CWI

Centrum Wiskunde & Informatica

Automotive Architecture Description Mechanisms:

Between Past and Future

[Invited Talk]

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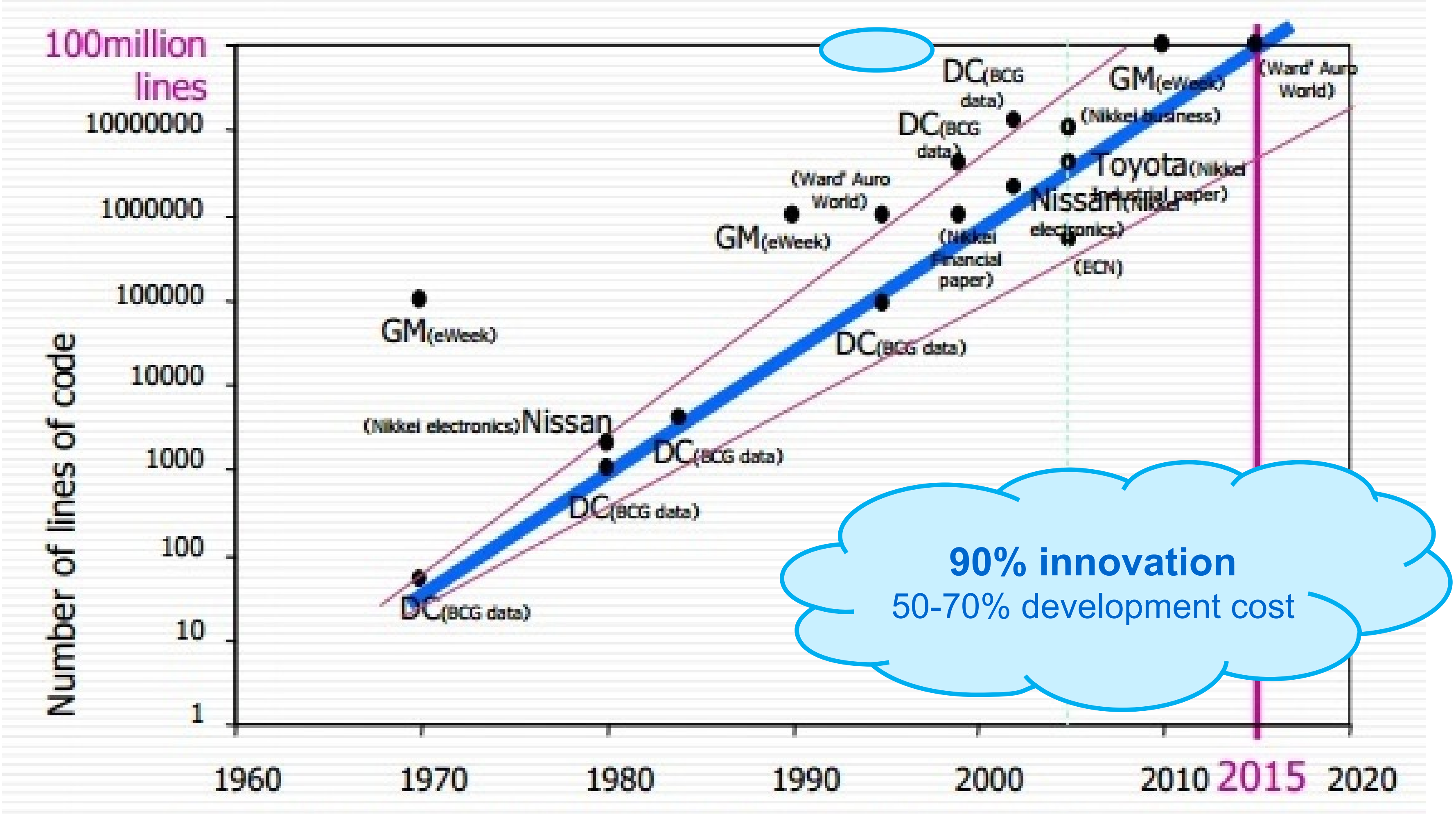


