

Presentation Outline

- ❑ Research Need
- ❑ Analysis Approach
- ❑ Data Selection
- ❑ Analysis Scope
- ❑ Results
- ❑ Summary

Research Needs

Safety challenges posed by the proliferation and increasingly-interconnected electronic systems¹:

- ❑ Increased amount of complex software that cannot be exhaustively tested
- ❑ Highly interactive nature of the electronic control system – more interactions exist among system components, and the outcome may be difficult to anticipate
- ❑ Growing importance of human factors consideration in automotive electronic control system design
- ❑ Potentially harmful interaction with the external environment including EMI
- ❑ Novel and rapidly changing technology

1. National Research Council Committee on Electronic Vehicle Controls and Unintended Acceleration, "TRB Special Report 308: The Safety Promise and Challenge of Automotive Electronics: Insights from Unintended Acceleration," Transportation Research Board, 2012

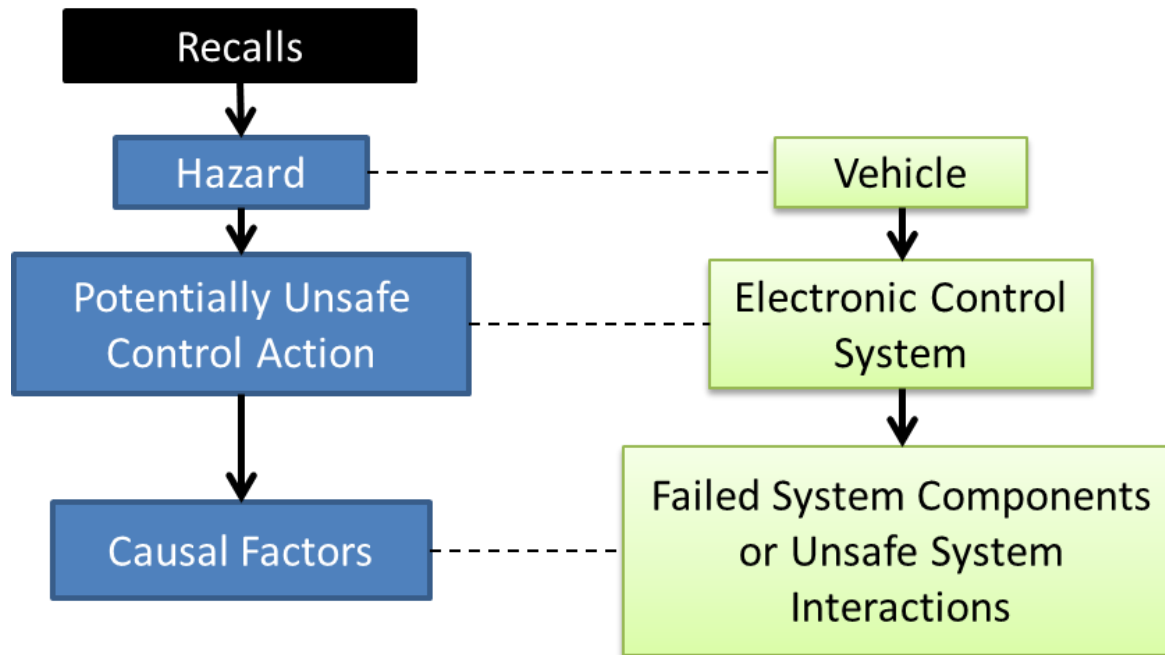
Research Goals

Build a scientific foundation to identify and define automotive electronic control system safety issues:

1. Characterize documented electronic control system safety issues, including the creation of a failure causal factor typology
2. Quantify safety-critical electronic systems safety issues (not ranking or prioritize)
3. Research and develop a new data coding scheme to allow for more efficient data mining for quantification of trends and causal factors

Analysis Approach

- Develop a typology of automotive electronic control system failures based on control system engineering principles
- Populate a database for analysis using historical vehicle failure data



Data Source Selection Process

❑ Data Requirements:

- Publically available
- Definitively demonstrates that a safety issue exists

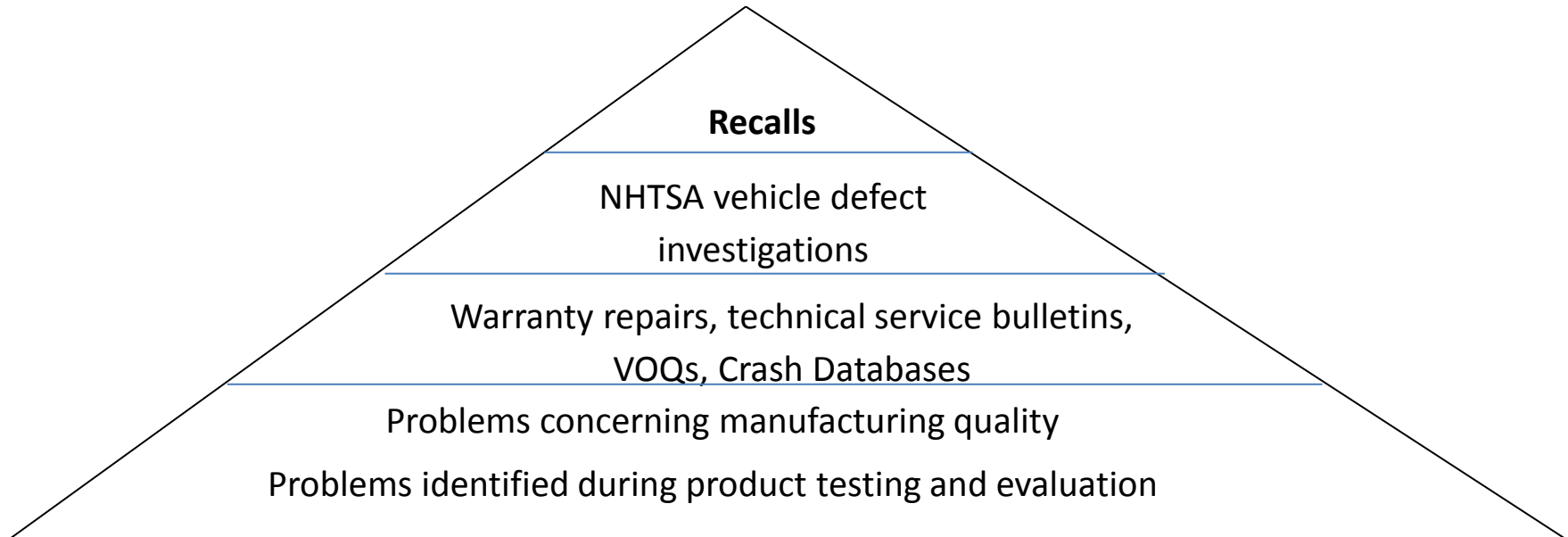
❑ Data Considered:

