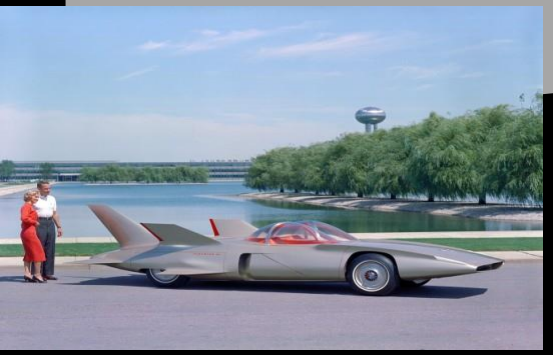
A(G)I based Automotive Features and Safety and Development Lifecycle



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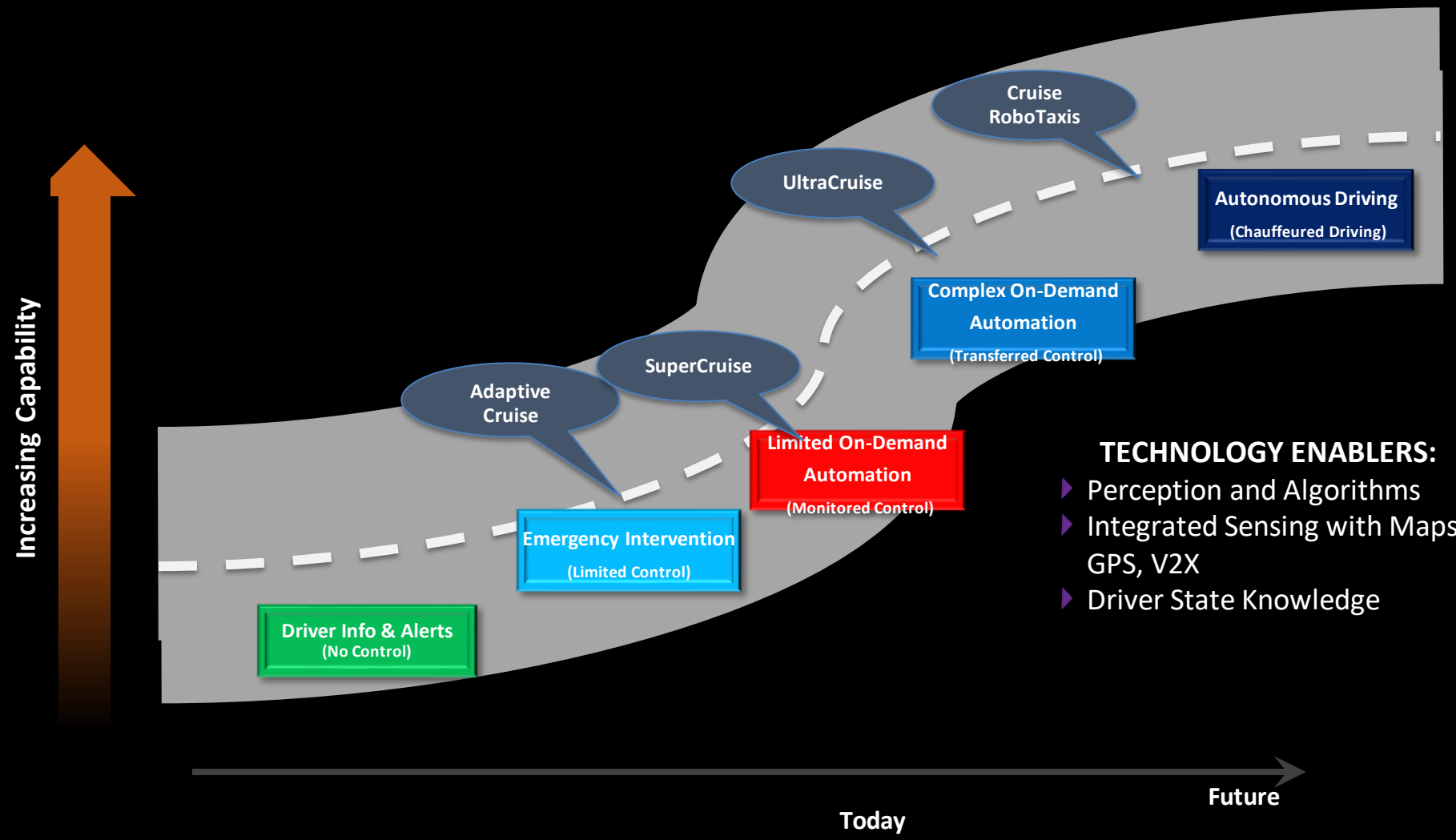
General Disclaimer

- Based upon my observations
- Not the Opinion of GM
- Tried my best to quote the original source of diagrams wherever possible