90% innovation

50-70% development cost

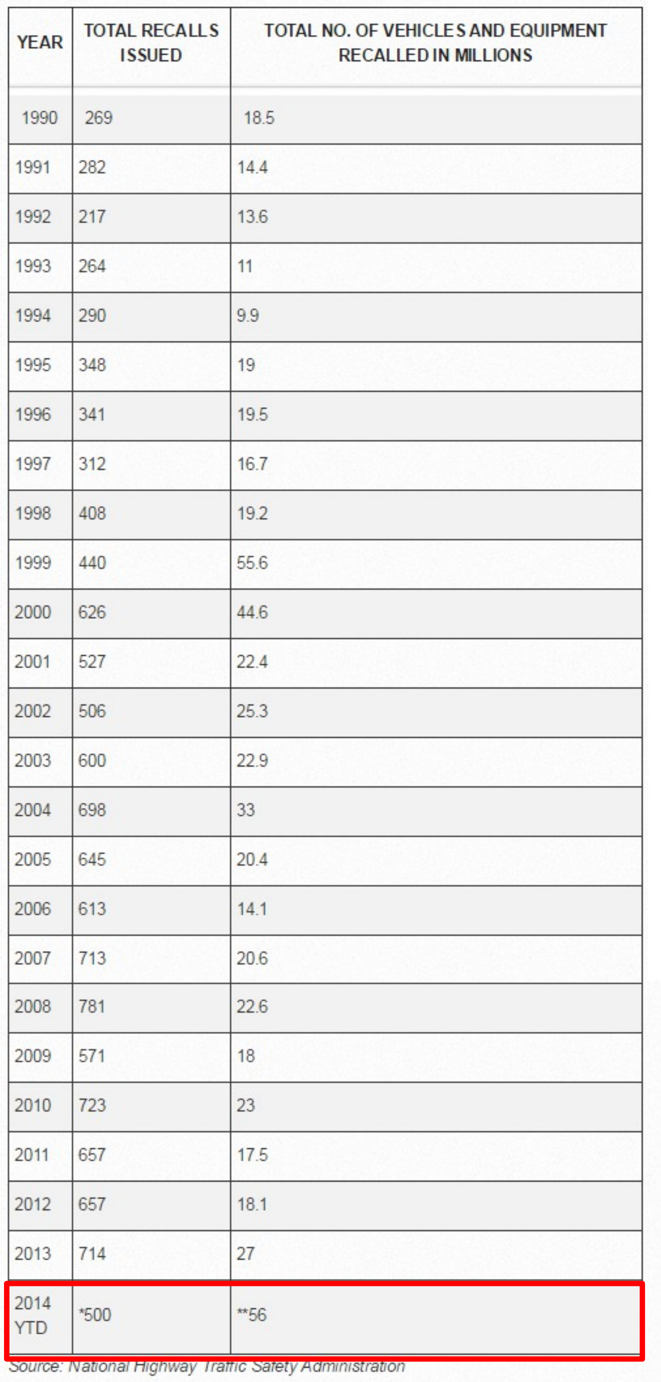
Electronic Spark Timing (EST) System (1 ECU)

2000 functions enabled by software (70-100 ECUs)

