Safer Streets need Smarter Science

Zero can't be just a Goal

Tjark Kreuzinger
Toyota Motor Europe NV/SA

The situation: Persistent Fatalities and Injuries Demand Renewed Focus

- Emerging Risks from New Mobility Trends
- Vulnerable Road Users need Targeted Solutions
- Technology and AI Offer unprecedent Potential
- Human Factors must shape ADAS and Automated Functions implementation
- Rural Safety and Inclusiveness have to be the Focus
- Evidence-Based Policy and Public Support is Crucial

1. Predictive road safety management

Reliability and Quality Assurance of Road Safety Data

- Reliable data is the foundation of predictive safety. What we need is
  - **Pan-European harmonised crash & scenario database**
  - Pre-crash and crash
  - Long-term impairment
  - **Near-miss and safety-critical events**
  - Sustainable only based on a **reliable business case**
- EU project SYNERGIES establishes a unified European Scenario Data- and Marketspace for development, testing, and validation of Connected and Automated Mobility (CCAM) systems

Advanced Safety Modelling and Accident Prediction

- V4SAFETY developed a **Predictive Safety Assessment Framework (PSAF)** - simulation models forecasting effectiveness of safety measures
  - Naturalistic Driving Studies (NDS)
  - Pre-crash phase simulating evasive actions and near-miss scenarios
  - Outcome severity estimation metrics (e.g. Abbreviated Injury Scale / AIS)
- The PSAF is a **first step** for evaluating safety solutions - technologies, infrastructure, or policies - via simulation and scenario-based analysis

2. Inclusiveness in occupant protection and HMI design

New Interior Use Cases and Reclined Seating Biomechanics

- Several studies highlight **biomechanical risks** of reclined seating (e.g. spinal and abdominal injuries) and the need for adaptive restraint systems (IRCOBI conference, EU project OSCCAR, Consortium ENOP)
- EU project SAFE-UP explored **occupant monitoring-based** restraint strategies for future seating configurations, including reclined
- CarHMI June25 explored **HMI strategies** for reclined seating affect on user interaction and safety

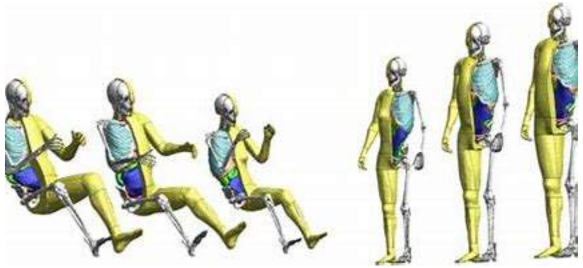
This **highlighted the concerns** → further collaboration studies will have to lead towards **guidelines for the best strategies**.

AI-Boosted Development of Smart HMI and Occupant Monitoring

- Smart HMI is central to inclusive design in complex traffic and vehicle infrastructure. Interfaces must adapt to user state (e.g. stress, fatigue), seating positions, and even emotional cues
  - Empathic HMI adjusting communication based on user condition
  - Multi-user interface strategies
  - Seamless integration with occupant monitoring systems (OMS) and driver monitoring systems (DMS)
- AI has potential to simulate scenarios and restraint systems using AI-generated synthetic datasets for validation of occupant monitoring and safety systems
  - Personalised safety responses
  - Continuous emotion and health monitoring

Virtual Human Body Models (HBMs) and Injury Detection Beyond Dummies

- Traditional crash dummies can’t capture real injury risks. HBMs can simulate a broader range of body types and postures.
  - Predicting injuries in reclined or rotated positions
  - Evaluating adaptive restraint systems
  - Addressing long-term impairments from traffic injuries



- However, model variability and validation could delay introduction in evaluation and requirements assessment
- Inconsistencies in positioning tools and anatomical alignment may compromise virtual testing reliability