Talk Highlights

- Next Gen Automotive Systems employ AI components in a variety of domains including perception, planning and control
  - No AGI yet
- AI components and their development lifecycle differ in many aspect from traditional components
  - Data (experience based) rather than `physics'-based
- Current automotive safety standards assume
  - human in the loop
  - Pre-deployments assets
  - integrated safety and development lifecycle
- New standards and guidelines emerging to comprehend AI based systems
  - demand new lifecycle assets for AI components

A- Z of Cruises: Road to Autonomy

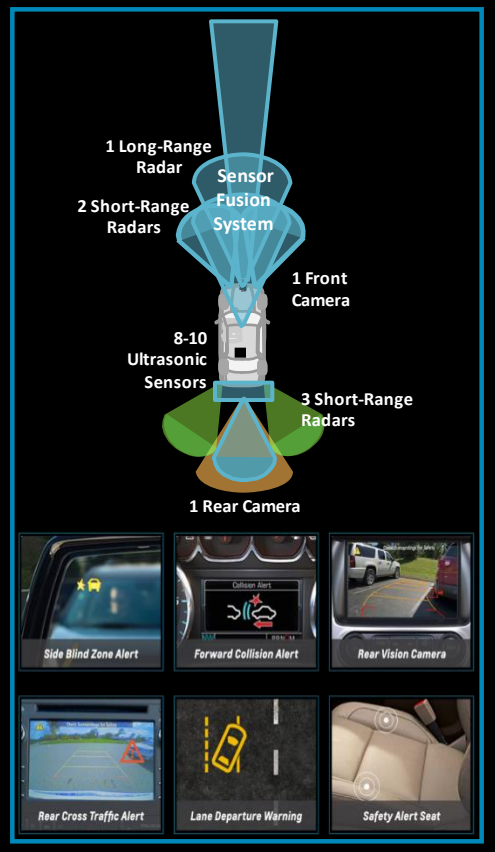


TECHNOLOGY ENABLERS:

- Perception and Algorithms
- Integrated Sensing with Maps, GPS, V2X
- Driver State Knowledge

Super Cruise – Hands Free Driving Feature

ACTIVE SAFETY



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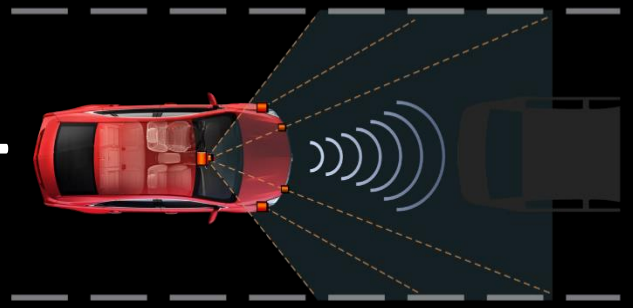
AUTOMATED STEERING & LANE FOLLOWING



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CADILLAC SUPER CRUISE

HOW IT WORKS

LANE FOLLOWING: Using a combination of GPS and optical cameras, Super Cruise watches the road ahead and adjusts steering to keep the car in the middle of its lane.

COLLISION AVOIDANCE: A long-distance radar system detects vehicles more than 300 ft. ahead. The vehicle will automatically accelerate or apply the brakes to maintain a preset following distance.

Prevents 10 K deaths, Saves 250 Billion Dollars – Boston Consulting Co.

Levels of Automation in Vehicles

- SAE definition identifies 5 levels
- Features of Level 2+ (likely to) use AI/ML components
- Level 2+: Increasing range of Operation Design Domain (ODD) and Dynamic Driving Tasks (DDTs)
- Level 5 unlimited ODD and probably beyond all DDTs
  - corresponds roughly to AGI
- Industry focus has been primarily on Level 2 - 4

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

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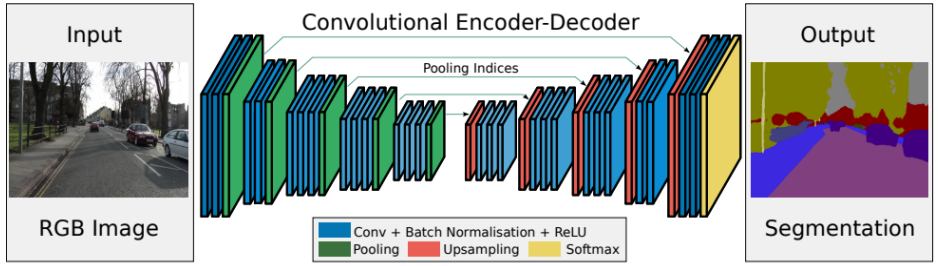
AI/ML Fundamentally Transforming every industry including ours

AI/ML in Automotive

- Shift in Functionality as we move to Level 2+ features
  - From Traditional Control System Paradigm
    - Sense – Control – Actuate
  - To AI Robotics Paradigm
    - Perceive – Plan - Action
- Level 2+ use AI/ML components mainly in perception and planning
  - Eg., Lane and Traffic Signal Detection, 3D Object Classification, Image Segmentation,
- They can be camera-based or Lidar based
- OEMs develop in-house as well as integrate 3rd party supplier AI/ML components

