Usage of ASAM OpenX standards in Offroad Applications

Proposal Workshop
14:00 – 18:00 CEST | 08:00 – 12:00 EDT

2023-09-14
Online

ASAM
Association for Standardization of Automation and Measuring Systems

Welcome and Introduction to ASAM

Matthäus Lang
ASAM, e.V.

2023-09-14
Virtual Proposal Workshop

ASAM
Association for Standardization of Automation and Measuring Systems

Welcome and Introduction to ASAM

Proposal Workshop Agenda (revised)

Time	Topic	Speakers
14:05	Welcome and Introduction to ASAM	Matthäus Lang (ASAM)
14:10	ASAM & Relevant Activities Overview	Ben Engel (ASAM)
14:35	Usage of ASAM OpenX standards in Offroad Applications	Daniel Carruth (Mississippi State University), Mihir Acharya (Mathworks)
16:20	ASAM Development Process for Standards	Matthäus Lang (ASAM)
16:50	Break	All
17:00	Proposal Content	Daniel Carruth (Mississippi State University), Mihir Acharya (Mathworks)
17:55	Next Steps	Matthäus Lang (ASAM)

ASAM - Introduction

Compliance Statement

For more than 25 years, ASAM e.V. (Association for Standardization of Automation and Measuring Systems) is actively promoting standardization within the Automotive Industry. Together with its more than 400 members worldwide, the association develops standards that define interfaces and data models for tools used for the development and testing of electronic control units (ECUs) and for the validation of the whole vehicle.

ASAM standards are recommendations, they do not have an impact on regulatory framework.

From the beginning, ASAM has requested and encouraged an open exchange among all stakeholders: manufacturers, suppliers, tool vendors and research institutes. Following this ASAM policy, technical experts from ASAM member companies worldwide commonly develop new standards in working groups. The developed standards are accessible for all interested companies and serve as basis for the development of tools and ECUs within the respective companies worldwide. Tools and products developed based on ASAM standards allow easy integration into existing value chains and seamless data exchange.

ASAM working groups do not define products or take any business decisions preventing competition.

https://www.asam.net/about-asam/compliance/

ASAM Standards Portfolio

ASAM is currently active in 7 domains

Simulation

OpenCRG | OpenDRIVE | OpenLABEL | OpenSCENARIO | OSI

Measurement & Calibration

ARTI | CDF | CPX | HMS | MCD-1 CCP / XCP | MCD-1 POD | MCD-2 MC | MCD-2 CERP | MDF

Data Management & Analysis

CEA | ODS

Diagnostics

MCD-2 D | MCD-3 D

Test Automation

ACI | ASAP 3 | ATX | GDI | iLinkRT | MCD-3 MC | XIL | OTX Extensions

ECU Networks

MCD-2 NET

Software Development

CC | FSX | ISSUE | LXF | MBFS | MDX | SCDL

https://www.asam.net/standards/

Usage of ASAM OpenX standards in Offroad Applications

Daniel Carruth, PhD
Mississippi State University

Mihir Acharya
MathWorks

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Agenda – Offroad Applications

- Introduction
- Motivation
- User stories
- Offroad features and requirements
- Proposed approach for concept project
- Review of selected examples
- Expected outcomes
- Relevant Standards
  - ASAM OpenX Standards
  - Other standards

Introduction

- ASAM standards within the Simulation domain have been driven by automotive industry need for testing and developing on-road ADAS/AD functions
- ASAM standards apply to other application domains, particularly as scenario-based and simulation-based testing becomes more prevalent
  - Offroad Applications Areas - Landfill, construction, agriculture, and mining

