NITRD
Automotive CPS Workshop

Working Group on Model-based Design

MBD - Participants

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- Hideo Sato, UCI
- Alan Kushner, NTSB
- Mikael Nolin, MRTC,
- Ryan McGee, Ford
- Jorgen Hansson, CMU
- Chris Walter, WWTechGrp
- Elizabeth Latronico, Bosch
- Craig Stephens, Ford
- Sandeep Kulkarni, Mich. State
- Medjan Jankovic, Ford
- Igor Mezic, UCSB
- Sibin Mohan, NC State U.
- Gabor Karsai, Vanderbilt
MBD State-of-Industry

- Requirements are primarily text based today
- System’s engineering V is the primary process

What is special about Automotive

- Uncertainty in the driver and passenger behavior. They are not trained.
- Hybrid systems – both continuous and discrete combined into a vehicle.
- Complexity in variants
- Changing requirements – Unplanned interactions arise due to technological changes/
- Requirements that cross cut across the vehicle (e.g. Safety, Security, Privacy, Reliability, …ility)
- Models come from multiple parties in multiple geographical locations
- Suppliers develop large parts of the system
Grand Challenges

- Define processes, methods, and tools that support developing models that can be analyzed from different perspectives
  - Performance
  - System Safety
  - …
- Integration of models – Uncertainty, complexity, multiple domains –
  - Mechanical component models with controls development models
  - Integrating multiple elements from multiple people
  - Integrating control and plant models
  - Finite element, thermal, etc. models
- Define a theoretical framework for verifying and validating Cyber Physical Systems in a model based environment
- Physical world -> Cyber world -> Physical world
- Open source integrated, wide-spectrum tool chain to be used in model based development
- Zero prototype vehicles
- Push button verification
- Zero recalls
- Formally verified safety properties

New Research Needs, Directions and Strategies

- Models to help look at non functional properties. Not just models for algorithm development or software components
  - Architectural Trade offs
- Model integration
- Safety modeling and analysis
- Verification and Validation for large-scale models
- Process research
  - How to develop engineering artifacts?
  - The right model for the right job
- Global uncertainty analysis
- Infrastructure models
  - Highways
  - Power System (PHEVs)
- Fault tolerant modeling techniques -> fault tolerant software
- Theoretical basis for model creation (Advanced mathematical concepts, integration of continuous and discrete systems, …)
**Education**

- Merging of E/E and M/E and ?/E capabilities
- Both ‘generalist’ and ‘specialist’ curriculum
- Project based ‘capstone’ courses to promote model-based design
- Utilize state of the art tools and techniques
- Open source tool chain to use in education and industry

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**Timeline**

- 2008
  - Domain models for automotive CPS
  - Open source toolset with push button verification
  - Update engineering curriculum

- 2013
  - Models to support autonomous driving
  - Integration of fully validated models used in vehicle development (mechanical, electrical, software, …)
  - No hand code

- 2018
  - First prototype vehicle ‘works’ with the first key turn
  - Full integration of models to design, test, manufacture
  - Adaptable design process to support changing user requirements

- 2023
  - Flatten the systems engineering V (requirements to implementation in one step)
  - Zero prototype vehicles
MBD – Where are we know?

- What is MBD providing?
  - CAE Environment
- Different ‘areas’ use models of varying depth
  - AutoSAR as a modeling approach? --- NO!
  - Cost of getting accurate models
- Up-front engineering (as opposed to back-end)
  - Use models instead of real artifacts (to develop software, for instance)
  - The relevance of the process
MBD – Where are we know?

- What is the proper modeling mechanism?
  - Bounds on models of components → Composed into a system architecture → Interactions???
- Modeling from multiple aspects
  - Integrating/interrelating different models is difficult
- Challenges
  - Legacy systems and models (that work…)
  - Parallel/concurrent development
  - Organizational inertia
  - Complexity management

Kickoff questions

- What is in MBD that is not being done today but is essential for CPS?
  - What is special about CPS MBD?
  - Fundamental limitations with today’s MBD
  - What is the ‘Science of Model-based Design’ in CPS?
  - Promising directions?
- Grand challenges problems for MBD?
  - CP that can be solved in an academic setting?
- Education
  - What does industry need in MBD- engineers?
  - How do we teach MBD?
- Milestones & assessment
  - R&D Focus for the next 5/10/15/20 years
  - Strategy for Deploying R&D Results