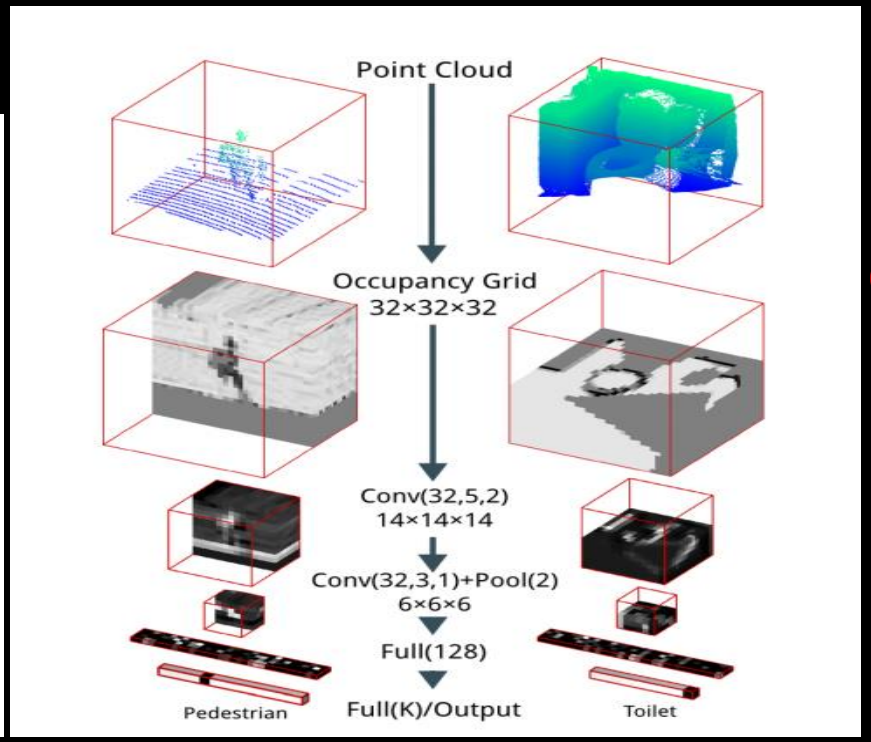
AI/ML Components – Huge and Complex

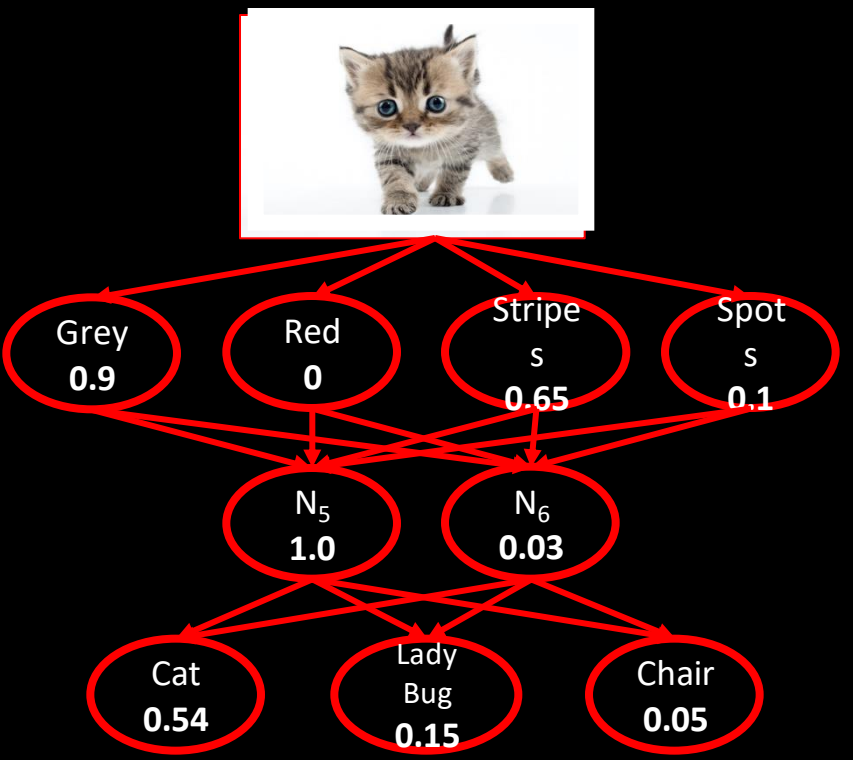
- Typical Sizes of Deep Neural Networks
  - 20 to 50 Layers (many convolutional layers)
  - Millions of Parameters
- SegNet (pixel-wise semantic segmentation) has
  - 30 Layers – Convolution, Pooling, ReLU, Softmax
  - Around 50M parameters
  - Hierarchical Architectures: Encoder-Decoder