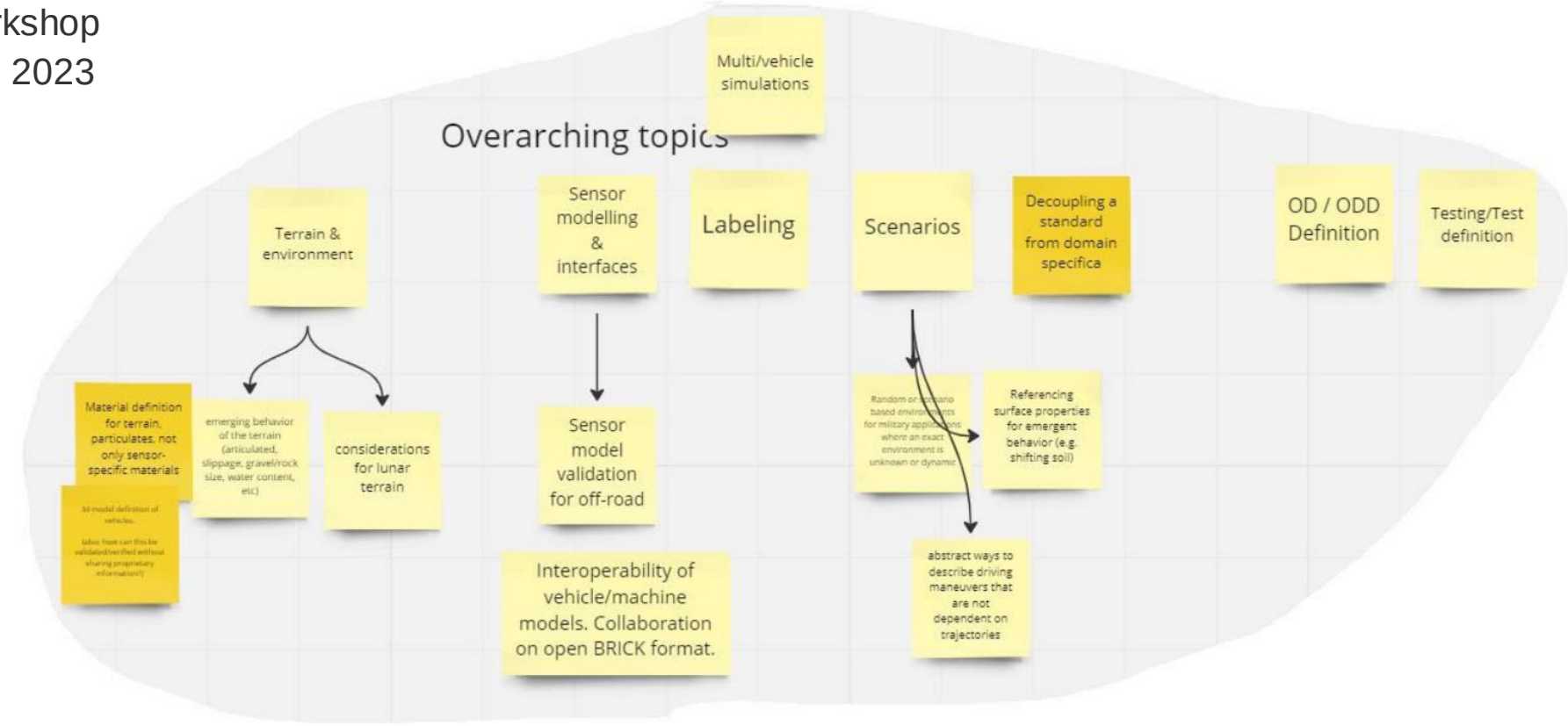
Motivation for the Activity

Interest in offroad applications

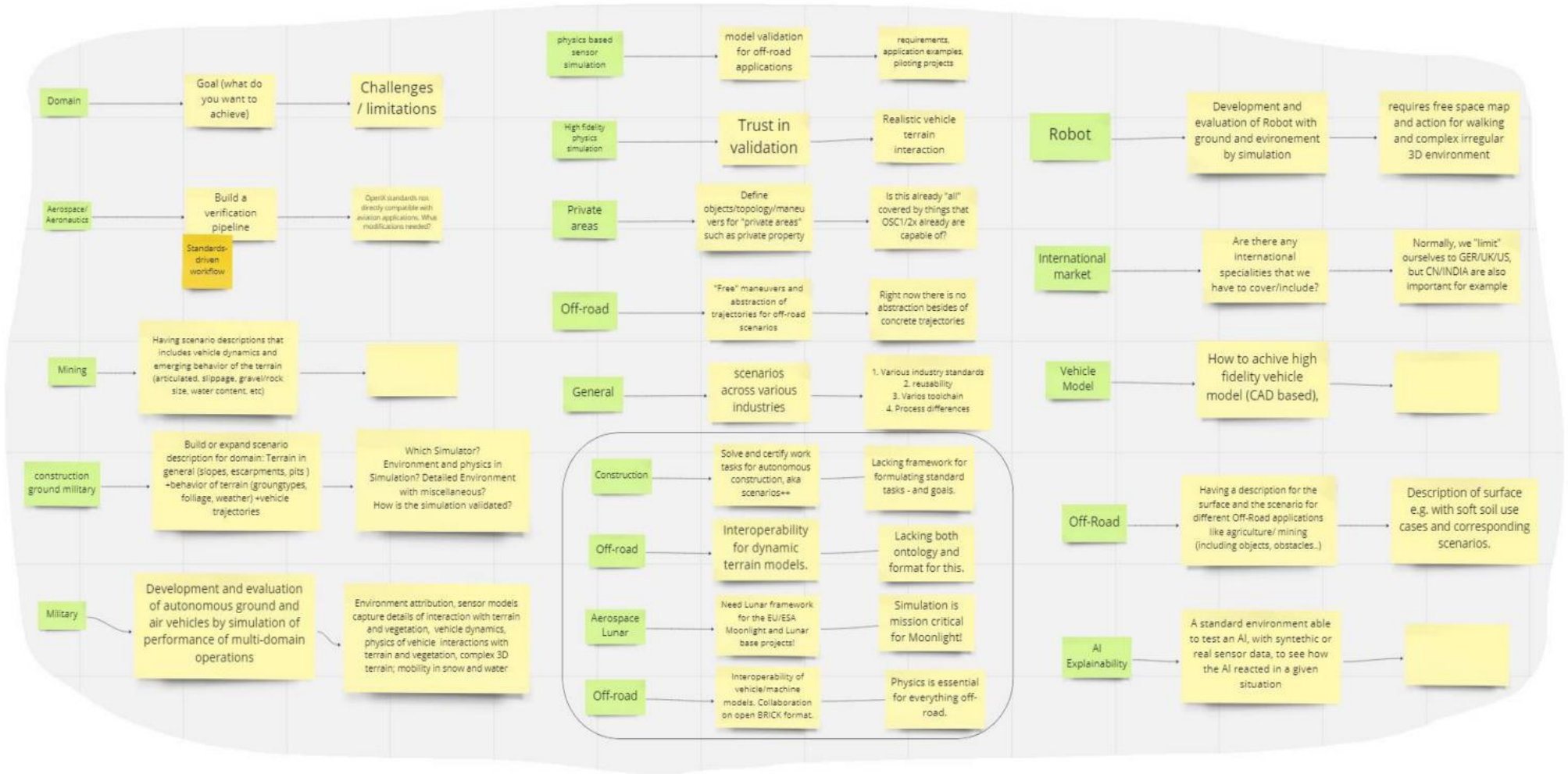
- Landfill
- Construction
- Agriculture
- Mining
- Military
- Recreational

Offroad Applications Ideation Group

- ASAM OpenX standards for offroad applications
- Ideation Workshop
- February 23, 2023



Ideation Workshop Topic Areas



Characteristics of Offroad Applications

- Potential beneficial features
  - restricted public access
  - controlled environments
  - clear understanding of other traffic participants
  - smaller Operational Design Domains

- Offroad application requirements
  - vehicle-terrain interactions
  - complex terrain and vehicle dynamics
  - working in close proximity with other vehicles