- NHTSA Complaint Monitoring and Investigation Databases:
 - Vehicle Owner's Questionnaire (VOQ)
 - Defect Investigations
 - Motor Vehicle Recalls
- NHTSA Crash Databases:
 - National Automotive Sampling System (NASS) General Estimates System (GES)
 - Fatality Analysis Reporting System (FARS)

❑ Data Selected:

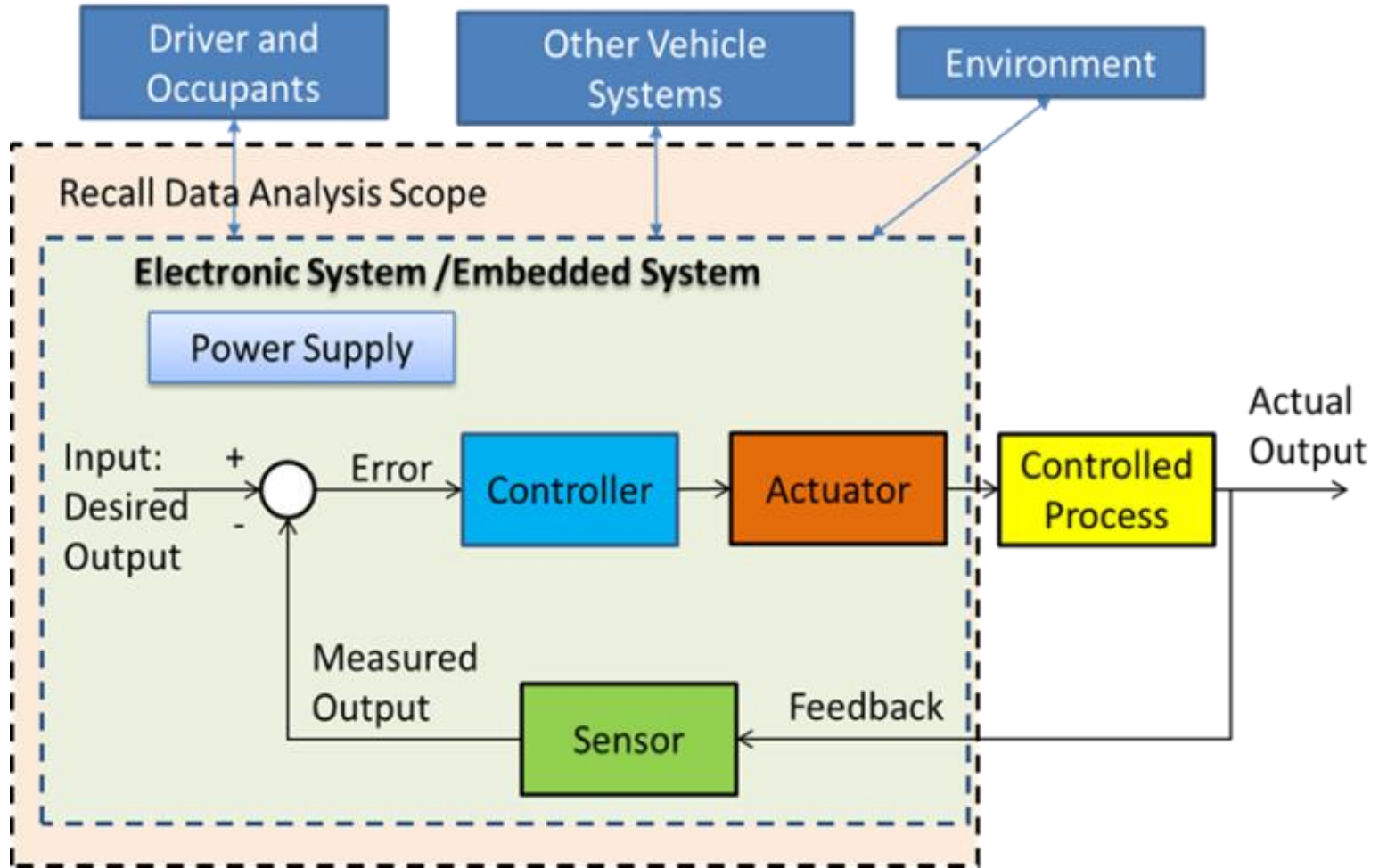
- NHTSA Motor Vehicle Recalls

Data Limitations



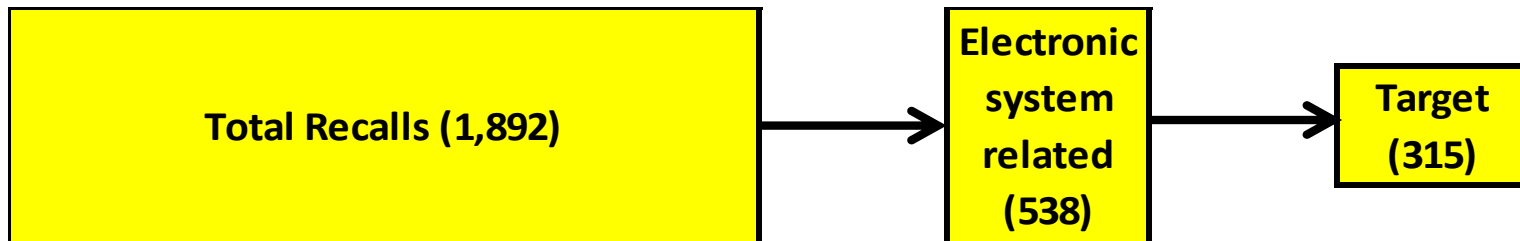
- Recall data may not be representative of all vehicle failures in the field
- If observations made from recall statistics were to be generalized, a weighting scheme must be carefully devised.
- Publically available recall documents provide varying amount of technical details, which may cause misinterpretation for data coding.
- Historical trends may not be truly indicative of future problems