AI/ML Components – I/O Behavior

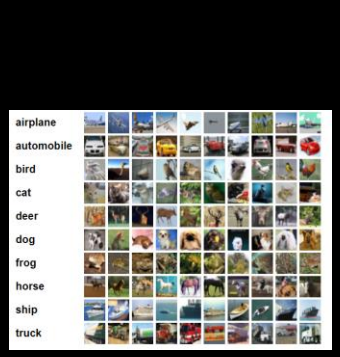
- Quite different, compared to conventional components
- Input: RGB pixel data, Point clouds
- Outputs: Probablistic

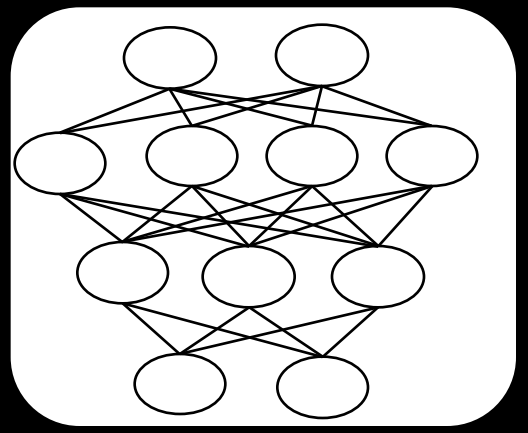


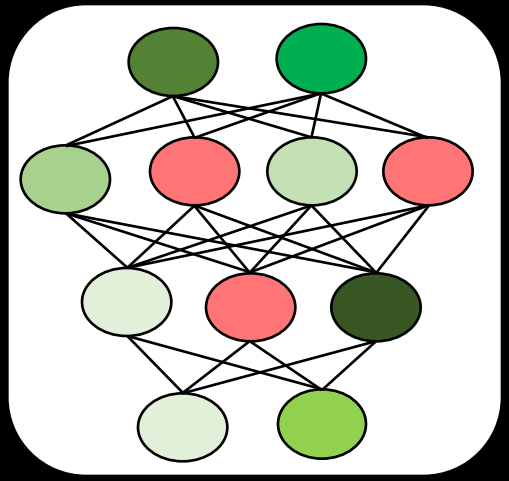


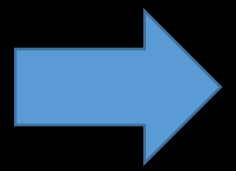
AI/ML Component Development

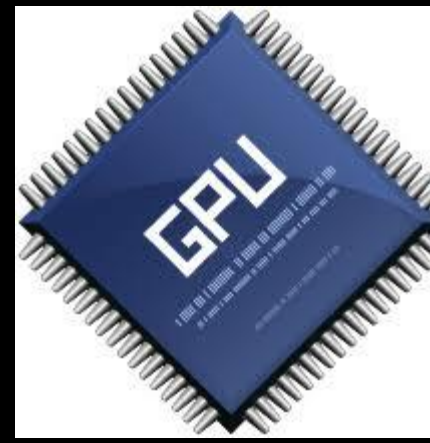
- Significantly different from traditional systems – data based than `physics' based
  - Starts with a specific architecture or network which gets
  - Trained using a huge data set which
  - Deployed upon a hardware platform
- Training data set primarily decides the quality of final system