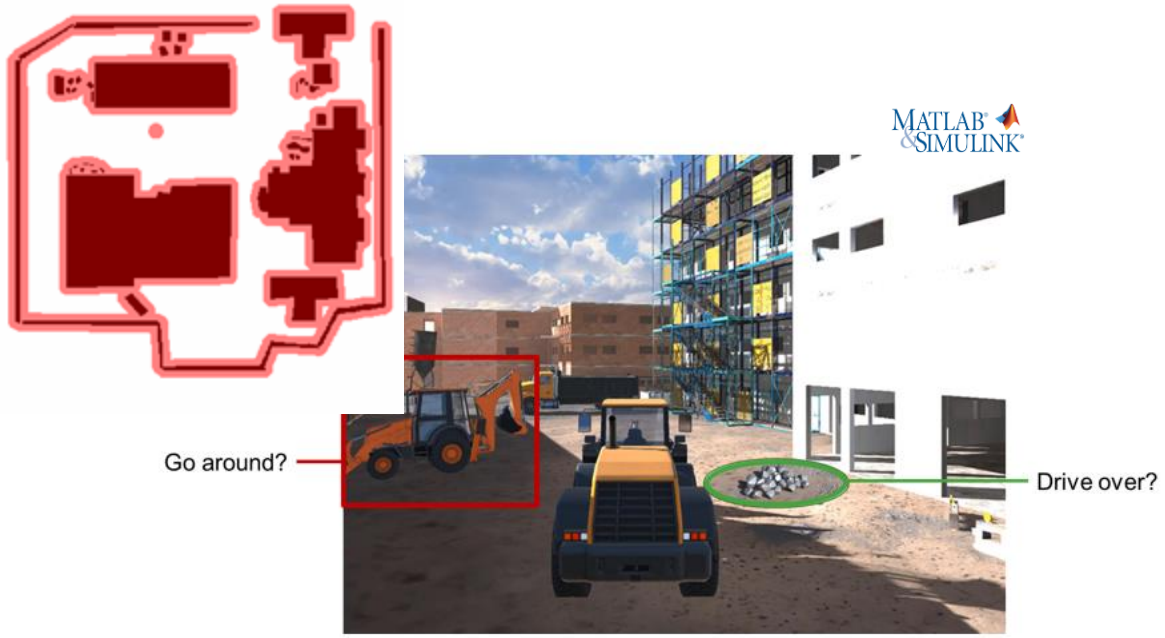
Offroad Challenges

- Complex 3D terrain
- Representation of the subsurface
  - Soil strength, density, temperature, water content
  - Effects on mobility
- Surface materials (including link between appearance and physical characteristics)
- Vehicle-terrain interaction and material dynamics
  - Mud and water spray
  - Mud and snow deformation
  - Accumulation of material on vehicles
- Object representation
  - Vegetation and other natural obstacles
  - Meshes, materials, physics
- Weather conditions
- Occlusion of sensors
  - Mud, snow, dirt in the air and on camera lens

Operations and Activities

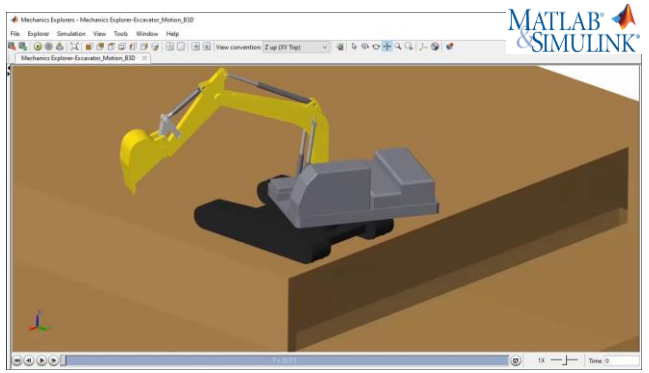
Based on where the activity is happening

Movement on the driving plane



- Navigation
- Interaction with objects

Movement outside the driving plane



Excavating a pit

Manipulating material

Loading a vehicle

Excavator Simulation Model - https://www.mathworks.com/matlabcentral/fileexchange/119268-excavator-design-with-simscape

MathWorks Webinar on "Design and Simulating Autonomy for Construction Vehicles", https://www.mathworks.com/videos/design-and-simulating-autonomy-for-construction-vehicles-1679066541903.html

Kaibab National Forest, 2019,[Grassland Restoration 2019(4886791186).jpg][Photograph], https://commons.wikimedia.org/wiki/File:Grassland_Restoration_2019_(4886791186).jpg, CC-BY-SA-4.0.

Proposed Approach

Exercise the Standards

Offroad Applications Concept Project

Hypothesis: Current standards do not adequately support requirements for offroad applications

Exercising the Standards

Use cases and requirements for offroad applications

Use Cases Driven by Personas

- What kind of simulations do users want to build for offroad applications?

Vehicle Developer

- Develop and test mechanical, electrical, hydraulic, and electro-mechanical systems for offroad scenarios
- Build physics-based vehicle models to test vehicle behavior in 3D simulations

Autonomy Developer

- Create algorithms, software and supporting documentation for perception, planning and control of the vehicles and their support tools
- Collect sensor and mobility data for training AI/ML models
- Work with control engineers to investigate, test, and select software toolsets or hardware components and peripherals

Test Engineer

- Develop and evaluate detailed offroad test scenarios for both component and system level testing and validation.

