AUTOMOTIVE CPS ARCHITECTURE

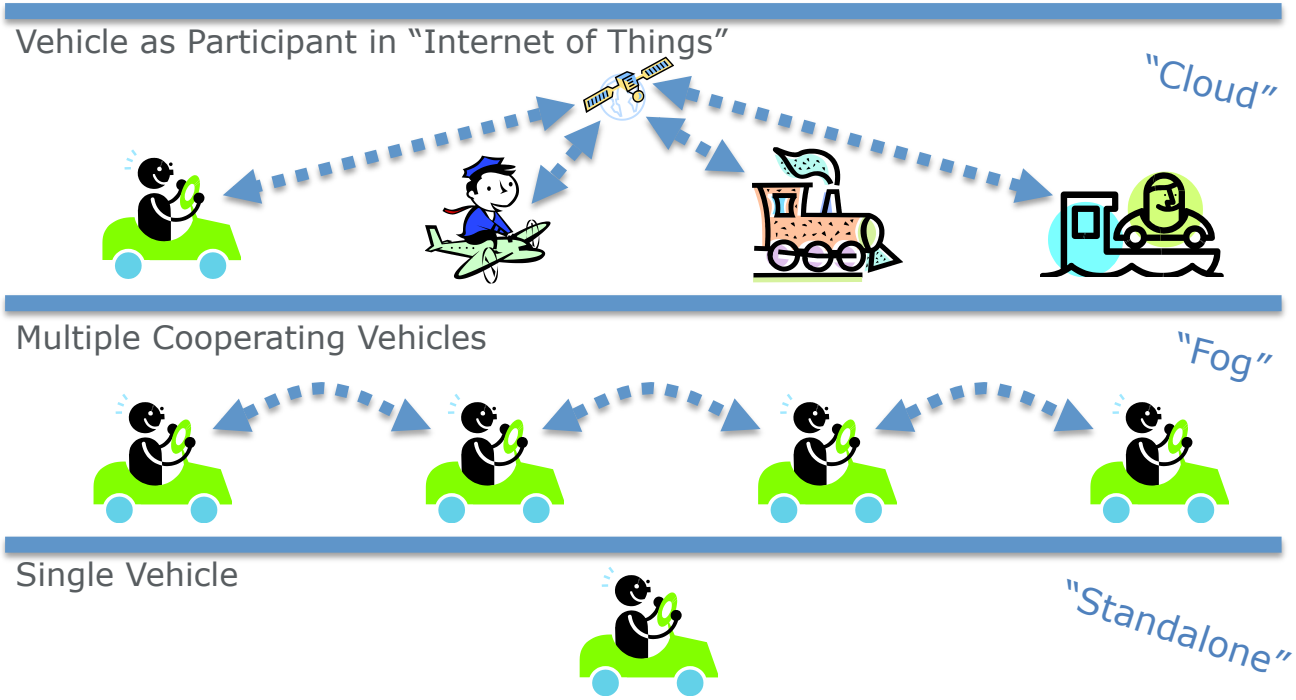
Tom Fuhrman
GM R&D

NSF CPS Reference Architecture Workshop
March 26, 2014

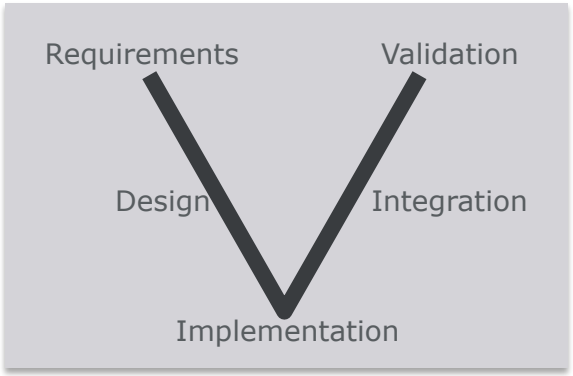
AUTOMOBILE INDUSTRY CHALLENGES

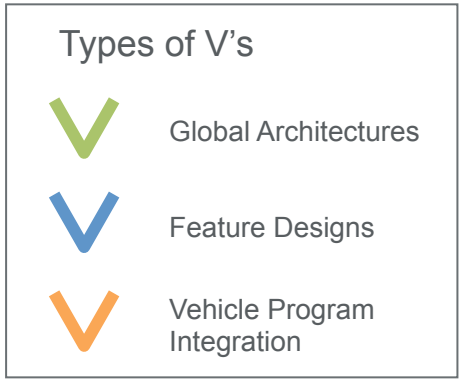
Challenges	Stretch Goals	Required Technologies Enablers/Inventions
Energy	High-efficiency vehicles using low-cost renewable energy	■ Bio/alternative fuels ■ Propulsion efficiencies ■ Light weighting ■ Aerodynamics ■ Tire rolling resistance ■ Electrification
Emissions	No tailpipe environmental impact	
Safety	Vehicles that don't crash Autonomous driving	■ Electronics, Controls, Software & Networks ■ 360° sensors ■ GPS + digital maps ■ Vehicle Connectivity ■ High Computation
Congestion	Congestion-free routing Megacity parking	
Affordability	"Personal mobility for every purse and purpose"	■ Manufacturing & vehicle system/component cost