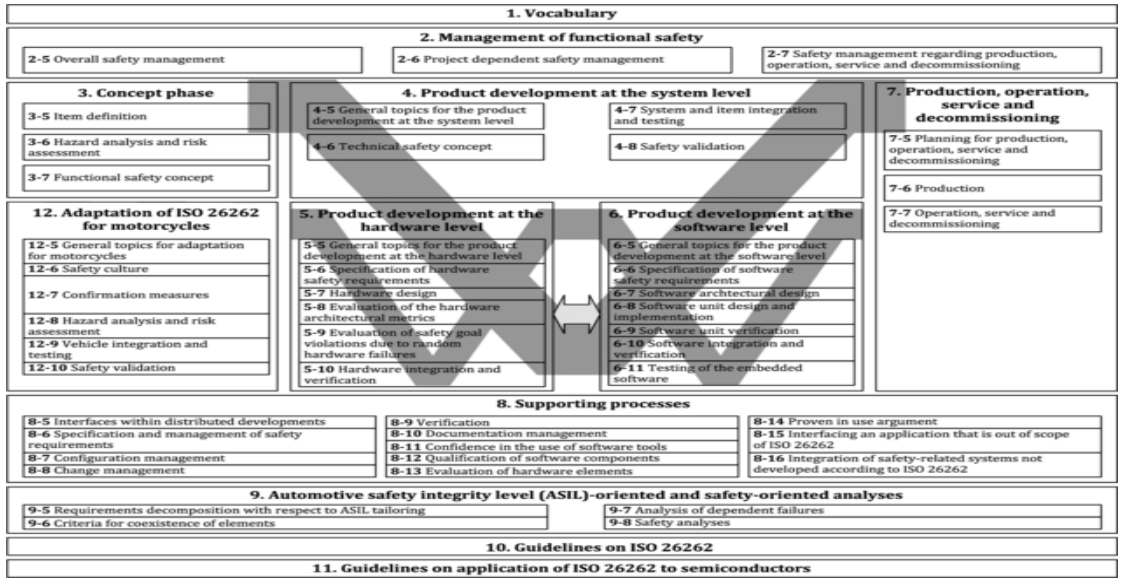


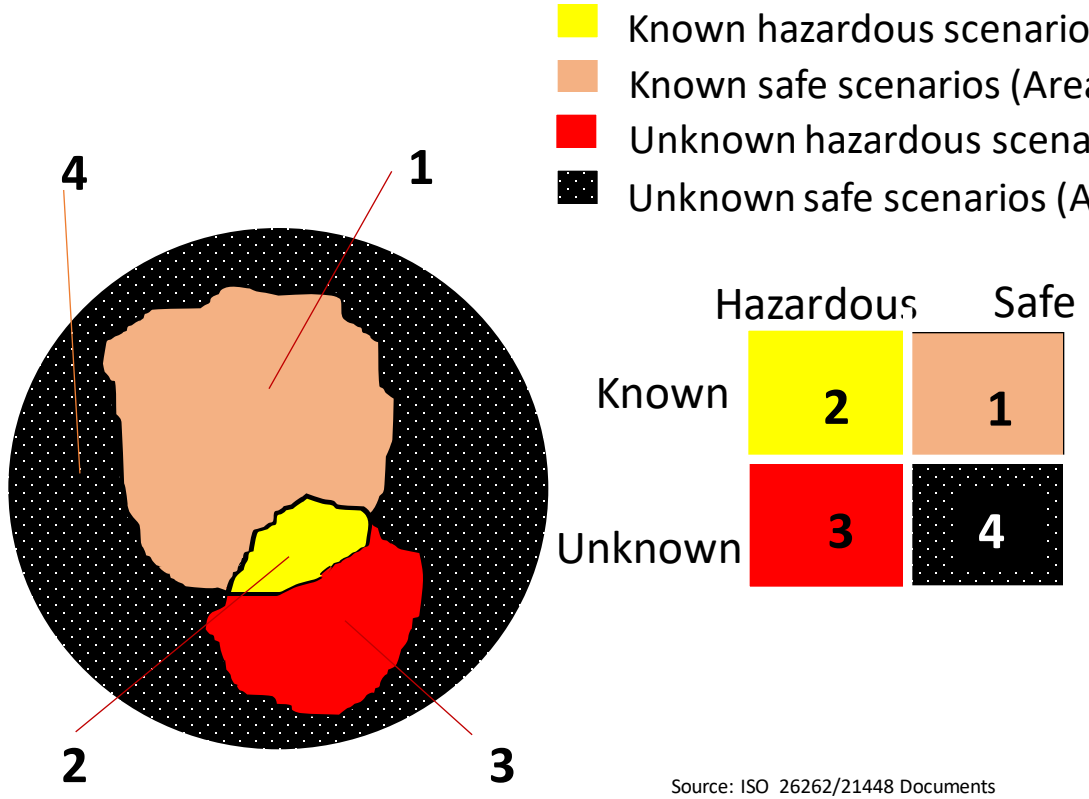




Safety and AI/ML

- Level 2+ features perform critical functions
  - Collision Avoidance
  - Situation awareness
- AI/ML becoming part of the Safety-Equations
- Current automotive Safety Standards
  - Functional Safety (FuSa), ISO 26262
    - Safety under failures
  - Nominal Safety (NoSa) - SotIF, ISO 21448
    - Safety under Limitations
- Assumes Human in the loop

