CAR Breakfast Briefing

TRW Systems Engineering
- Slip Control Systems

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TRW – Slip Control Systems
Background

What are “Slip Control Systems”

– Electronically controlled elements of today’s automotive brake systems that provide safety and convenience features such as:
  • Anti-Lock Braking (ABS)
  • Electronic Stability Control (ESC)
  • Traction Control (TC)
  • Adaptive Cruise Control (ACC)
  • Regenerative Brake Blending Systems (RBS) {EVs & Hybrids}
  • Hill Descent Control (HDC)
  • Etc……..

– As all of these systems control the pressure being applied to each of the vehicle wheels, they dynamically control the ‘Slip’ of each wheel.
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Brief History

Early ABS

Present ESC

2-wheel ABS

4-wheel ABS w/ EBD

SCB - Regen

ESC Features & Functions explosion

EPB Integration with ESC

TC Added

2-whl ESC

Electric Park Brake Generations 1 --> 5

MODEL YEAR

1987 --> 1997

Integrated Brake Control

Present EPB

IBC - Actuation Integration
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Trends

- From Humble Beginnings
  - Rear Wheel Anti-Lock (RWAL)

- To Complex Feature Additions
  - TSC, ACC, Disc-Brake Cleaning, iTPM, Hill Assist, etc.

- To Standard Equipment
  - Electronic Stability Control

- To Integration Hub
  - EPBi, Chassis Domain Control, Steer Torque Overlay, etc.

» To Next Generation ‘Green’ Technology
  - Regen Braking support for EVs and Hybrids
  - ‘0’ vacuum brake systems:
    • Reduce engine parasitic / increase Fuel Economy
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Systems Engineering Challenges

What are the Challenges Today?

1. Growing levels of functionality
   - NCAP / Collision Mitigation expectations
   - Hosting of OEM / 3rd party software
     - Processing power and memory continue exponential trend
       - *Multi-core uP with 8Mbytes of ROM by 2019*
   - Support of fault tolerant ‘Semi or Fully’ Autonomous Driving

2. Increasing Standardizations and Safety Requirements
   - Growth in AUTOSAR adoption – standard software modules
   - Process adherence – Automotive SPICE
   - ISO 26262 ASIL-D system compliance
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Systems Engineering Challenges

What are the Challenges Today?

3. Requirements Capturing / Decomposition
   - Multiple formats from Customer base
   - Various levels of detail / completeness
   - Insufficient internal requirements captured to ‘link’ to.

4. Bi-lateral Traceability
   - Present systems not compatible with the concept
   - Lack of original decomposition – difficult to now insert ‘back’
   - Not enough experience yet to determine the right fidelity of detail
     - Ex: every line of code?
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Systems Engineering Challenges

What are the Challenges Today?

5. Lessons Learned Feedback / Incorporation
   - Back into the Requirements / Design documents
   - Across to other similar projects
   - Forward to new projects

6. Employee Training / Knowledge / Experience
   - Present culture of career rotation

   The Next Generation Transition:

   The ‘Old Guard / Tribal Knowledge’ vs.
   The ‘Transitionals / Mobile Connected’
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What is coming next?

- Industry desires a system that is
  - Vacuum independent
  - Fast Pressure Apply Dynamics {NCAP / Collision Mitigation}
  - Seamless pressure control {Stop-N-Go ACC, etc.}
  - World class pedal feel
  - Support for EVs & Hybrids
  - Fully Fault Tolerant / High Quality / No issues
  - Scalable for all known functions
  - Ability to host ‘black box’ OEM software
  - Etc.
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Integrated Brake Controls (IBC)

- Vacuum Pump
- Vacuum Pipe
- Vacuum Booster & M/C
- Vacuum Sensor
- Brake Pipe
- Brake Light Switch
- ESC HCU/ECU
- ESC Bracket + Grommet
- Weight
- Number of Parts
- Installation
- Logistics
- Wiring Harness
- etc.

IBC
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Systems Engineering Process

How Does TRW Design / Develop such Systems?

1. Strong Systems Engineering Organization and Culture
2. Cross Discipline Engineer Development
3. High use of analysis tools in the process
4. Tight communications between Component Engineering and Systems Design
5. Global Operation
Cross Discipline Engineer Development

- Systems Design Staff comprised of engineers from various educational backgrounds:
  - Mechanical Engineers
  - Electrical Engineers
  - Control Systems Engineers
  - Software Engineers

- Cross Discipline work assignments are encouraged:
  - Mechanical Engineers writing software
  - Electrical Engineers designing motors / valves
  - System Analysis Engineers – from all disciplines
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Systems Engineering Process

What is the TRW Design / Development Process?

1. Utilizes the traditional ‘V’-cycle methodology

2. Today’s emphasis is to comply with the industry process standards:
   1. Automotive Spice
   2. ISO 26262 {Safety products}
   3. AUTOSAR interfaces
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Analysis Tools / Process

– Simulation / Software-In-the-Loop, Hardware-In-the-Loop Verification tools

HIL Rigs

Predicting ESC performance

For Unique vehicles with complex variant configurations
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Systems Engineering Process – Requirements Management

The Biggest Challenges:

1) Requirements Capture  2) Requirements Decomposition  3) Bi-lateral Traceability

Today’s Methods

Customer Requirements
- Word
- PDF
- Excel
- E-mails
- Doors Module

System Requirements
- Word
- Excel
- DFMEA
- Visio

Component Requirements
- Schematics
- Prints
- Test Specs
- CR’s
- Word
- Excel

Software Requirements
- Word
- Excel
- SCR’s
- E-mails

Verification
- Test Reports
- Excel

Gap analysis, PDTs, Design Reviews, Project Issue Tracking
Tomorrow’s Methods?

A Fully Integrated Database?
What are TRW Expectations of the Tool Chain?

Not practical that the OEM’s / Tier 1’s will commonize to a single tool chain

Tools must remain flexible and maintain ability to work with data / databases already developed

✅ Mimic the Instrumentation / CAD tools progression
  ➢ Concentrate on the information structures
  ➢ Maintain ‘Open’ architectures
  ➢ Develop common interfaces

Converting / Linking between tool chains will be a must!
Efficient use of cross-discipline engineering analysis, design & verification processes to deliver increasingly robust safety systems to the Global Automotive environment.