Disruptive Innovation: Griswold 1902-1920
Number of Nonfarm Draft Animals and Automobiles in US

SOURCE: Nakicenovic (1986)
The Use of S. A. E. Standards

The Society of Automotive Engineers has made a canvas of a large number of car makers and some parts makers. A list of 67 standards was prepared, and each maker was asked which of these standards he used in his car or parts. The information thus obtained was embodied in two large charts, presented at the Cleveland meeting of the Standard Committee. We print below a condensation of these charts. One and two tables show respectively the number of users of each standard, so far as the inquiry went, and the number of standards in use by each maker represented in the returns. It is a rather interesting fact pointed out by Chairman Clayden that whereas standardization is generally believed to be particularly advantageous to assemblers, the greatest number of standards are employed by the Mercer Automobile Company, which builds most of the parts of its cars itself. Among the standards which are in very extensive use are those pertaining to threads, lock washers, ball bearings, yokes, and rod ends and spark plugs. That some standards are used by few makers is due to the fact that the thing standardized is in little use in any form that is illustrated by four speed gear positions.

<table>
<thead>
<tr>
<th>Number of S. A. E. Standards Used by Individual Firms.</th>
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<tbody>
<tr>
<td>Firm</td>
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<tr>
<td>Abbott-Detroit</td>
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<td>Allen</td>
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<td>Apperson</td>
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<td>Franklin</td>
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<td>Gen. Motors</td>
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<td>Gen. Vehicle</td>
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<td>Jackson</td>
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<td>Jeffrey</td>
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<td>Kelly-Springfield</td>
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<td>Kissel</td>
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<td>Knox</td>
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<td>Keesler</td>
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<tr>
<td>Leominster</td>
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<tr>
<td>Locomobile</td>
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<tr>
<td>Marmon</td>
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</tbody>
</table>


Standards
- Ground vehicle
- Aerospace
- Information reports
- Recommended practices
- SAE standards
George Booth’s Virtual Driver in “Automatic Motorist” (1911)
Automated Vehicle System, Graham Institute
Market Introduction (SAE Levels), Median, IQR

5 FULL AUTOMATION
(Driver not required, e.g., robotic taxi)

2015 2020 2025 2030

Freight Platooning
2020

Urban Highway & Surface
2025

Full Automation 2030 2035

4 HIGH AUTOMATION
(fail-safe)

2016 2019 2020 2025

Shuttle Freeway

3 CONDITIONAL AUTOMATION
(driver fallback)

2018

Freeway

Institute for Advanced Vehicle Systems
University of Michigan – Dearborn

S. Underwood
Q2: What level of safety do you believe an automated driving system (at any level of automation) should be required to demonstrate before it is authorized for public use?

http://goo.gl/zzQYBF
“Telematics”
Infotainment, Consumer Electronics
Location, Navigation, Route Guidance, Mayday, Digital Maps
(Cellular, 4G, LTE, GPS, Satellite, etc.)

e.g., OnStar, ATX, Sync, Qualcomm,

“Connected”
Cooperative Short-Range Com.
Vehicle-Infrastructure Integration (VII)
Collision Warning, Signal Pre-emption,
Platooning, CACC, Toll Collection, Demand Mgt.
(Wi-Fi, DSRC, V2V, V2I, V2X)

e.g., CAMP, USDOT Safety Pilot,

“Automated”
Robotic Unmanned Autonomous
ABS, ESC, TCS, CIB, EBA, BSD, LDW, FCW
Lane Keeping, ACC, CACC, Collision Avoidance
Convoys Platoons, Autonomy
(Military Robotics, Radar, Lidar, Vision,
Map-based Localization, navigation, control)

e.g., DARPA Challenges, TARDEC,
NHTSA, AHS, Google, OEMs, Tier
Chartered September 2011

Information Reports

Recommended Practices

SAE Standards

Reports to the Driver Assistance Systems Steering Committee of the Motor Vehicle Council.
Engaging Experts

- Automotive Manufacturers
- Automotive Equipment Suppliers
- Government Safety and Regulatory Organizations
- University Robotics R&D Organizations
- Commercial Robotics R&D Organizations
- DoD Robotics Organizations
- Industry Consultants
- Industry Consultants
- Industry Consultants
- Industry Consultants
ORAV Task Forces

- Planning (Bryant Walker-Smith, Paul Perrone)
- Definitions (Barbara Wendling), J3016 information report, 2014
- Safe On-Road Testing (Steve Underwood), J3018 report, 2015
- Verification and Validation (Venki Agaram), information report
- Reference Architecture and Interfaces (Steve Underwood, Dan Bartz, TARDEC), recommended practice, anticipated report June 2016
J3018 Safe On Road Testing Guidelines, Levels 3-5

- Test driver training: Novice, trained, expert; problems, safe harbor
- Test driver workload: Add engineer to driver
- Test program management: Experienced, briefing, rules
- Functional safety: Hazards, risks, mitigation
- Software development and release requirements
- Operating conditions
- Graduated road testing
- Test data capture
- Safety override
Model Based Systems Engineering Process

**Concept**
- Define System Requirements
  - Modeling & Simulation
- Model Functional Architecture
  - Modeling & Simulation

**Development**
- Specify Logical and Physical Architecture
  - Component Verification Procedures
- Design and Implement (Hardware & Software)
  - Component testing & HIL

**Approval**
- Validate Systems
  - Pilot, operational and natural use testing
- Integrate and Define Parameters for Verification
  - Controlled field and track testing
- Integrate and Test Components

- Test Cases
  - System Verification Plan, Performance Requirements
  - Vehicle Validation Plan and Performance Measures

- Management Plan
- AVS CONOPS, operational need

**Functional Subsystems**
- Define and Decompose

1/8/2016 SAE International
SAE Reference Architecture and Interface (RAI)  
TARDEC Interoperability Profile (IOP)

Control Layer

Motion Layer

Behavior Layer

Mission Layer

By-Wire and Active Safety Controller

Autonomous Behavior Computer

“Virtual Driver”

Messages and Databus?
Why are we doing this?