THE BIG PICTURE – LAYERS OF ABSTRACTION

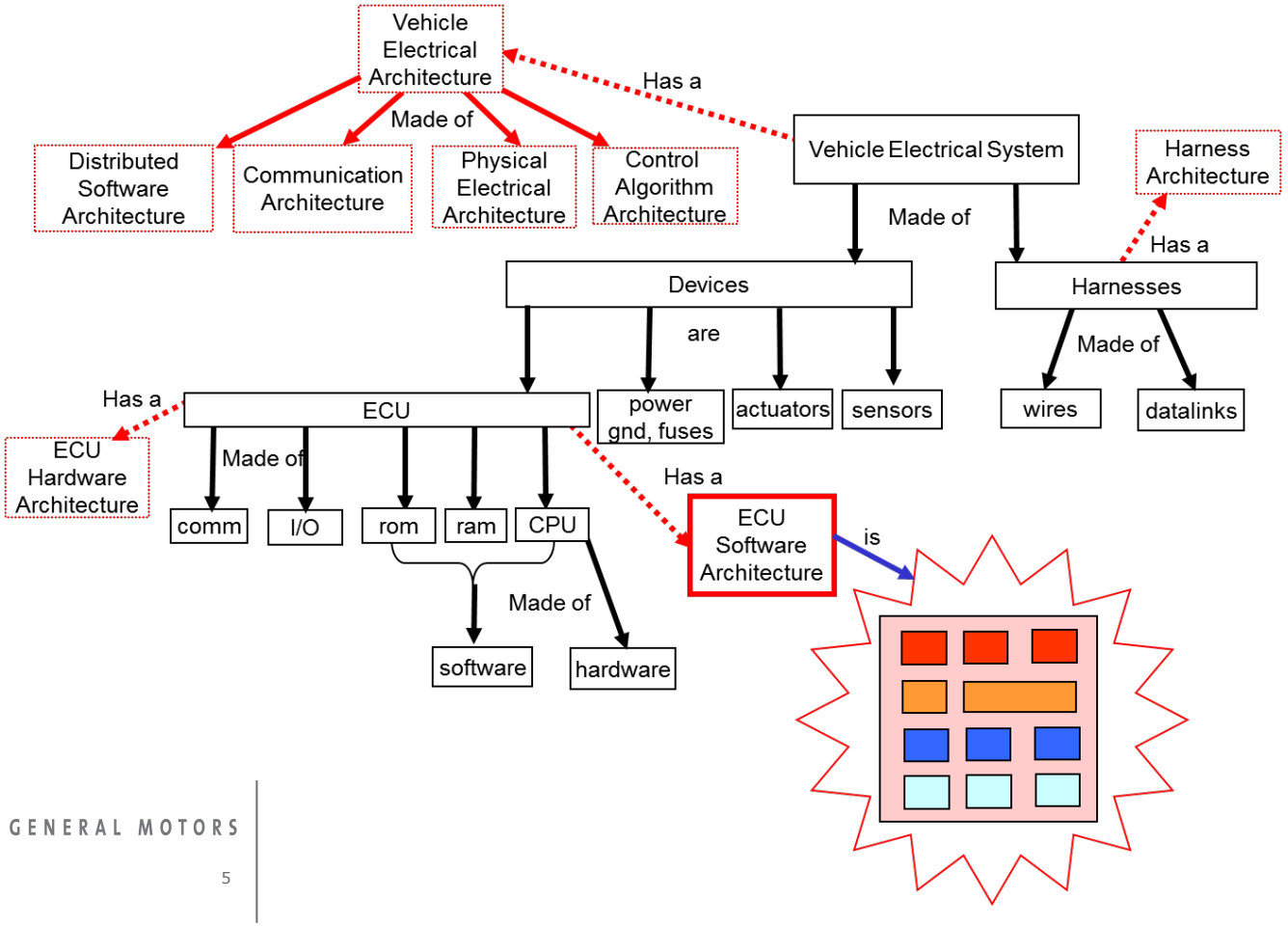


LIFECYCLES OF ARCHITECTURES

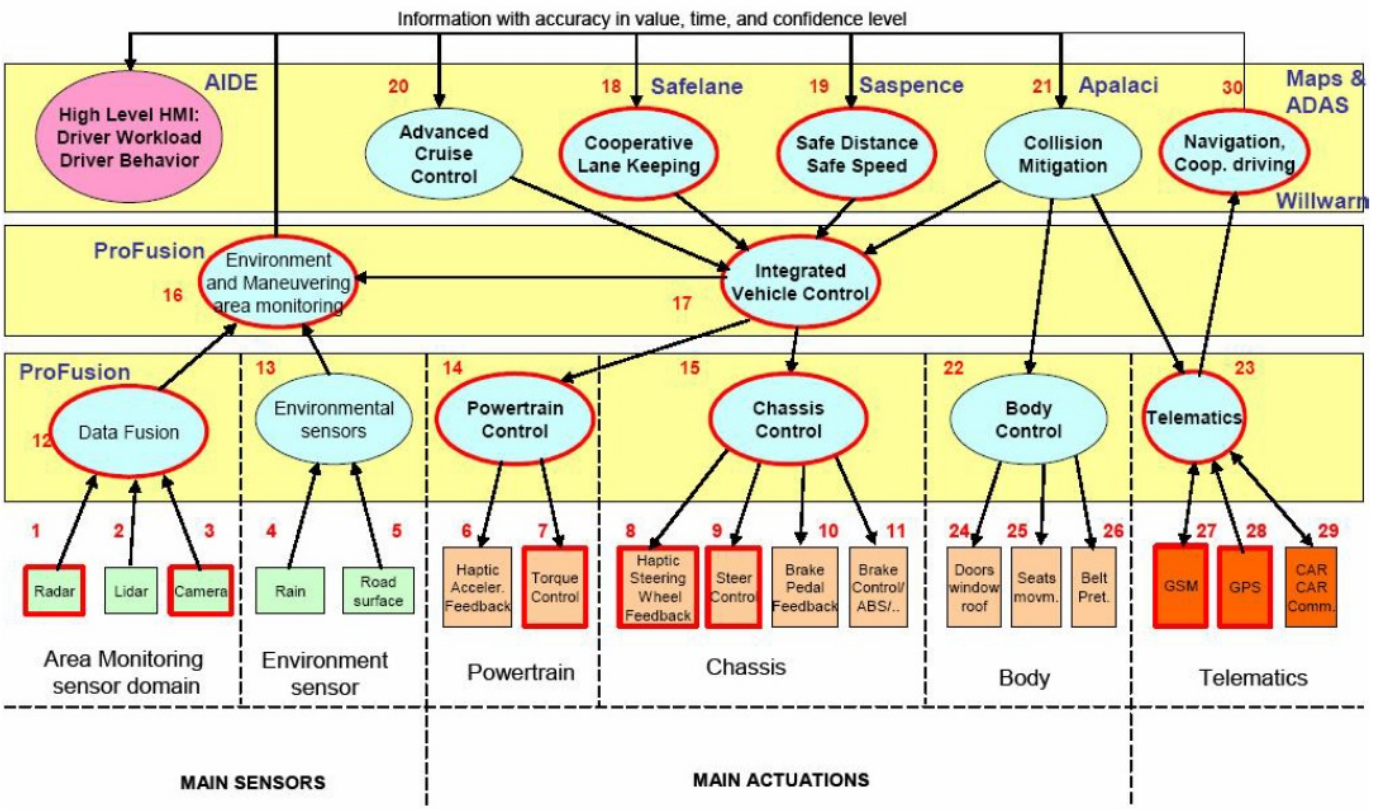




INTER-RELATIONSHIPS BETWEEN ARCHITECTURES