2014 record recall year

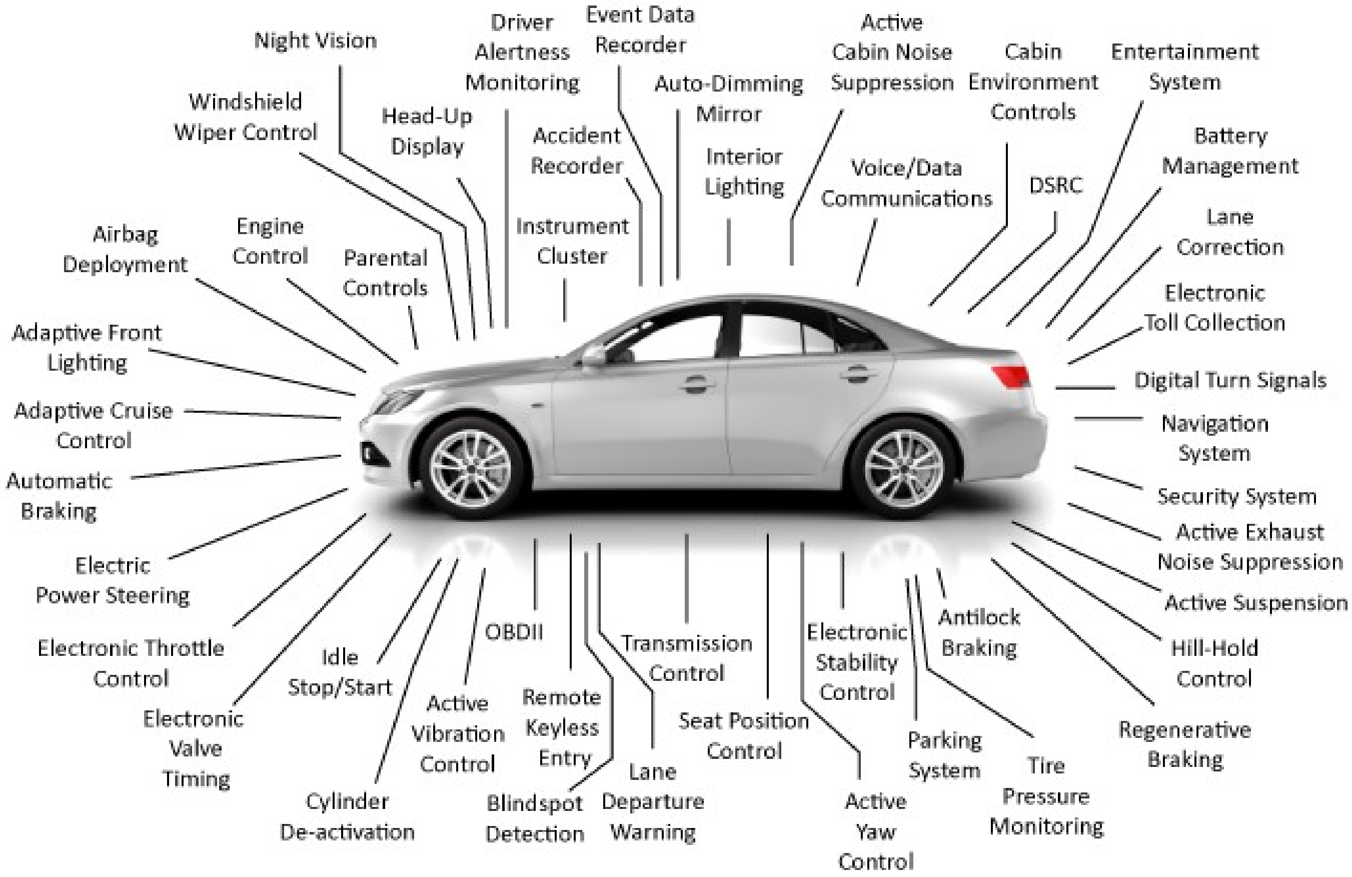
Software problem that could cause

- the cars to stop suddenly
- accelerate without warning
- overheats/damages power electronics
- …



YEAR	TOTAL RECALLS ISSUED	TOTAL NO. OF VEHICLES AND EQUIPMENT RECALLED IN MILLIONS
1990	269	18.5
1991	282	14.4
1992	217	13.6
1993	264	11
1994	290	9.9
1995	348	19
1996	341	19.5
1997	312	16.7
1998	408	19.2
1999	440	55.6
2000	626	44.6
2001	527	22.4
2002	506	25.3
2003	600	22.9
2004	698	33
2005	645	20.4
2006	613	14.1
2007	713	20.6
2008	781	22.6
2009	571	18
2010	723	23
2011	657	17.5
2012	657	18.1
2013	714	27
2014 YTD	*500	**56

