system architects and program leaders.
- Climate change and sustainability: Environmental constraints are becoming first-order system requirements, demanding that energy, transportation, and infrastructure systems be redesigned holistically.
- Urbanization and demographic change: Expanding cities with aging populations and lagging infrastructure create mounting demand for integrated, human-centered system solutions.
- Rising systemic risk: Pandemics, cyberattacks, and cascading infrastructure failures highlight the vulnerability inherent in tight interdependencies—and the cost of inadequate system governance.

Do we have the workforce to cope with these developments?

- ▶ Are there enough mechanical, electrical and software engineers to deal with the myriad interfaces and interactions of complex system products?
- ▶ Do we have enough qualified multi-disciplinary System Competencies to design, build and test systems and System of Systems?

Today's transformations and products all need:

- ▶ Full life cycle design approaches to complex systems, from concept through retirement, to reveal critical issues, such as technical cost and schedule risks as well as sustainability, security, and societal impacts.
- ▶ Systems competencies across product tiers to ensure compatibility of interdependent elements at system integrator levels.
- ▶ Highly functional and integrated hardware and software teams to develop architectures and sustainment strategies for software defined systems that take software stack interdependencies, cyber-resilience and artificial intelligence dependencies into account.

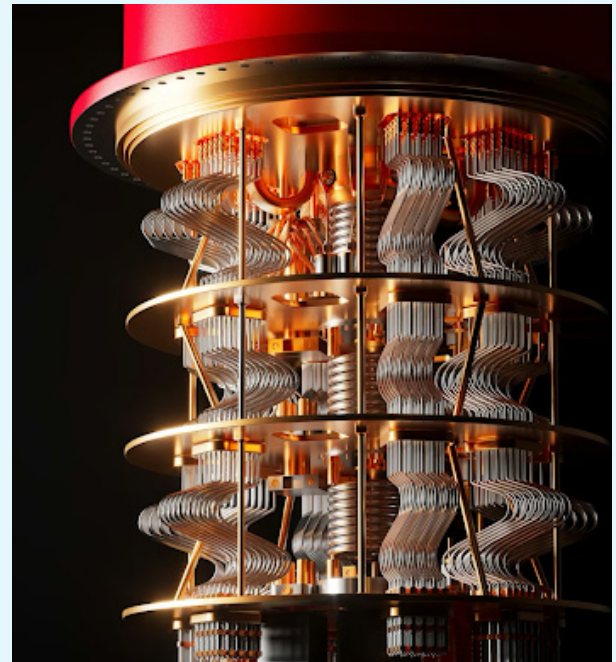
1.2 Technology Innovations and Systems Implications

The digital and cyber-physical transformation is enabling qualitatively better system solutions while simultaneously raising the competency threshold required to realize them. Model-based systems engineering, digital twins, AI-enabled analytics, advanced simulation, and collaborative robotics give well-prepared teams the ability to design, verify, and operate systems of unprecedented complexity. The same technologies create new integration challenges, security exposures, and workforce development obligations.

Three capabilities deserve particular attention – AI, Digital Twins and Quantum Technologies.

Digital Twins

A digital twin is not merely a static simulation—it is a continuously evolving knowledge asset that absorbs the system's full life cycle: from requirements and design through manufacturing, operations, and maintenance. Digital twins bridge the transition from system design to prototyping and manufacturing, establishing a continuously updated knowledge asset that carries design intent forward into production. Beyond development, they enable predictive maintenance, performance optimization, and scenario analysis at both asset and System of Systems scale. As systems become increasingly model-based and data-centric, engineering shifts from episodic testing to continuous simulation and verification. The systems workforce must be capable not only of building and maintaining digital twins, but of governing the data quality, interoperability, and cybersecurity that underpin their integrity.



Quantum Technologies

Large-scale quantum applications are not a near-term operational reality, but their strategic implications demand attention now. Quantum computing and quantum communications will each emerge as hybrid components within classical infrastructure rather than wholesale replacements, introducing new architectural layers, scheduling logic, and performance trade-offs that systems designers must anticipate and plan for.

Quantum computing, especially when combined with AI, will rapidly accelerate the digital revolution. For example: quantum algorithms threaten widely deployed public-key cryptography, requiring a global transition

to post-quantum cryptographic standards. Long-lifecycle assets (e.g. infrastructure, defense systems, financial systems, satellites) are particularly exposed, and the window for proactive architectural response is narrowing. At scale, quantum computing promises to accelerate optimization, simulation, and complex system analysis in ways that could fundamentally compress development life cycles.

The three elements of a digital twin



Quantum communications offer a complementary set of capabilities with the prospect of inherently secure data exchange across critical infrastructure. Where quantum computing challenges current security assumptions, quantum communications may provide the means to restore and extend them. This will create a dual imperative for systems architects to engage with both dimensions together.

The systems workforce must therefore anticipate quantum technologies not as a curiosity but as a structural evolution in digital architecture, cybersecurity posture, and competitive strategy with the potential to reshape how large-scale integrated systems are designed, secured, and operated.

Artificial Intelligence

AI is reshaping how complex systems are designed, analyzed, verified, and operated. Its influence will deepen as tools mature and engineering workflows become more model-based and data-centric.

In design, AI augments the ability for systems specialists to explore solution spaces that would be intractable through manual analysis alone. Architectural alternatives can be generated and evaluated against competing objectives (e.g performance, cost, weight, power, resilience, risk) faster than traditional trade study methods. Requirements analysis, interface definition, and failure mode identification are increasingly supported by AI tools that enable early detection of ambiguities, gaps, and conflicts.

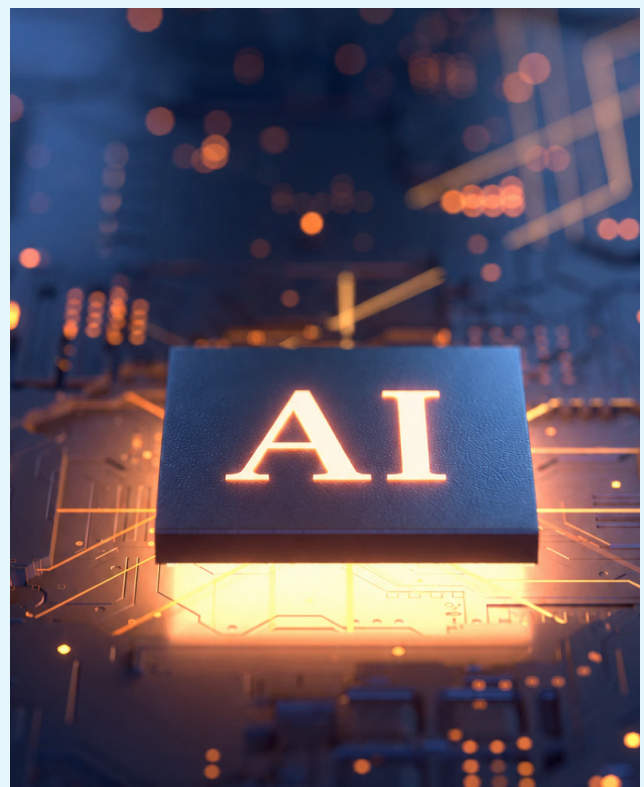
Digital twin environments, coupled with AI-driven simulations, allow design decisions to be stress-tested against operational scenarios in real time, compressing the iteration cycle between concept and validated architecture.

In verification, AI enables testing tools to generate test cases autonomously, identify coverage gaps, and prioritize effort based on risk. Anomaly detection models can flag integration and test deviations that human reviewers might miss. At the same time, AI-enabled system functions — autonomy, adaptive control, predictive analytics — cannot be verified through traditional deterministic methods alone. They require probabilistic, scenario-based, and adversarial

approaches, along with rigorous governance of training data, model boundaries, and edge-case behavior. The systems workforce must leverage AI as a verification accelerator while holding AI-enabled functions to the same assurance standard as any other safety-critical component.

In addition, AI is being beneficially applied to supply chain management, logistics, manufacturing, operations and sustainment. Predictive maintenance shifts servicing from scheduled intervals to condition-based intervention, reducing downtime and extending asset life. At the System of Systems level, AI enables dynamic resource allocation and real-time optimization of interdependent assets that static operational planning cannot match. AI also transforms in-service system evolution via continuous learning models that adapt behavior to changing conditions. AI-assisted configuration tools help govern software updates across distributed fleets.

However, each update to an AI-enabled function or digital twin is itself a verification event requiring the same rigor as original development. Organizations that treat AI as a one-time integration rather than a continuously managed system component will find their operational advantage eroding as the technology drifts beyond their ability to assure it.



1.3 The Explosion of Knowledge and Its Accessibility

Information and knowledge are expanding at an unprecedented rate, and access has never been easier. This creates both opportunity and obligation. More connected, faster-moving knowledge ecosystems make systems more adaptive and innovative—but also more complex to govern. Systems professionals face rising stakeholder expectations of transparency, accountability, and speed of response. They must be equipped to distinguish authoritative knowledge from misinformation, govern data quality across distributed systems, and navigate the regulatory and ethical dimensions of AI-generated insight.



1.4 The Evolution Toward Systems of Systems

Modern society depends not on machines alone but on networks of independent systems that interoperate to produce outcomes no individual system could achieve alone. Transportation, healthcare, finance, energy, and digital communications all exemplify this structure. A daily commute, for instance, draws on satellite navigation, telecommunications infrastructure, traffic management platforms, payment systems, and vehicle technologies operating in concert. Equally, products as familiar as mobile phones, washing machines, agricultural equipment, and aircraft have become highly complex System of Systems, incorporating sophisticated hardware and software components that each carry their own functionality, and requiring rigorous architecture development, interface management, and change control throughout their life cycles.

System of Systems introduce capabilities and vulnerabilities that cannot be designed or managed from within any single component. The same interdependencies that enable resilience — power grids rerouting electricity, networks selecting alternative paths, supply chains adjusting to disruptions — also allow failures, cyber-attacks, or policy changes in one domain to cascade across others. Managing this is a system-level discipline, not a specialist function.

Effective governance requires coordination, interoperability, shared standards, and adaptive mechanisms across stakeholders with differing incentives and authorities. Without a workforce capable of reasoning across these interdependencies, neither system performance improvement nor prevention of failures with significant societal consequences is reliably achievable.



What do the following system products have in common?