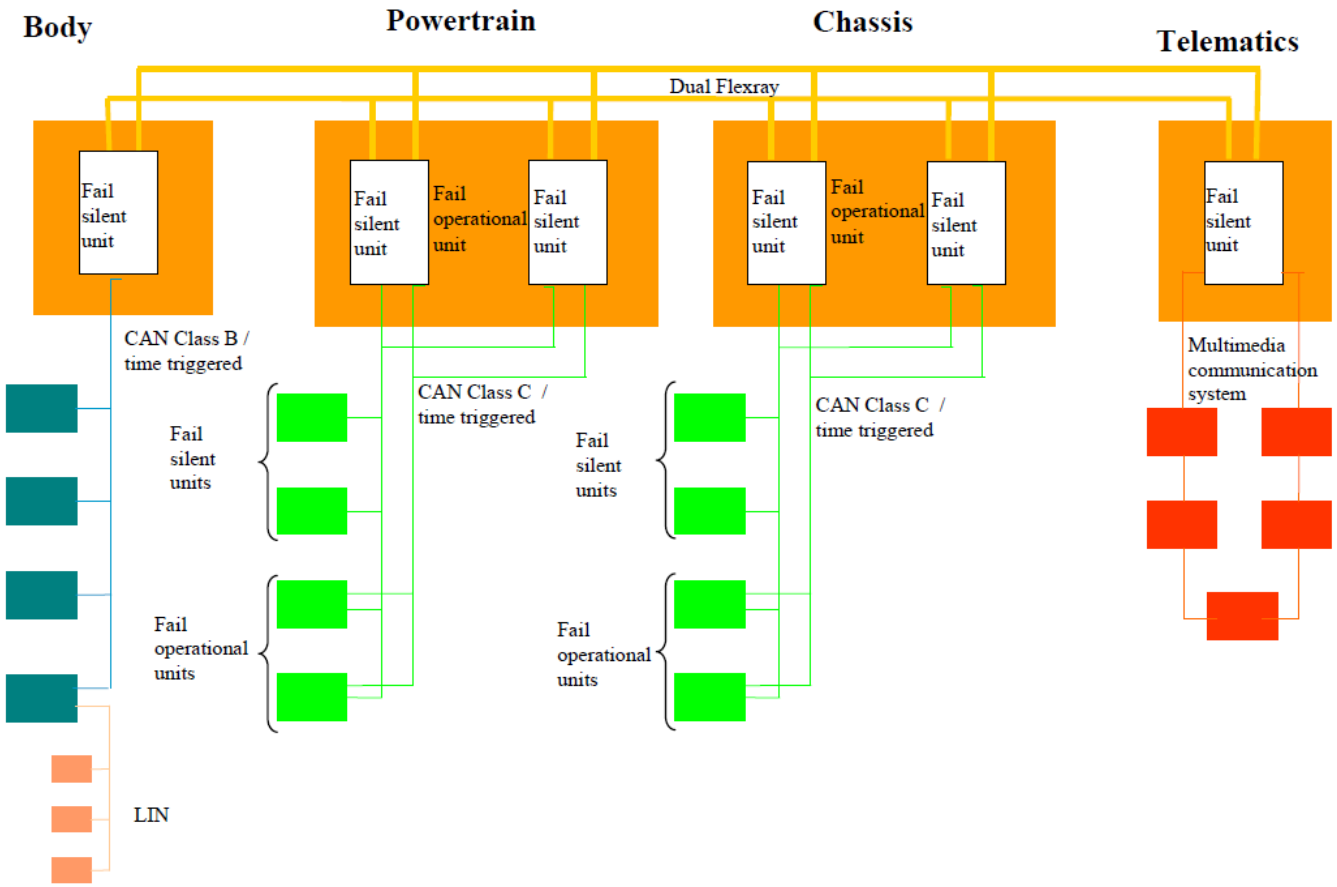


FUNCTIONAL ARCHITECTURE



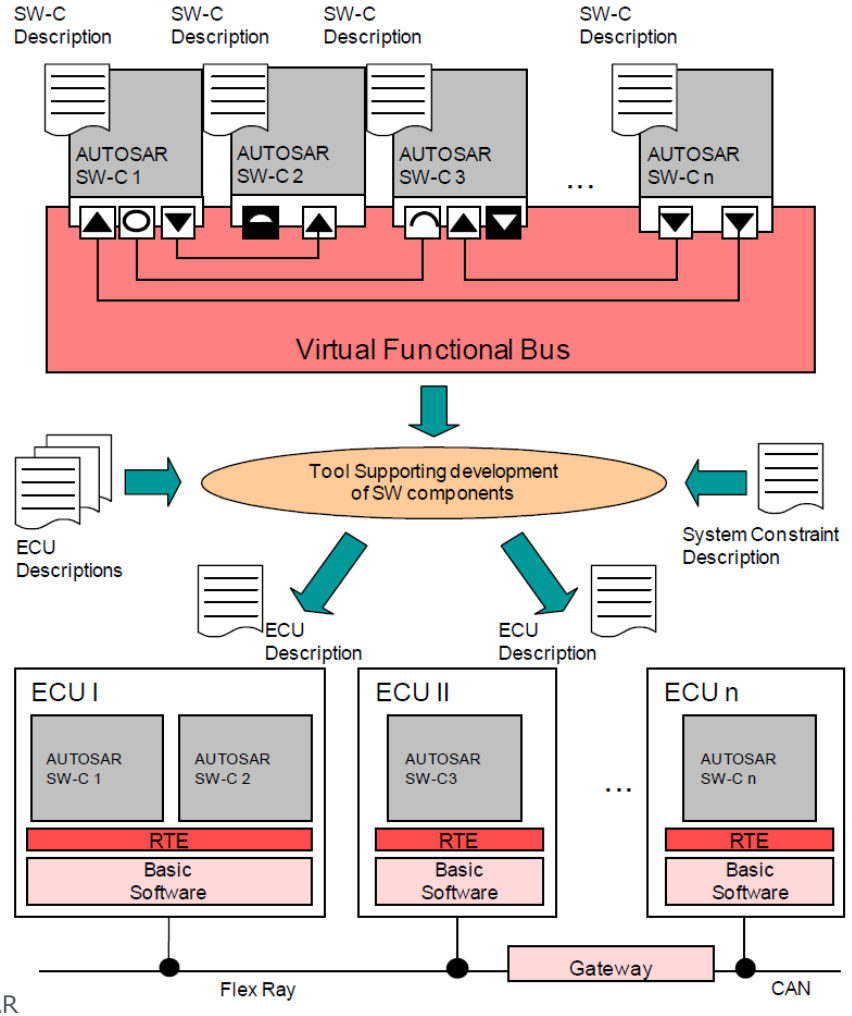
Source: EASIS

PHYSICAL ARCHITECTURE (NETWORK TOPOLOGY)



