



33rd Annual **INCOSE**
international symposium
hybrid event
Honolulu HI USA



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Engineering Sustainable Products with Collaborative Multi-Domain Modeling



15-20 July - 2023

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Agenda

- Sustainability landscape and challenges
- Multi-domain collaboration
- Siemens and IBM joint announcement
- Model-based multi-domain collaboration
- Demonstrator
- Software & beyond - Future opportunities
- Q+A

Sustainability as Megatrend

INCOSE Vision 2035
mentions “sustainability”
and related terms 105
times, more than any other
topic area covered in the
document!

INCOSE | *Vision35* | [Introduction](#) | [Chapter One](#) | [Chapter Two](#) | [Chapter Three](#) | [Chapter Four](#) | [Summary](#) | [More](#) | [Contact](#)

GLOBAL MEGATREND 1

ENVIRONMENTAL SUSTAINABILITY BECOMES A HIGH PRIORITY

Consumption of non-renewable resources resulting from economic activity will increasingly require better global management, recycling strategies, sustainable policies, local actions, and supporting systems, such as energy conversion and infrastructure for clean transportation and manufacturing.

Environmental change will result in shifts in living conditions, and impacts bio-diversity, climate, global heat transport, the availability of fresh water, and other natural resources necessary for human sustenance and well-being.

Overall environmental quality will be a priority, requiring global cooperation. The trend toward greater concern for environmental sustainability will result in several key societal and system imperatives.

Engineering for sustainability, a system characteristic, will create a new generation of engineers who routinely assess the societal impacts of engineered systems.

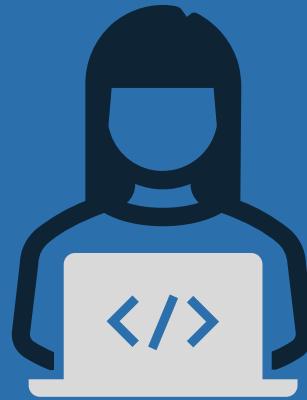


The diagram illustrates the Circular Economy process. It starts with 'Primary Resources' (Exploration, Mining, Processing, Raw Materials) which feed into 'Design' (Substitution of Non-Renewable Resources). 'Design' leads to 'Production' (Use, Reuse). 'Production' leads to 'Collection' (Collection, Recycling). 'Collection' leads back to 'Design'. Arrows indicate a continuous flow between these stages, with recycling and reuse at the center.

Society will place great importance on reuse, giving rise to Circular Economies.

Engineering Sustainable Systems & Products

Systems Engineering Challenges



Sustainability characteristics

Compliance and reporting

Multi-discipline collaboration

Full lifecycle



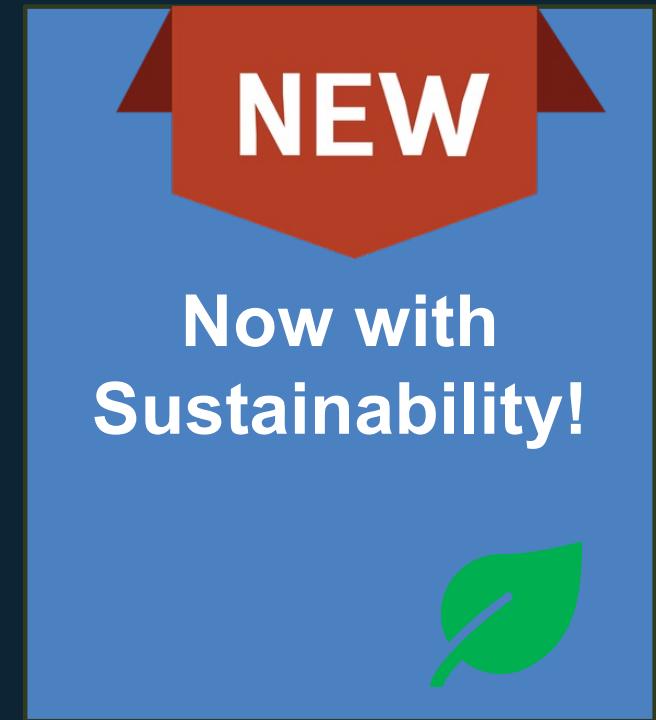
Sustainability as a Design Goal

Sustainability characteristics as design goals are not new

- Examples: mileage, materials, emissions, etc

What is new?

- holistic system focus
- core engineering competency
- multi-disciplinary collaboration
- regulatory compliance
- supply chain reporting
- full lifecycle impact
- software as sustainability tool



Sustainability Regulatory Impact

Understanding Scope 1, 2 and 3

- First appeared in the Green House Gas Protocol of 2001
- The basis for mandatory GHG reporting in many countries
- **Scope 1 emissions**— Green House Gas (GHG) emissions that a company makes directly in operation (e.g., heating)
- **Scope 2 emissions** — These are the emissions it makes indirectly – like the energy it buys for heating and cooling buildings,
- **Scope 3 emissions** — All the emissions that the organisation is indirectly responsible for, from components provided by suppliers to final product in use by customers
- Mandatory scope 3 reporting is likely in multiple countries
- Scope 3 reporting includes **supply chain** impacts (e.g., GHG contribution for each supplied component)



Product-Specific Sustainability Reporting

Corporate level ESG report



Emissions Covered by IBM's Fifth-Generation Goal (Metric Tons of CO ₂ -equivalent)					
	2018	2019	2020	2021	2022
Scope 1 (direct emissions)*	105,000	100,000	74,000	79,000	79,000
Scope 2 market-based (indirect emissions)**	505,000	460,000	262,000	221,000	183,000
Scope 3 (indirect emissions)*	252,000	251,000	234,000	176,000	169,000
Total emissions covered by IBM's current goal	862,000	811,000	570,000	476,000	431,000
Reduction of GHG emissions against base year 2010	26.6%	31.0%	51.5%	59.5%	63.3%

*Emissions associated with IBM's use of fuels for building operations and transportation, as well as from the use of refrigerants and chemicals with a global warming potential.

**Emissions from IBM's use of electricity, cooling, heat and steam at IBM-managed locations, accounting for our purchases of renewable electricity.

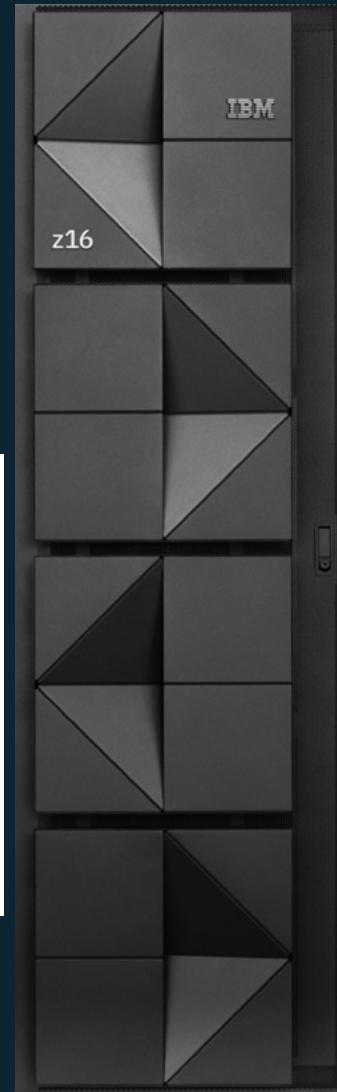
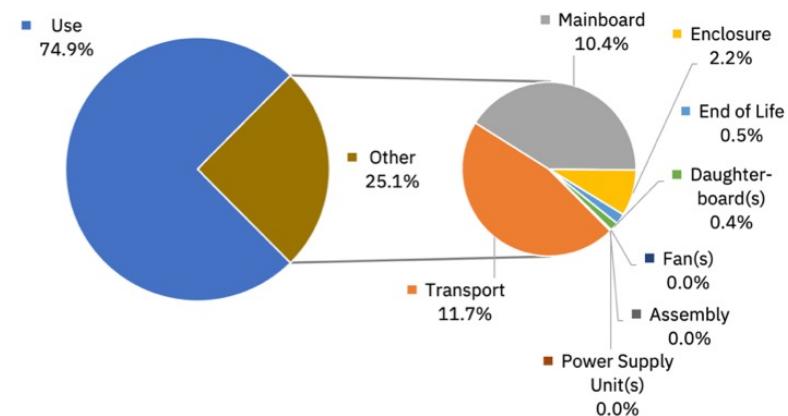
*Includes only those emissions associated with the generation of electricity consumed by IBM's data centers located in third-party managed facilities.