Source: National Highway Traffic Safety Administration



Night Vision

Driver Alertness Monitoring

Event Data Recorder

Active Cabin Noise Suppression

Cabin Environment Controls

Entertainment System

Windshield Wiper Control

Head-Up Display

Accident Recorder

Auto-Dimming Mirror

Interior Lighting

Voice/Data Communications

DSRC

Battery Management

Airbag Deployment

Engine Control

Parental Controls

Instrument Cluster

Lane Correction

Electronic Toll Collection

Adaptive Front Lighting

Adaptive Cruise Control

Automatic Braking

Digital Turn Signals

Navigation System

Security System

Active Exhaust Noise Suppression

Active Suspension

Electric Power Steering

Electronic Throttle Control

Idle Stop/Start

OBDII

Transmission Control

Electronic Stability Control

Antilock Braking

Hill-Hold Control

Electronic Valve Timing

Active Vibration Control

Remote Keyless Entry

Seat Position Control

Parking System

Tire Pressure Monitoring

Regenerative Braking

Cylinder De-activation

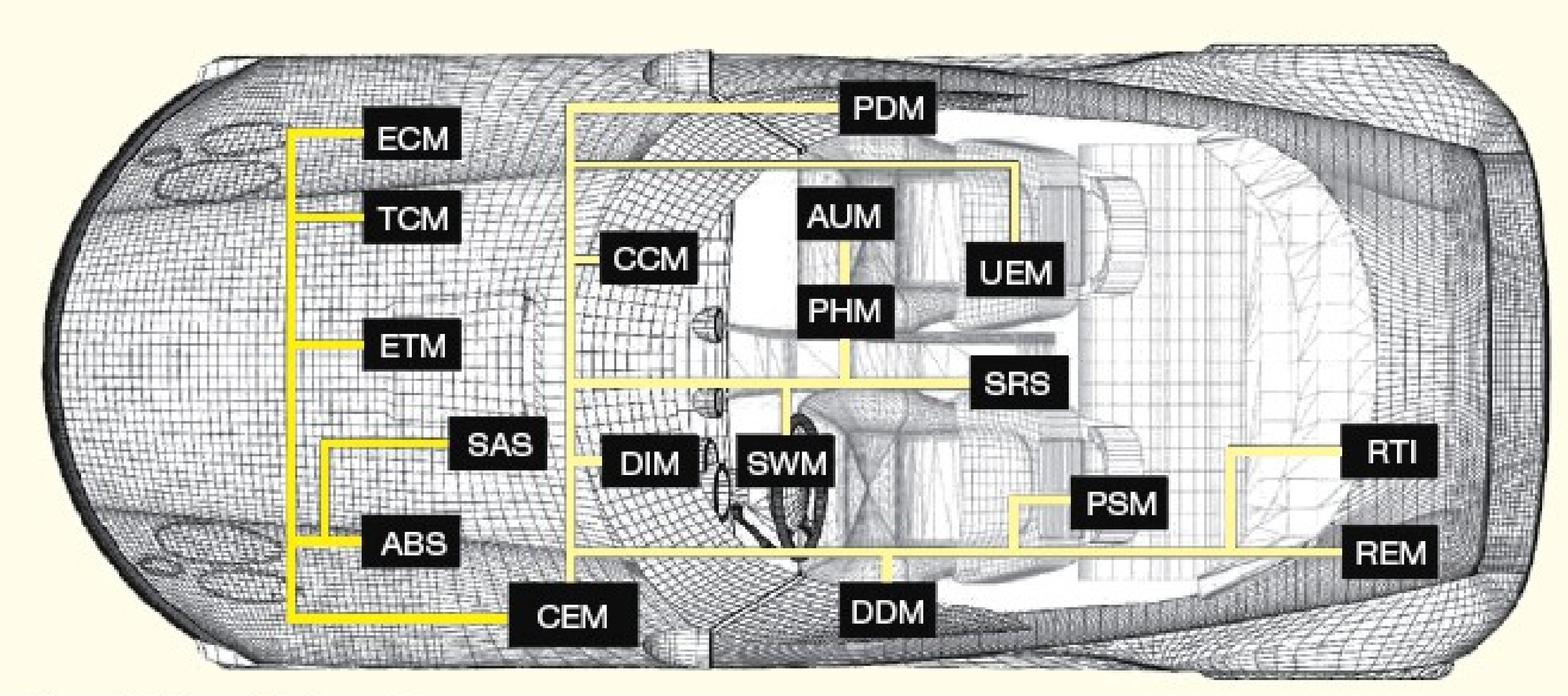
Blindspot Detection

Lane Departure Warning

Active Yaw Control

http://www.cvel.clemson.edu/auto/systems/auto-systems.html

Toyota Prius - Software Issue in ABS

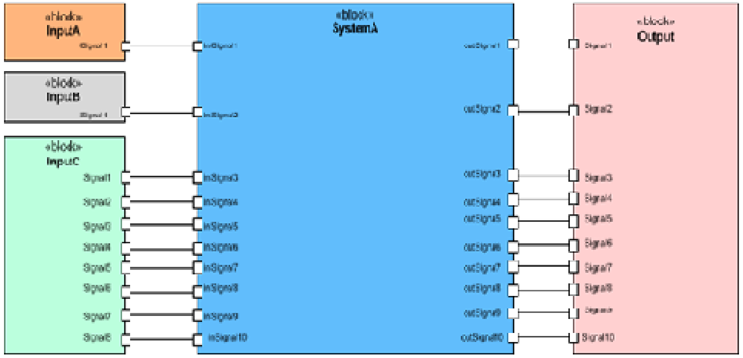