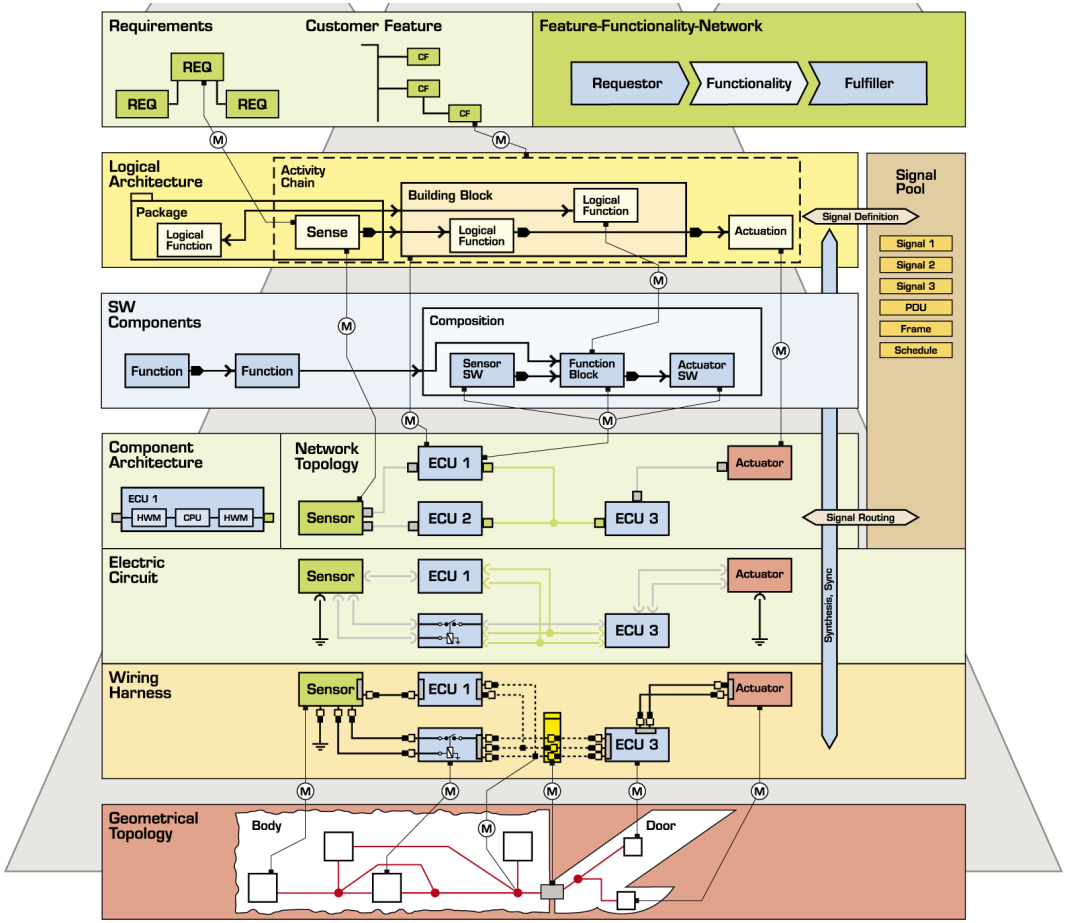
Source: EASIS

SOFTWARE ARCHITECTURE



Source: AUTOSAR

ARCHITECTURE METAMODELS



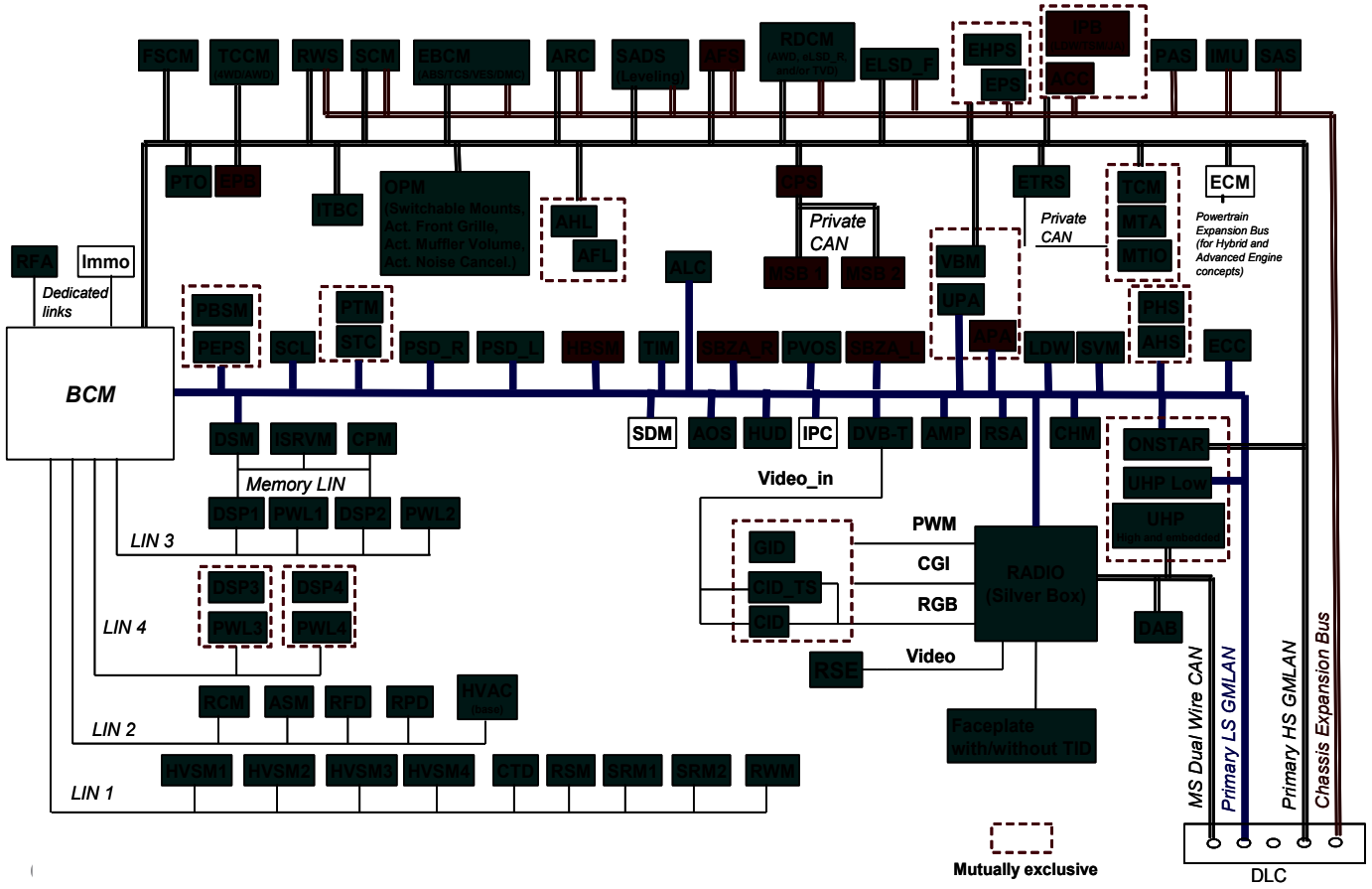
Source: Aquintos

ARCHITECTURE DECISION POINTS

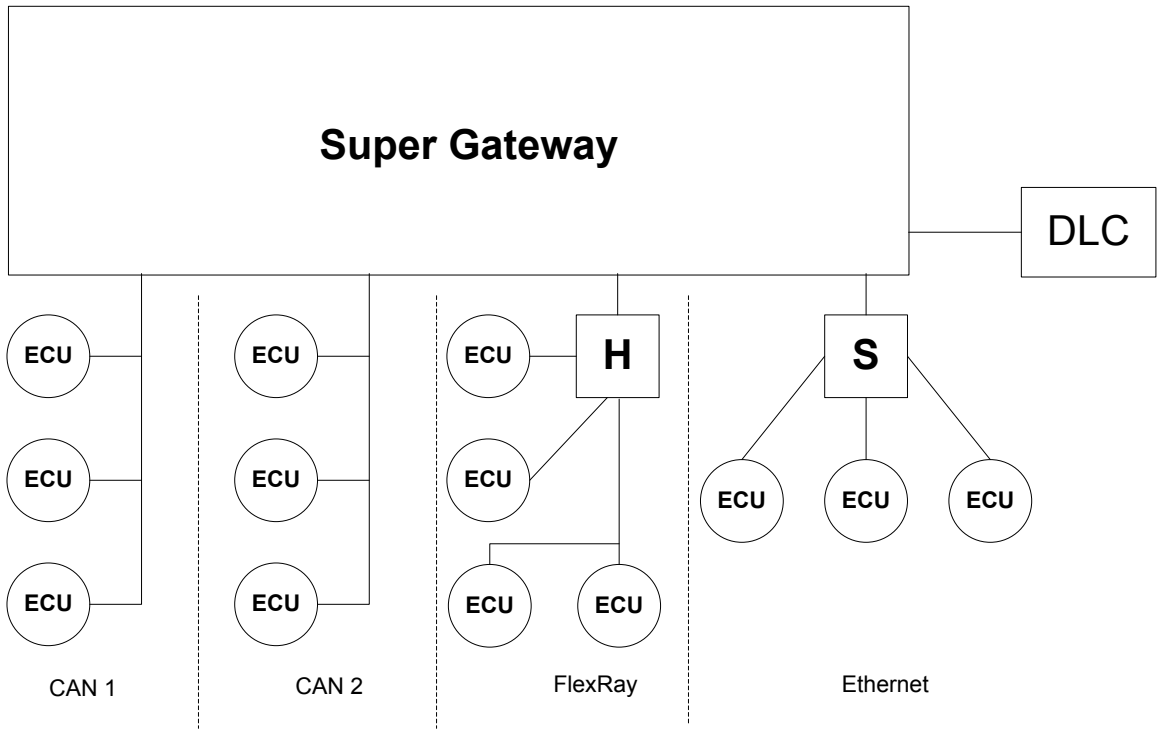
Structure of network connectivity
Integration type (domain, geographic, etc.)
Fault tolerance strategy
Level of intelligence of sensors & actuators
Development / sourcing (separate HW/SW vs. black-box)
Dynamically reconfigurable architecture
Power generation/storage/distribution strategy
Discrete vs. multiplexed sensors & actuators
Wired / fiber vs. wireless
Degree of separation of I/O processing from control processing
Federated vs. integrated (degree of Mixed-IP)
Centralized vs. decentralized control
Post manufacture update strategies
Number of architecture families (one / few / many)
End-of-line programming strategy (cals only, all code, mixture)