IBM 2022 ESG Report: https://www.ibm.com/impact/files/reports-policies/2022/IBM_2022_ESG_Report_and_Addendum.pdf

Product level ESG report

IBM z16™ multi frame

Product Carbon Footprint



→Moving from Corporate to Product- Specific Sustainability Reports

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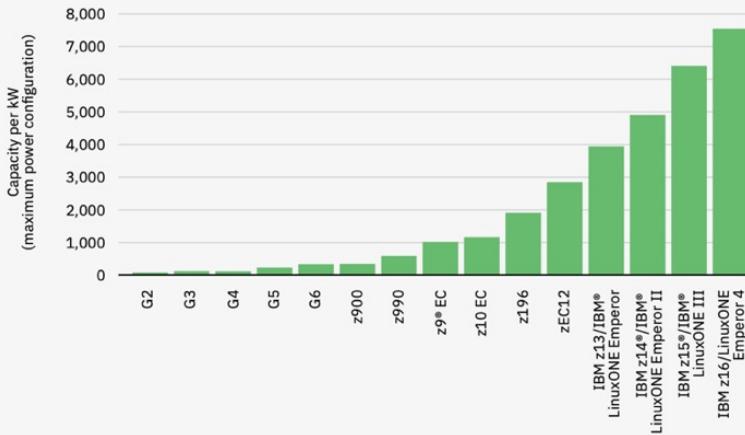
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Goals and KPIs

*IBM Z16 Goal:
+15% improvement in
capacity per KW*

- Identifying sustainability related product objectives and measurements is an essential first step
- Understanding how to calculate, track and report over time
- **Continuous improvement** shouldn't stop at the factory door

IBM zSystems and LinuxONE Improved System Capacity per Kilowatt



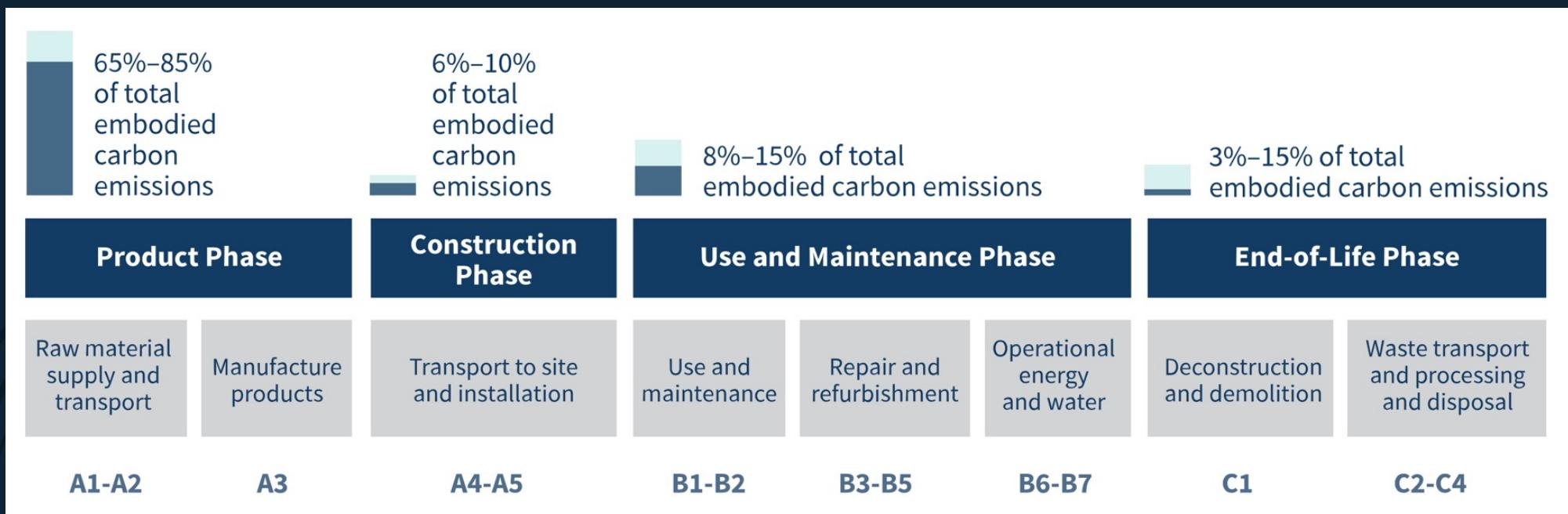
DISCLAIMER:

System capacity based on the LSPR data available [here](#).

Power consumption published in the IBM 8561 Installation Manual for Physical Planning, available [here](#) and the IBM 3931 Installation Manual for Physical Planning available [here](#). To allow a consistent, historical comparison to previous generations, only single thread based, general-purpose MIPS are used. All the systems are externally air cooled. Uses worst-case power conditions with the absolute maximum system power configuration at the maximum utilization and for the system environment driven maximum power condition which occurs at the hottest supported system air inlet temperature (40°C/104°F), at the highest supported altitude (914 meters/3,000 feet) allowed for the maximum allowable temperature (above this altitude an inlet temperature derating is required). Results may vary.

Total Lifecycle Measurement

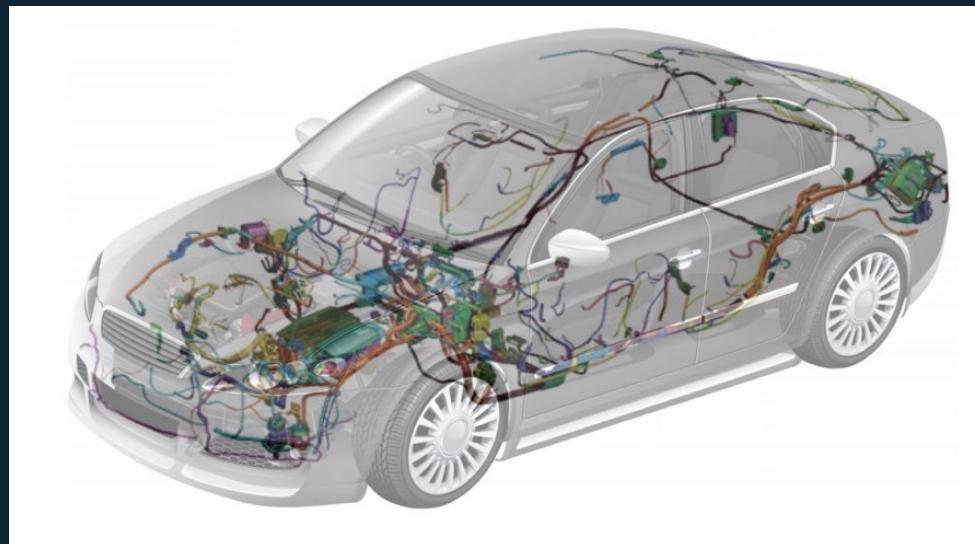
Embodyed Carbon Emissions



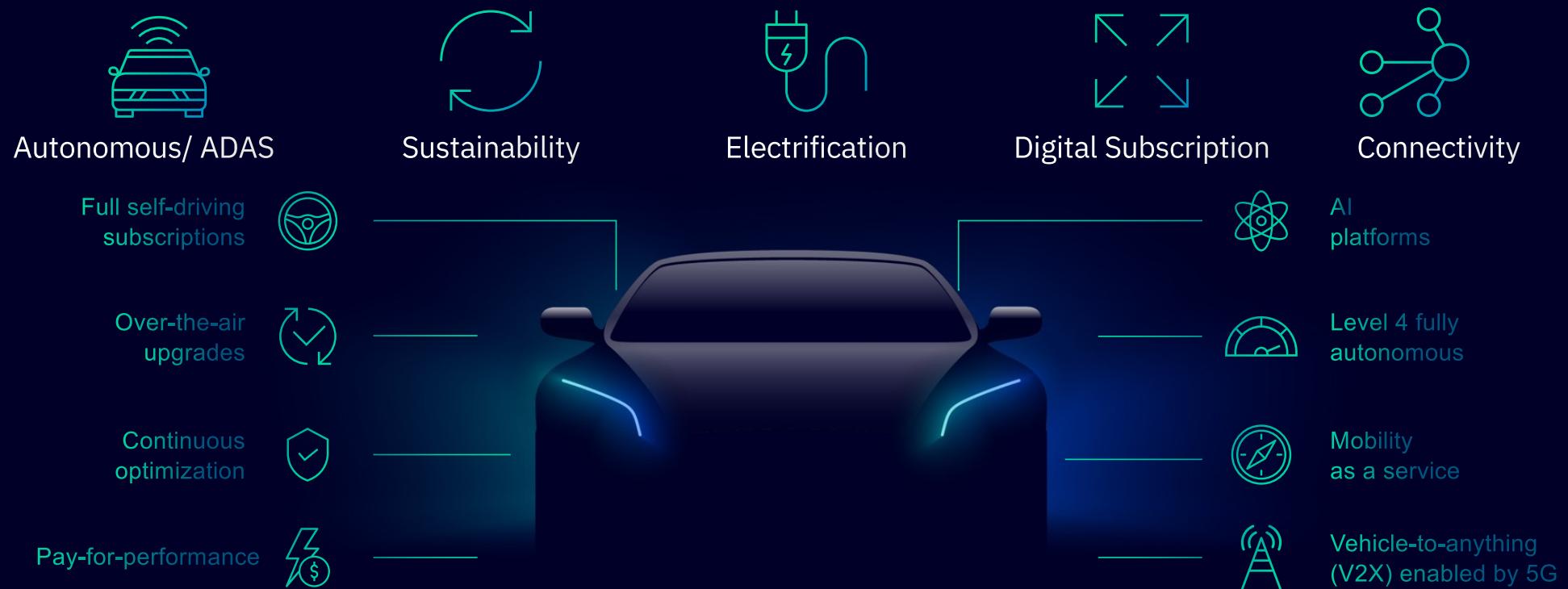
Source: RMI (<https://rmi.org/wp-content/uploads/2023/03/exhibit-6-embodied-carbon-life-cycle-assessment-phases.svg>)

Example: Lower Vehicle Carbon Footprint

- Reducing weight is one of the most direct ways to lower carbon footprint
- 10kg reduction in weight = 20kg of CO2 emission per vehicle (avg) per year (at 20.000 km driven)
- x 500,000 vehicles = 10M KG CO₂ savings
- Wiring harness in modern vehicle can weigh 70kg
- Changing connectivity and moving to thinner/lighter wires can reduce harness weight significantly, but
 - every electrical change impacts mechanical, electronics and software
 - requires close collaboration across system, mechanical, E/E & software domains