Toyota Hybrid Model recall:

- Global recall of ~ 400,000
- The total recall cost ~$2 billion

Average automobile:

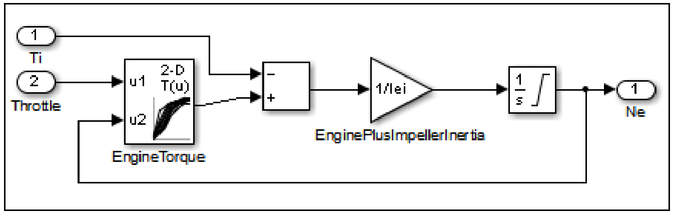
- **70 to 100 ECUs**
- **~100 million LOC**



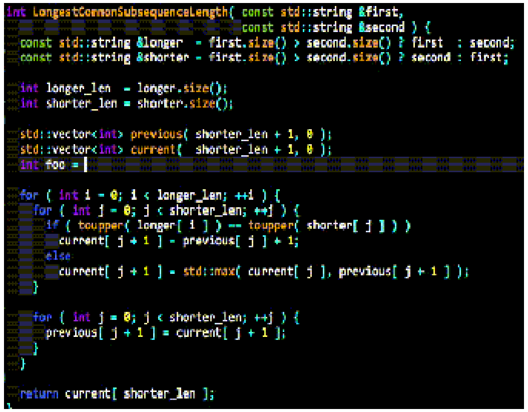
Architecture Model

Architecture Framework (AF)

Architecture Description Language (ADL)



Design Model



```
int LongestCommonSubsequenceLength( const std::string &first,
                                    const std::string &second ) {
  const std::string &longer  = first.size() > second.size() ? first  : second;
  const std::string &shorter = first.size() > second.size() ? second : first;

  int longer_len  = longer.size();
  int shorter_len = shorter.size();

  std::vector<int> previous( shorter_len + 1, 0 );
  std::vector<int> current(  shorter_len + 1, 0 );
  int foo = 

  for ( int i = 0; i < longer_len; ++i ) {
    for ( int j = 0; j < shorter_len; ++j ) {
      if ( toupper( longer[ i ] ) == toupper( shorter[ j ] ) )
        current[ j + 1 ] = previous[ j ] + 1;
      else
        current[ j + 1 ] = std::max( current[ j ], previous[ j + 1 ] );
    }

    for ( int j = 0; j < shorter_len; ++j ) {
      previous[ j + 1 ] = current[ j + 1 ];
    }
  }

  return current[ shorter_len ];
}
```