Recall Analysis Scope



Data Scope

- ❑ This study concentrates on malfunctions of electronic control systems caused by:
 - Components (including software) not performing manufacturers' intended functions
 - Unsafe system interactions with other vehicle components
 - Unsafe interactions with the external environment
- ❑ Target Data Filtering:
 - Light Vehicles with gross vehicle weight rating less than 10,000 lbs
 - Model Year (MY) 2002-2013
 - Recalls recorded by April 30, 2013



Electronic Control Systems Considered (Alphabetical Order)

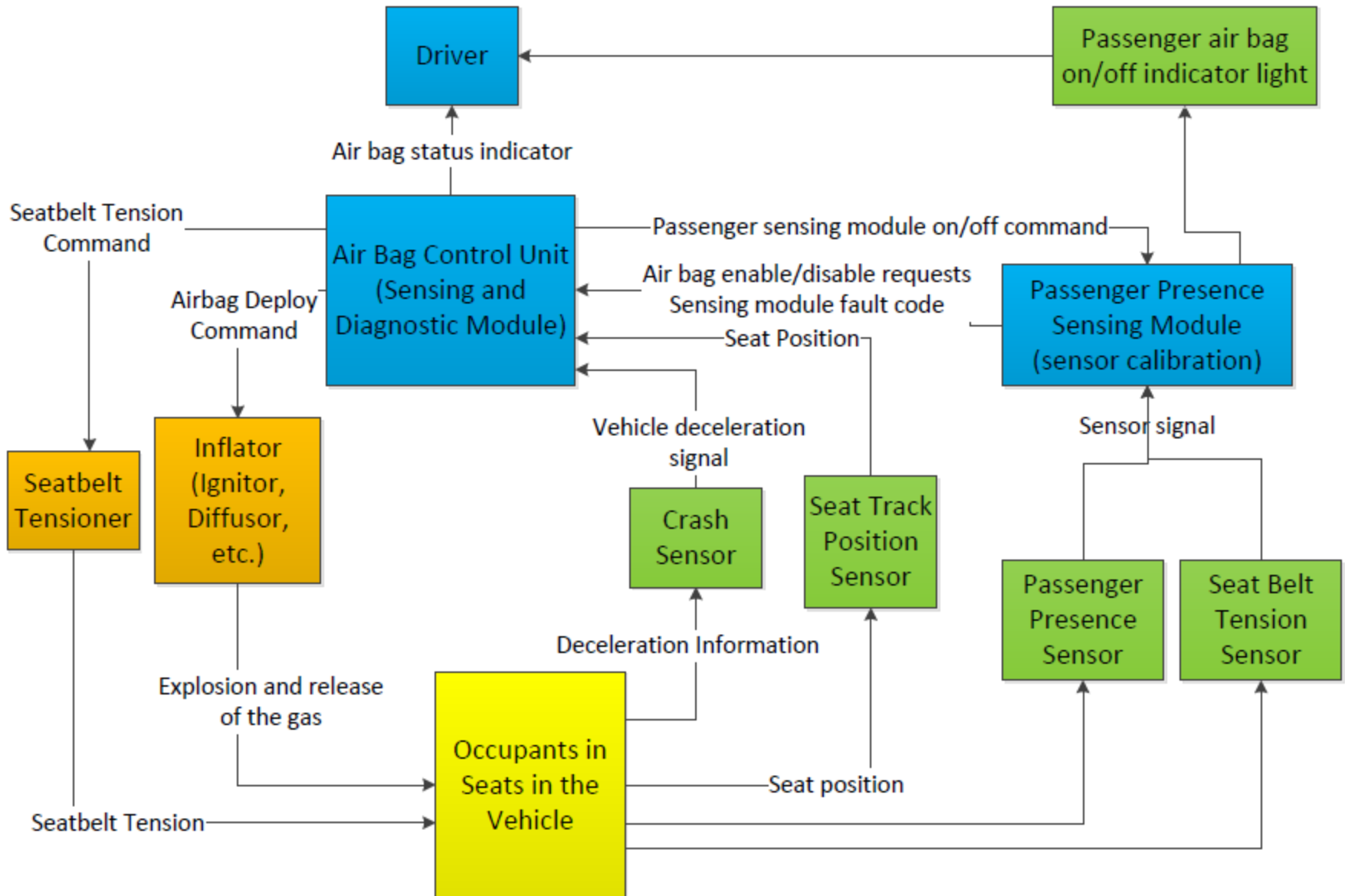
- ❑ Active suspension management
- ❑ Antilock brake system (ABS)
- ❑ Electronic parking brake
- ❑ Climate control
- ❑ Electronic power steering
- ❑ Electronic stability control (ESC)
- ❑ Powertrain control
- ❑ Engine cooling control
- ❑ Exterior lighting
- ❑ Hybrid and electric vehicle (HEV) cooling
- ❑ HEV electrical
- ❑ Ignition key/starter
- ❑ Instrument cluster and driver-vehicle interface
- ❑ Integrated motor assist
- ❑ Power door/window control
- ❑ Restraints
- ❑ Tire pressure monitoring system (TPMS)
- ❑ Traction control
- ❑ Transmission control
- ❑ Vehicle speed control
- ❑ Windshield wiper and washer

Example Recall Analysis

- ❑ Campaign Number: 07V178000
- ❑ Model Year: 2007
- ❑ Component: Air Bags: Frontal: Sensor/Control Module
- ❑ Summary: Certain passenger vehicles fail to conform to the requirements of Federal Motor Vehicle Safety Standard No. 208, 'Occupant Crash Protection.' The front passenger seat has a sensing system to detect if the seat is occupied. This sensing is programmed to detect if the seat is occupied by a small adult or certain child restraint seats. Placing certain child seats on the front passenger seat is designed to result in the automatic deactivation of the front seat passenger's air bag.
- ❑ Consequence: In some cases, the sensing system may misinterpret a properly seated small adult as one of these specific child seats, resulting in deactivation of the front passenger air bag when the air bag might be beneficial for the adult, increasing the risk of injury in a crash.
- ❑ Remedy: Dealers will replace the front passenger seat sensor.