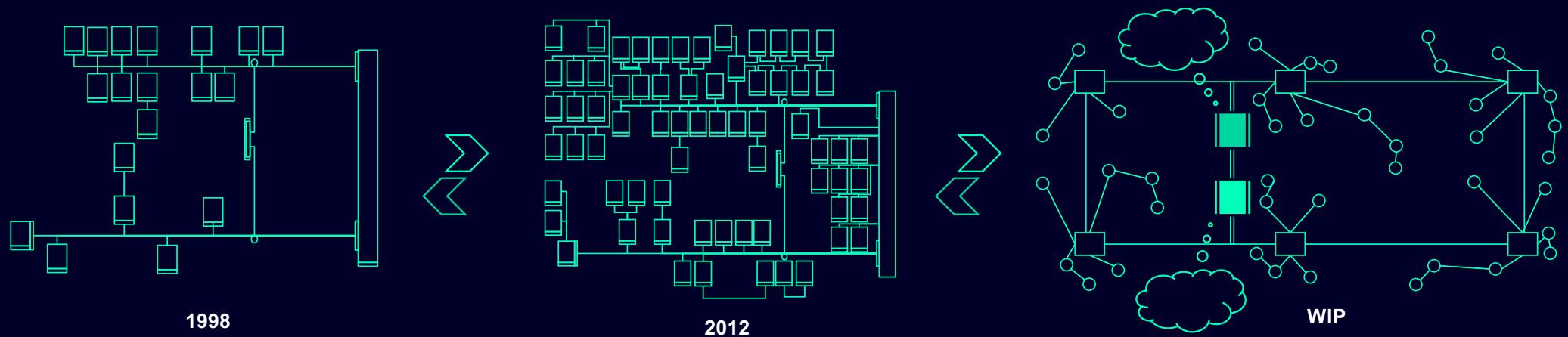


Software as Sustainability Enabler

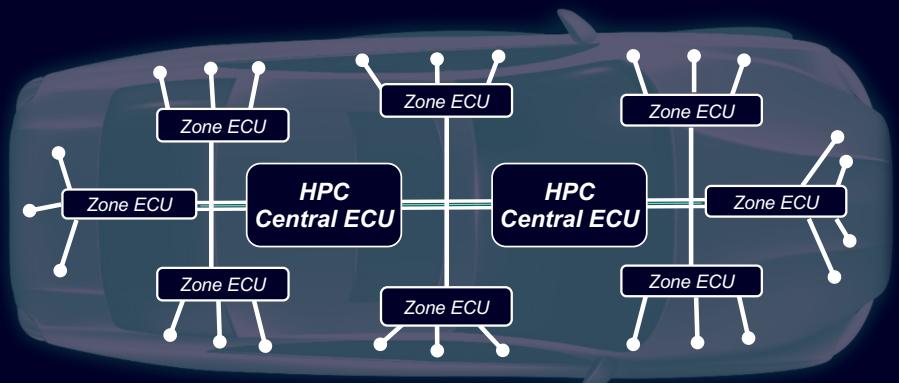
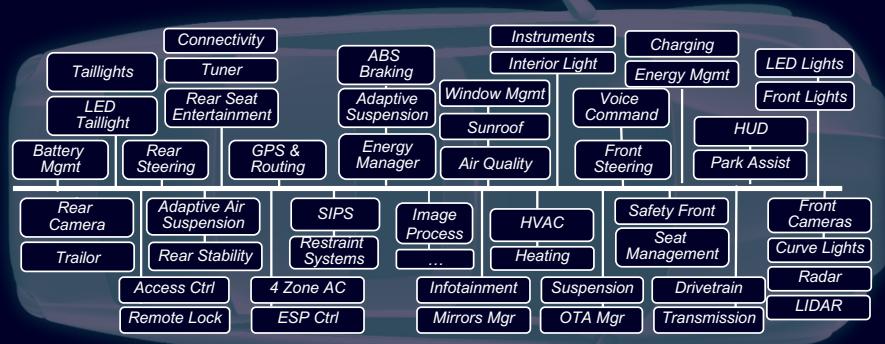


“Software will account for **90%** of future innovations in the car”

E/E architecture **revolution**

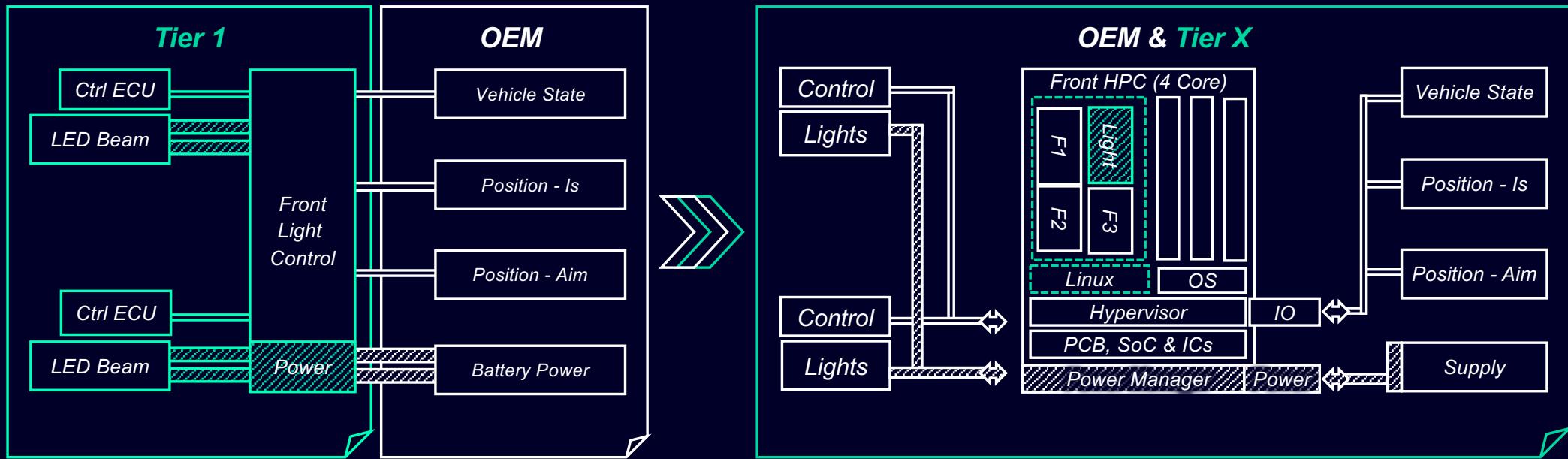
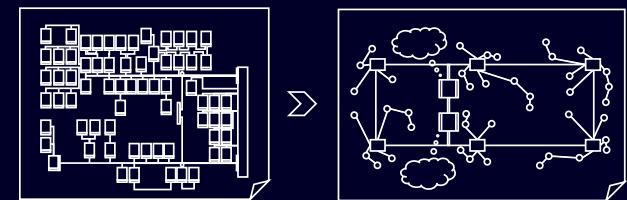


E/E architecture revolution

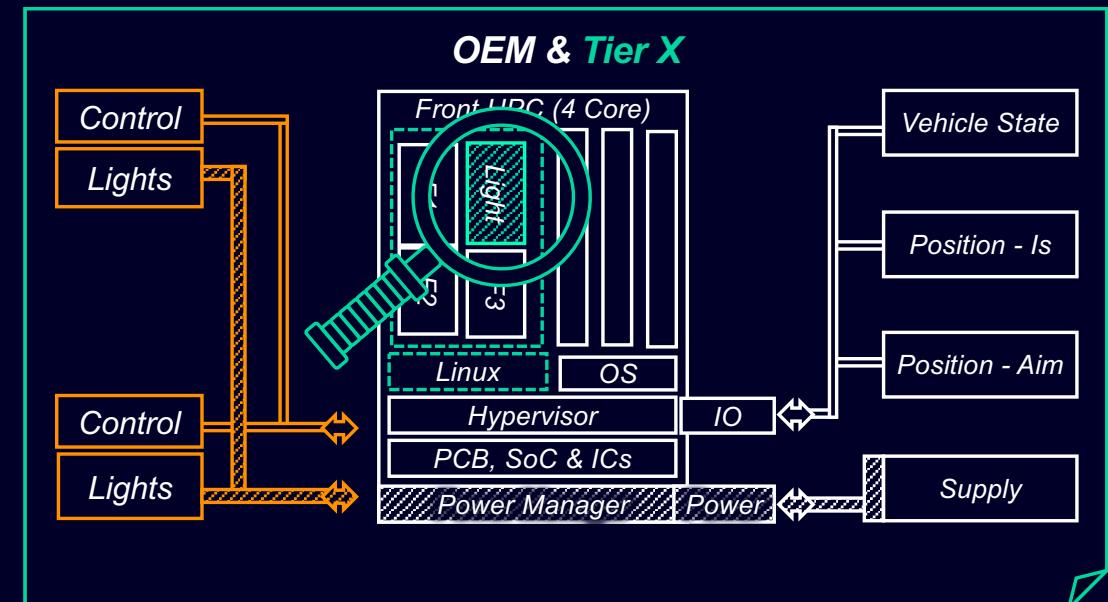
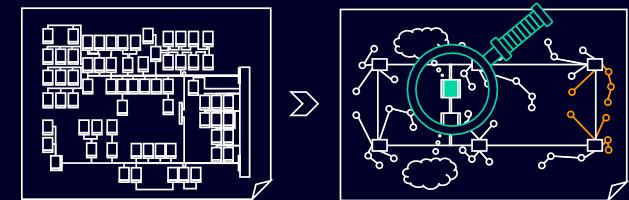