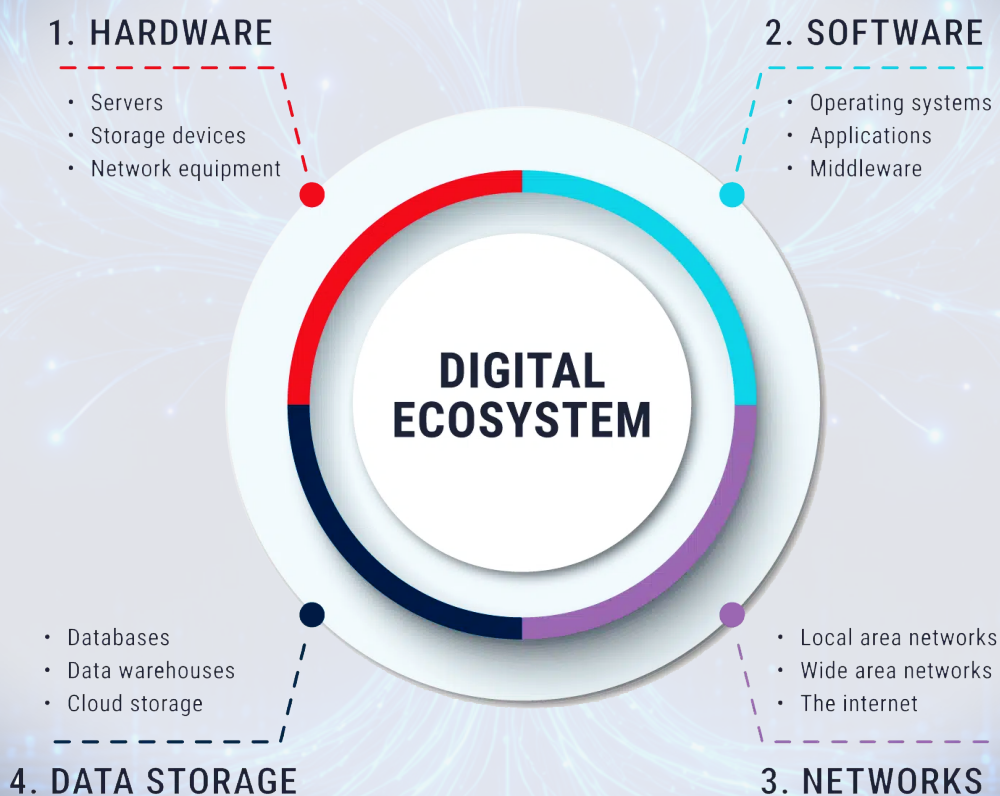
- ▶ They all need multi-disciplinary cooperation of specialists, system integrators and managers at equipment, subsystem and system levels
- ▶ Most all have become complex, interdependent and self-adapting software defined System of Systems

1.5 The Pervasiveness of Software and the Digital Ecosystem

Industry 4.0 and its successor, Industry 5.0, describe a world in which cyber-physical systems, AI, automation, and collaborative robotics define competitive advantage. Industry 5.0 extends this further by emphasizing human-machine collaboration. AI is a partner that enhances human decision-making and creativity rather than displacing it. Across both paradigms, software has become the primary medium through which system behavior is defined, differentiated, and updated throughout the life cycle.

This pervasiveness creates a structural obligation in both directions. Systems professionals with roots in physical engineering must develop genuine expertise in software architectures and verification methods, along with a working fluency in AI. Software engineers must engage with traditional engineering disciplines and understand they are ideally suited to broader roles in which they can reason about system behavior in its physical, operational, and regulatory context. The early and continuous integration of these perspectives is essential to building systems that are balanced, safe, and secure.

✓ Key Components of Digital Ecosystems



2. The Systems-Competent Workforce: Roles and Perspectives

Systems competencies are not the exclusive province of a single profession. They are an integrating layer of capability required at multiple tiers of virtually every

complex enterprise. Understanding what this workforce does, and where it is needed, is the starting point for developing it effectively.

2.1 What the Systems Workforce Does

The systems-competent workforce integrates the competencies needed to analyze complex challenges and market opportunities to generate solutions that serve both social and industrial needs. Members of this workforce bring together engineering, economic, business, cybersecurity, risk, and supply chain viewpoints to produce coherent answers to problems that no single discipline can solve alone.

In practice, this means:

- Eliciting and reconciling stakeholder needs across diverse, often conflicting constituencies
- Developing system requirements, architectures, and implementation options
- Selecting and integrating technologies across hardware, software, and AI domains

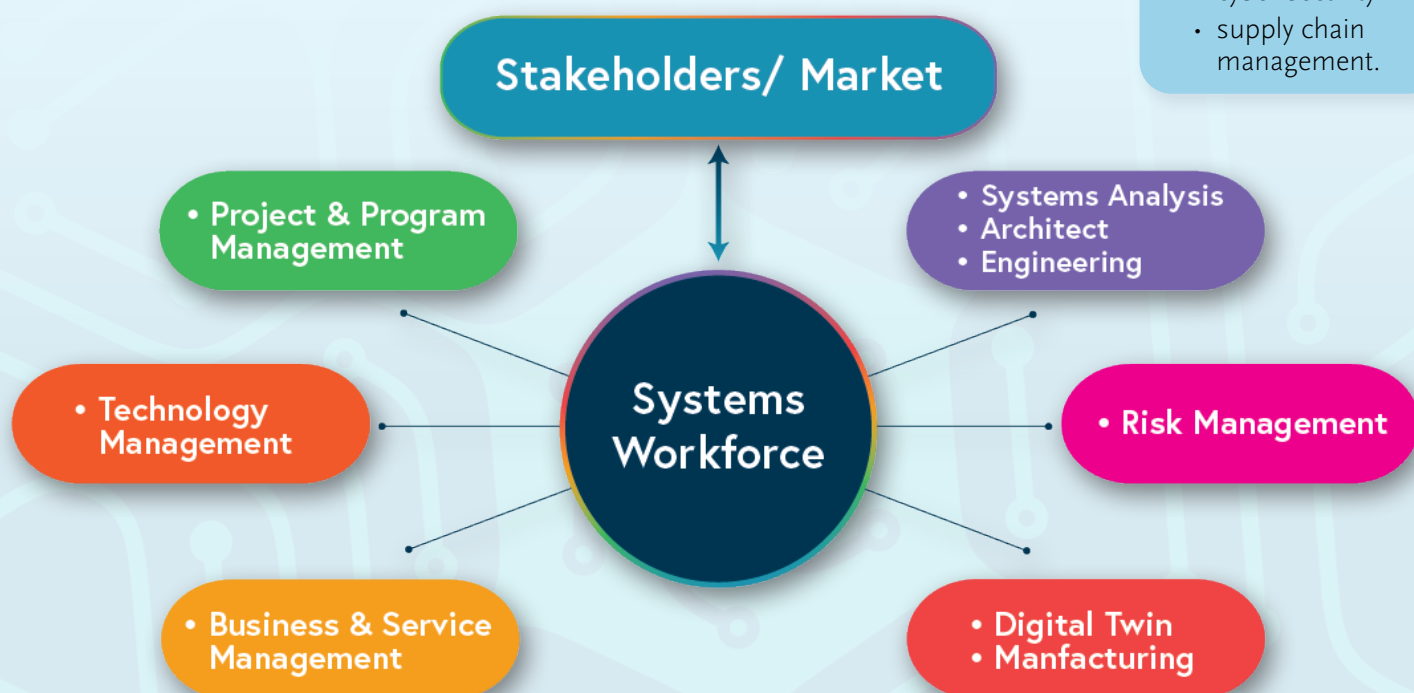
- Generating design solutions, digital twins, and prototypes
- Governing manufacturing, testing, verification, and service implementation
- Managing end-to-end program execution, business trade-offs, and risk across the full life cycle

As systems grow more software-defined and AI-enabled, these activities require increasingly close collaboration between hardware and software engineers, data scientists, cybersecurity specialists, operations managers and business leaders. The system architects and other systems specialists are the professional team that holds this collaboration together to ensure successful realization.

All address:

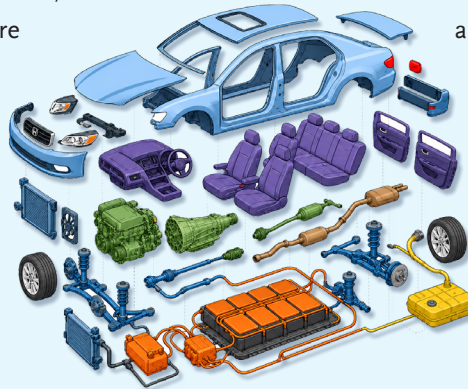
- complexity
- sustainability
- cyber-security
- supply chain management.

Core Competencies of the Systems Workforce



2.2 Systems Competencies Are Needed at Every Tier

Complex products—automobiles, aircraft, infrastructure, defense platforms—are characterized by multiple tiers of design, development, assembly, and integration. Each tier, from chips to subsystems, is itself a system with its own interfaces, requirements, and integration obligations. Systems competencies are therefore needed not just at the top level, but throughout the supply chain.



In the automotive example, subsystems such as suspension, electrical architecture, software, and passenger experience each require a degree of systems literacy—an understanding of OEM requirements, verification processes, and interactions with other subsystems. The depth and breadth of systems competence required varies by tier; but at every tier, purely specialist knowledge without any integrating perspective creates risk.

2.3 The Multidisciplinary Nature of the Systems Workforce

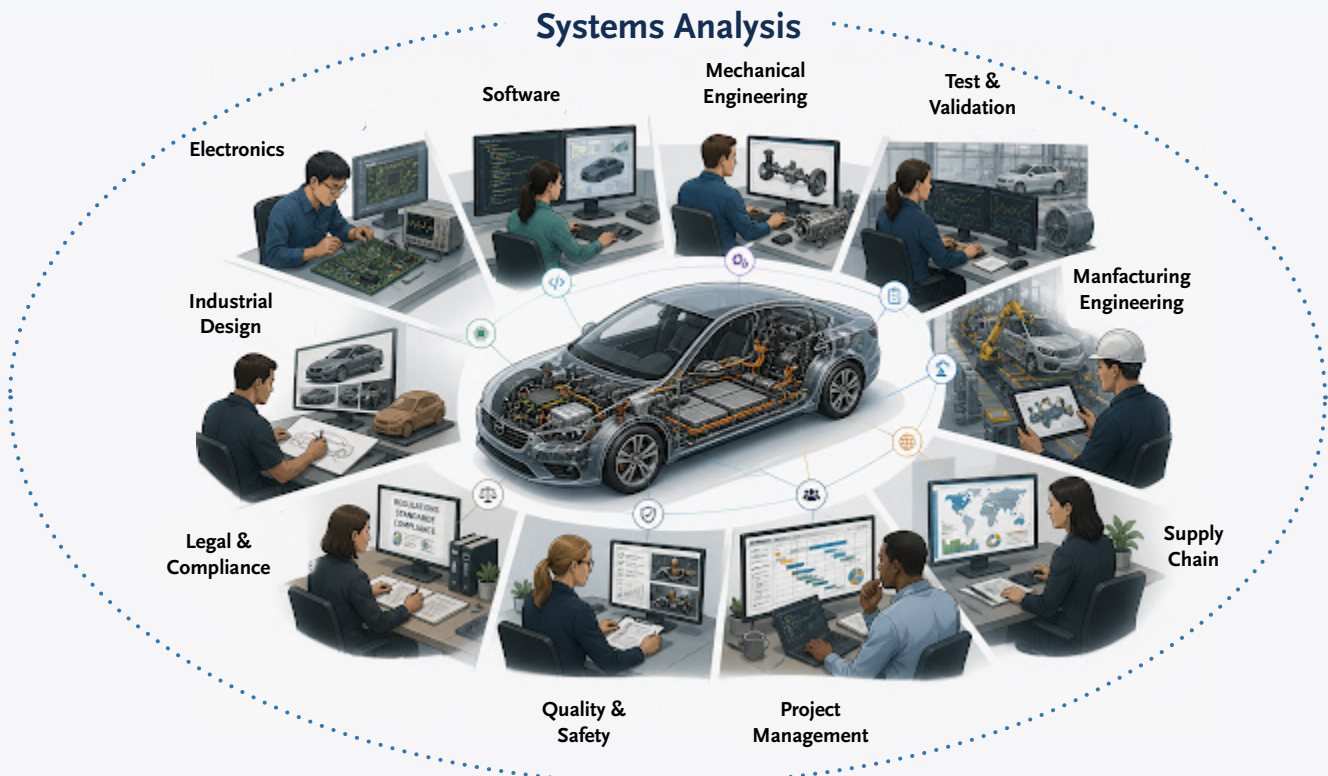
The systems-competent workforce spans engineering, computer science, business, management, and the social sciences. As systems become more multidisciplinary, digital, and intelligent, the workforce required to design, integrate, and govern them must reflect the same breadth. Meeting this challenge requires enterprises to build several core functional capabilities:

- Architecting and Ideation
- Systems Analysis, Engineering and Optimization
- Risk Management
- Business Engineering

- Manufacturing
- Operations
- Systems Management
- Digital Twin Development and Management
- Supply Chain Management
- Sustainability Optimization

These functions are not performed by generalists who know a just little about everything. They are performed by professionals who have developed genuine competence in their functional area while maintaining the breadth to collaborate across all the others.

Systems Analysis



2.4 Domain-Specific Bodies of Knowledge

The systems workforce must possess domain-specific knowledge relevant to the application sector. Across industries, certain complementary systems competencies consistently emerge as critical:

- Data Analytics: AI, machine learning, software, cloud computing, human-machine interaction, and systems analysis
- Complex Processing Plants: fluid dynamics, thermal systems, logistics, controls, and process design
- Communication and Energy Networks: electrical, electronics, control systems, operations, and communications engineering

- Automated and Autonomous Systems: IT, software, sensors, communications, cybersecurity, control theory, and robotics
- Medical and Smart Devices: sensors, IT, software, and communications

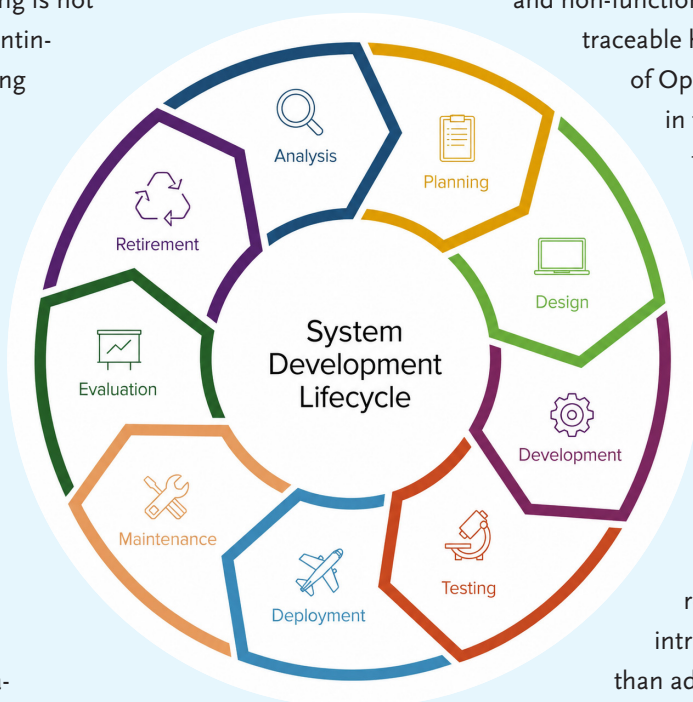
Artificial Intelligence deserves particular emphasis. AI is now embedded in systems across all these domains—creating challenging new requirements for verification, assurance, and trust. The systems workforce must be capable of governing AI inputs (training data provenance, model boundaries, failure modes) as rigorously as any other safety-critical system component, while also leveraging AI as a tool for navigating standards, supporting trade studies, and enhancing decision analysis.

2.5 Systems Perspectives Across the Life Cycle

Effective systems thinking is not phase specific. It is a continuous thread of integrating perspectives that must be maintained from the first stakeholder conversation to final decommissioning. The challenge is that each phase demands a different dominant focus while preserving fidelity to all prior commitments.

Early phases establish the architectural foundation on which everything else depends. Stakeholder needs analysis requires operational thinking—understanding what the system must accomplish, for whom, and under what constraints, before any solution space is considered. This feeds requirements development, where functional

and non-functional needs are structured into a traceable hierarchy anchored by a Concept of Operations. Errors or omissions in these early phases propagate through the entire life cycle at compounding cost.



Architecture and development demand the broadest simultaneous perspective. The systems architect must govern functional, physical, software, and interface architectures in parallel, treating cybersecurity, safety, resilience, and sustainability as intrinsic architectural drivers rather than add-ons. During development, the dominant concern shifts to configuration and coherence—ensuring that parallel specialist contributions remain faithful to the architecture, that interface changes are governed, and that emergent behaviors are detected early through simulation, digital twins, and hardware-in-the-loop testing.

and coherence—ensuring that parallel specialist contributions remain faithful to the architecture, that interface changes are governed, and that emergent behaviors are detected early through simulation, digital twins, and hardware-in-the-loop testing.

Verification, operations, and sustainment extend the perspective into operational experience and system longevity:

- Demonstrating not just that the system was built right (verification) but that the right system was built (validation against original stakeholder needs)
- Managing continuous updates, cybersecurity re-hardening, and AI model evolution without losing configuration integrity

- Tracking component and software obsolescence proactively—one of the most chronically neglected systems responsibilities

- Ensuring end-of-life retirement addresses data security, dependent-system impacts, and environmental obligations

Three perspectives must be sustained across all phases: traceability to stakeholder needs to verify performance; explicit trade-off discipline when competing objectives conflict; and whole-system thinking that refuses to optimize any element in isolation from its effect on overall mission achievement, cost, and risk.

2.6 The Role of Prime Contractors/Original Equipment Manufacturers (OEMs)

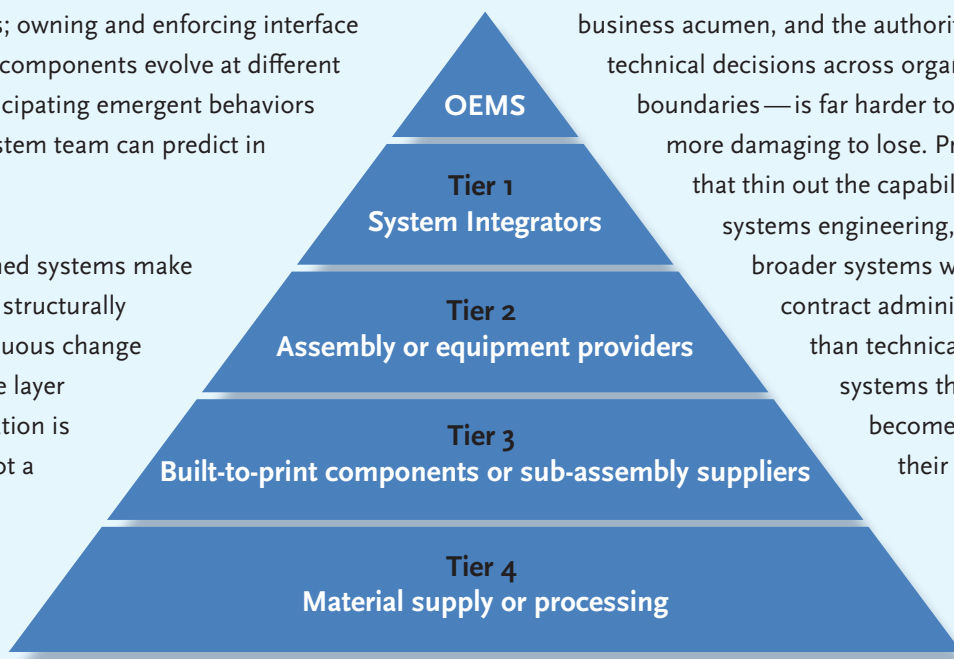
In programs developing complex software-defined systems, the prime contractor occupies a structurally singular position. Unlike specialist subcontractors who own a domain, the prime sits at the intersection of all domains simultaneously—the entity that must understand the whole when everyone else is optimizing a part.

A persistent misconception treats this role as primarily managerial. In software-defined products or System of Systems, this is dangerously inadequate. The prime must maintain genuine technical authority: governing layered software stacks and hardware configurations; owning and enforcing interface definitions as components evolve at different rates; and anticipating emergent behaviors that no subsystem team can predict in isolation.

Software-defined systems make this challenge structurally harder. Continuous change at the software layer means integration is permanent, not a phase. AI and autonomy introduce

non-determinism that traditional verification cannot address alone. Cybersecurity is a system-level architectural property, not a supplier-by-supplier concern. The digital thread demands prime-level stewardship to remain authoritative.

Ironically, the prime contractor/integrator role is precisely where the systems workforce shortage can impact the greatest. Specialist skills are addressable through targeted recruitment. The integrating, multi-domain perspective that primes must provide—combining technical fluency across multiple domains, whole-system reasoning, program and business acumen, and the authority to govern technical decisions across organizational boundaries—is far harder to develop and far more damaging to lose. Prime contractors that thin out the capabilities of their systems engineering, as well as their broader systems workforce, become contract administrators rather than technical integrators. The systems they nominally lead become incoherent under their own complexity.



2.7 The Systems Supply Chain

As systems become more software-defined, interdependent, and life-cycle intensive, the supply chain is no longer just a sourcing function. It becomes an extension of the system architecture itself.

Supply chain workforce competencies must therefore extend beyond procurement expertise to encompass the following:

Early supplier involvement, collaborative governance, and shared digital ecosystems transform suppliers from component vendors into genuine integration partners—a shift that requires both cultural change and deliberate workforce development.

