Prof. Philip Koopman

Automated Vehicle Safety Update for 2021

February 2, 2021

Carnegie Mellon University

@PhilKoopman

EDGE CASE RESEARCH

Overview

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- Where is the industry in general as of early 2021?
- Beyond the SAE Levels
  - Role of human vs. technology
- Industry trends for 2021
  - Role of standards
  - Technical challenges
  - Organizational challenges

Low Speed Shuttles

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- Low speed shuttles
  - Up to 15 passengers
  - Fixed route at perhaps 5-10 mph
  - Demonstrations in cities worldwide
- Safety approach
  - Slow speed limits kinetic energy
  - Often a non-driver safety conductor
- Example Mishaps
  - Shuttle hit by backing truck (Las Vegas, 2017)
  - False alarm emergency stop with passenger injury (Ohio 2020)

NHTSA lifts suspension of EasyMile vehicles

Smart Columbus

https://bit.ly/39ki41t

By Cailin Crowe

Updated May 19 2020, 10:30 a.m. EDT •Published Feb. 27, 2020

Parcel Delivery

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- Parcels to stores, houses
  - Short range delivery
  - Roads, bike lanes, sidewalks
  - Demonstrations in several cities
- Safety approach
  - Early: trailing vehicle
  - Later: remote human
- Example Incidents
  - Sidewalk bot blocks wheelchair ramp (Pittsburgh, 2019)
  - Tension over use of sidewalk space

Nuro Gets First Commercial Autonomous Vehicle Permit in California

Prepare yourself mentally to see a Prius driving itself if you live in the Bay Area.

BY JAY RAMEY ◆ DEC 31, 2020

Driver-Monitored Automation

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- Automated driving of car or truck
  - Continuous driver supervision
  - OEMs in production already
- Safety approach
  - Human driver monitors automation
  - Human driver responsible for safety
- Example Mishaps
  - Multiple fatal Tesla crashes
    - Issue: driver complacency
    - Issue: under 10 seconds from OK to fatal crash
  - Tempe Arizona fatality in testing (Tempe, 2018)

NTSB: Tesla Autopilot, distracted driver caused fatal crash

https://bit.ly/3bnk3EZ

By TOM KRISHER February 25, 2020

Fully Autonomous Operation

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- Fleet vehicles
  - Waymo robotaxis deployed a limited scale
  - Middle-mile trucks gained interest in 2020
  - Many players pushing hard in this area
- Safety approach
  - Early: Human safety driver
  - Later: Human on-call if car asks for help
- Example incidents
  - California reports indicate minor incidents in testing

https://bit.ly/39j4yeC

Industry Trends

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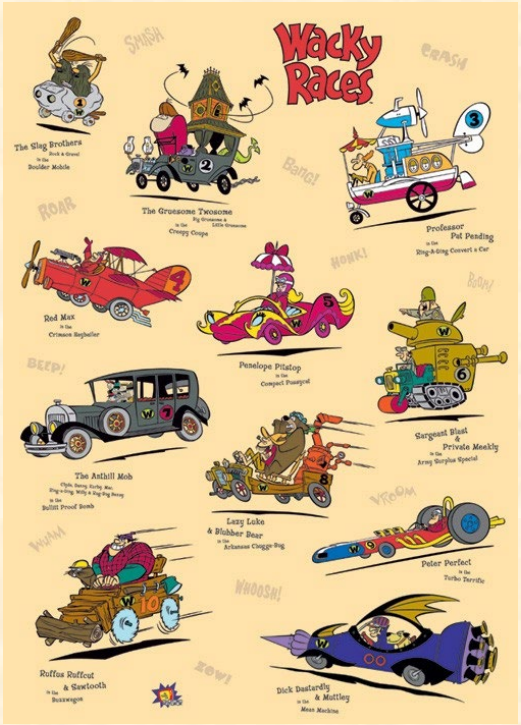
- Consolidation in the “race” to autonomy
  - It takes huge resources to succeed
  - Trend to OEM + ADS supplier teaming
  - Smaller players fail, team, or acquired over time
- Fully autonomous pivot toward freight
  - Low kinetic energy for last mile service
  - Middle mile highways less chaotic than urban
- Shift of “SAE Level 3” vehicles to L3+
  - Strict L3 means human driver supervision
  - OEMs shifting to L3+ with car safe stopping on its own



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A User-Centric Classification

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Operating Mode	Human Role	Driving	Driving Safety	Other Safety
Assistive	Driving			
Supervised	Eyes ON the road			
Automated	Eyes OFF the road			
Autonomous	No human driver			