Inclusive Road Safety and Vehicle Compatibility

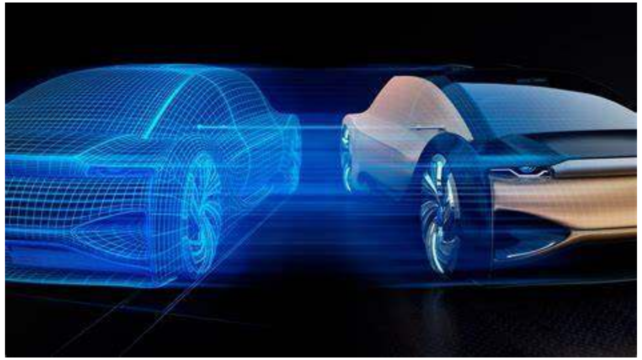
- A new vehicle category ("M0") could address several challenges. Studies by EU, VDI and EU projects have investigated the potential
  - Reduce carbon footprint
  - Improve usage of precious urban space
  - Increase affordability of mobility

- Distinct Safety requirements are needed to enable lower mass and consumption while keeping compatibility between vehicles of different size and propulsion, ensuring safety across mixed traffic environments

3. The digital transition in safety verification and validation

Generative AI and Digital Twin-Based Validation for AI-Driven Safety

- The use of generative AI and digital twins rapidly transforms how safety can be validated in automated driving systems reducing test time and enhancing the depth of validation data
  - AI-generated test scenarios across Operational Design Domains (ODDs)
  - Digital twins that simulate vehicle behaviour under (unsafe) edge-case conditions
  - Integration of physical sub-system results into full virtual system validation
- In order to make it a trustworthy tool chain we have to identify rules for
  - Transparency, Reproducibility of AI-models
  - Avoiding bias in training data and ensuring relevance



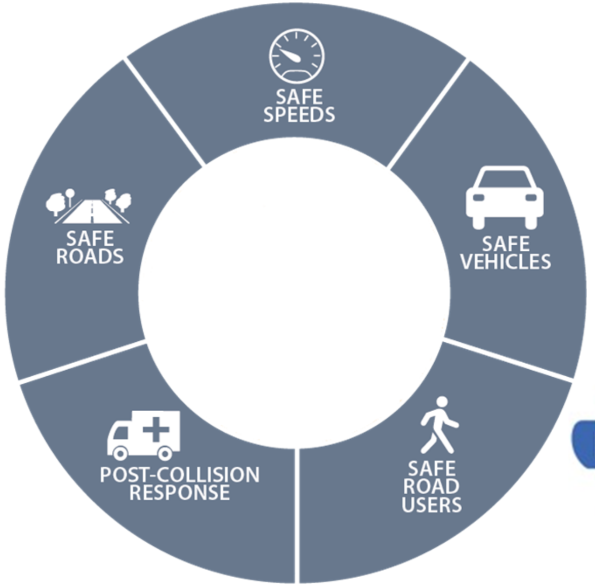
Verification and Validation (V&V) of AI Models for Driving Functions

- The complexity of driving support systems demands new V&V frameworks
- Standardisation across all use cases is impractical
- Validation must be tailored per system and scenario, with statistical confidence indicators
  - Scenario-specific validation protocols
  - Interpretability of HMI outputs in safety-critical transitions
  - Validation of AI behaviour in rare/ambiguous traffic situations

4. Evidence-based prioritisation of road safety measures and their integration in a sustainable road transport system (from theory to practice)

From Safe System Theory to Practice

- The Safe System Approach is evolving from theoretical framework into practical implementation. The ERTRAC Safety & Security WG emphasised that while the Safe System (safe roads, safe speeds, safe vehicles, safe road users, and post-crash care) is well established, the challenge lies in operationalising them across diverse national contexts
  - Predictive safety assessment frameworks
  - Integration of AI and big data for crash/scenario prediction
  - Cultural and organisational shifts to embed safety in all transport decisions



Effective Implementation and Organisational Integration

- The “Integrated Approach” is the next maturity level beyond Safe System, embedding road safety into broader sustainability and public health agendas
  - Cross-sectoral collaboration (e.g. health, education, urban planning)
  - Accountability for safety outcomes among stakeholders
  - Cultural transformation within institutions shaping transport systems
- EU project TRUST is expected to start laying out real-world implementation of integrated safety strategies that will require further development

KEY MESSAGE

Sustainable mobility requires more

- Accessibility for the whole population
- Appropriate priority for the vulnerable
- Lowest negative impact on environment
- Highest level of user protection

Contact me

Dr.-Ing. Tjark Kreuzinger (He/Him pronouns)
Senior Manager Safety Research & Technical Affairs
Toyota Motor Europe NV/SA
+32 (0)476 36 03 23
tjark.kreuzinger@toyota-europe.com