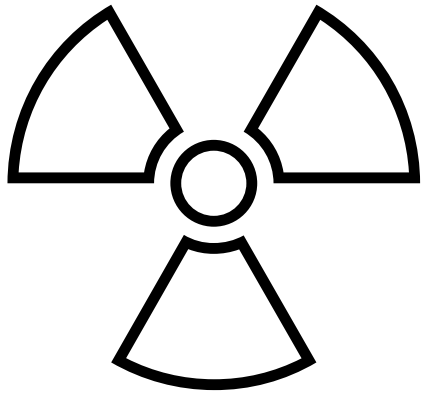


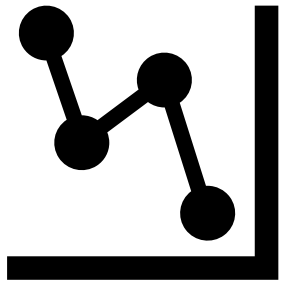


Source: ISO 26262/21448 Documents

Deductive Approach to Safety

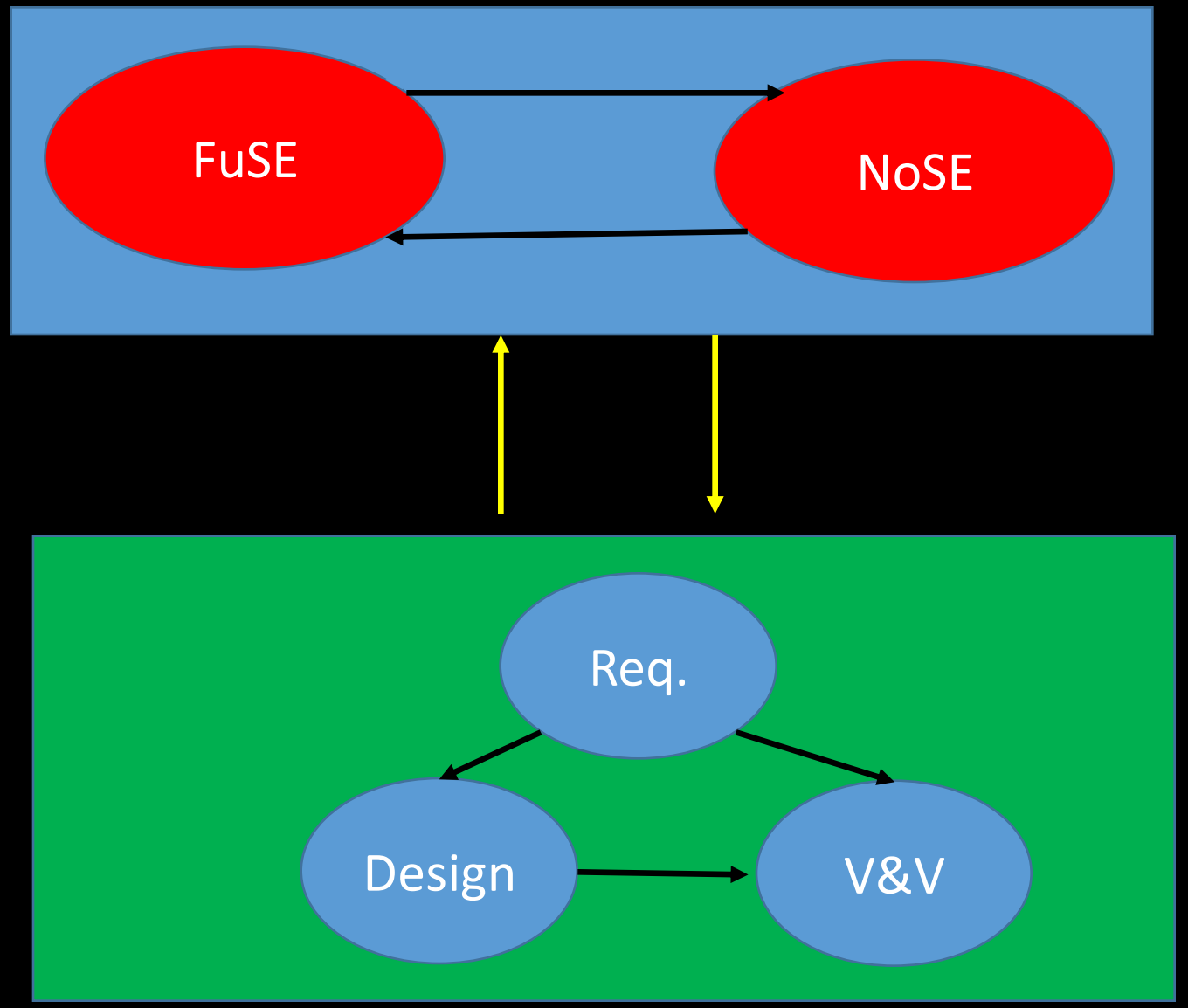
- Safety is Absence of unreasonable risk
- Systematic Identification and analysis of risks
- Risk Acceptance Criteria – basis for safety analysis
  - ALARP, PRB, GAMAB
- Safety Case: arguments & evidences
  - The arguments emphasize well understood and accepted engineering practices, methods and tools
    - Process focused, Standards & Guidelines
- Safety Life Cycle
    - Many assets: Hazard Metrics, Safety Goals and requirements
    - Fault Injects Test Results, Edge Cases
- All assets are pre-deployment assets
  - Prevents on-the-fly learning