Function consolidation

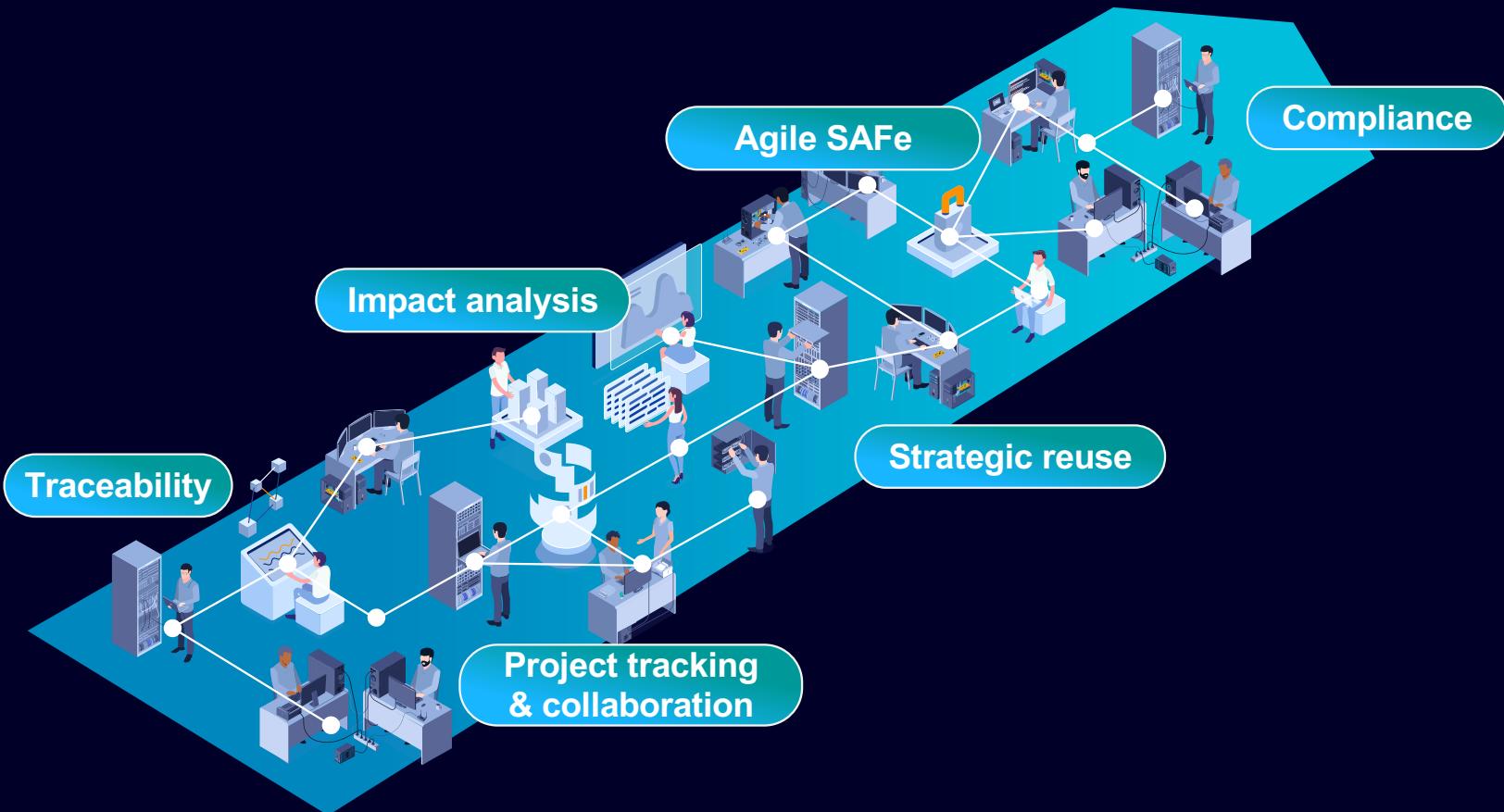
Function **consolidation** - driven & enabled by SDV



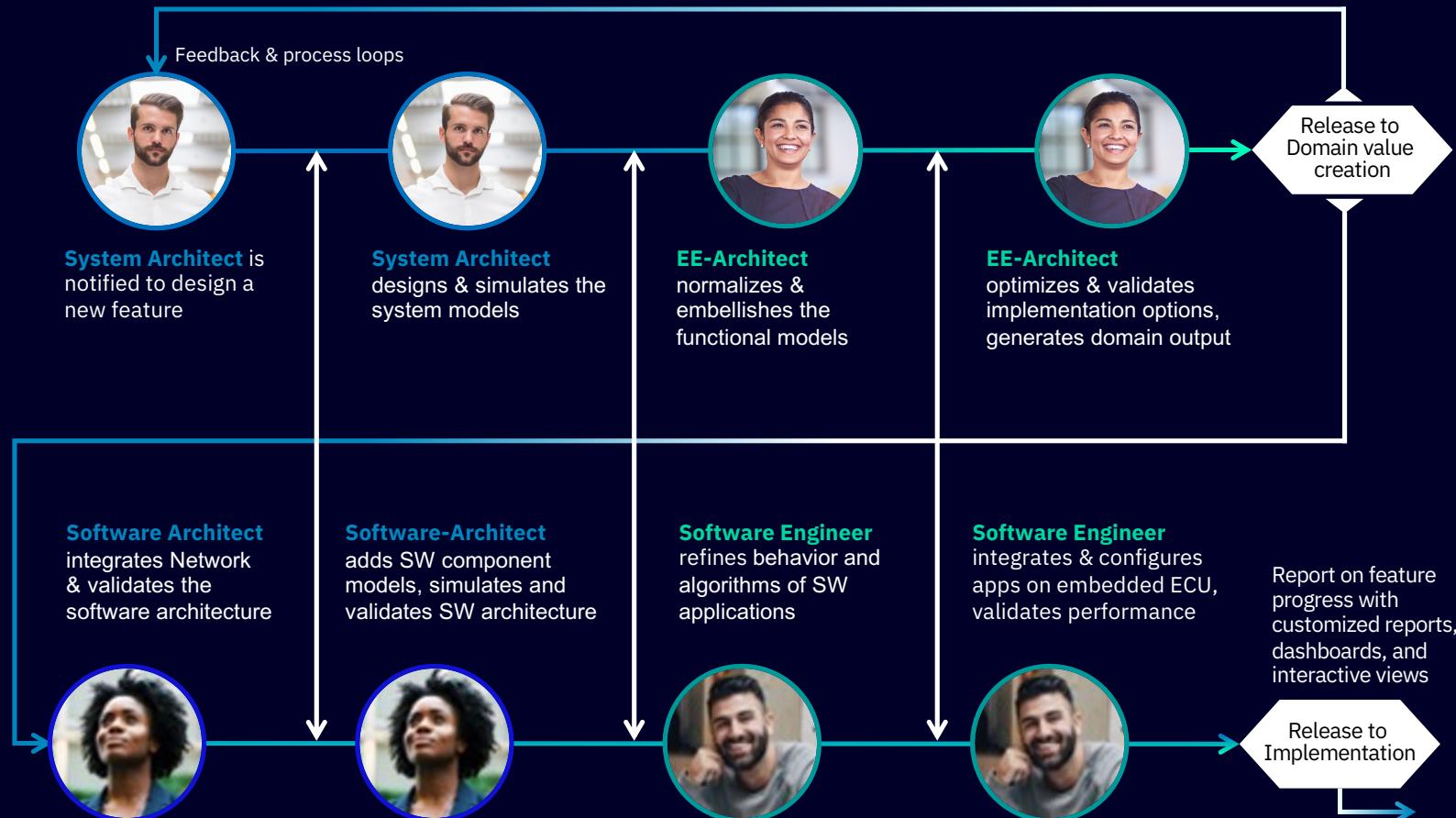
SDV driven changes in OEM & Supplier integration



The IBM-Siemens partnership helps to break down silos and creates a comprehensive digital thread



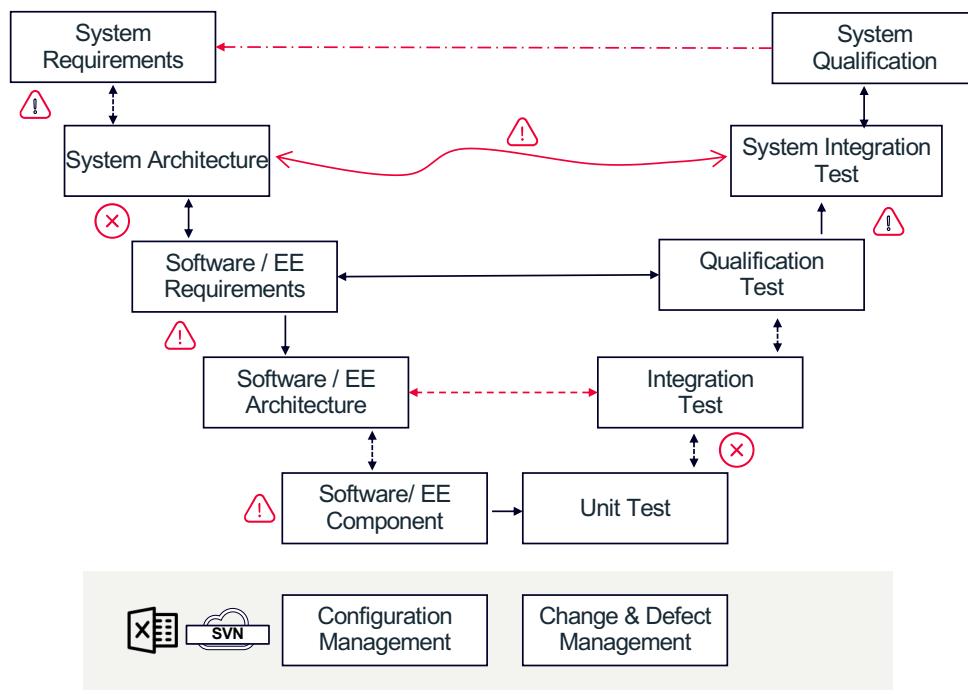
Engineering teams succeed when they collaborate across functional domains