Vehicle Automation Modes

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www.ecr.ai

Standards-Based Engineering Approach

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SYSTEM SAFETY	UL 4600		**Safety Beyond Dynamic Driving**
DYNAMIC DRIVING FUNCTION	ISO/PAS 21448	SaFAD/ISO TR 4804	**Environment & Edge Cases**
FUNCTIONAL SAFETY	ISO 26262		**Equipment Faults**
CYBER-SECURITY	SAE J3061	SAE 21434	**Computer Security**
VEHICLE SAFETY	FMVSS	NCAP	**Basic Vehicle Functions**

HIGHLY AUTOMATED VEHICLE SAFETY CASE

UL 4600

2021 Technical Safety Challenges

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- Perception & prediction
  - Safety of machine learning-based functions
  - Need more than object motion tracking
- Safety of Intended Function (SOTIF)
  - Drive/Fix/Drive iteration with lots of testing
    - Waymo: 6M test miles; 65K deployed miles
  - How will safety be argued for larger fleets?
    - Likely will involve UL 4600 concepts and safety cases
- Getting from “works OK” to “safe”
  - You can brute force the first few “nines” … but not all of them.
  - Field feedback into safety cases

Developing Trust for Full Automation

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- Still an open world with unknowns & changes
  - Want "Positive Risk Balance" (safer than human driver)
  - But … *no human driver responsible*
- Use Positive Trust Balance
  - Engineering rigor
  - Practicable validation
  - Strong safety culture
    …. and …
  - Field feedback to handle surprises
- UL 4600 ties feedback to Safety Case

Safety Arguments (Safety Case)

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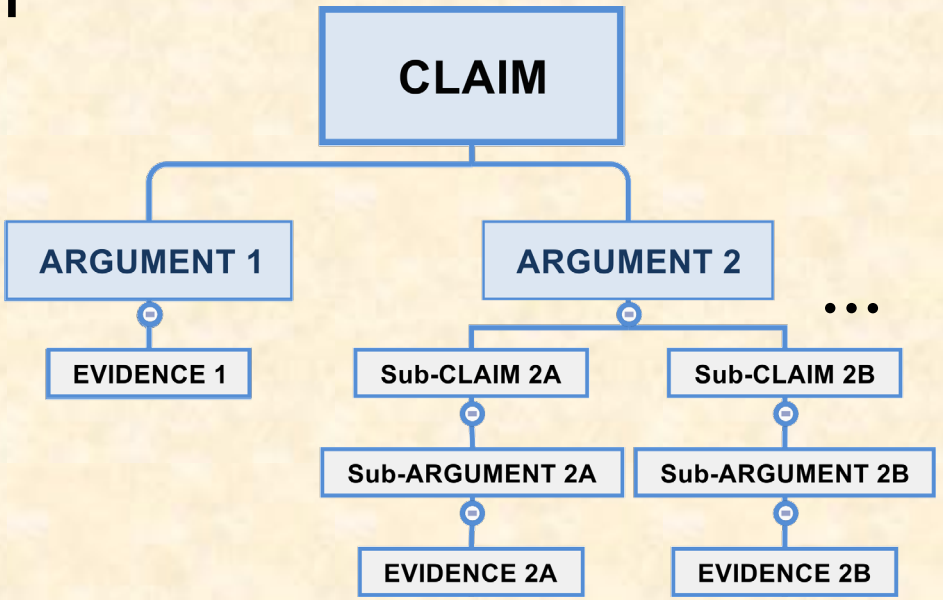
- Claim – a property of the system
  - "System avoids pedestrians"
- Argument – why this is true
  - "Detect & maneuver to avoid"
- Evidence – supports argument
  - Tests, analysis, simulations, …
- Sub-claims/arguments address complexity
  - "Detects pedestrians" // evidence
  - "Maneuvers around detected pedestrians" // evidence
  - "Stops if can't maneuver" // evidence



Safety Performance Indicators (SPIs)