Source: <http://safercar.gov>

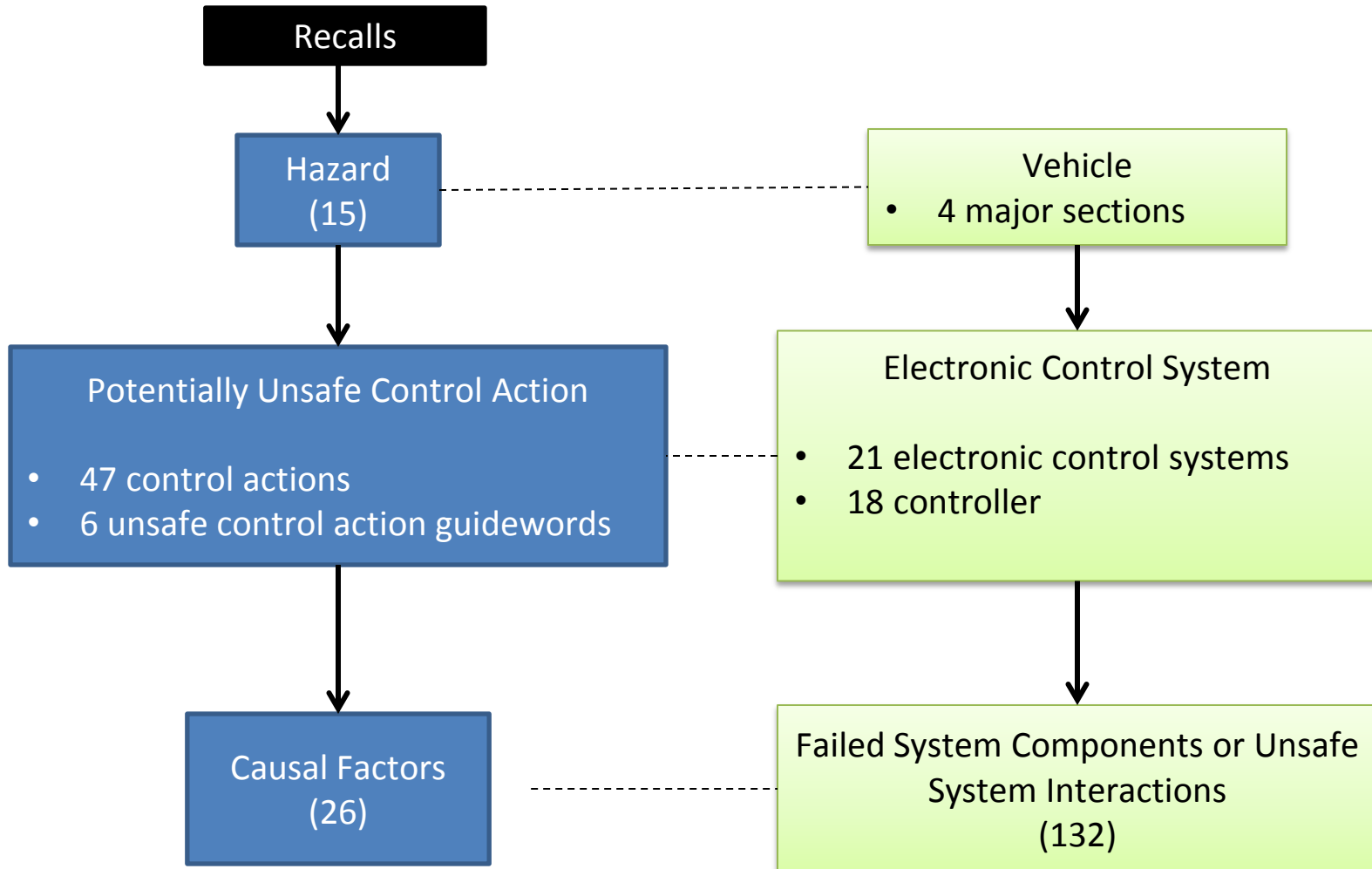
Air Bag Control System



Example Recall Analysis (Cont.)

- ❑ Hazard: Restraint system loss or degradation
- ❑ Vehicle Section: Body
- ❑ Vehicle System: Restraint System
- ❑ Unsafe Control Action: Air bag may not deploy when it should
- ❑ Component failure: Failed component is within the air bag control system
- ❑ Hardware failure: Electronics/Electrical component
- ❑ Causal Factor: Sensor inadequate operation, change over time
- ❑ Causal Component: Passenger Presence Sensor