Modern engineering processes require an actionable digital thread connecting all engineering domains

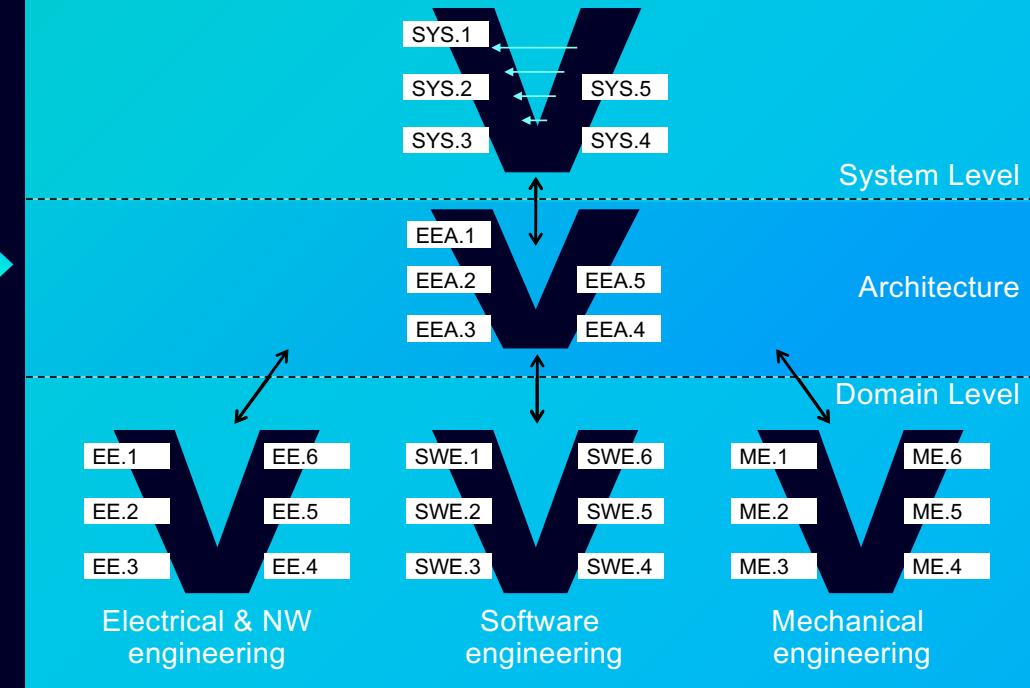
CURRENT

- Only covers one domain
- Even within the domain it is disconnected



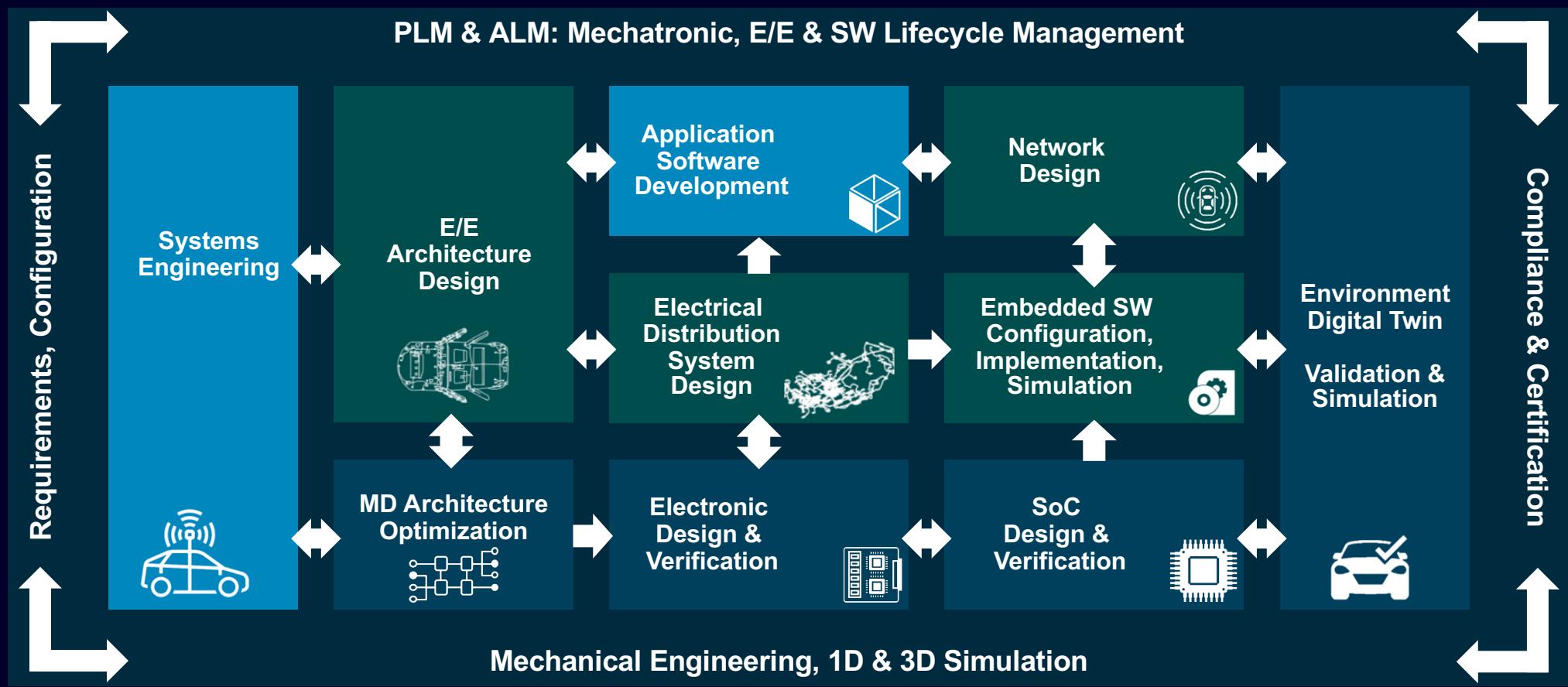
FUTURE

- Connections are needed between domains
- Teams need collaboration, ability to track progress across multiple tools and stream-lined compliance/ regulatory reporting



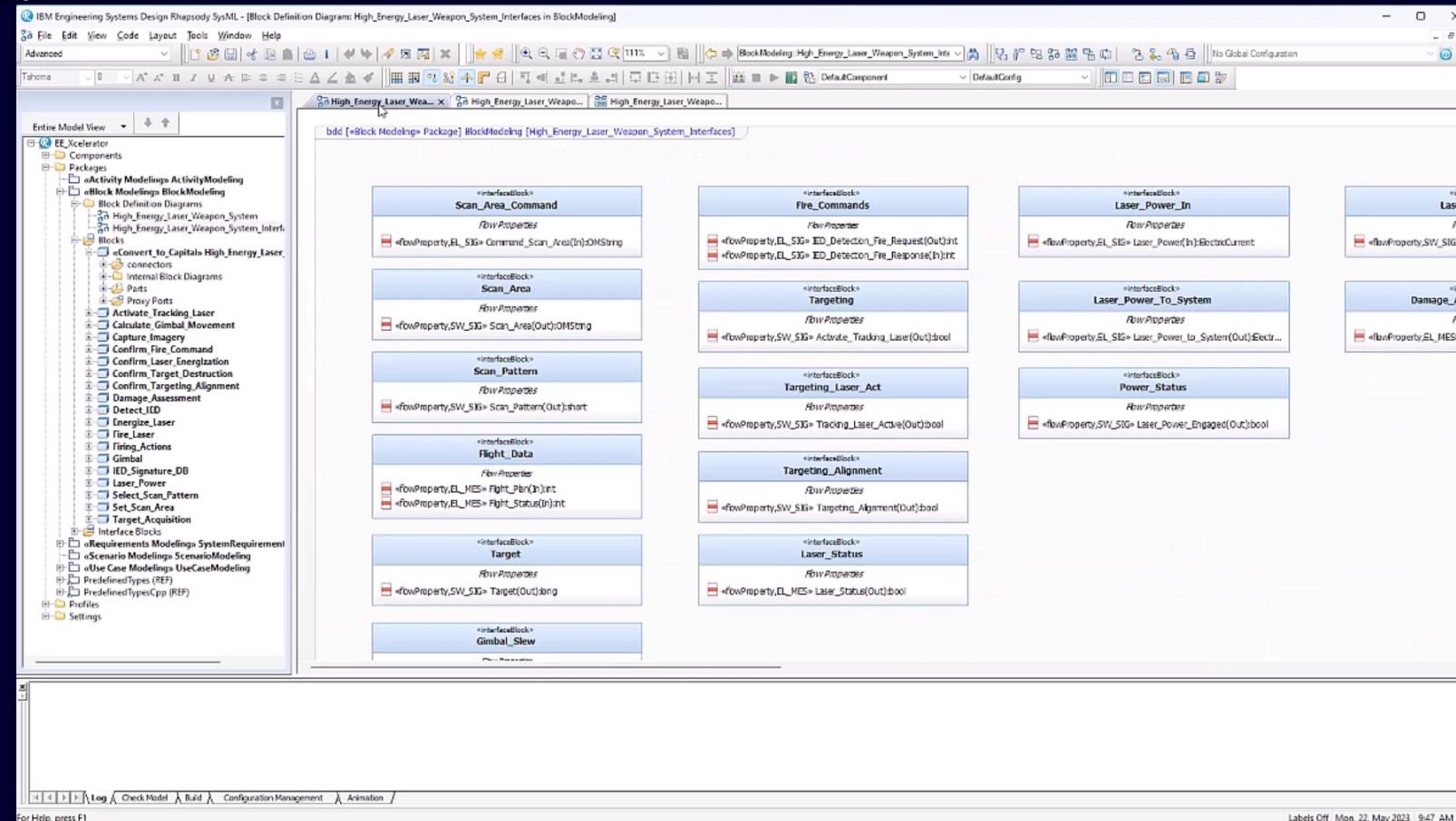
Model Based Design – Systems, E/E, Software, Compliance