System Integration Engineer

- Create scenarios to help understand the requirements for systems.
- Create schematic representations of mechanical, electrical, hydraulic, and electro-mechanical systems
- Work with other disciplines to create the specifications that outline the control system logic necessary for haul truck functions

Site Manager

- Manage and assess the application of vehicle systems on-site.
- Work with the environment, health, and safety teams and security teams to conduct regular risk assessments
- Maintain a risk register and develop and implement risk mitigation plans

Technical Requirements Driven by Use Cases

Vehicle Developer

- Represent vehicle components relevant to VTI/mobility
- Represent driveline/powertrain for the vehicle
- Modelling of heavy machinery on soft terrain (deep tracks)
- Represent vehicle loads including specification of type and volume of material being transported and estimating effects caused by the load including stability, traction, deformation of road surfaces, and maneuverability
- Evaluate or optimize efficiency of vehicle systems in the operating environment

Autonomy Developer

- Model vehicle perception and mobility and dynamics as it traverses an offroad environment
- Model GPS sensor data accounting for effects of vehicle movement, terrain, and vegetation including loss of signal, multipath, etc.
- Model common sensors (e.g., LiDAR, EO camera, IR, radar, GPR, etc.) accounting for effects of vehicle movement, terrain, and vegetation including occlusion, material attribution, etc.

Test Engineer

- Evaluate or optimize efficiency of vehicle systems in the operating environment
- Represent effects of adverse conditions (dust, standing water, mud, etc.) on terrain properties and on sensors (e.g., occlusions from dust clouds, water spray, water or mud on lenses, etc.)
- Estimate effects of vegetation on sensors and vehicle mobility
- Extract sensing and mobility data for learning how to traverse terrain

System Integration Engineer

- Generate prior information to the autonomy stack (e.g., simulate extraction of maps, etc. from previous drives, UAS, or other sources)
- Represent vehicle loads including specification of type and volume of material being transported and estimating effects caused by the load including stability, traction, deformation of road surfaces, and maneuverability
- Share and reuse off-road scenarios in a common format for shared understanding

Site Manager

- Incorporate fuel depot/charging stations (capacity, charge/refuel rate)
- Collecting performance data for benchmarking systems

Exercising the Standards

Example Scenarios to Investigate Level of Support

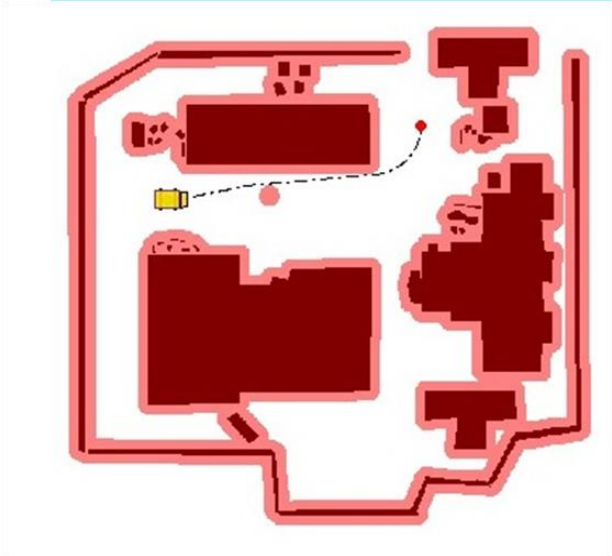
Scenarios

- **Basic Navigation (Moving from Point A to Point B)**
  - Following a Path
  - Finding a Path
  - Carrying a Load
  - Using Sensors to Respond to the Environment
  - Navigating without GPS
- **Vehicle Interaction**
  - Following a Lead Vehicle
  - Environmental Effects
  - Interacting with Traffic
  - Incorporating drones – ground-air vehicle teaming
- **Loading and Hauling**
  - With a Hauler
  - With an Excavator
  - Evaluating Fuel Efficiency

