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Beyond Traditional Engineering: Transformative Approaches for a Changing World

Why complexity is increasing, and what makes it complex?

Significant increases in complexity are driven by technological advancements, integration of AI, regulatory requirements, and system interdependencies, amongst others, over the past decade.

1950: Flashback Naval ship

2021: Formidable Shield NATO

The environment for complex systems is changing

99

Time-to-mission is a priority in national security and industry in the current geopolitical context

Traditional SE often takes 5-10+ years from concept to deployment of complex systems, and this doesn't serve the current needs. New technology is deployed in months, and competitive advantage is lost during long cycles.

01 Operational environment

02 Development environment

03 Business demands

04 Accessibility to new technologies

05 Legislation

↘ Artificial Intelligence and Machine Learning

It is continually becoming more complex with integration of huge datasets, unsupervised learning, needs for safety, ethical considerations.

↘ Cloud Distributed Systems

Microservices, Serverless. In SW intensive systems, elements as scalability, resilience, availability have a large technological impact on systems.

↘ Cybersecure systems

The main complexity driver is a constantly evolving threat landscape together with more complex architectures and protections. Impact on e.g. detection, identity management...

↘ Autonomous Systems

Interaction with unpredictable environments, real-time decision-making, AI, safety protocols, compliance. Real-world deployment demands robustness, redundancy and self-diagnosis.

The main drivers of complexity in modern systems →
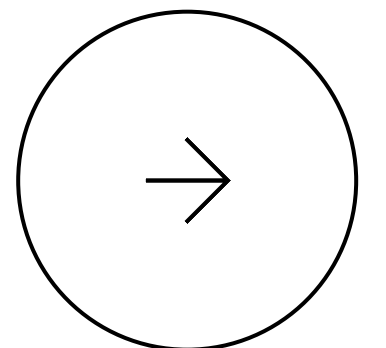
Why traditional SE practices are no longer valid for modern complex systems' development?

01 **Linear, waterfall processes can't handle constant change**

Complex systems require continuous concurrent and iterative development.

02 **Emergent behaviour in SoS is unpredictable**

Traditional SE lacks sufficient understanding and coverage of emergent behaviour in Sos

03 **Cybersecurity is siloed in traditional SE practices**

Cybersecurity mitigations require now system-wide design changes.

04 **Product Lifecycle has shifted from lasting to evolve**

Traditional methods consider a system that is developed to be delivered and forgotten. Modern systems require a continuous evolution via SW updates, AI learning and operational feedback.

05 **Massive Scale and Data volumes overwhelm manual process**

Complex systems have now thousands of requirements, millions of line of code and multiple versions in operation simultaneously that cannot be managed with manual traceability and testing.

TRANSFORMING SYSTEMS ENGINEERING

01 **From Document Centric to MBSE**

02 **Adoption of Digital Engineering & Twins**

03 **Agile and DevSecOps**

04 **Federated and Collaborative Eng Environments**

05 **There are many more transformation pillars...**

Traditional SE principles	Modern systems Reality
Systems are fully specifiable	Requirements evolve continuously
Systems are isolated and owned	Systems are networked and federated
Integration is a final phase	Integration is continuous and iterative
Testing is verification-focused	Testing must uncover emergent behaviors
Security comes at a later stage	Security is intrinsic to the design choices
Deliverables are documents	Deliverables are living models
Systems are fixed once deployed	Systems must evolve and self-adapt

↗ # Organizational aspects in the transformation of SE

- **SE transformation is a strategic capability** and must be sponsored by the leadership to avoid that the transformation efforts become a siloed "pilot".

- **Cross-functional collaboration is essential** to embed the multiple domains involved: SW, HW, Safety, cybersecurity, IVVQ, operations, etc.

- Organizational structure may need to evolve to break the verticalized departments and have more **integrated teams.**

- Build the transformation upon key **change management principles**: explain the "why", identify and empower champions, upskill the workforce and communicate continuously.

Conclusions

Ever growing complexity has crossed a threshold where **traditional SE practices do no longer suffice**.

Complexity is not just technical; it is dynamic, emergent and systemic.

Transforming SE is not simply about adopting new tools—it's about redefining how complex systems are conceived, designed, built, and evolved. And it must not be understimated.

The **organizations succeeding** are those that combine updated process, digital environment and systems thinking—and back it up with training, leadership, and strategic clarity.

Thank You

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