PLM and ALM underpin seamless, open, closed loop engineering flow



From multi-domain to E/E domain Transform Systems into E/E

 E/E architect

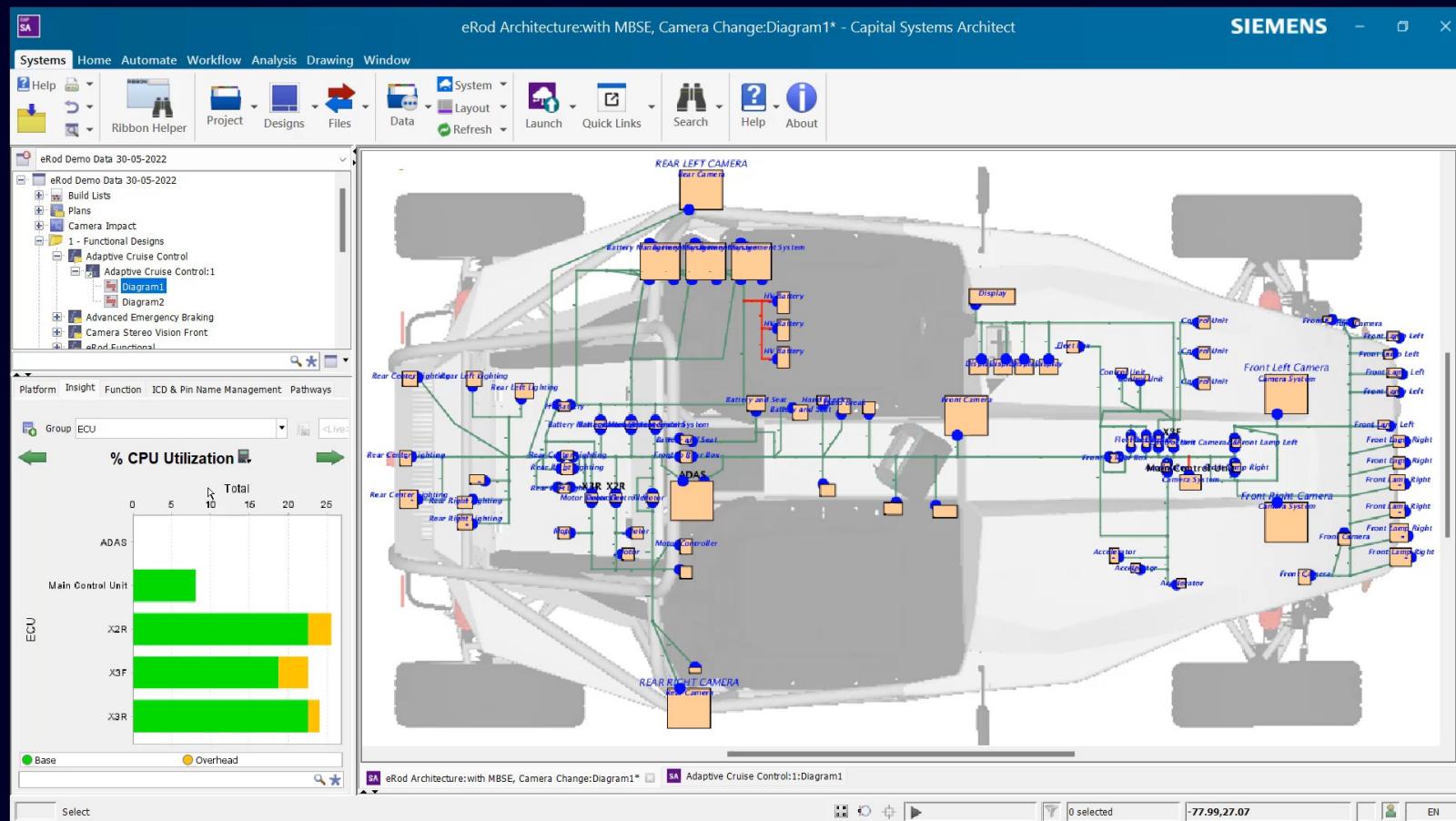


SysML systems modeling - Internal Block Diagram (IBD)