Competency Domain	Core Capabilities	Strategic Impact
Systems & Architectural Literacy	System architectures, requirements traceability, interface structures, and SoS dependencies	Aligns supplier contributions with overall system performance and life-cycle objectives
Digital Integration Capability	Model-based collaboration, digital thread participation, configuration control, cross-supplier integration management	Enables coherence in software-defined, continuously evolving systems
Risk, Resilience & Sustainability Management	Multi-dimensional risk assessment (technical, cyber, geopolitical), continuity planning, life-cycle cost awareness, ESG integration	Protects long-term system viability and infrastructure robustness
Regulatory & Trust Competence	Certification literacy, cybersecurity assurance, responsible AI and technology sourcing	Safeguards compliance, safety, and public trust in complex systems
Collaborative Governance & Socio-Technical Skills	Early supplier involvement, structured decision alignment, multidisciplinary communication	Transforms suppliers into integration partners within distributed system ecosystems



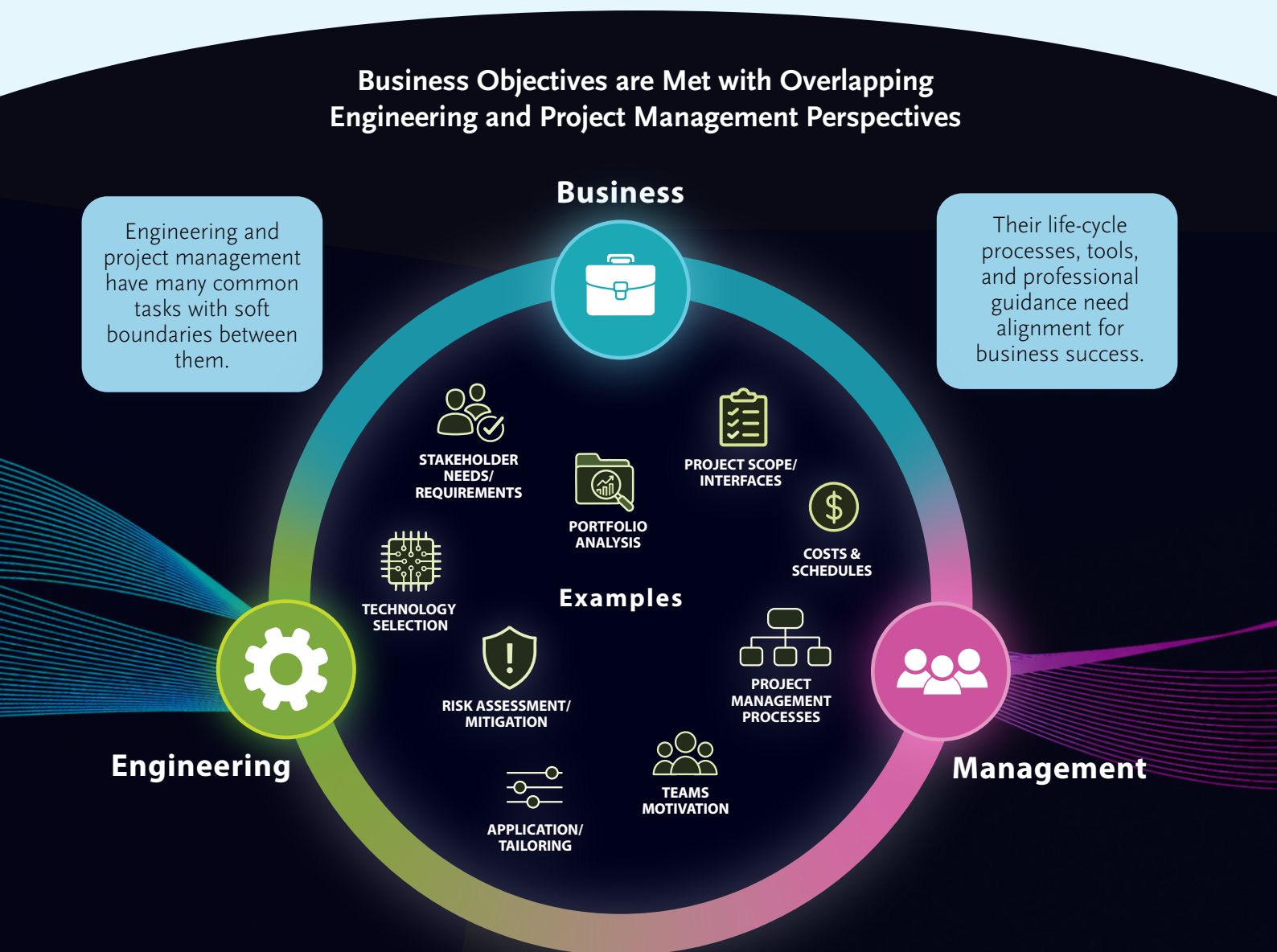
2.8 Integrating Engineering and Program Management for Business Success

The effective realization of complex systems requires more than technical depth or delivery discipline in isolation. It requires a workforce that integrates systems-centric engineering, business considerations, and program management as complementary, tightly coupled disciplines.

The systems specialist frames the right problem, evaluates architectural alternatives, quantifies trade-offs, and assesses technical and life-cycle risks. The program/project manager translates those decisions into executable plans—aligning scope, resources, cost, schedule, governance, and stakeholder engagement. The business manager evaluates whether the investment is warranted.

Neither discipline functions effectively without the others, yet they are often developed, trained, and managed in organizational silos.

A systems-competent workforce is fluent in all three perspectives. Technical professionals must understand cost, schedule, and programmatic constraints. Program leaders must understand architectural drivers, technology risks, integration risks, and long-term system sustainability. Business leaders must ensure customer acceptance and market success. Organizations that develop this combined competency improve predictability, reduce late-stage rework, and strengthen stakeholder trust; those that do not, amplify risk, cost growth, and schedule instability.



2.9 Systems Specialists and Domain Specialists: Complementary, Not Competing

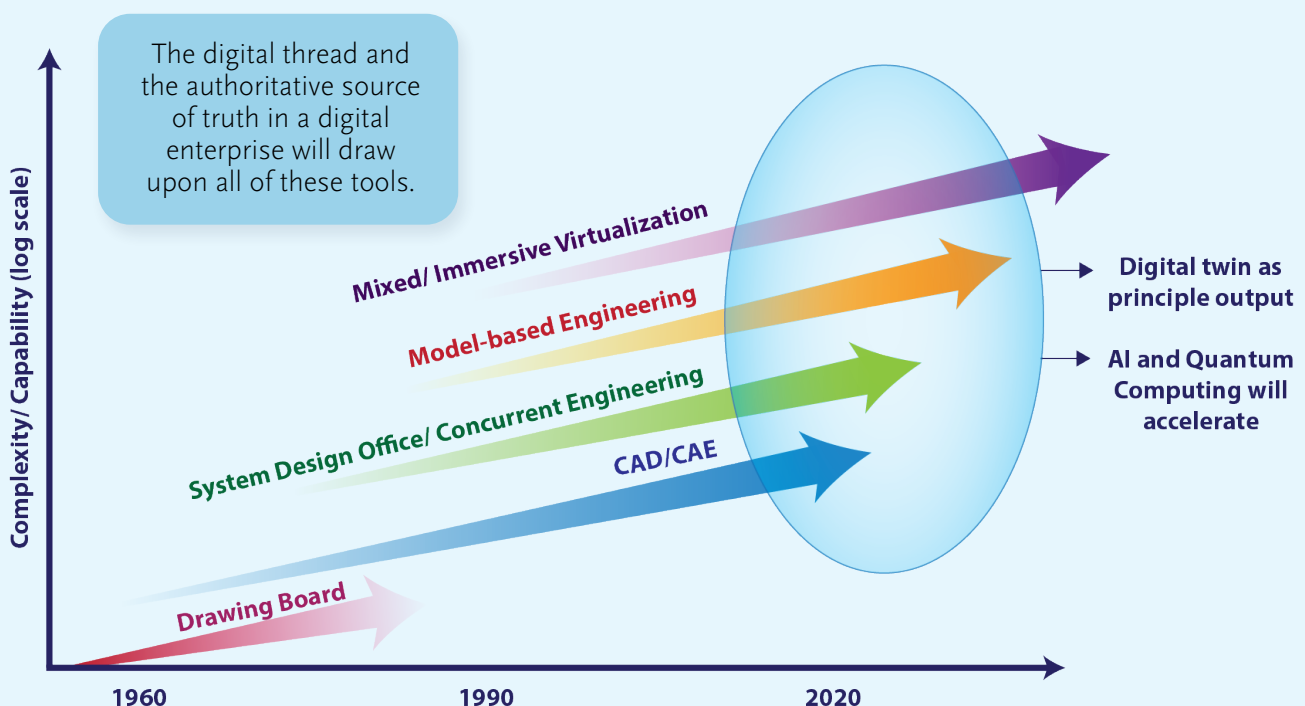
Systems competencies and deep disciplinary specialization are complementary—and equally valued—career orientations. Domain specialists possess deep expertise in a specific field, optimize within their domain, and are accountable for the performance and integrity of their subsystem contribution. Systems specialists focus on the overarching picture: architecture, interfaces, trade-offs, and life-cycle viability. They translate stakeholder needs into system requirements and ensure that subsystems work together coherently across the full life cycle.

One goes deep. The other goes wide. Both are indispensable—and the most effective systems professionals understand both worlds well enough to work fluently across the boundary.

2.10 Evolving Systems Tools

Systems analysis is evolving to increasingly involve digital methods, making digital engineering central to systems analyses of the future. Digital engineering tools—Model Based Systems Engineering platforms, product lifecycle management systems, digital twin environments, simulation and virtual testing infrastructure, and AI-assisted analysis—are rapidly maturing. Their integration into coherent engineering practice is itself a complex systems undertaking. Systems engineers and specialists must achieve genuine mastery of these tools; awareness is not sufficient.

Importantly, recent digital advances enable close collaboration between acquirers and suppliers even in the concept phase—reshaping tendering, contracting, and intellectual property frameworks in ways that the workforce must understand. Education on data sharing legalities, export control, intellectual property rights, and data protection is no longer optional for system professionals, especially those operating in international programs.



3. Strategies for Developing the Systems-Competent Workforce

Developing a systems-competent workforce is not a single initiative. It requires coherent, sustained action across the full progression from school-age education through senior career development—and across the institutions responsible for each stage.

3.1 Characteristics of Highly Valued Systems Professionals

A 2005 NASA study of high-performing systems engineers captured the mindset well: highly regarded systems engineers view the system as a non-linear web of connections and disconnects. Systems competencies can be assessed across four dimensions, beyond basic analytical and domain proficiency:

- Mastery of the techniques and methods of systems analysis—requirements development, architecture, modeling, trade-off analysis, verification, and risk management
- A systems mindset—the ability to see the system as a non-linear web of interactions, zoom in to diagnose a specific problem, and zoom out to assess its broader consequences

- Interpersonal skills for working effectively in multidisciplinary teams and coordinating across the problem and solution domains
- Technical leadership—the ability to guide a diverse team of experts toward a specific goal, integrating their contributions without losing system-level coherence

These qualities are not fully teachable in a classroom. They are shaped by experience, mentoring, and organizational culture. The institutions responsible for workforce development must create environments in which these qualities can emerge, be recognized, and rewarded.