Source Code

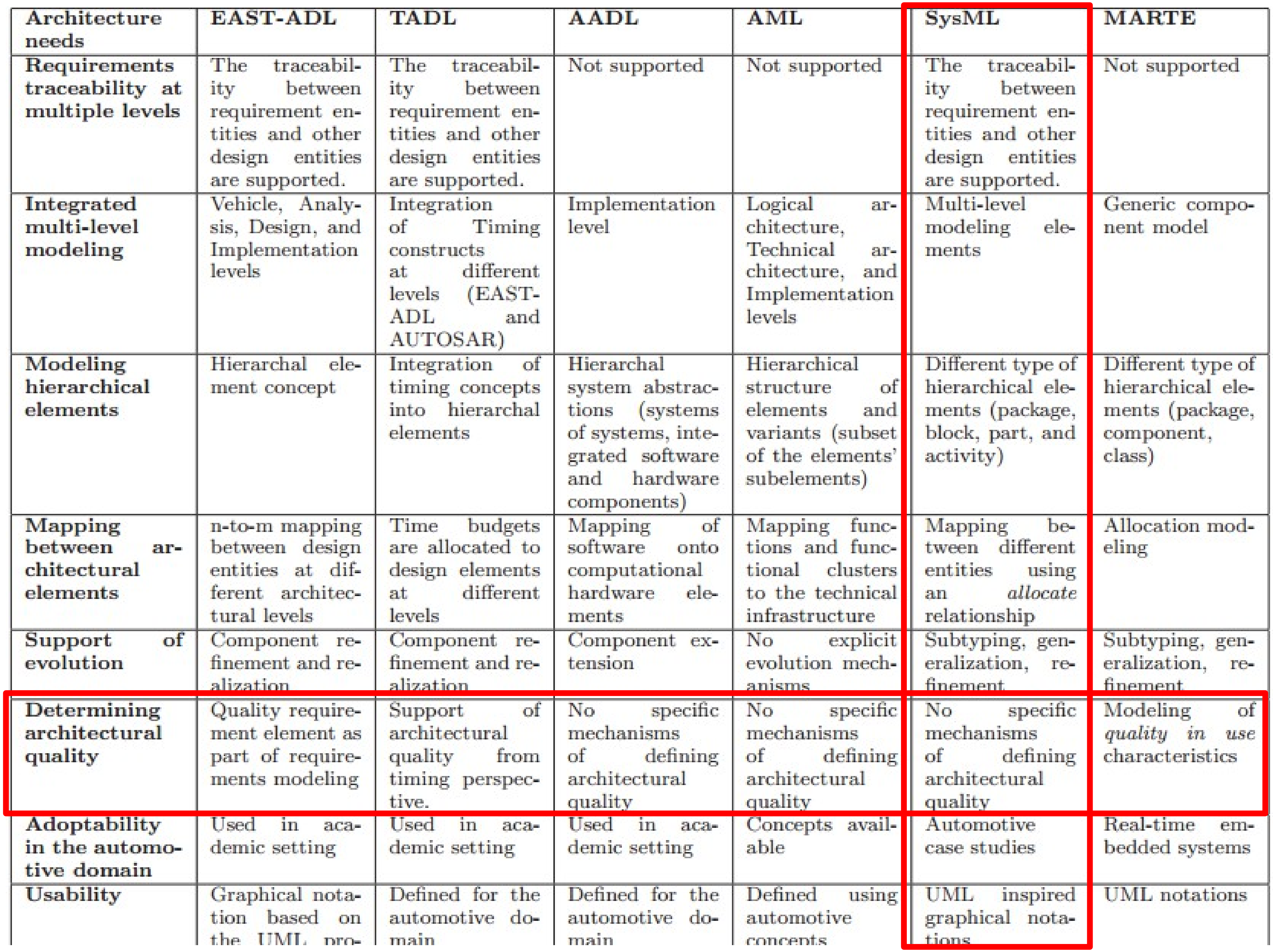
Automotive companies and ADLs

- Automotive Modeling Language (**AML**)
- COmponent Language (**COLA**)

- **EAST-ADL**
- Timing Augmented Description Language (**TADL**)

- The ICT MAENAD project **EAST-ADL2**

Automotive ADL comparison



Architecture needs	EAST-ADL	TADL	AADL	AML	SysML	MARTE
Requirements traceability at multiple levels	The traceability between requirement entities and other design entities are supported.	The traceability between requirement entities and other design entities are supported.	Not supported	Not supported	The traceability between requirement entities and other design entities are supported.	Not supported
Integrated multi-level modeling	Vehicle, Analysis, Design, and Implementation levels	Integration of Timing constructs at different levels (EAST-ADL and AUTOSAR)	Implementation level	Logical architecture, Technical architecture, and Implementation levels	Multi-level modeling elements	Generic component model
Modeling hierarchical elements	Hierarchal element concept	Integration of timing concepts into hierarchal elements	Hierarchal system abstractions (systems of systems, integrated software and hardware components)	Hierarchical structure of elements and variants (subset of the elements' subelements)	Different type of hierarchical elements (package, block, part, and activity)	Different type of hierarchical elements (package, component, class)
Mapping between architectural elements	n-to-m mapping between design entities at different architectural levels	Time budgets are allocated to design elements at different levels	Mapping of software onto computational hardware elements	Mapping functions and functional clusters to the technical infrastructure	Mapping between different entities using an *allocate* relationship	Allocation modeling
Support of evolution	Component refinement and realization	Component refinement and realization	Component extension	No explicit evolution mechanisms	Subtyping, generalization, refinement	Subtyping, generalization, refinement
Determining architectural quality	Quality requirement element as part of requirements modeling	Support of architectural quality from timing perspective.	No specific mechanisms of defining architectural quality	No specific mechanisms of defining architectural quality	No specific mechanisms of defining architectural quality	Modeling of *quality in use* characteristics
Adoptability in the automotive domain	Used in academic setting	Used in academic setting	Used in academic setting	Concepts available	Automotive case studies	Real-time embedded systems
Usability	Graphical notation based on the UML pro-	Defined for the automotive domain	Defined for the automotive domain	Defined using automotive concepts	UML inspired graphical notations	UML notations