Data Coding

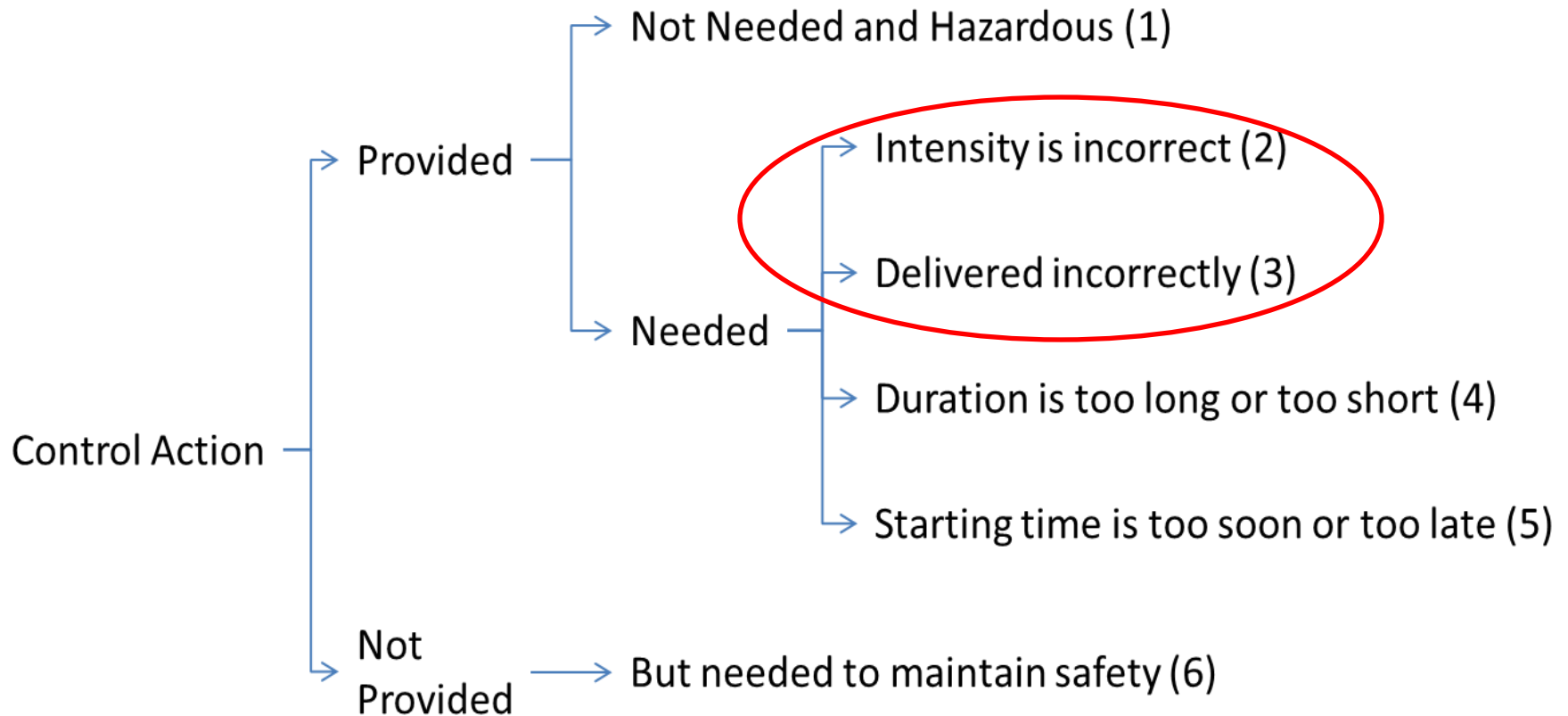


Vehicle Level Hazards

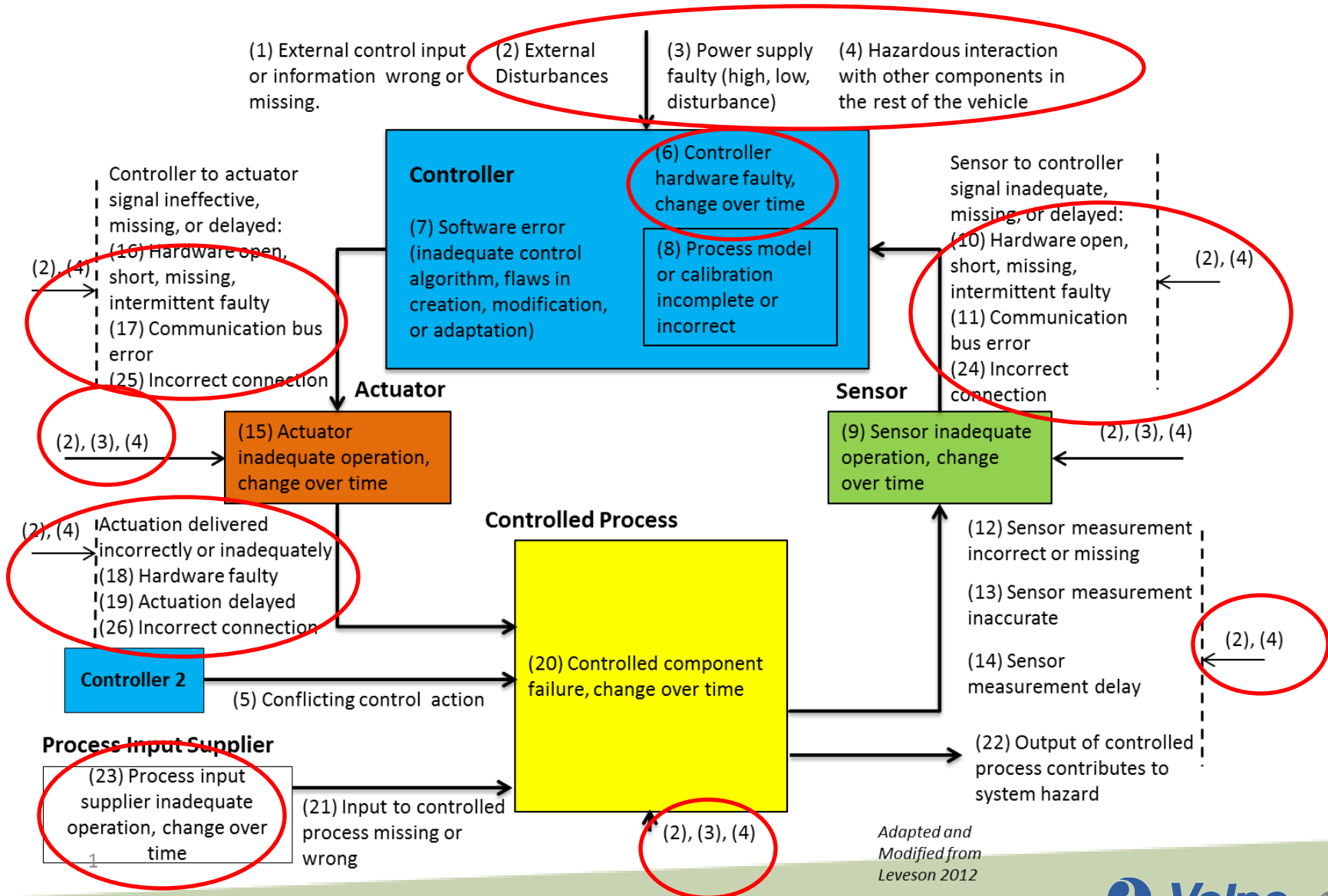
1. Anti-theft function loss or degradation
2. **Braking malfunction**
3. Electronic component overheating
4. **Impeding driver ability to control vehicle**
5. **Inadvertent engine start**
6. Pinch detection loss or degradation
7. Restraint system malfunction (loss, degradation, or inadvertent deployment)
8. Roadway illumination and vehicle conspicuity loss or degradation
9. **Steering loss or degradation**
10. Unintended door opening
11. **Vehicle inability to accelerate or stalling**
12. **Vehicle unintended acceleration**
13. **Vehicle instability**
14. **Vehicle movement in unexpected direction**
15. Windshield visibility loss or degradation