From multi-domain to E/E domain

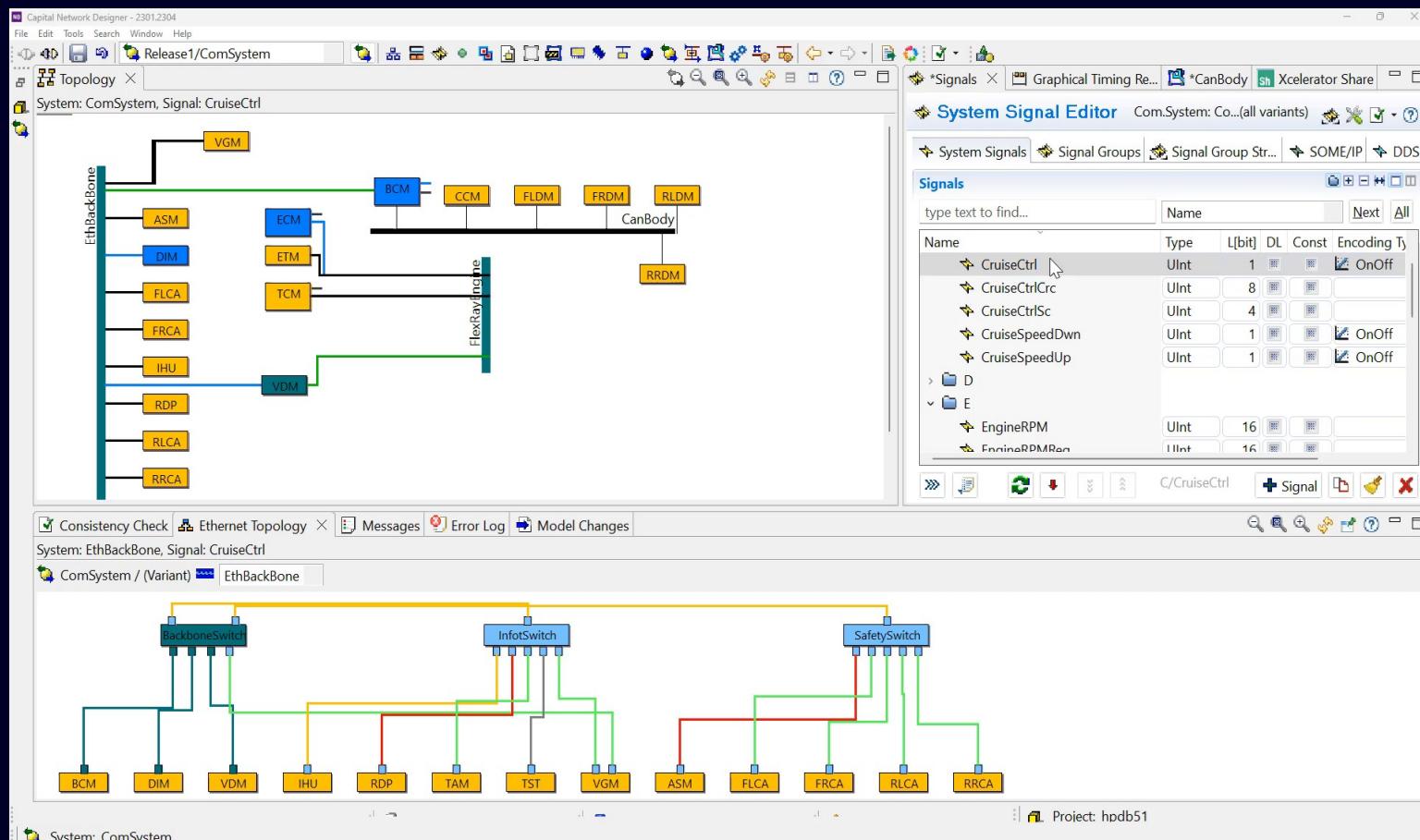
Optimize E/E Architecture

 E/E architect

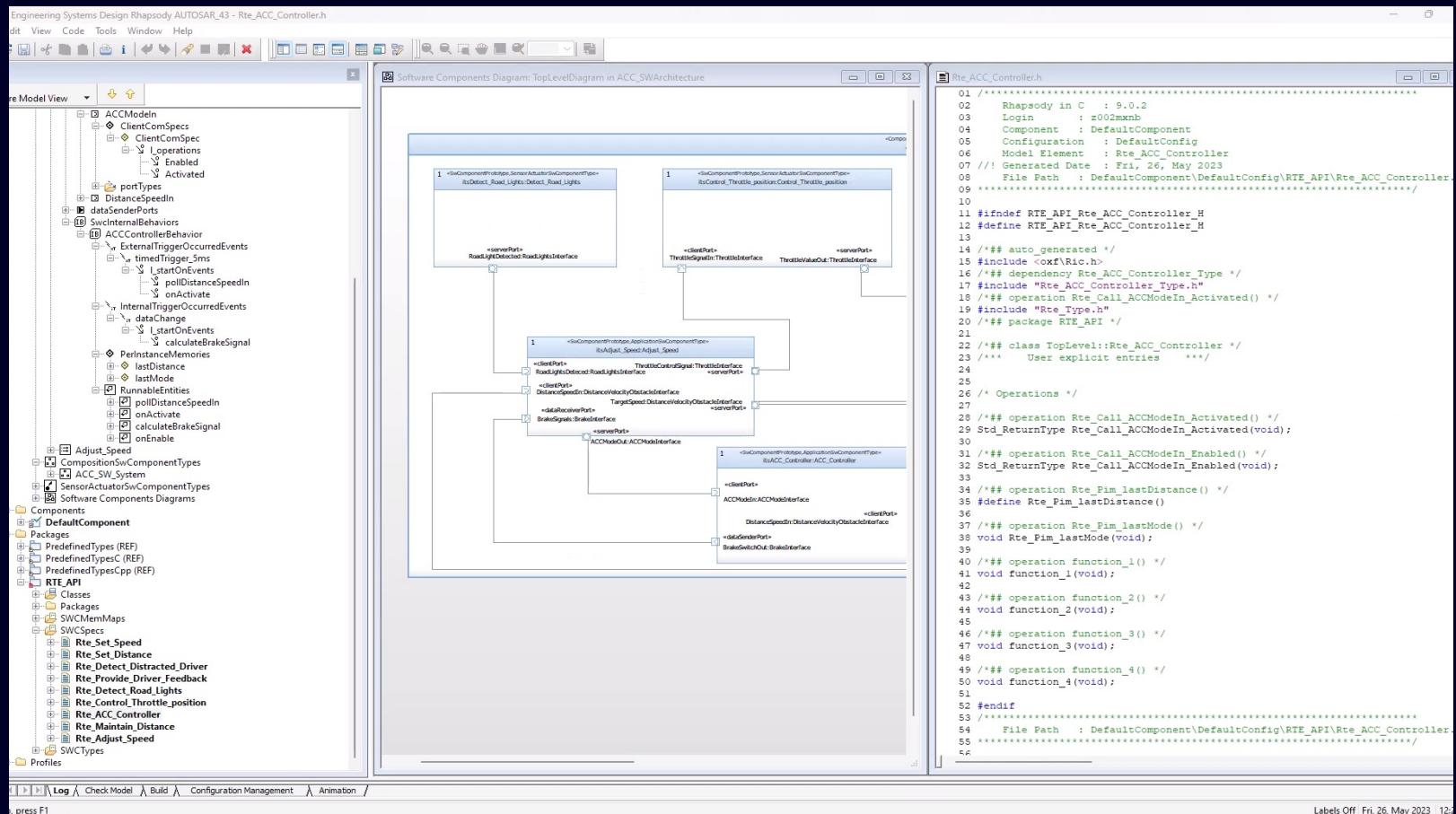


From multi-domain to E/E domain

Rapid design of validated and correct networks



From multi-domain to E/E domain Model-Driven software architecture on rails

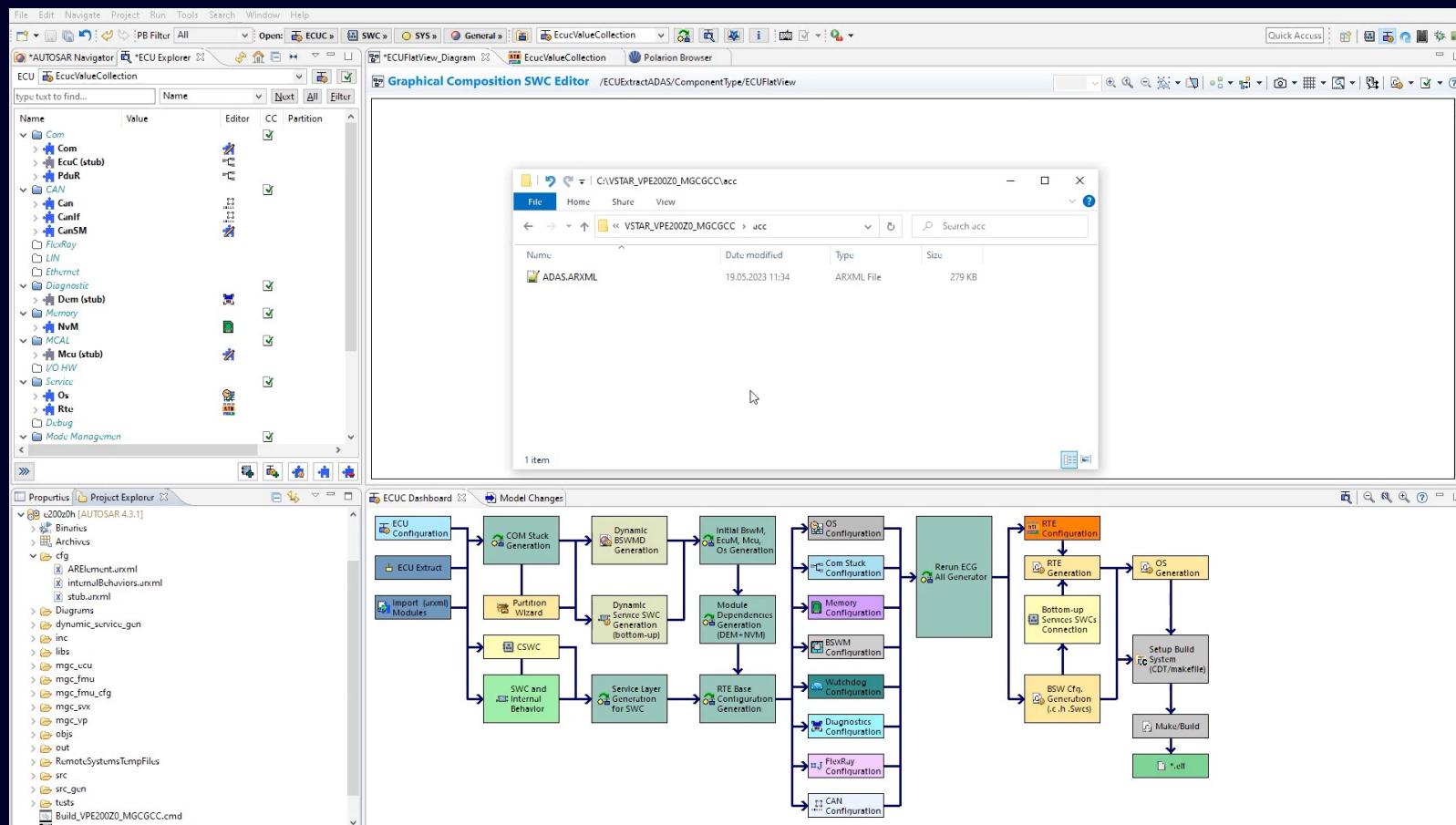


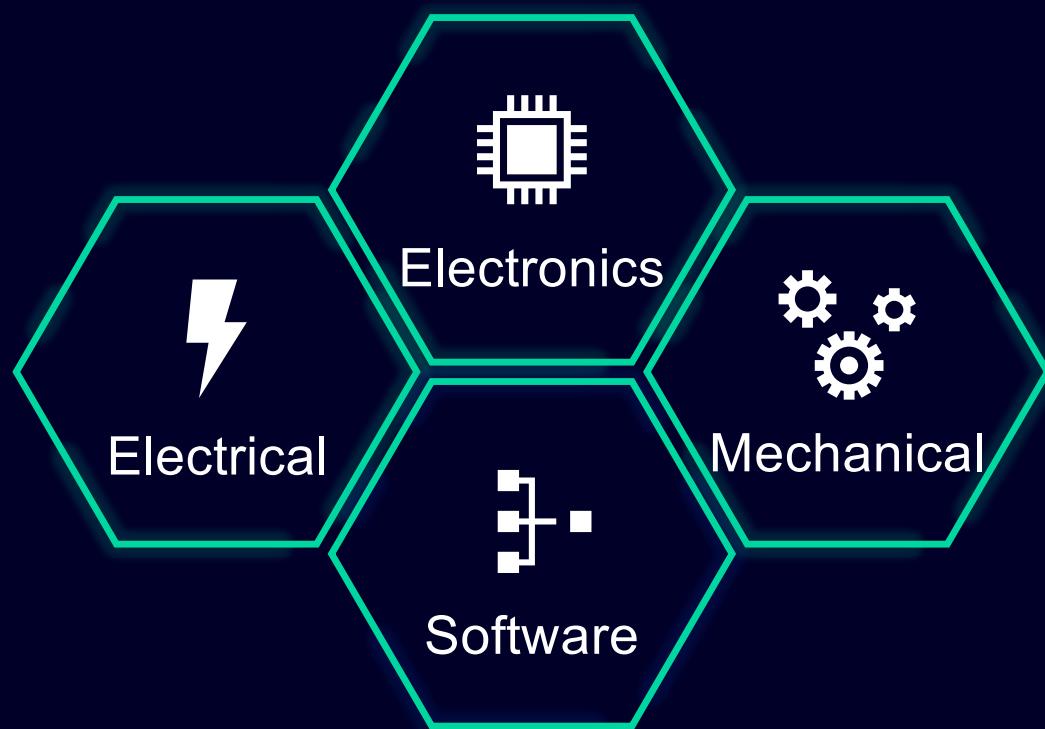
From multi-domain to E/E domain

Integrated software configuration & validation



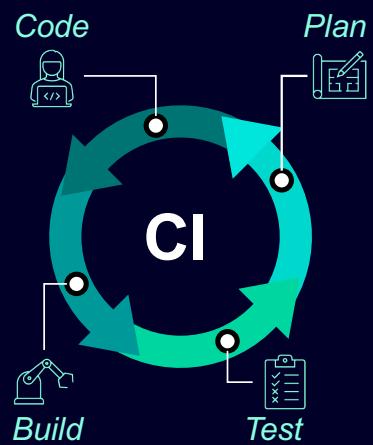
Software
implementer





The path to CI / CD / CC

Continuous integration

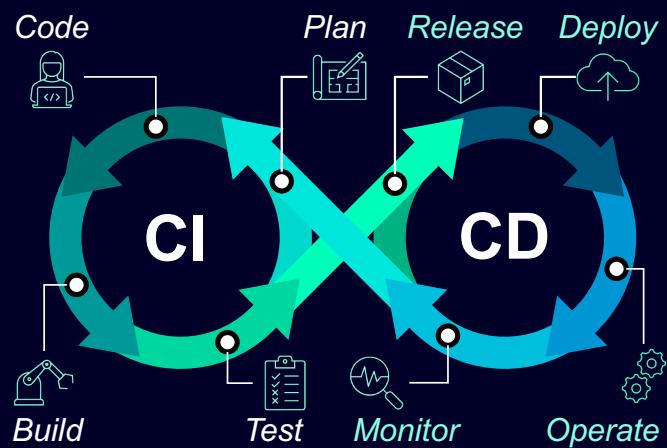


Continuous software integration

- Iteratively develop tested applications
- Continuous Application SW integration
- Plan and requirements driven throughout