...

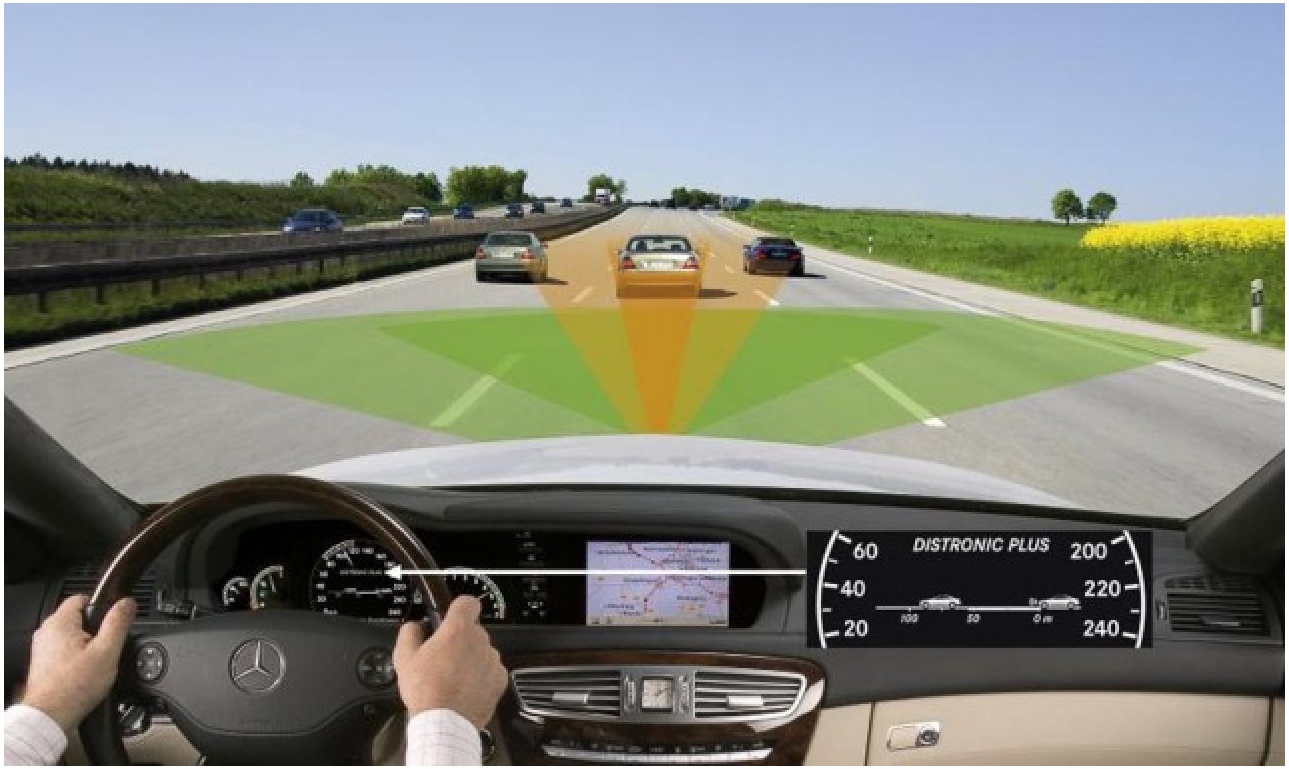
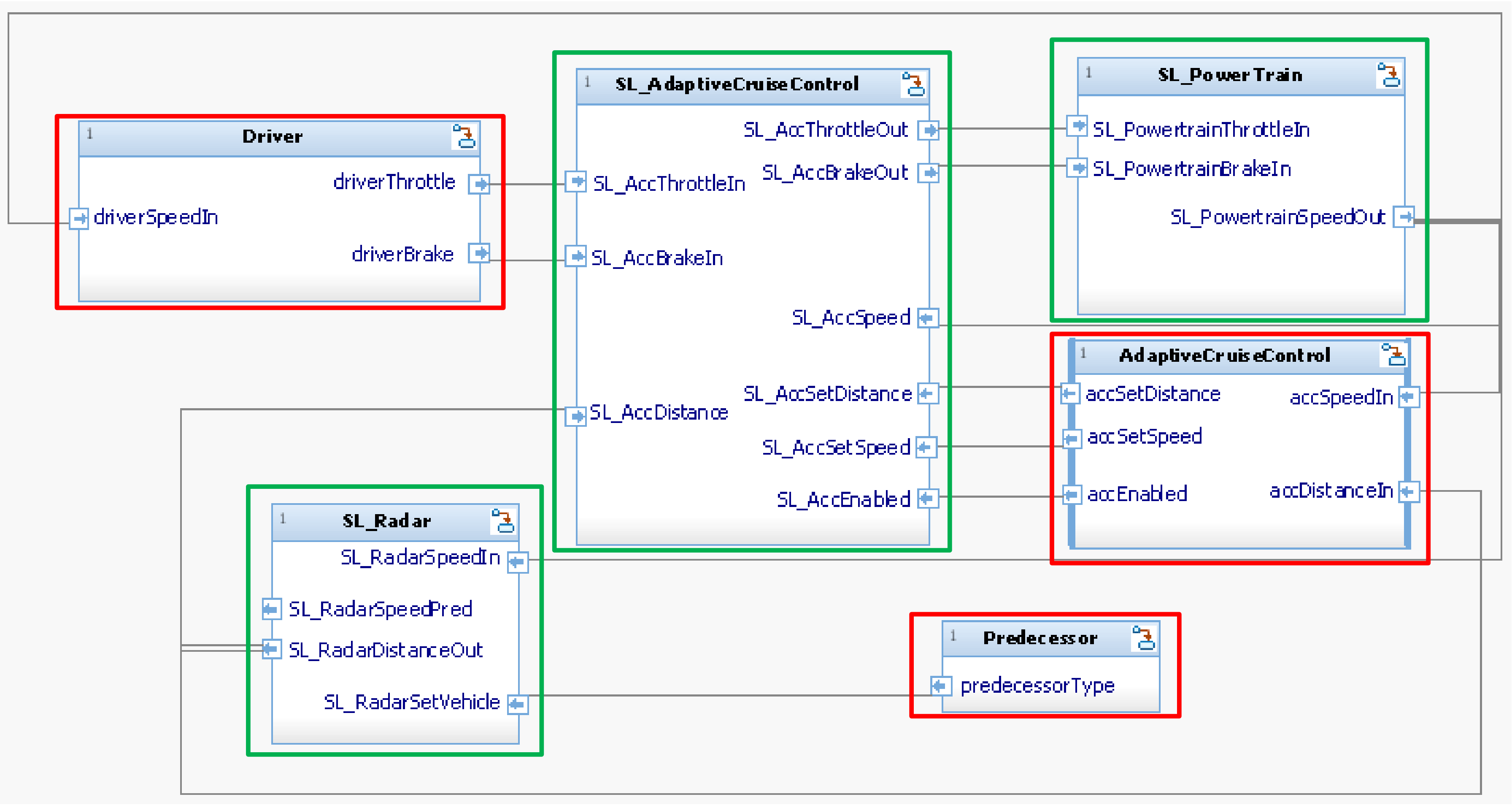