(…and 10 others…)

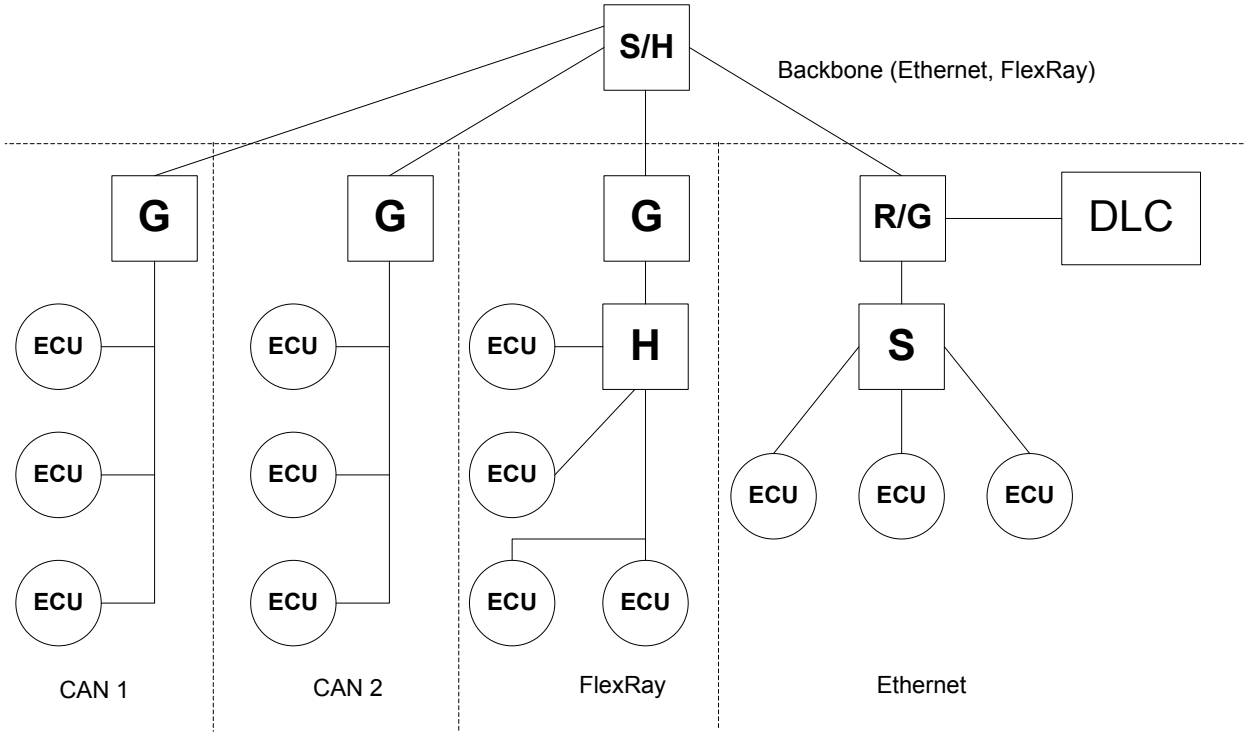
NETWORK TOPOLOGY



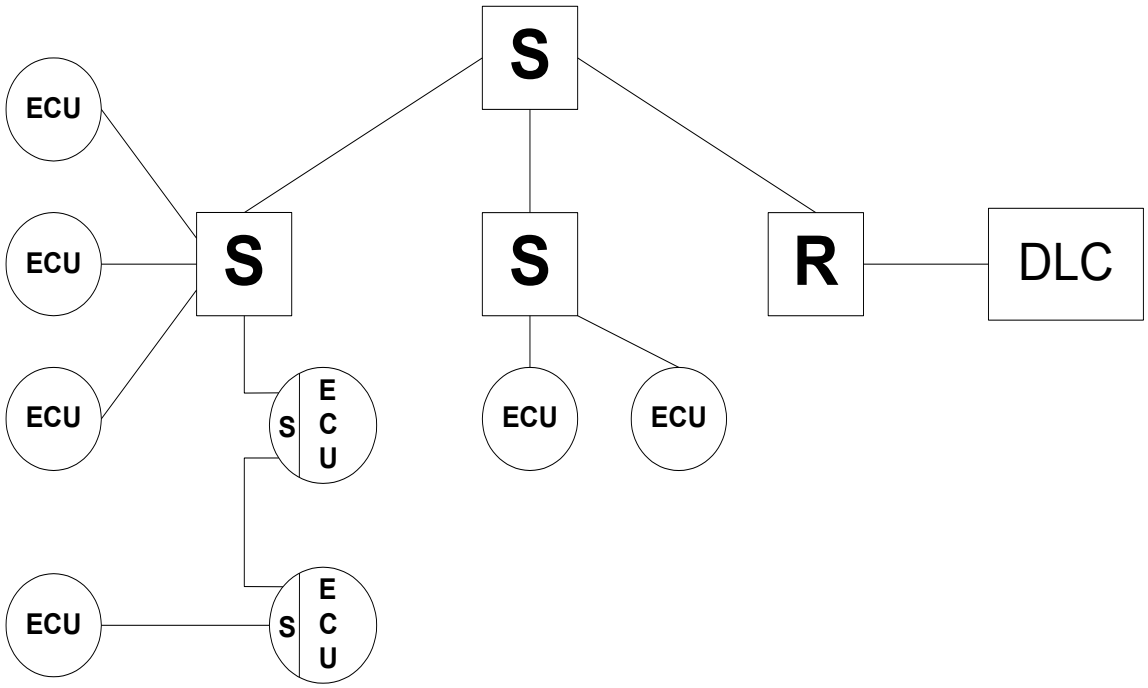
NETWORK TOPOLOGY



NETWORK TOPOLOGY



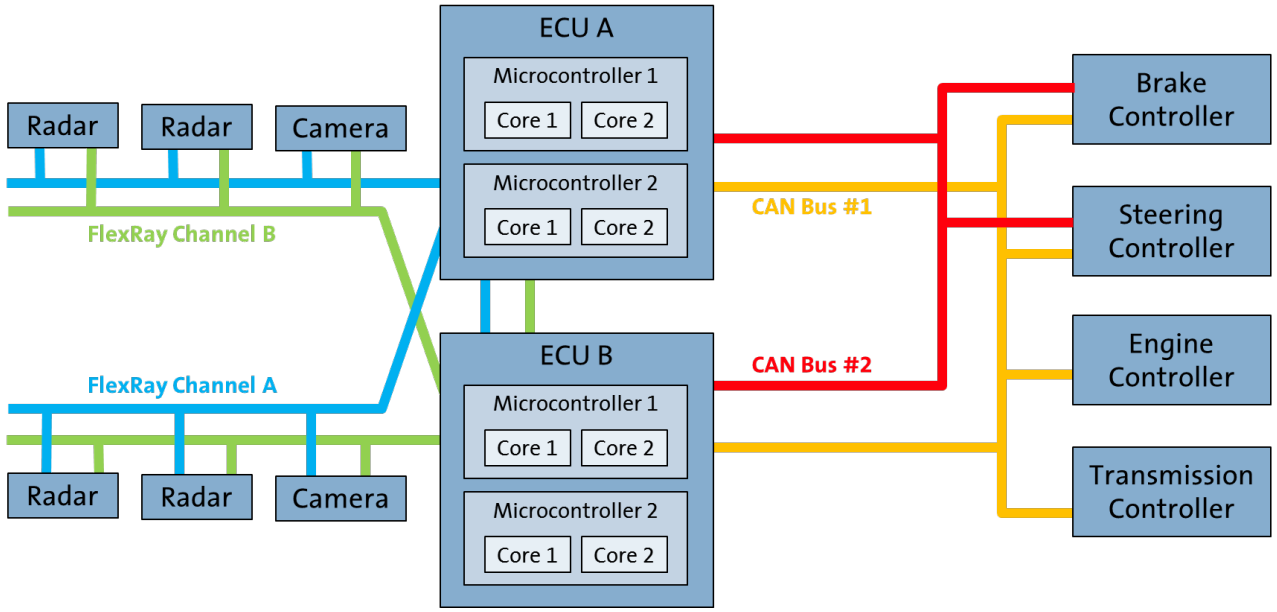