Functionality & Safety

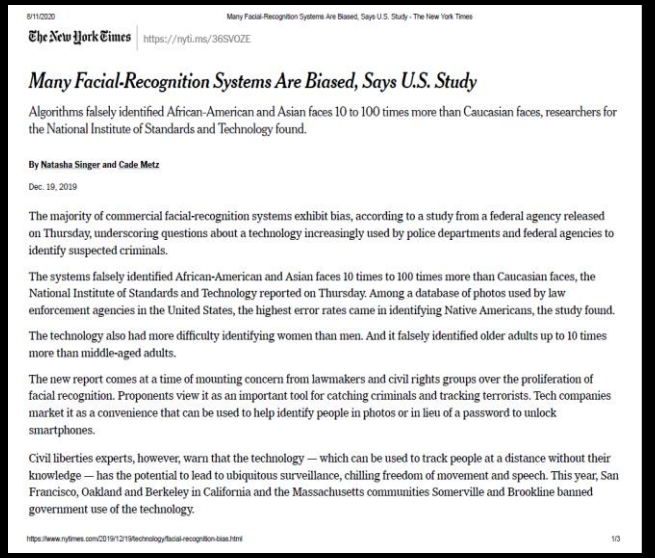
- Integration of Safety and Development Life Cycle
- Every design step undergoes safety analysis
- Safety Analysis leads to design iterations
- Iteration and Integration of FuSa and NoSa Analysis Steps as well



AI Safety and V&V

- AI problem is ill-posed
  - Likelihood Estimation, Stochastic
  - Incomplete (Frame Problem)
- Predictability
  - Flounder in rare or new situations not encountered in training data set
  - Black swan issue
- Functional Safety process assumes a traditional view of development and verification
- Missing safety lifecycle assets and new assets
  - Hardly any requirements
  - Training and Test Data Sets
- Development Lifecyle for AI/ML components is non-traditional
  - Data Intensive

Source: https://nativeausanimals.weebly.com/animal-gallery.html



8/11/2020 Many Facial-Recognition Systems Are Biased, Says U.S. Study - The New York Times

The New York Times https://nyti.ms/36SVOZE

Many Facial-Recognition Systems Are Biased, Says U.S. Study

Algorithms falsely identified African-American and Asian faces 10 to 100 times more than Caucasian faces, researchers for the National Institute of Standards and Technology found.

By Natasha Singer and Cade Metz

Dec. 19, 2019

The majority of commercial facial-recognition systems exhibit bias, according to a study from a federal agency released on Thursday, underscoring questions about a technology increasingly used by police departments and federal agencies to identify suspected criminals.

The systems falsely identified African-American and Asian faces 10 times to 100 times more than Caucasian faces, the National Institute of Standards and Technology reported on Thursday. Among a database of photos used by law enforcement agencies in the United States, the highest error rates came in identifying Native Americans, the study found.

The technology also had more difficulty identifying women than men. And it falsely identified older adults up to 10 times more than middle-aged adults.

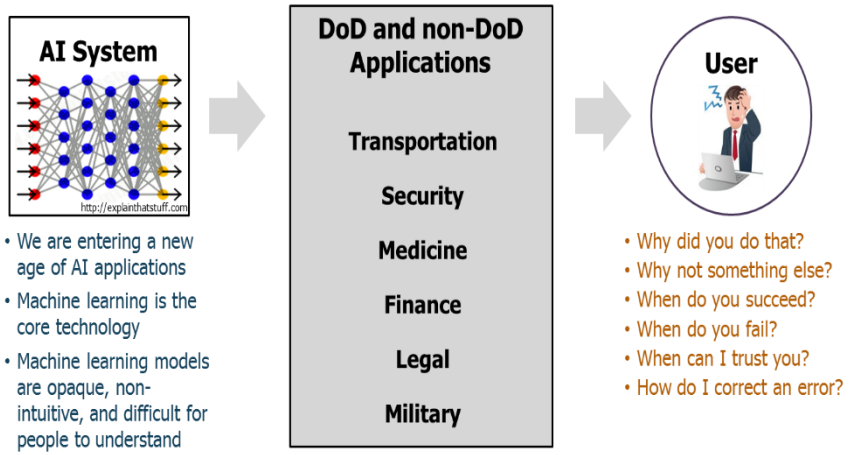
The new report comes at a time of mounting concern from lawmakers and civil rights groups over the proliferation of facial recognition. Proponents view it as an important tool for catching criminals and tracking terrorists. Tech companies market it as a convenience that can be used to help identify people in photos or in lieu of a password to unlock smartphones.

Civil liberties experts, however, warn that the technology — which can be used to track people at a distance without their knowledge — has the potential to lead to ubiquitous surveillance, chilling freedom of movement and speech. This year, San Francisco, Oakland and Berkeley in California and the Massachusetts communities Somerville and Brookline banned government use of the technology.

https://www.nytimes.com/2019/12/19/technology/facial-recognition-bias.html 1/3

AI/ML System Requirements

- Challenges Galore
- The complexity of specifying I/O very high
  - Complex Visual inputs,
  - Structurally complex (Pixels, Point Clouds) Semantically ill-defined. e.g., vehicles, pedestrians, animals
  - Lighting & Weather Conditions
  - Distortions, Noises
- `ty - ness' requirements
  - Security, Reliability,
  - Trustability, Explainability,
  - Robustness, Fairness