Image: http://www.extremetech.com/

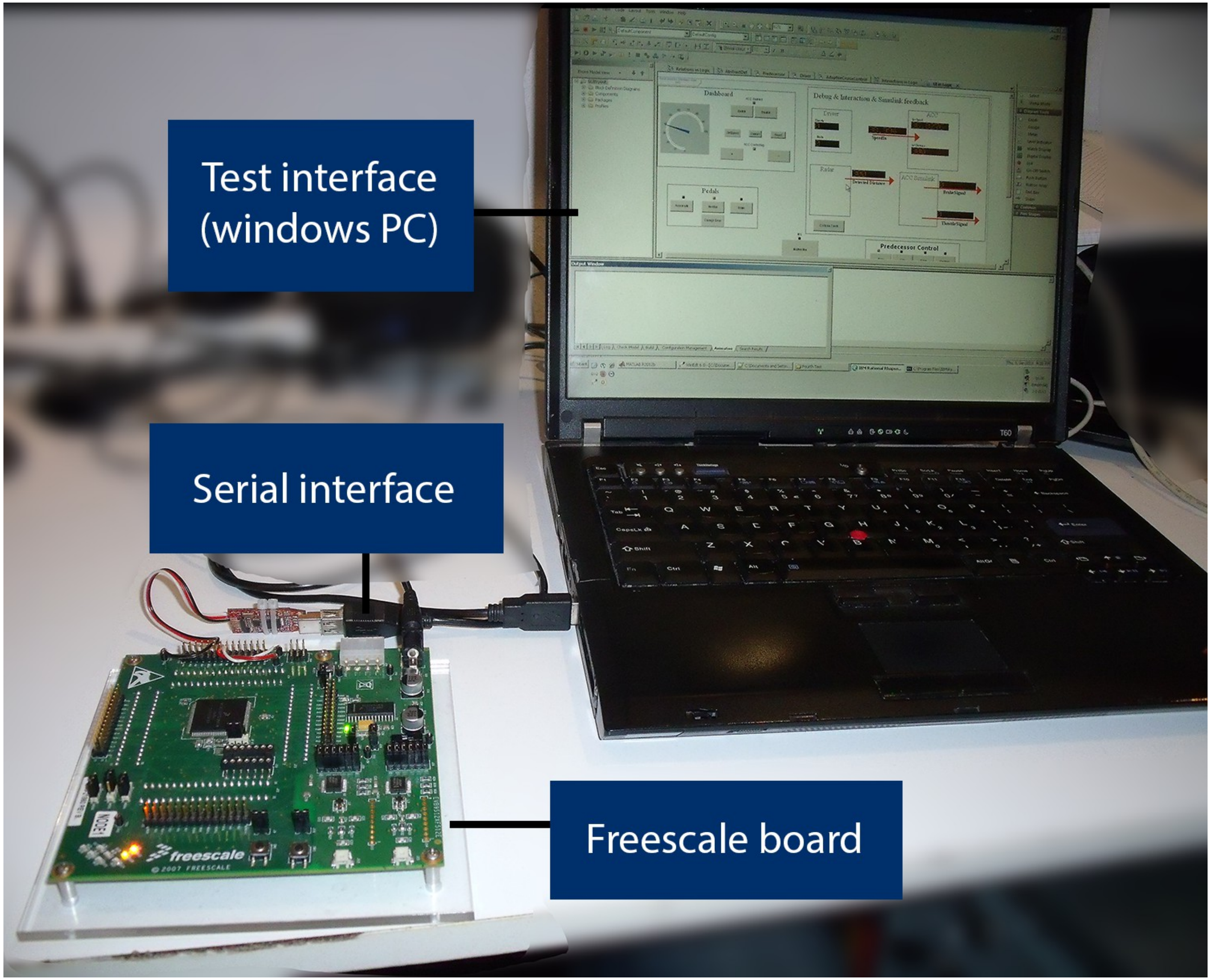
Modeling the ACC system for an E-truck with a top-down approach in SysML

ACC Architecture



- Software
- Hardware

ACC Evaluation



Test interface (windows PC)

Serial interface

Freescale board

Automotive @ TU/e

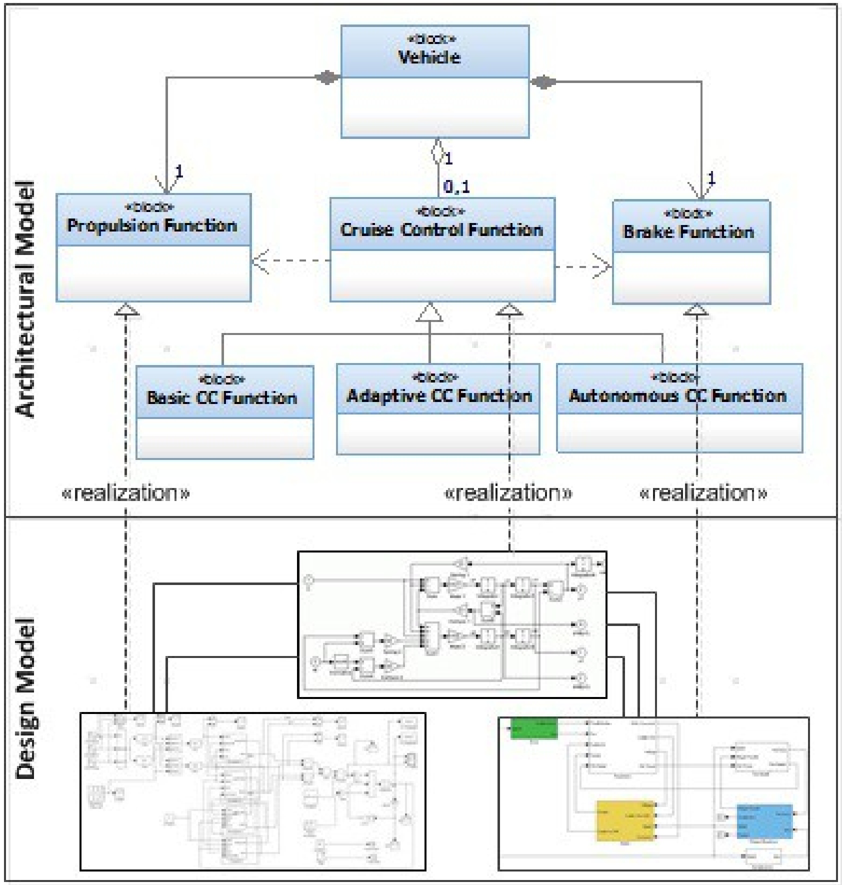
Cooperative Driving (platooning), A270:
Helmond-Eindhoven, 2011
(Mechanical Engineering/TNO)

Solar Team Eindhoven and **Stella** (World champion in the Michelin Cruiser Class of the Bridgestone World Solar Challenge 2013.)

TU/E URE team

Further Work

- Automotive architecture framework
- Integrating automotive ADL (e.g. SysML) with verification
- Defining quality-driven architecture modeling



THANK
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