The path to CI / CD / CC

Continuous integration, continuous delivery

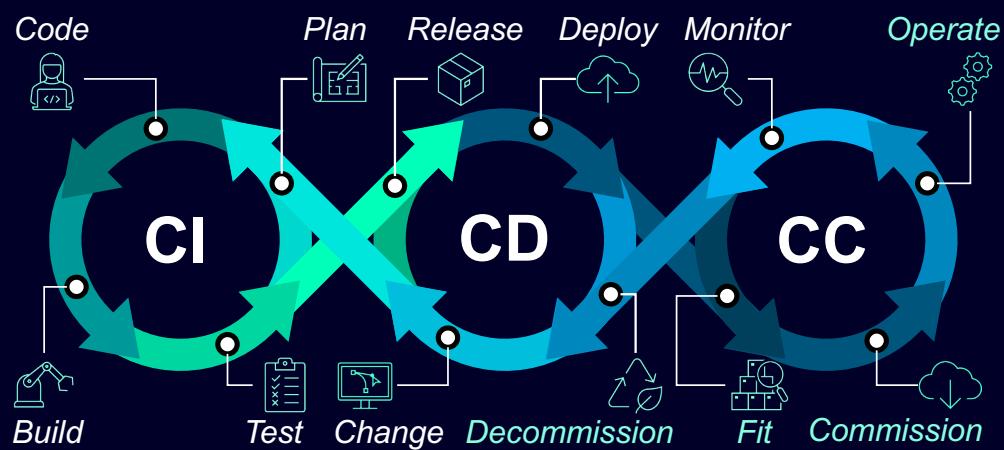


Continuous delivery of verified software

- Automated integration, build pipeline
- Rapidly deploy validated applications
- Requirements traceability throughout

The path to CI / CD / CC

Continuous integration, continuous delivery, continuous commissioning

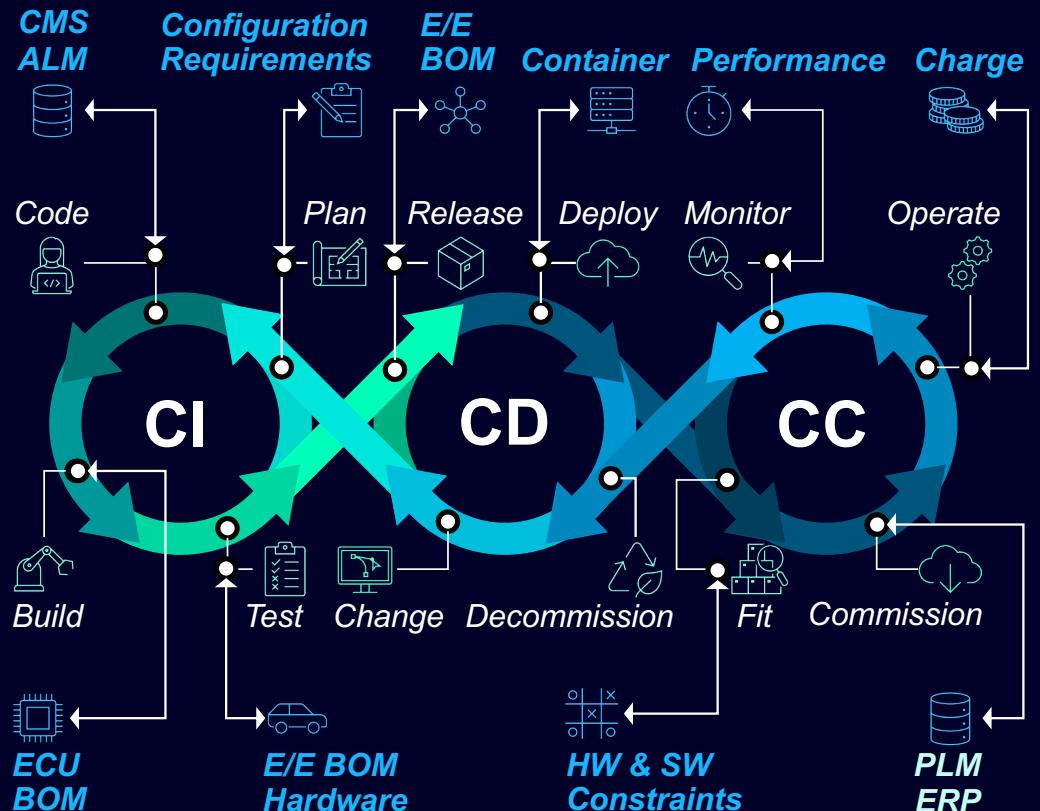


Continuous Commissioning

- Capability compatible vehicle record & timeline
- SaaS enabled through OTA deployment & order fulfilment
- Automate decommissioning, monitoring, charging, change

CI / CD / CC integrated: Enabling the software warehouse

Continuous integration, continuous delivery, continuous commissioning

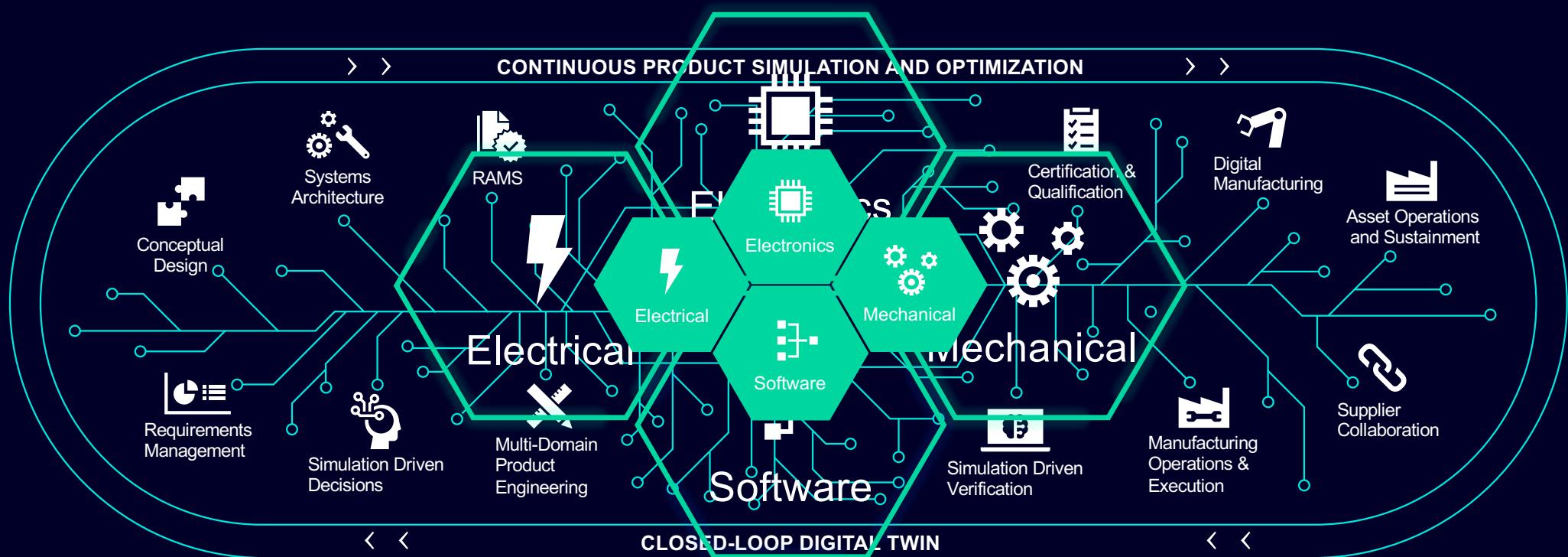


Continuous Commissioning

- Capability compatible vehicle record & timeline
- SaaS enabled through OTA deployment & order fulfilment
- Automate decommissioning, monitoring, charging, change

Multi-domain E/E systems architecture

Start integrated. Stay integrated.- Multi domain, multi discipline, full lifecycle



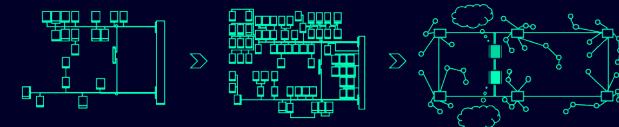
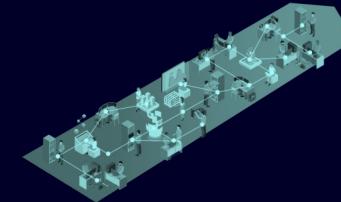
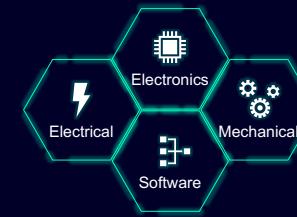
Conclusion

Software & beyond

IBM & Siemens for sustainability

E/E architecture

Sustainability paradigm shift





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