The... systems engineers studied typically view the system or subsystem as a non-linear web of connects or disconnects to be solved. They have the ability to view the big picture, zoom in to pinpoint the disconnect, and then zoom back out to the big picture, while at the same time looking at the interrelationships and patterns in the system or design. They have a high degree of curiosity mixed with self-confidence and persistence and are achievement oriented. They may describe themselves as having extraordinary physical insight to see the connections and interrelationships between what they are doing and the world around them. They are drawn to the challenge of solving complex problems and are creative, in the midst of numerous constraints.



3.2 Building Systems Perspectives in Formal Education

Formal education at all levels plays a foundational role—not by adding systems engineering as a separate subject, but by framing learning in ways that develop systems thinking as a natural habit of mind.

Primary and Secondary Education

The 21st-century skills already emphasized in many educational systems—critical thinking, creativity, teamwork, digital literacy, civic awareness—align naturally with systems thinking. The objective is not to add more content, but to surface interdependencies, constraints, stakeholder perspectives, and structured problem-solving as explicit themes within existing disciplines. By secondary school, students should encounter foundational systems analysis concepts: identifying stakeholder needs, defining requirements, evaluating alternatives, and understanding trade-offs. Practical, project-based learning—ideally in partnership with regional industry—makes these concepts concrete and motivates mastery of the underlying mathematics, science, and social disciplines.



University Education

Universities bear the primary institutional responsibility for forming the systems workforce. This demands several structural commitments:

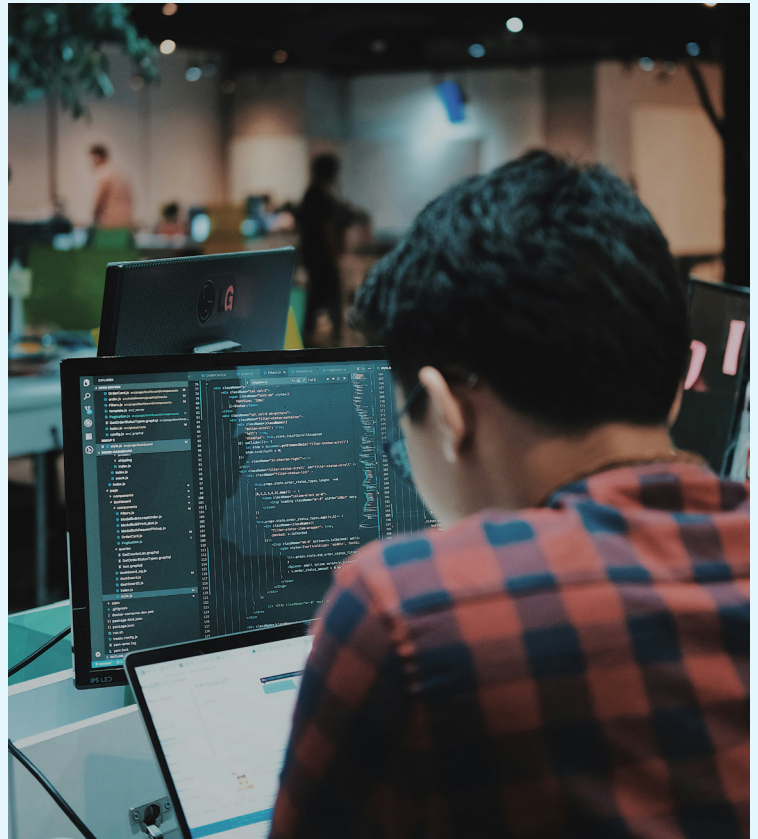
- Curricula must bridge traditional boundaries, integrating hardware and software architectures, modeling and simulation, AI, cybersecurity, and life-cycle reasoning into coherent program design
- Engineering, computer science, business, and management programs should incorporate systems-oriented coursework—particularly systems thinking and end-to-end systems analysis—as standard elements
- Multidisciplinary applied projects—capstones, internships, integrated learning experiences—should be structural curriculum elements, not electives
- The shift from design-build-test to analyze-model-simulate-build must be embedded in academic practice, with MBSE, high-fidelity simulation, digital twins, and agile development treated as standard tools
- As regulatory environments grow more complex, curricula must include policy analysis,



regulatory assessment, safety engineering, cybersecurity, and data privacy as recognized components of professional competence

- Educators themselves must engage in continuous professional development through cross-institutional collaboration, industry engagement, and professional exchanges—teaching teachers is a precondition for curricular relevance

Stronger, more systematic university-industry collaboration is equally critical. Early and sustained dialogue on curricular needs, co-sponsored capstone projects, shared mentoring, and structured internships facilitate smoother transitions between academia, industry, and government—while addressing real societal challenges including responsible AI, privacy, safety, and cybersecurity.



3.3 Enterprise Training for Innovation and Competitiveness

Most practicing systems specialists and engineers did not follow a formal systems educational path. They built domain expertise first, then expanded their breadth through experience, or post graduate studies. This is a feature of the systems analysis, architecting and engineering discipline, not a deficiency—but it creates a structural obligation for enterprises to invest continuously in developing and refreshing systems competencies within their workforce.

Certain career roles are particularly formative. Validation roles reveal how design decisions support or undermine customer satisfaction. Integration and test roles expose the consequences of treating subsystems in isolation. Operations roles demonstrate the long-term implications of architectural decisions made in the earliest program phases. Enterprises that deliberately rotate promising engineers through these roles accelerate the development of genuine systems perspective far more effectively than classroom instruction alone. Enterprise training programs should address three levels simultaneously:

- Early to mid-career: enterprise-specific practices, standards, tools, project management fundamentals, and the integration of domain expertise with systems methods
- Mid to senior career: advanced systems and digital engineering capabilities, AI integration, regulatory complexity, risk and business fundamentals, and cross-disciplinary leadership
- Continuous refreshment for all: keeping pace with technology evolution, new methods and tools, changing regulatory frameworks, and supply chain developments

Commercial training providers, university certificate programs, summer schools, and professional certifications (including professional organization training and certification) serve as valuable complements to enterprise programs. They provide standardized benchmarks, cross-industry exposure, and access to emerging practice that internal programs cannot always replicate.

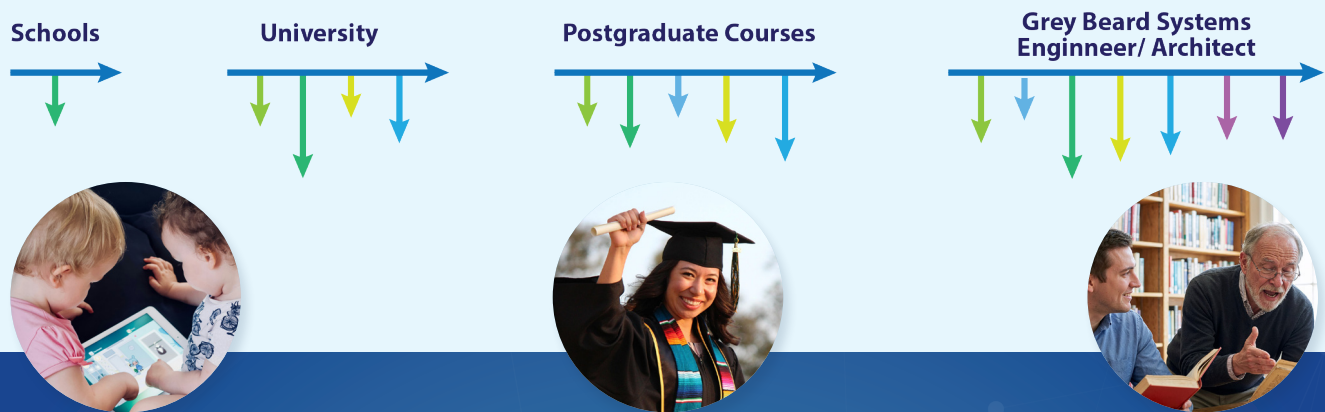
3.4 Career Paths: From Specialist to Systems Leader

The development of a systems professional follows a recognizable pattern, captured in the T-shaped competency model: deep expertise in a founding discipline, progressively broadened through engagement with neighboring disciplines, programmatic functions, and leadership responsibilities. The more a practitioner engages across engineering, business, finance, planning, and leadership domains, the more they develop the perspective needed for senior systems roles—chief engineer, system architect, program director, or chief technical officer.

Enterprises that create parallel expert career tracks—offering senior specialists’ recognition and reward comparable to management

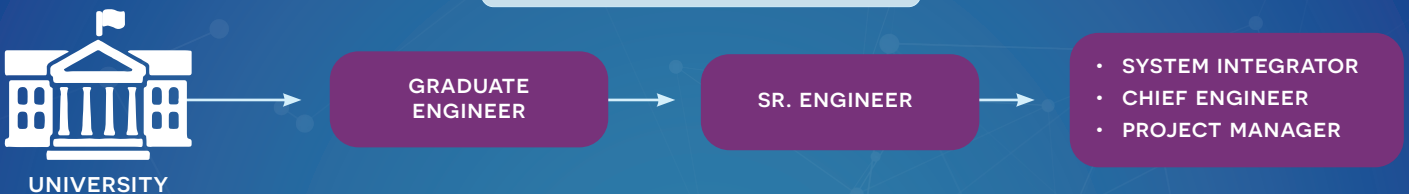
advancement—retain the deep systems talent that would otherwise migrate into management or leave. In small and medium enterprises, this progression is often simpler in structure but no less important in intent: from junior engineer to senior systems integrator to chief engineer or program manager.

Systems engineering and program management have traditionally followed separate educational and professional paths. Given their deep interdependence, their continuing education, methods, and implementation practices increasingly need alignment—consistent with the strategic direction of the enterprises they serve.