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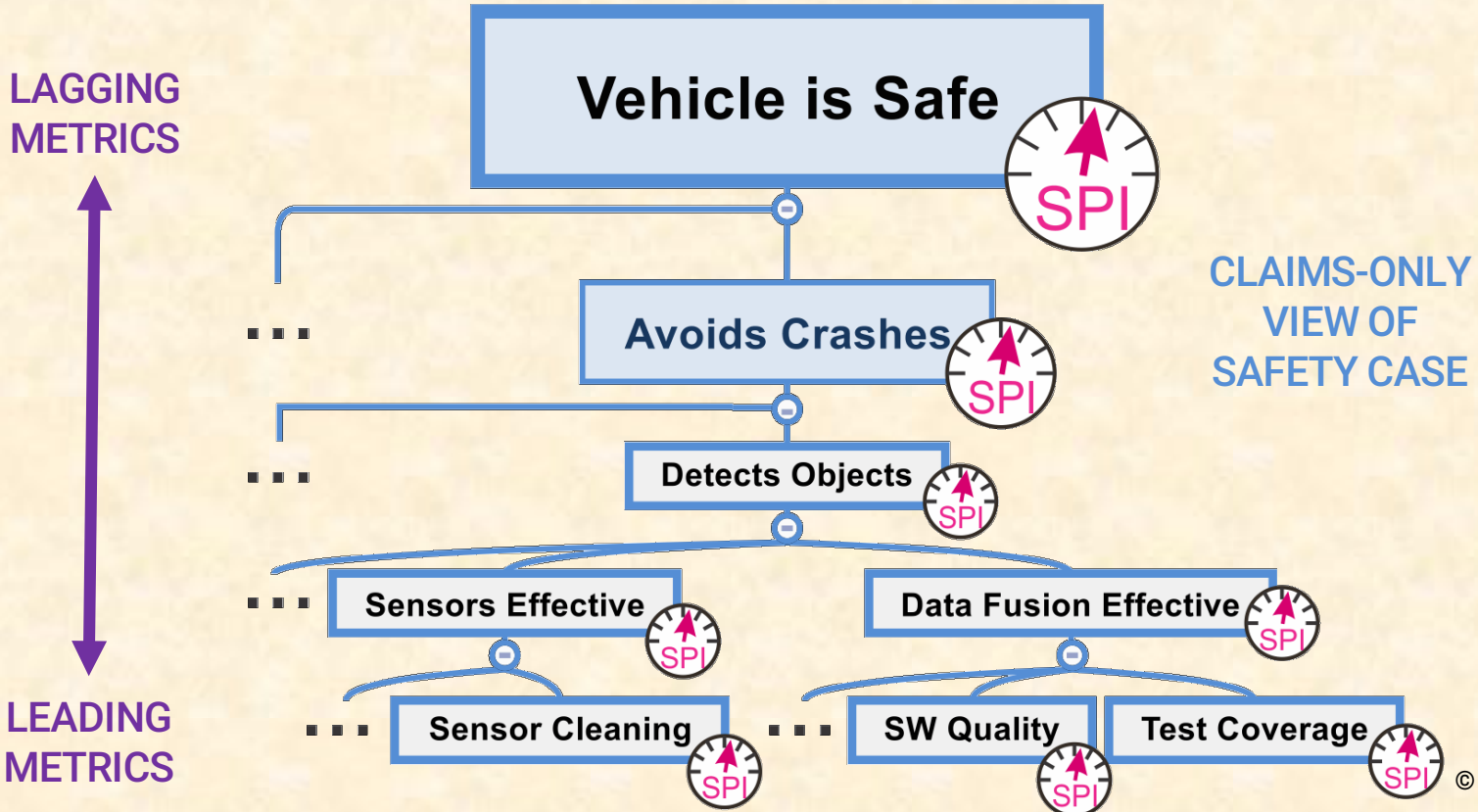
- SPIs monitor the validity of safety case claims (UL 4600)



Examples of SPIs

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- "Acts dangerously" is only one dimension of SPIs
  - Violation rate of pedestrian buffer zones
  - Time spent too close per following distance math
- Components meet safety related requirements
  - False negative/positive detection rates
  - Correlated multi-sensor failure rates
- Design & Lifecycle considerations
  - Design process quality defect rates
  - Maintenance & inspection defect rates
- Is it relevant to safety? ➔ Safety Case ➔ SPIs

2021 Safety Themes

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- Positive Trust Balance:
  - Engineering Rigor, Validation, Feedback, Safety Culture
  - Standards-driven safety
  - Transparency
- Safety Performance Indicators (SPIs)
  - Continual improvement & updates
  - Field feedback: development; deployed
- Scalability past pilot vehicles
  - Accurate perception/prediction is still work in progress
  - Transition from brute force data to safety case approach

2021 Organizational Safety Challenges

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- Significant pressure to deploy
  - Flurry of empty driver seat demos in late 2020
  - Can teams take the time needed for safety?
- Industry transparency needed
  - Safety collaboration rather than competition
  - Public trust in face of an adverse news event
- Ensuring robust safety cultures
  - Silicon Valley culture + automotive culture + no human driver
  - We need to get this right to succeed!

https://youtu.be/nhqyrze30bk
Yandex demo video,
Ann Arbor MI, Aug 2020

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WE DELIVER THE PROMISE OF AUTONOMY