NETWORK TOPOLOGY



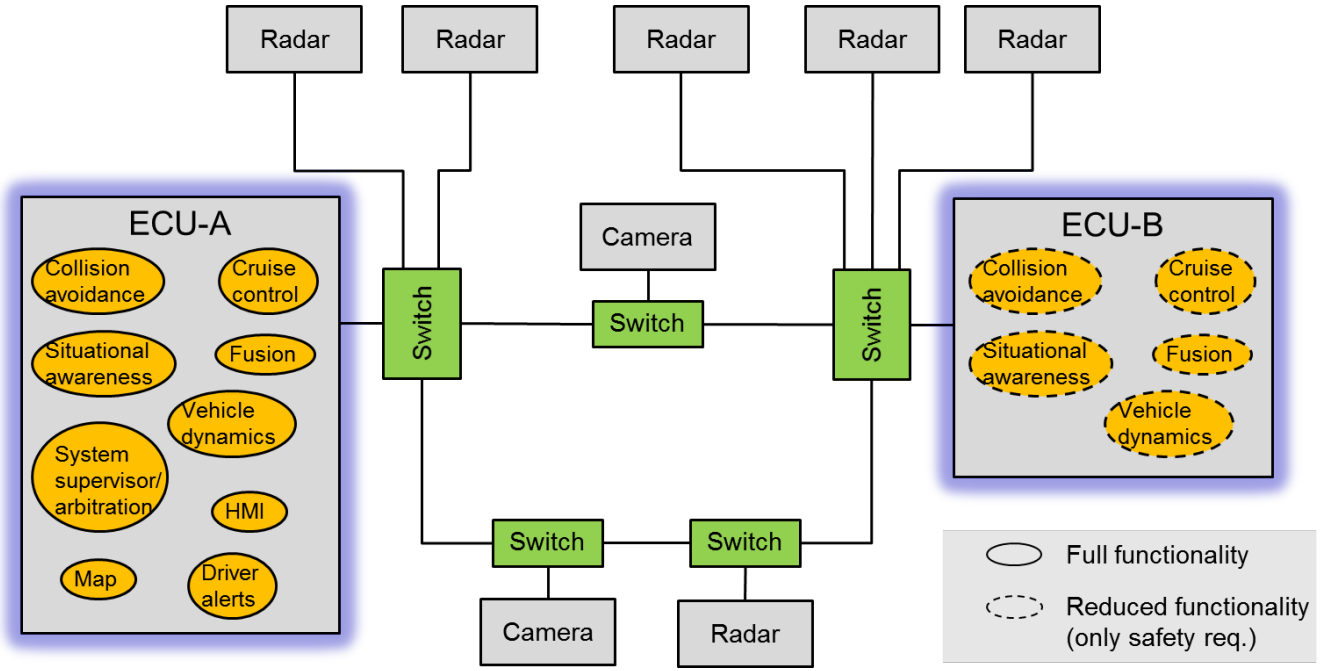
INTEGRATION TYPE

Functionality (domain)
Geographic location (zone)
Power mode
IP source
Safety criticality
OBD (on-board diagnostics) regulations