• Supporting and extending TARDEC’s Interoperability Profile message sets.
• Develop a shared framework and language for discussing standards and issues related to automated driving systems,
• Identify promising areas for standards development with the goal of increasing interoperability of products,
  – Assure consistent implementation of technology to solve problems,
  – Support the validation of solutions against the Reference Architecture, possibly through conformance testing,
  – Helping to minimize redesign and recertification of safety critical features while promoting competition on customer-facing features,
  – Potentially reducing the cost of introducing new automated driving systems, possibly from different vendors, to specific vehicles,
  – Increase the modularity, flexibility, and extensibility of products designed to the architecture, and as with most standards-related activity, and
  – Potentially increasing the rate of technology development and economies of scale associated with the production of automated driving systems.
1. Review State of Art and Mine Patterns

- Use cases
- Literature
- Existing architectures
- Purpose/customer
- Challenges
- Requirements
- Lessons learned
- Activities
- System designs
- Instantiations
- Conceptual framework

2. Analyze and Decompose Requirements

- Functional and performance requirements
- Non-functional requirement focus: module interoperability, scalability
- Edge cases
- Spatial coordinate frames
- RCS controller hierarchy
- Temporal span of control
- Data management, maps
- Communications analysis

3. Model (SysML) and Integrate Scalable Architecture across Levels

- Using SysML and MagicDraw
- Interoperability focus
- Requirements (F & NF)
- Activities
- Use Cases
- Block diagrams
- Software modules
- Messages
- Traceability
- Integration and verification plan

Reference Architecture: Requirements, Modules, Interfaces, Messages
Freeway Pilot Use Case:
Leader/Follower Behavior: Focus on Unmanned Leader

Draw on:
- TARDEC IOP
- Adaptive, Highway Chauffeur
- DARPA Challenges
- HAVEit, EU
- AUTOSAR
- USDOT CV Architecture
  CAMP Automation Architecture
SAE Autonomous Mode Functional Flow Diagram (Detail)

Sensing
- Radar
- Laser Scanners
- Cameras
- UWB
- Network Radios
- Fiducials, Sensors

Perception
- Roads & Objects Sensory processing:
  - Detect road features
  - Detect static obstacles
  - Detect dynamic obstacles
  - Track dynamic obstacles
  - Lead/following vehicle

A- Localization

World Model
- Persistent
  - Road map
  - Static map
  - Topological map
  - Traffic rules
  - Static obstacles
  - Route Network Definition
  - Designated Safe Harbor

- Transient
  - Pose
  - Dynamic map
  - Dynamic obstacles
  - Cooperating vehicles
  - Construction
  - Traffic
  - Visibility

Non-Driving or Remote Operator

Navigation or Planning
- 10 + sec
- 0.1 to 10 sec
- 0.02 to 0.1 sec

Path Planning
- Temporary Path
- State Harbor

Mission Planning
- Mode
- Road network fragment
- Route
- V2V gap

Control Commands
- Preview motion commands
- Route & SH

Path motion commands

Active Safety Driver Assist
- ADAS Map
- Location
- Fusion Object Level
- Active Safety
- Example ADAS
  - Route guidance
  - Driver information
  - Collision warning
  - Collision avoidance
  - Cruise control (CC)
  - Adaptive CC (ACC)
  - Cooperative ACC (CACC)

Vehicle Controls

Command Arbitrator
- AUTOSAR Vehicle Dynamics Mgt
- Vehicle Dynamics Mgt
- 0.02 to 0.1 sec

Steering
- Braking
- Powertrain

Driver*
- Destination
- On/off
- Mode

A- HMI

B- HMI

Active Safety
- Avoidance braking
- Gap keeping

Mission Planning

Path Planning

Control Commands

Environment

Health Monitor, Data Logger, Diagnostics, Prognostics, Heartbeat

Other Functions/Features Common across A-B:
- Deterministic Control
- Cybersecurity
- Fault Tolerance

* - If present
Reviewing State of Art and Mining Patterns

- Sensing
- Perception
- Road World Model
- Navigation
- Active Safety
- Vehicle Control
- Driver Operator
- Localization

- Health Monitor, Data Logger, Diagnostics, Heartbeat
- Road World
- Safe Harbor
- Motion Commands
SysML Model-Based Reference Architecture Process
Possible Future Activities

• Safe harbor (use case just initiated)
• 3D prior maps for localization
• Cybersecurity of automated driving system
• Interfaces: Sensors, vehicle, connected
• Levels of redundancy
• Functional safety where driver is not backup

(coordinate with others as required)
Functional Safety and Safe Harbor

• Functional Safety refers to the ability of the automated driving system to accommodate internal hazards & failures, which could be electrical, mechanical, or software.
  – Cannot be evaluated through comprehensive testing
  – Achieved during the design and development using methodologies such as those described in ISO 26262

• ISO 26262 currently relies on the driver as a backup
  – Driver intervention not required in Levels 4+ ADS
  – Also not entirely considered are interactions between the ADS and driver: Errors, Misuse, and Abuse
  – Efforts to modify ISO 26262 for ADS will take time

• Few avenues to define sensible functional safety regulations, especially in the short term