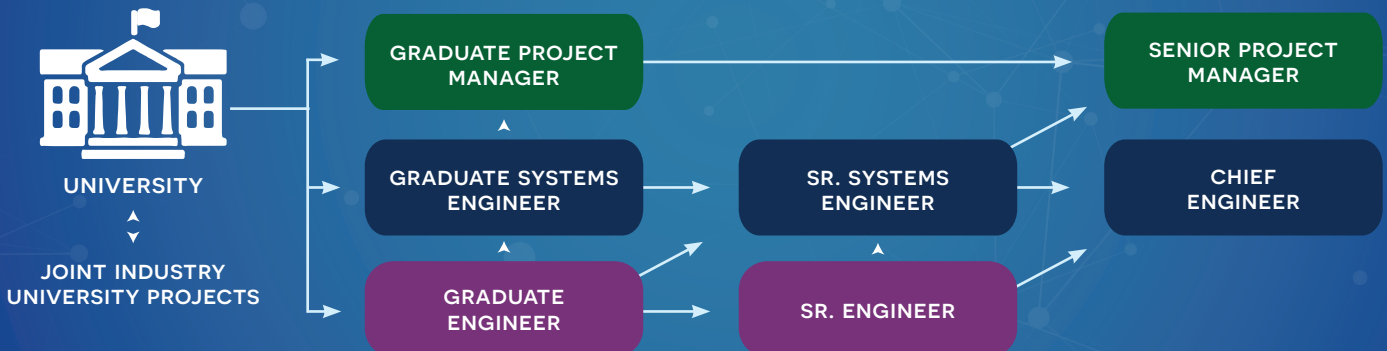


EDUCATION AND CAREER DEVELOPMENT FOR SYSTEM ENGINEERS

IN SMALL & MEDIUM ENTERPRISES



FOR VERY LARGE ENTERPRISES



CERTIFICATIONS

BASIC

ADVANCED

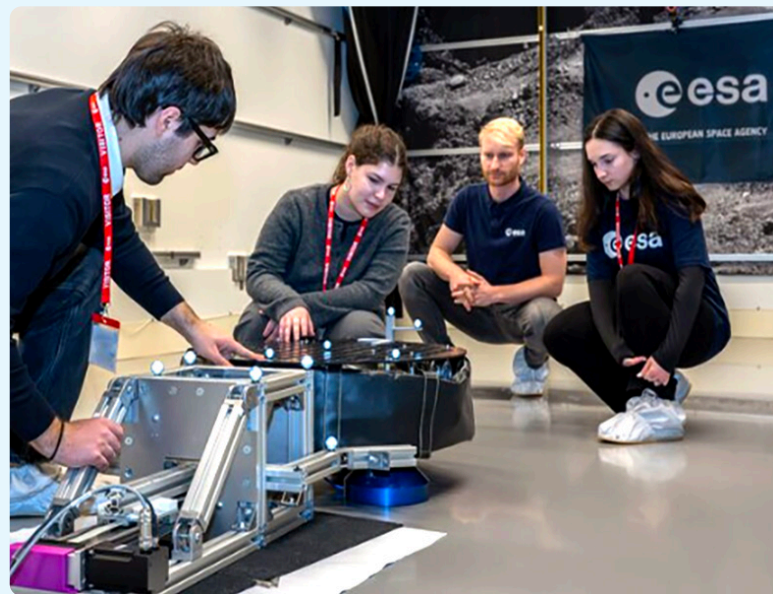
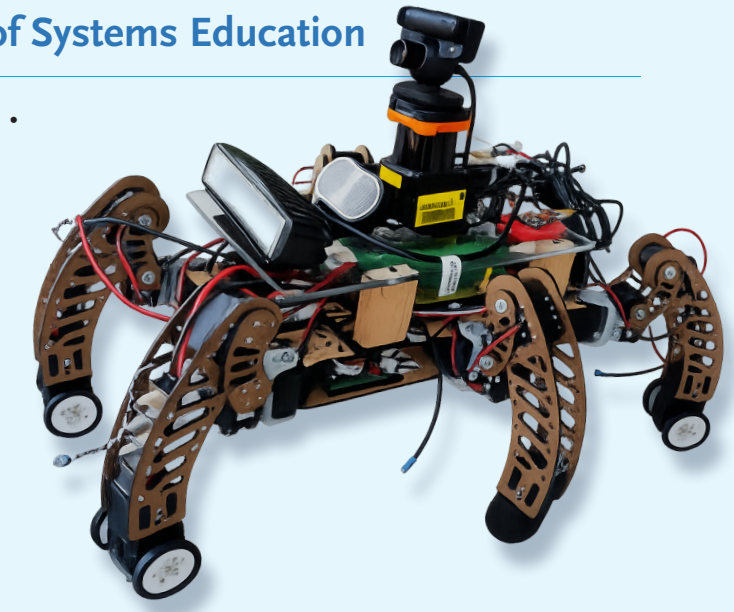
EXPERT

MOST ARROWS ARE OCCASIONALLY ASSOCIATED WITH TRAINING UNITS
STEPS FROM GRADUATE TO SR. POSITIONS ARE OCCASIONALLY ACCOMPANIED BY AN ADDITIONAL DEGREE IN A RELATED FIELD

3.5 Capstone Projects as the Crucible of Systems Education

Systems perspectives cannot be fully developed through theoretical instruction alone. They are best acquired by applying theory in teams working on representative, real-world problems. Capstone projects are the most effective mechanism for developing the integrative judgment, team collaboration, and stakeholder orientation that define the systems professional.

- Capstone projects apply across secondary, undergraduate, postgraduate, and professional development levels
- Project complexity and scope should be calibrated to team experience and institutional resources
- Formalized project reviews provide structure, accountability, and preparation for real-world program environments
- Involving industry customers or potential employers in reviews develops market orientation and provides direct feedback on product value
- Where external customers are unavailable, these roles can be simulated within the institution
- The formative value of the capstone experience is determined by the quality of the integrative challenge it presents — not by its scale



3.6 The Role of Professional Organizations

Professional organizations play a unique and largely irreplaceable role in the ecosystem of Systems workforce development. They are simultaneously custodians of the discipline's standards, advisers to governments and industry, providers of training and certification, advocates for professional recognition, and catalysts for incorporating new technologies into practice.

Their responsibilities in helping to build and enlarge the systems workforce include:

- Promoting the value of systems competencies across all application domains to executives, senior leaders, educators, and policymakers
- Offering professional forums where exchanges of experience and the success and failures of system approaches can take place
- Coordinating guidance, standards, and digital tool interoperability across specialized disciplines and sectors

- Developing and maintaining certification frameworks that provide recognized benchmarks for competence at each career stage
- Supporting the introduction of systems analysis, architecting, engineering and management into existing traditional engineering curricula
- Nurturing students and early-career professionals, including through programs targeted at under-represented discipline groups
- Facilitating knowledge sharing through case studies, publications, and forums that document both achievements and failures
- Supporting developing nations to build systems competencies via their educational systems and industries



The global diversity of the systems community is a strategic asset. Professional organizations are uniquely positioned to translate that diversity into shared frameworks and mutual capability.

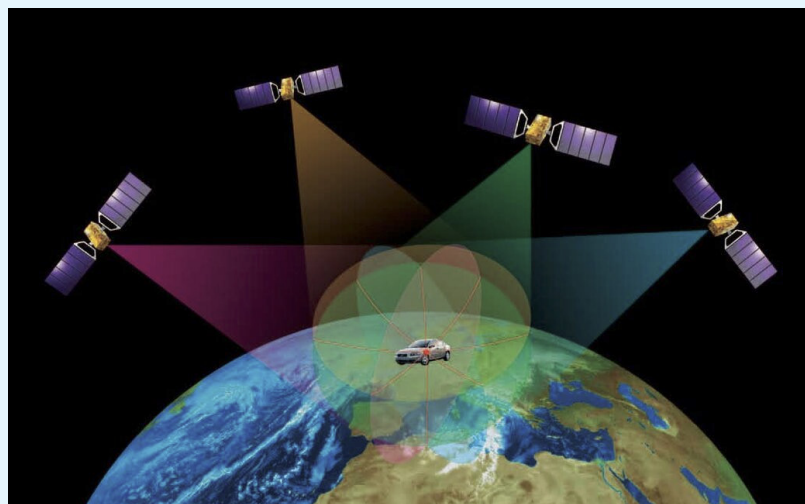
3.7 The Role of Government Agencies

Government agencies are both major users of a systems-competent workforce and essential catalysts for its development. The complexity of systems in energy, transportation, defense, space, healthcare, and public infrastructure continues to grow—and governments are taking increasing responsibility for defining the parameters and architectural frameworks within which these systems must operate.

Simple market-driven development of complex public systems can produce sub-optimal outcomes and create costly governance failures. Agencies need combined end-to-end systems architecting, engineering, and management competencies to represent stakeholder interests effectively, assess the consequences of policy choices, and oversee complex procurements. These competencies are currently as scarce inside government organizations as they are in industry.

Governments, for examples, via their agencies, can exert decisive influence through policies, regulations, subsidies, procurement standards, and workforce development investments. To do so responsibly requires

a broad systems understanding encompassing political, economic, business, social, technological, environmental, and legal dimensions. Formalization of systems analysis and trade-off evaluation as standard elements of policy assessment, alongside close cooperation between agencies, research institutions, and industry, can significantly reduce the risk of failed implementations and improve the quality of strategic decision-making.



Summary and Conclusions

The systems-competent workforce tackles the complex transformations and product challenges of today and tomorrow. Building and expanding it to focus upon priority needs is not a long-term option. It must be a strategic imperative for industry, government, academia, and the professional community alike.

The realization of the transformations that will define the 21st century—in energy, mobility, health, security, communications, and public infrastructure—depends on a workforce capable of doing what no single discipline can do alone: integrating technology, management, business, sustainability, risk, and AI into coherent systems that serve human needs across their full life cycle.

That workforce is scarce, and the shortage is growing. The complexity of systems is increasing faster than the capacity to produce the professionals required to design, integrate, and govern them. The consequences are evident: integration failures, cost overruns, capability shortfalls, and missed opportunities for innovation in sectors critical to national and global welfare.

Three conclusions follow with strategic importance:

1. Systems workforce development is a matter of national policy, not just organizational HR strategy. Governments and their agencies responsible for critical infrastructure, defense, energy, health, and digital transformation must treat systems competency as a strategic national capability—one that warrants investment, governance, and active development comparable to physical infrastructure.
2. Educational transformation is overdue. Universities, secondary schools, and professional training providers must reorient around the integrative, multidisciplinary realities of modern software enabled systems and System of Systems. This requires curricular change, faculty development, industry partnership, and the institutionalization of lifelong learning as a professional expectation rather than a personal option.
3. Industry must invest in systems depth, not just specialist breadth. Prime contractors/OEMs, major systems integrators, and complex product manufacturers without up-to-date systems capabilities become structurally unable to fulfill their core function. Career pathways, training programs, and organizational cultures must be designed to develop and reward the integrative perspective—at every tier of the supply chain, not just at the top.

An Example: Academic Masters Program Rationale for Systems Education

The University of Nebrija, Spain, offers Masters degrees in Space Systems (MASE) and Aeronautical systems (MASAE) that stress systems engineering. Following is a statement by the university articulating their rationale for a strong systems approach to the space and aerospace engineering domains.

MASE and MASAE: Academic Director Bernardo Delicado

Modern engineered systems are characterized by increasing complexity, requiring a structured approach to integration and coherence across multiple dimensions. Integration must ensure that all levels of the system hierarchy are consistently connected. Lower levels must support higher-level objectives, with full traceability maintained across requirements, functional, logical, and physical layers. This guarantees that design and implementation decisions remain aligned with the original intent and stakeholder needs throughout the lifecycle.