Source: https://www.darpa.mil/program/explainable-artificial-intelligence

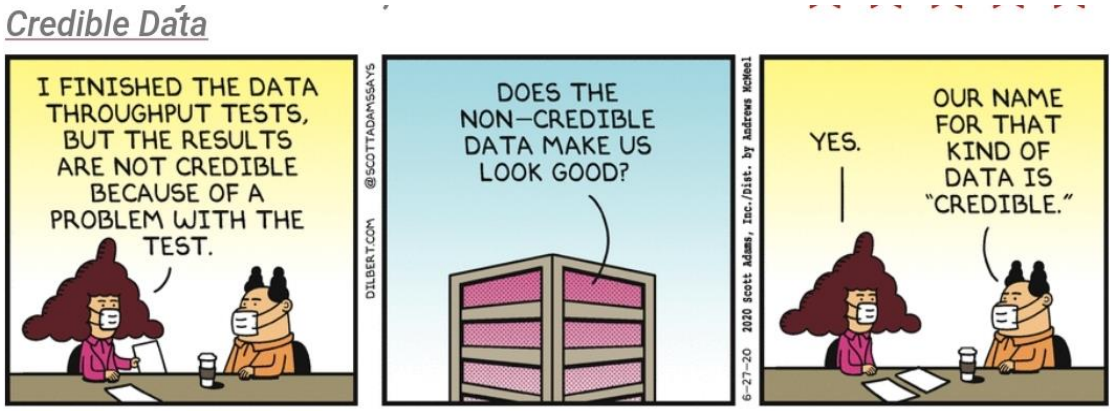
Subtle, adversarial perturbations to images

STOP sign classified as Speed Limit sign

Right turn sign classified as STOP sign

Everything about Data

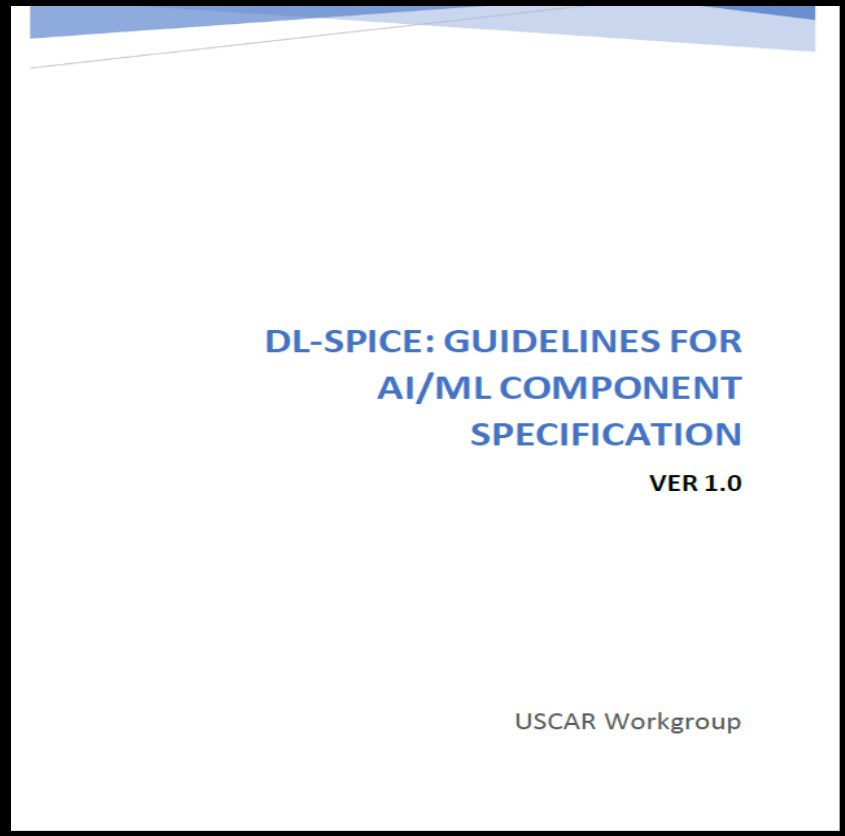
- Data is fundamental to ML Systems
- Decides the Quality of the Algorithm and its Implementation
- Several Questions to be answered
  - How representative the data set is?
  - How balanced the data set is ?
  - Do they include edge cases?
  - Are they traceable to requirements?
- There is a whole industry of data collection, data preparation and labeling
  - Very human intensive
  - Based upon other Machine learning components



Towards Standardization

- Industry-wide guidelines and processes, and standards underway
  - Level 3 and 4 but not yet Level 5 ADS systems,
  - AI based components
  - ISO/SAE
- Leading a USCAR workgroup on this topic and a preliminary draft prepared
  - 3 NA OEMs are involved
  - Would be happy to receive feedback

USCAR
UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH



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THANK YOU
GENERAL MOTORS