**Note: Bold fonts indicate vehicle motion related hazards*

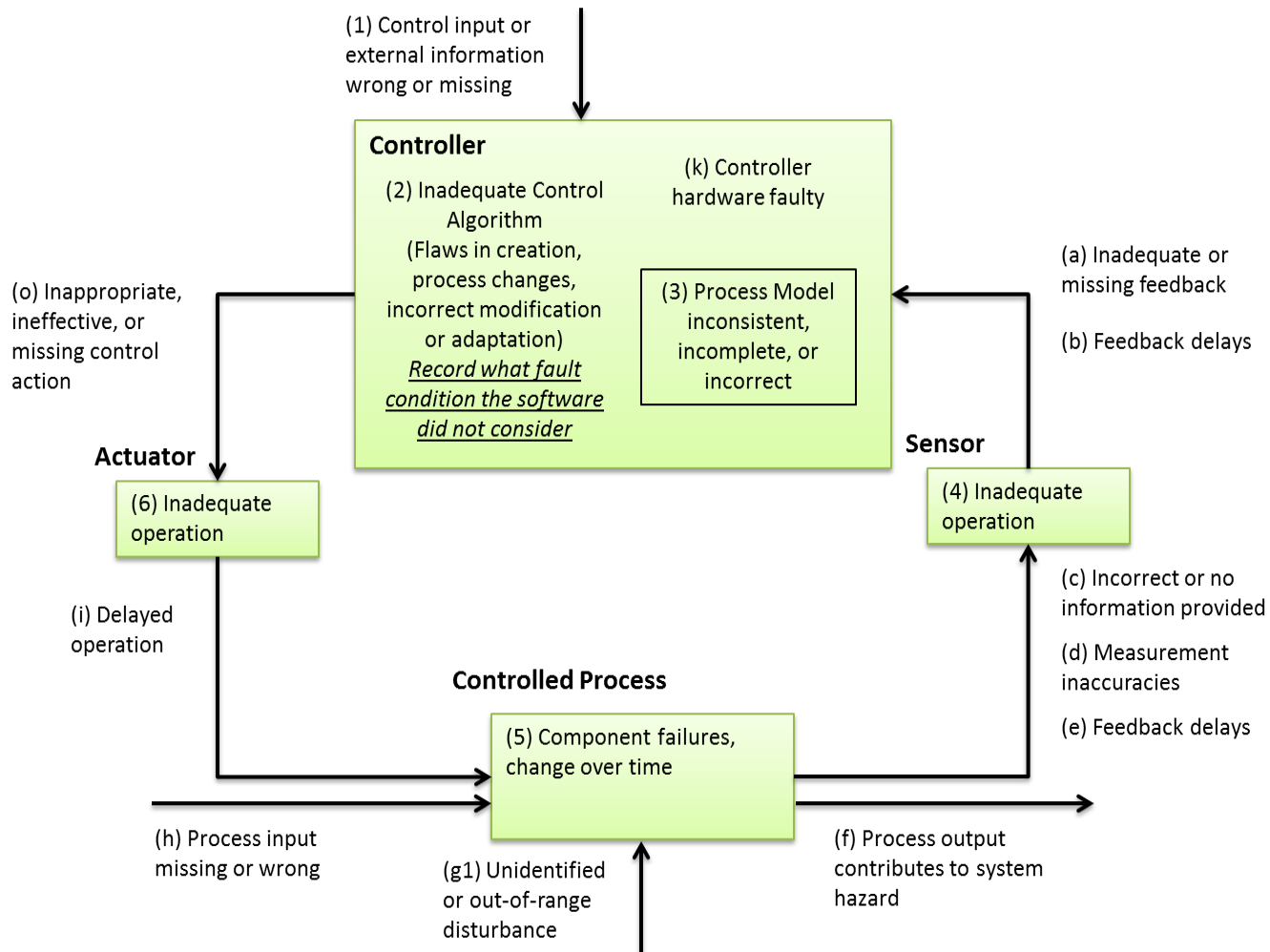
Unsafe Control Actions



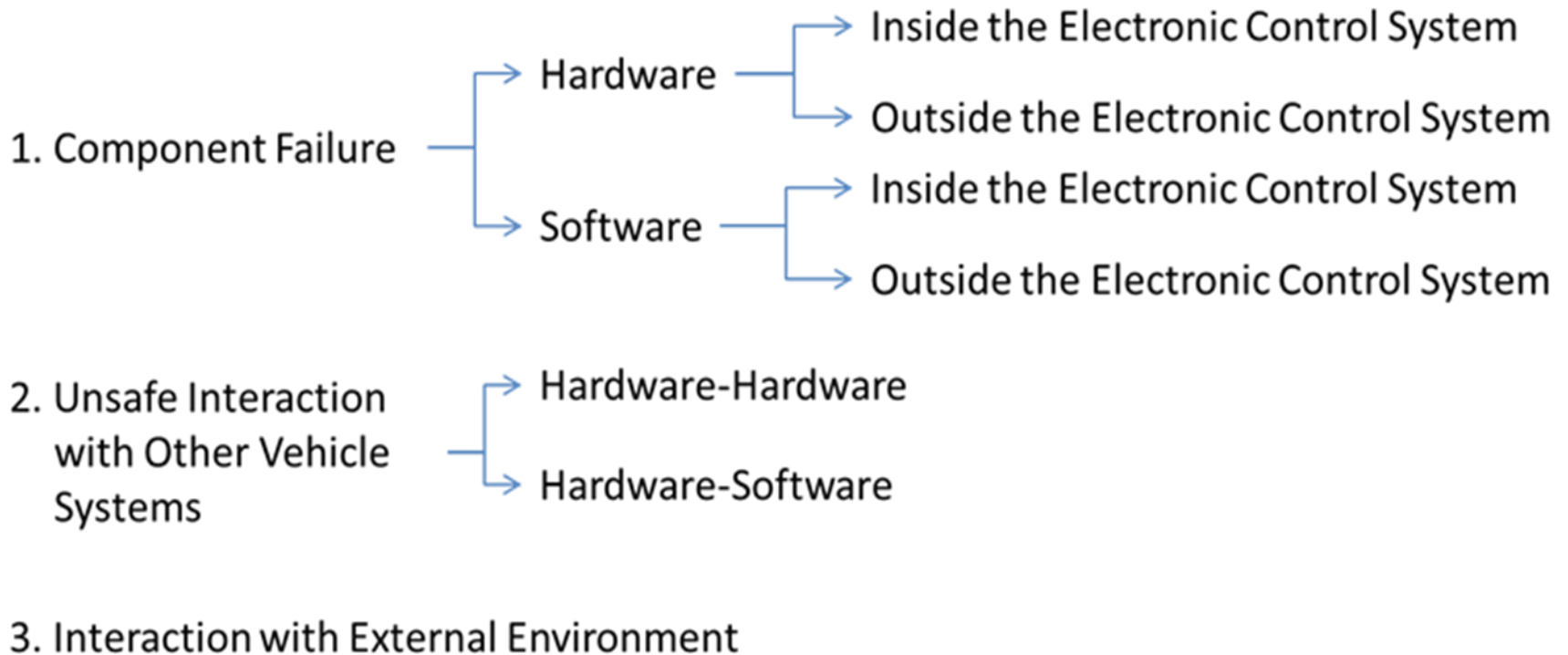
Causal Factors



Book Version of the Causal Factors

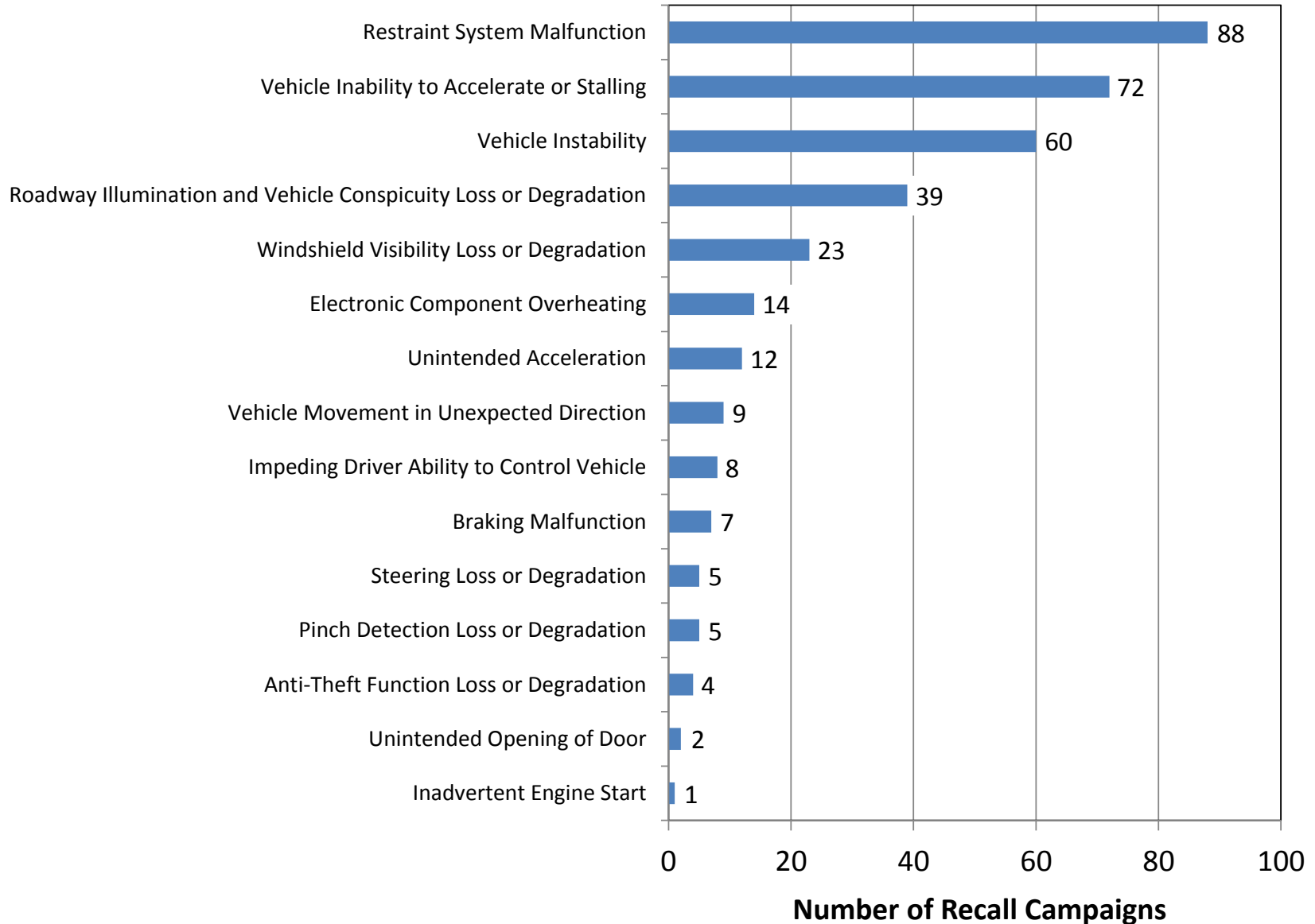


Component Failure and Unsafe System Interactions

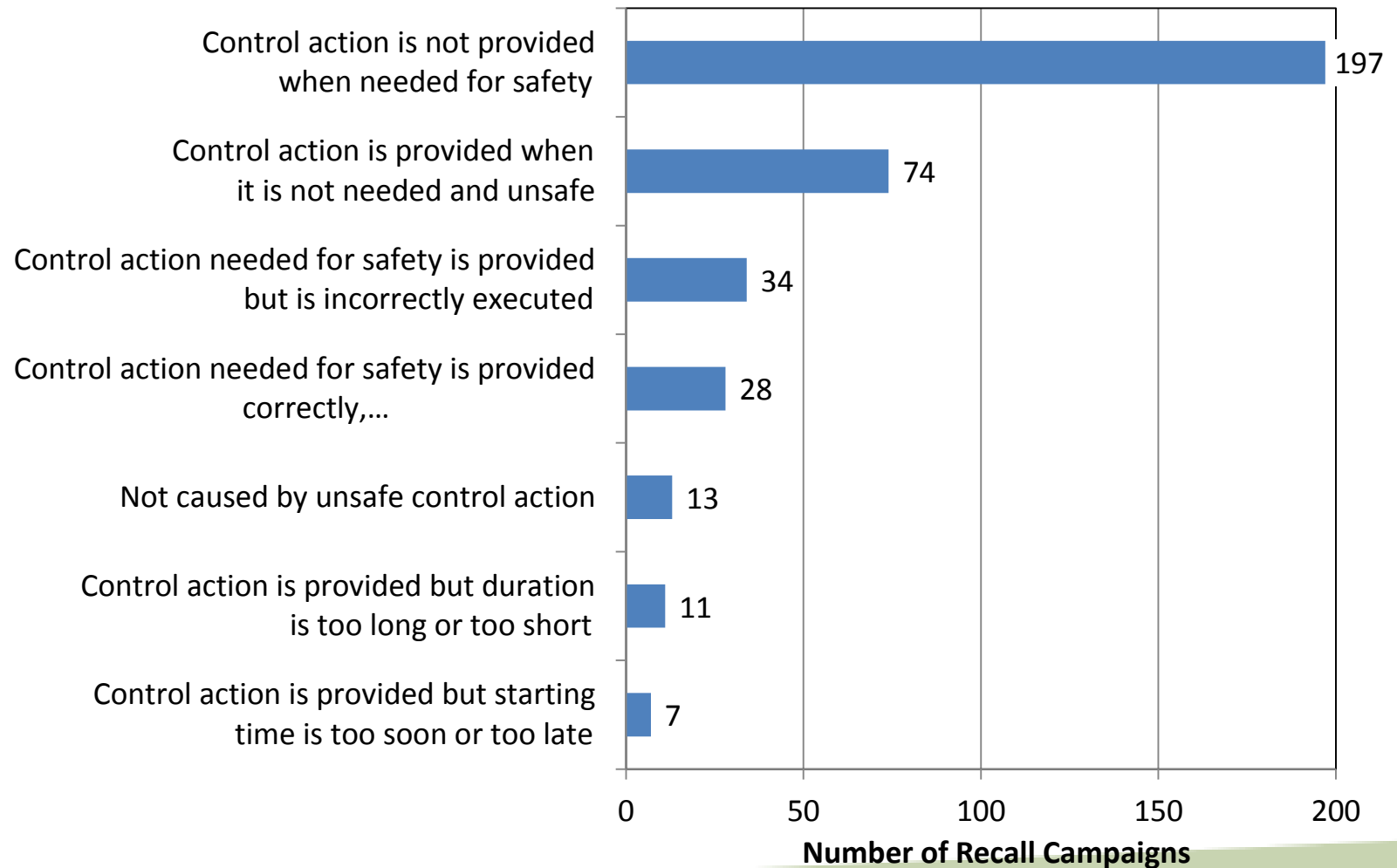


Preliminary Data Analysis Results

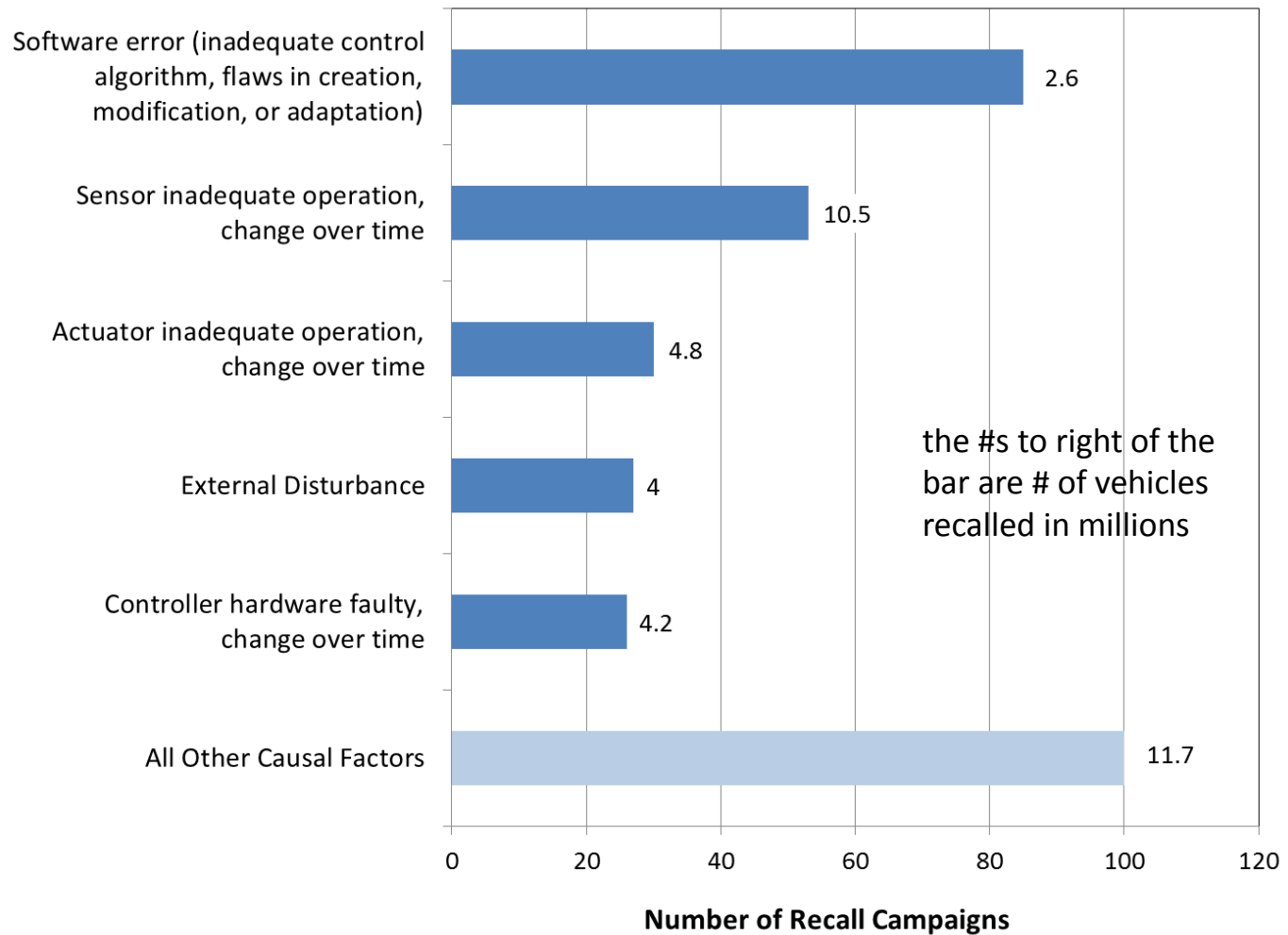
Frequency of Hazards



Frequency of Unsafe Control Actions



Frequency of Causal Factors



Summary

Built a scientific foundation to define and quantify automotive electronic control system safety issues:

1. Based on a top-down Systems Engineering approach and control system principles
2. Created a new failure causal factor typology and data coding scheme
3. Quantified automotive electronic systems safety issues using the new data coding scheme
4. Constructed a coded database with respect to automotive electronic control system safety:
 - Contains a comprehensive list of variables that classifies causes of safety problems associated with automotive electronic control systems
 - Easy to adapt to new safety-critical motor vehicle system technologies and future recalls
 - Enables us to:
 - Assess the overall state of electronic control system safety and identify existing and potential safety problems
 - Provide a basis for regulatory and consumer initiatives, evaluation of vehicle safety systems and designs, and focused cost-benefit analyses
 - Answer questions from researchers, private industry, students, public sector, and general public
 - Evaluate the effectiveness of motor vehicle and traffic safety program standards

Questions?

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