At the same time, integration must also ensure coherence within each level of abstraction. From components to subsystems and full systems, a consistent and well-defined product architecture is required so that elements can interact effectively and operate as a unified whole. Beyond integration, systems engineering should be viewed as a continuum of increasing scope and abstraction. It spans from component-level to subsystems and systems, and ultimately to interoperating Systems of Systems (SoS), where independently developed systems interact to deliver emergent capabilities. Across this continuum, the systems engineering approach applies at all levels, although in different forms and with varying scope and abstraction. At each level, it provides the structure, methods, and discipline needed to manage complexity, ensure coherence, and support decision-making. In this sense, systems engineering can be understood as an



applied systems science, grounded in systems thinking, enabling a holistic view that captures interactions, dependencies, and emergent behaviors across the entire system landscape. Today, systems engineering must explicitly include the human dimension, going beyond pure technology; this is at the core of the systems approach, which finds its fullest expression at the SoS level.

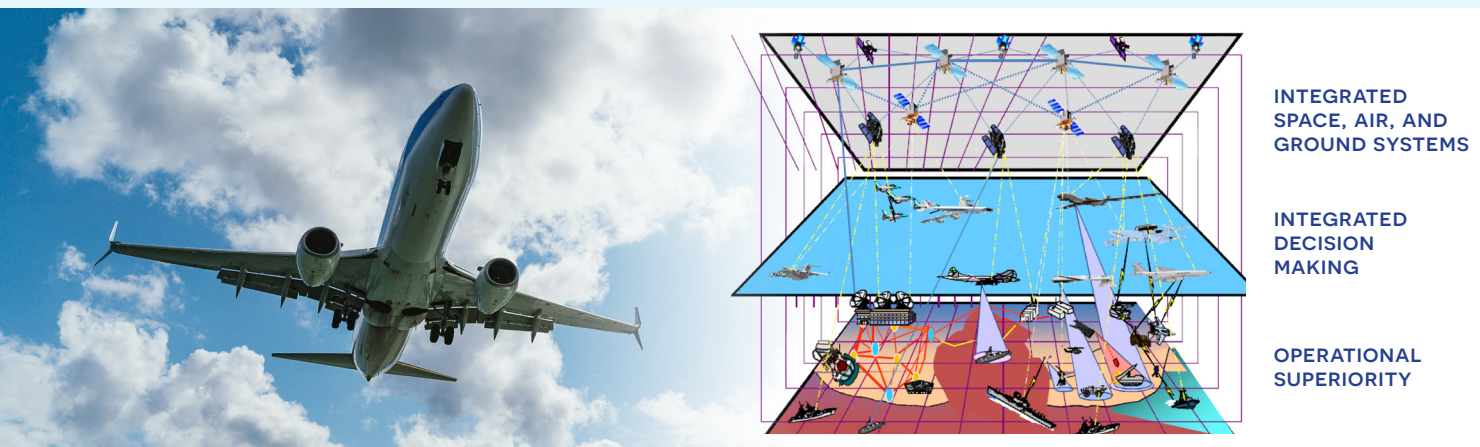
At the highest level, Mission Engineering ensures that all systems and systems of systems are aligned with operational objectives and mission outcomes. The focus shifts from simply building systems correctly to ensuring that the right capabilities are delivered to accomplish the mission effectively. In this context, Digital Engineering acts as a key enabler by providing model-based approaches and ensuring data and digital continuity across the lifecycle. This helps accelerate development, improve integration, and reduce inconsistencies.

As system complexity increases—driven by performance demands, functionality, integration depth, and data requirements—the associated integration risk grows significantly. System boundaries evolve from well-defined and rigid (hard boundaries) to more dynamic and interconnected (soft boundaries), making consistency, verification, and validation more challenging. A critical aspect across all levels is safety engineering. Safety must be addressed as an integral part of the systems engineering process, supported by rigorous methods, standards, and continuous assessment from early design through operation. This is especially important in highly integrated and mission-critical environments.

In summary, successful system development requires:

- Strong, multi-dimensional integration across all levels and domains
- A scalable systems engineering approach extending to Systems of Systems
- Clear alignment with mission objectives
- Robust and embedded safety engineering practices
- Effective use of digital engineering to manage complexity and reduce risk

Additional information can be found at the University of Nebrija website: masterx.es



SYSTEMS ENGINEERING

To manage complexity and ensure system success from concept to disposal

SYSTEMS OF SYSTEMS ENGINEERING

To manage and coordinate independent systems to achieve emergent capabilities

MISSION ENGINEERING

To align systems and operations with mission

DIGITAL ENGINEERING

To accelerate development and improve integration through digital models and data continuity

SMALLER SCOPE
LESS ABSTRACTION

COMPLEXITY AXIS

LARGER SCOPE
MORE ABSTRACTION

Technology/Physical

Subsystem/ Systems

Socio-Technical Systems

Multi-Domain - Mission

SYSTEMS ENGINEERING

COMPONENTS

SUB-SYSTEMS

SYSTEMS

SYSTEM OF
SYSTEMS

INTEROPERATING
SYSTEM OF
SYSTEMS

Systems Workforce Summit I | Call for Action

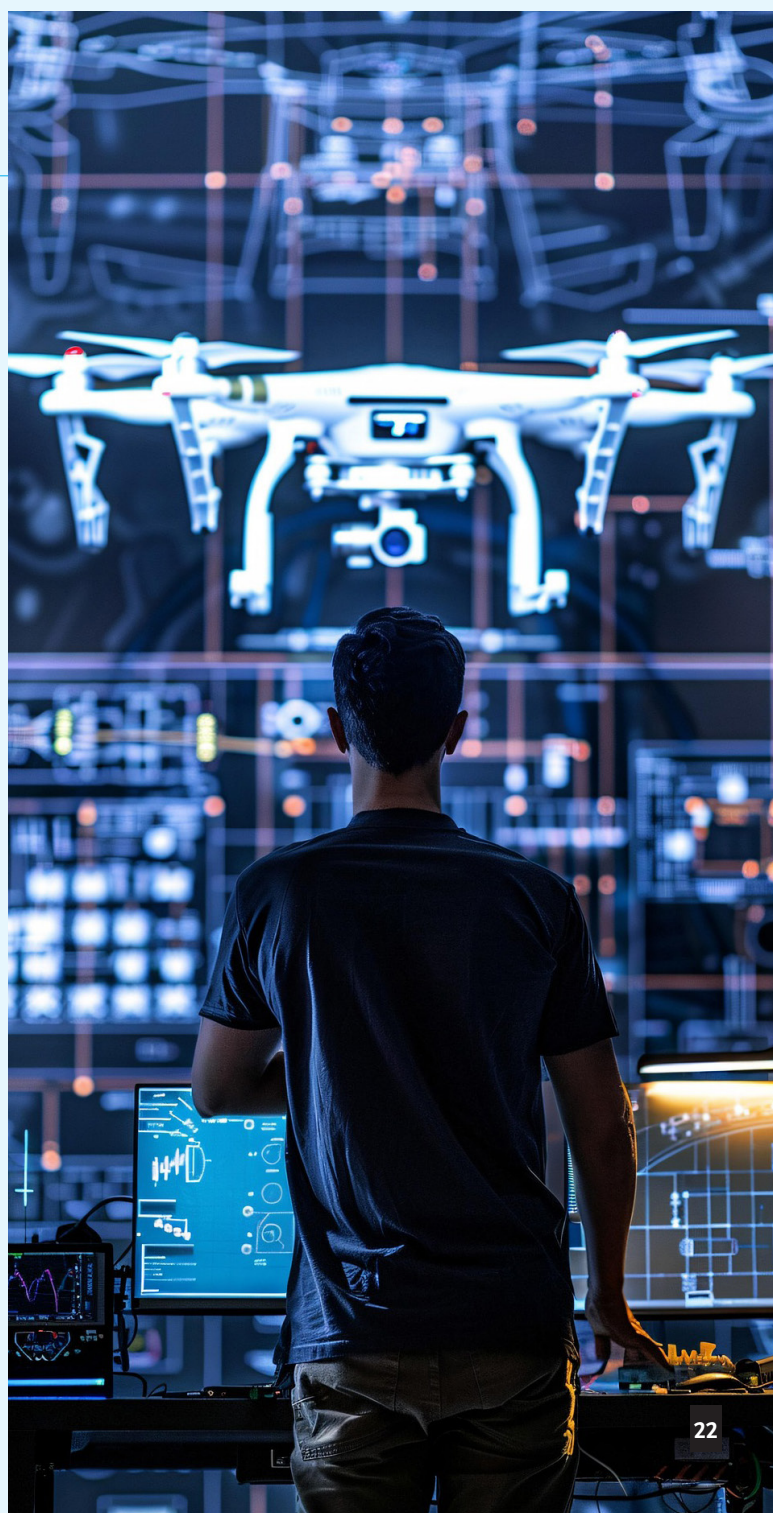
The accelerating complexity of modern systems, and the widening gap between the competencies and the workforce currently available to do so, has become a strategic concern of the first order. It is a concern shared across industries, governments, academic institutions, and professional organizations worldwide, and one that no single sector can address in isolation.

In October 2024, leaders from across these communities convened in Delft, the Netherlands, for the first-ever International Summit on Systems Workforce. Representing industry, academia,

government agencies, and professional bodies from multiple nations, participants examined the scale and nature of the systems workforce gap, the forces driving it, and the actions required to close it. The Summit concluded with a coordinated Call for Action — a collective commitment to the principles and priorities that must guide systems workforce development in the years ahead. What follows is that call: directed at the leaders, institutions, and policymakers with the authority and responsibility to act.

Systems Needs and Context

1. The effectiveness of transformations in our society, such as in the energy, transportation, aerospace, communication, agriculture, or health domains, depends upon multi-disciplinary system workforces. These are scarce and require development.
2. Systems have become increasingly complex, interdependent, self-adapting and interconnected digital ecosystems. Sustainability and circularity drive public and commercial undertakings. Their realization frequently demands cooperation of social, environmental, economic, legal, regulatory, engineering, and technology stakeholders to generate lasting societal or market value. Inter-disciplinary system and team competencies are needed to align stakeholder perspectives.
3. For systems to meet their intended goals, social acceptance, and economic success the systems workforce should, from the outset, apply an end-to-end architecting approach spanning from concept to retirement. Trust in complex systems will increase through an early understanding of critical realization issues, such as risks, cost, schedule, interdependencies, sustainability, and societal impact.



Systems Realization

4. Product developments require critical systems thinking and architecture design across many product layers from sub-assemblies to System of Systems. Success of system integrators and suppliers increasingly depends on system competencies across the product supply chain and life-cycle.
5. The rapid growth of software intensive systems demands close cooperation of hardware- and software experts from the early phases of systems architecture development to ensure seamless system interaction throughout the life-cycle. Artificial Intelligence (AI) will increasingly support system developments and will become elements of integrated systems.
6. Modelling, simulation and virtual reality engineering tools need to advance to enable systems data correlation and seamless exchanges during development, manufacturing, and operation.
7. Systems understanding and judgement are rooted in specific domain competencies. Coupling these with technological acumen, innovative curiosity, pragmatism, and effective team cooperation is essential for success.
8. Systems engineering and project management disciplines have strong interdependencies. Their life-cycle based processes and tools, along with their professional guidance, need to be aligned to ensure problem solving and value driven approaches for systems realizations.