FAULT TOLERANT ARCHITECTURE



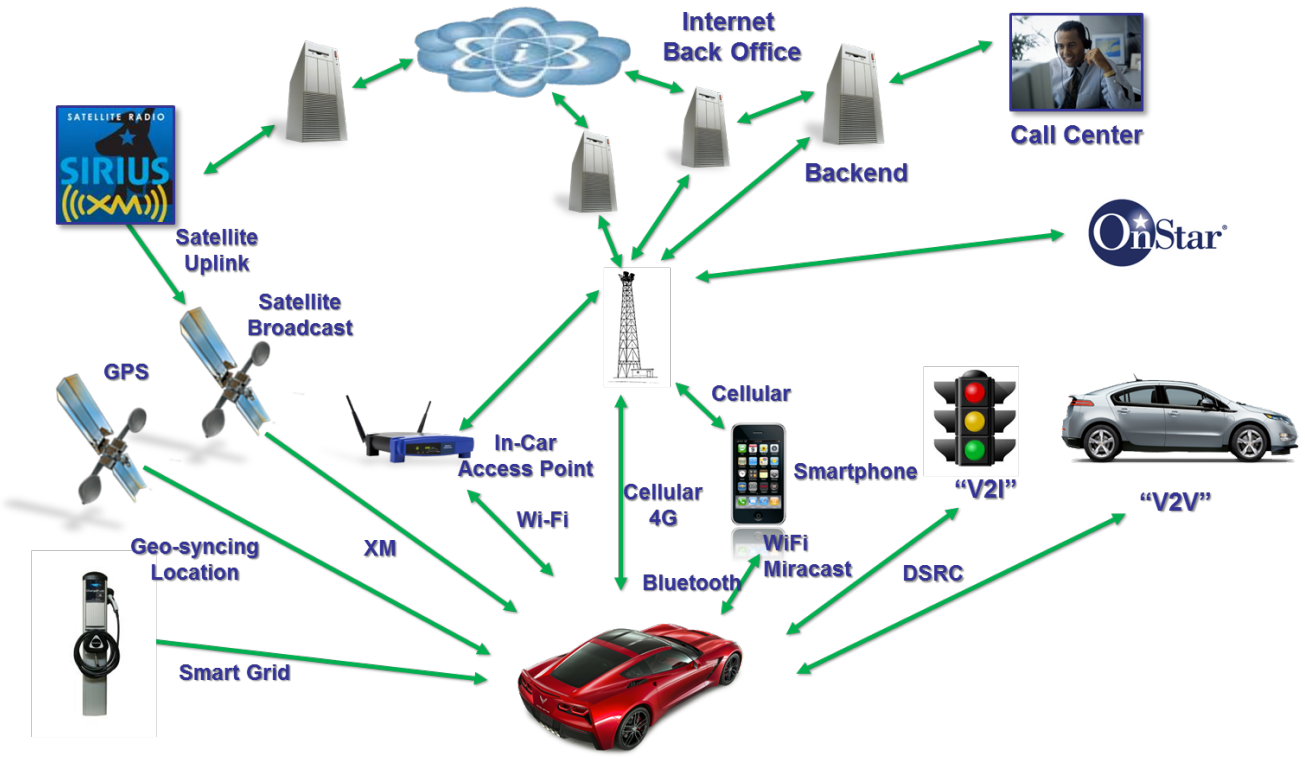
FAULT TOLERANT ARCHITECTURE



ARCHITECTURE METRICS

Metrics	Definition
Reliability / Quality	The ability of the system to perform intended/specified function satisfactorily for a prescribed time and under stipulated environmental conditions.
Energy Efficiency	The net electrical power consumed when no system is running, when a partial network is running, and when all systems are running (operational) .
Safety	Failure probability of critical event to attain freedom from unacceptable risk for personal goods (EASIS)
Cost	The net monetary cost for design/development, manufacturing, vehicle integration and ownership (including repair/maintenance).
Scalability	The ability to accommodate **anticipated** changes in hardware resources.
Flexibility	The ability to accommodate changes in features without any changes in hardware resources.
Reusability	The degree to which components are adapted to support different products (multiple Architecture variants) in the product line.
Expandability	The ability to accommodate **unanticipated** changes in hardware resources.
Maintainability/ Diagnosability	The ability to restore a failed system to an operational effective condition within a given period of time through repair and corrective action.
Vehicle Availability	The ability to perform basic vehicle operations in case of specific failure scenarios
Security	The ability to prevent unauthorized access to, or handling of, system state.
Timing	The ability of the system to ensure timely computation and communication.
Mass	The weight of the components in a design.
Integrity	The ability to prevent improper system alterations.
Complexity	An assessment of intricacies in a design.
Packagability	A measure of the freedom to place/style/redistribute hardware resources inside a vehicle.
Backwards Compatibility	The alignment of the design to historical data including past designs, data sets, code, supplier relations, tool availability etc.
Organizational Alignment	The alignment of the design to organization for design, development and integration.

VEHICLE CONNECTIVITY



FUTURE AUTOMOTIVE ARCHITECTURE TRENDS & CHALLENGES

- Up-integration of features and functions into a reduced number of nodes
- Fault-tolerance and fail-operational
- Cyber-security
- Energy efficiency
- Mass reduction
- Asymmetric redundancy (hardware, software, allocation)
- AVB Ethernet with time synchronization, ring topology for redundancy
- Consumer electronics pace of technology evolution

THANK-YOU!

Questions?