Acquiring System Competencies

9. Acquiring systems competencies is a life-long journey. It should involve critical systems thinking in schools, broader systems education in universities, and periodic updates for systems teachers, experts and practicing engineers. A paradigm shift is needed for ensuring the availability of systems workforce. Adjustments of university curricula and industry training concepts should involve advancing technologies, digital tools, agile practices, and the growing global access to knowledge as fundamental drivers for change.
10. Systems competencies are best learned by engaging students and professionals in real world problems through multi-disciplinary learning opportunities, e.g. capstone projects applying state-of-the-practice tools. System-level reviews should be held periodically to reinforce the importance of addressing cross cutting issues. Cooperation between academia, industry, government agencies, and professional organizations should be strengthened to enhance systems understanding and realization competencies.
11. Systems workforce careers often evolve from assembly, to subsystems, and system integration competencies. Multiple career paths can potentially lead to system architect, chief engineer, project or program manager or chief technical officer. Related career guidance for systems workforce should be developed by professional organizations for pragmatic application by the global systems community.



Additional information can be found at the Summit website: systems-workforce.eu/previous-results

Endorsed on behalf of the Summit Delegates

- Summit Chair: Prof.dr.ir. T.H.J.J. Tim van der Hagen, Rector Magnificus & President of the Executive Board, Delft University of Technology
- Chair of the Context and Systems Needs Theme, Henk van Hauten, Chair of the Board of the Netherlands National Academy of Engineering (NAE), NL
- Chair of the Industry System Workforce Needs & Sustainment Theme, Jan van Vlerken, Senior Vice President System Engineering, ASML
- Chair of the Education of System Engineers Theme Prof. Dr. Emma Sparks, Rector and Dean, University of New South Wales, Canberra
- Chair of the Government Agencies System Workforce Needs, Roles & Contributions Theme, Larry D.James, Lt Gen USAF (Ret), former Deputy Director NASA JPL, USA; currently Strategic Advisor to the SmartSat Cooperative Research Center, Australia's Space Research Organization, and Professor of Space Innovation at Monash University, Melbourne, Australia
- Chair of the Professional Organizations System Needs and Opportunities Theme, Prof. Dr. Daniel Hastings, President American Institute of Aeronautics and Astronautics
- Summit Architect: Prof. Dipl.-Ing. Heinz Stoewer, M. Sc. and the Associate Theme Chairs David Nichols, Kerry Lunney, Prof. Dr. Eberhard Gill, Twan de Wit, Steve Records



IAC Global Networking Forum Plenary

An international group of high-level representatives from academia, industry, government agencies, and professional organizations convened on 8 and 9 October 2024 at Delft University of Technology. They discussed technical, economic and societal challenges of today's complex systems and articulated the need for multi-disciplinary competencies for systems professionals which are in high demand worldwide.

They endorsed a Call for Action directed to the global systems policy, analysis, management, and engineering, communities, to mitigate current system workforce deficits.

Introduction

The International Astronautical Federation (IAF) held its 76th International Astronautical Congress (IAC) in Sydney, Australia, October 2025. The event featured historic plenaries focused on multi-disciplinary competencies and a Call for Action to address critical global deficits in the systems engineering workforce. System of Systems with diverging stakeholder requirements and functionality demands depend upon multi-disciplinary holistic analyses, architectures and realization approaches. Software driven and AI supported, cyber-secure autonomous solutions, based upon model/simulation/virtual reality engineering judgements ensure government, prime contractor and supply chain successes.

The challenge? System architects and engineers are scarce and in high demand. Will they be available tomorrow? What can be done? A paradigm change is needed for systems education and career paths. Closer cooperation between industry, universities, government agencies is mandatory.

This session featured several short and focused viewpoints from top-level executives and educators with vast experience in architecting and realizing complex space and defense programs. The outcome of this plenary was a Call for Action, below, with recommendations for coping with the challenge.



Prelude: Systems Architecting and Realization- Key Success Competencies

Multi-disciplinary life-cycle architecting brings together expertise from different specialty domains to tackle new mission or project ideas and explore technical and programmatic realization options against the objective to set programs up for success. Technology advances, market pressures, and growing interdependence between in-orbit and ground-based space systems drive solutions towards increased complexity and a System of Systems approach. Meeting diverse stakeholder and functionality requirements remains a challenge.

Today's space programs use systems which are software-driven, artificial intelligence (AI) supported, cyber-secure autonomous solutions and engineered by way of extensive models, simulations, and virtual reality.

However, there is a shortage of skilled system architects and engineers, and they are in high demand.

Following are recommended actions with global applicability that could help prevent, or at least mitigate, an impending crisis regarding the availability of the space systems workforce which can realize our future ambitions.

Call for Action

System Needs and Context

1. Multi-disciplinary system workforces are key to the success of space programs. These competences are scarce and require continuous development.
2. Civil and defense space systems have become complex, interdependent, interconnected ecosystems, an accelerating trend. To generate lasting societal and/or market value requires early integration of social, environmental, business, regulatory, engineering, and technology competencies to align stakeholder perspectives and create viable program realization plans.
3. Success of suppliers and integrators depends increasingly on system competencies across the supply chain and the system life cycle. Space products have many layers involving assemblies, sub-systems, systems, and System of Systems. Most all are interconnected and interdependent and need extensive systems analysis and design across their many interfaces.

Systems Architecting and Design

4. Early phases architecting is critical to program success in that it creates trust in solutions for critical life-cycle implementation issues, such as risks, cost, schedule, system interdependencies, sustainability, and societal impact.
5. Hardware and software system teams must be integrated from the outset of architecture development to ensure desired system performance, behavior, and sustained operations. The rapid growth of software intensive, AI supported cyber-secure autonomous solutions drives the need for end-to-end system architectures and realization plans.
6. Space systems employ an extensive inventory of modeling, simulation, and virtual reality tools for development and operations. Data exchanges across tools remain cumbersome. Additional efforts and R&D by universities, industry and agencies is encouraged to create generic vendor agnostic tool infrastructures which support seamless data exchanges between specialty disciplines and system layers throughout the life cycle.
7. Systems management and engineering processes can at times become overly prescriptive. Periodic reviews by experienced system developers are

recommended. They should be tasked to focus upon pragmatic, problem solving and value driven approaches while ensuring that enabling digital technologies are utilized.

8. Space systems acquisition processes are demanding and involve substantial documentation. Transformation efforts embracing state of the art digital engineering and management practices should be advanced. This implies jointly adopted tool suites, well-defined information exchanges and access rights, as well as data-based proposal evaluations and project reviews. Improved visibility and efficiency gains for customers, system primes and suppliers are likely to result.

How to Ensure the Availability of System Competencies?

9. Acquiring systems architecting and engineering competencies is a life-long journey. Systems understanding and judgement are rooted in domain and specialization competencies. Coupling these with technological acumen, innovative curiosity, pragmatism, and effective team cooperation is essential for success.
10. Embedding a systems mindset from an early age in schools with supporting interdisciplinary problem-solving exercises are recommended enablers for developing early system thinking.
11. System fundamentals should be taught in most fields at universities at undergraduate level to generate basic systems knowledge and team capabilities. System teachers should receive periodic trainings on recent developments in the field.
12. System competencies are best acquired by engaging students and professionals in multi-disciplinary real world problem solving practices, e.g. via capstone projects while applying state-of-the-practice tools. Periodic system-level reviews by experienced staff should accompany the learning process and question cross cutting system issues.
13. Practicing system engineers should strive to remain current on their systems competencies on the job and exercise curiosity in adopting evolving technologies, tools, and system practices. Industry and government system employers should encourage continued learning by offering internal and/or external opportunities designed to deepen or broaden employee's systems knowledge and experience.
14. System careers can take many different paths. They often evolve from special disciplines, to subsystems, and system integration competencies. Eventually they can lead to subsystem or system engineer, system architect, chief engineer, project or program manager, chief technical officer, or similar. A combination of domain, system and team competencies are ingredients for career advancements.
15. A paradigm shift is needed in schools, universities, industry and governments to ensure the availability of our future space systems workforce. Adapting curricula and training concepts, generating additional post-graduate offerings for practicing system professionals should be implemented with priority.

In Summary, this Call for Action appeals to academia, industry, government agencies and professional organizations to join forces and implement the recommendations to ensure that the space systems architecting and engineering workforce will be available for our future space ambitions.

Note 1: System competencies are multi-disciplinary skills involving assessment of customer(s) and/or market needs, development of system architectures, implementation options and requirements, evaluation of suitable technologies, system definition & design, prototyping, digital twins, manufacturing, testing and service. They include end-to-end systems & project/program management skills.

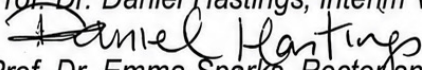
Note 2: This Call for Action draws upon the conclusions of the first ever international Summit on Systems Workforce held in October 2024 in Delft, The Netherlands.

Additional information can be found at the Summit website: systems-workforce.eu



This Call for Action is endorsed by the IAC GNF Plenary Participants

Prof. Dr. Daniel Hastings, interim Vice Chancellor of MIT and President AIAA, USA

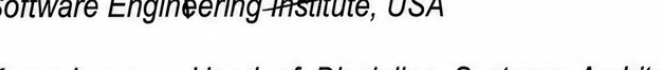


Prof. Dr. Emma Sparks, Rector and Dean at UNSW Canberra, Australia

Chiara Pederson, CEO of OHB System AG, Germany



Dr. Paul D. Nielsen, Director and Chief Executive Officer of Carnegie Mellon University's Software Engineering Institute, USA

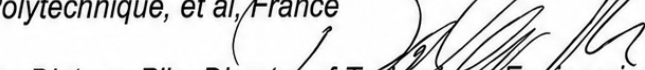


Kerry Lunney, Head of Discipline Systems Architecture and Engineering, Technical Director, Thales, Australia

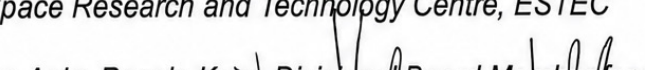
Lt Gen (USAF Ret) Larry D. James, Strategic Advisor for SmartSat Cooperative Research Centre (CRC) and Distinguished Professor of Space Research and Innovation at Monash University, Australia



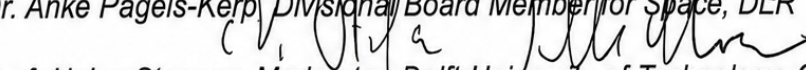
Prof. Jean-Jacques Dordain, former Director General ESA, Professor Ecole Polytechnique, et al, France



Dr. Dietmar Pilz, Director of Technology, Engineering and Quality, Head of the European Space Research and Technology Centre, ESTEC



Dr. Anke Pagels-Kerp, Divisional Board Member for Space, DLR



Prof. Heinz Stoewer, Moderator, Delft University of Technology, CEO Space Associates, et al, Germany



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In Memoriam

Professor Dr Eberhard Gill



Who left us much too early