Finding a Path

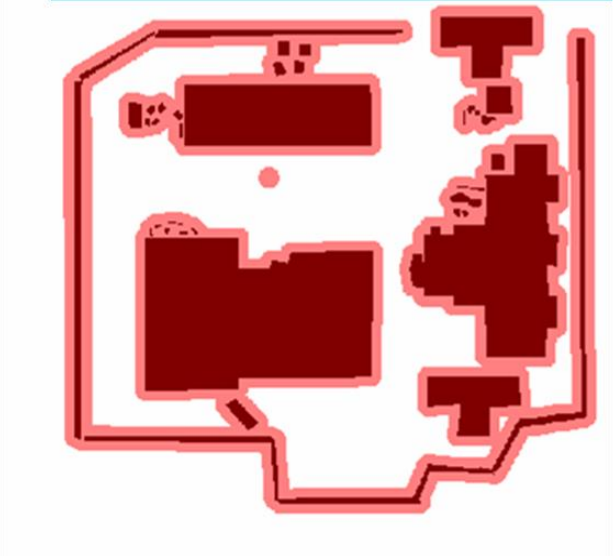
Basic Navigation (Moving from Point A to Point B)

Global Path Planning



Find a path from a start position to a goal position that is obstacle-free and satisfies operators' requirements

Local Path Planning



Define what vehicles should do in certain situations, such as running into an unexpected obstacle

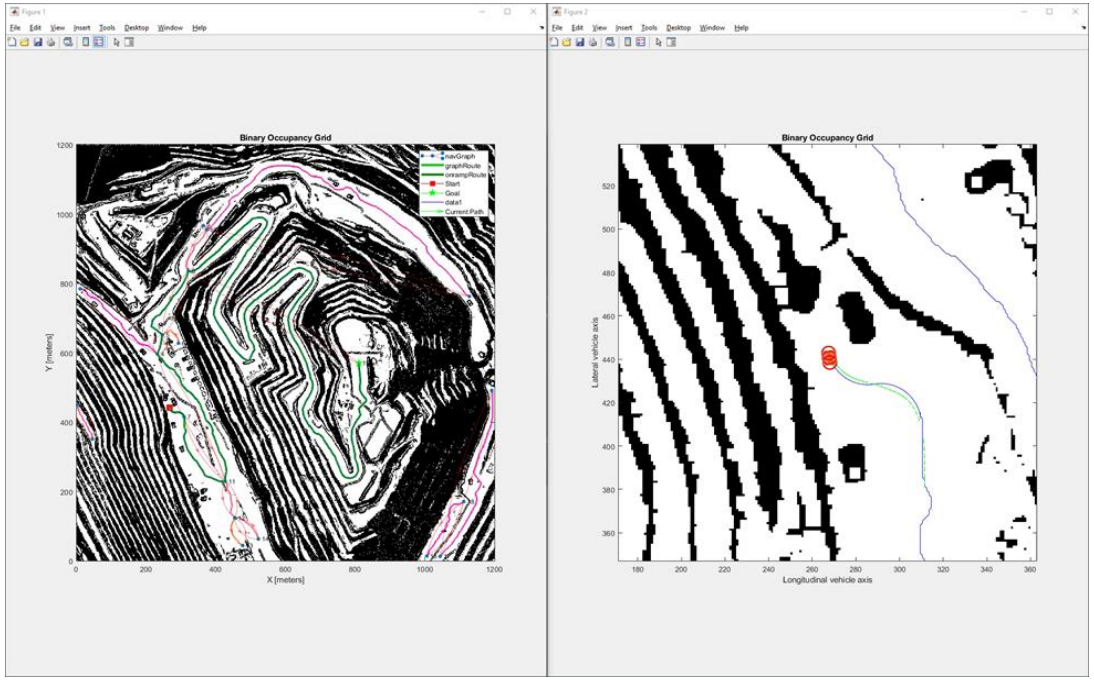
MathWorks Webinar on "Design and Simulating Autonomy for Construction Vehicles", https://www.mathworks.com/videos/design-and-simulating-autonomy-for-construction-vehicles-1679066541903.html

Following a path requires handling unexpected objects

Following a Path

Basic Navigation (Moving from Point A to Point B)

- Evaluate the performance of the path following algorithm in an environment characterized by soft soils
- Define safe velocity profiles for the controller
- Define metrics for path planning and following such as safe distance from obstacles

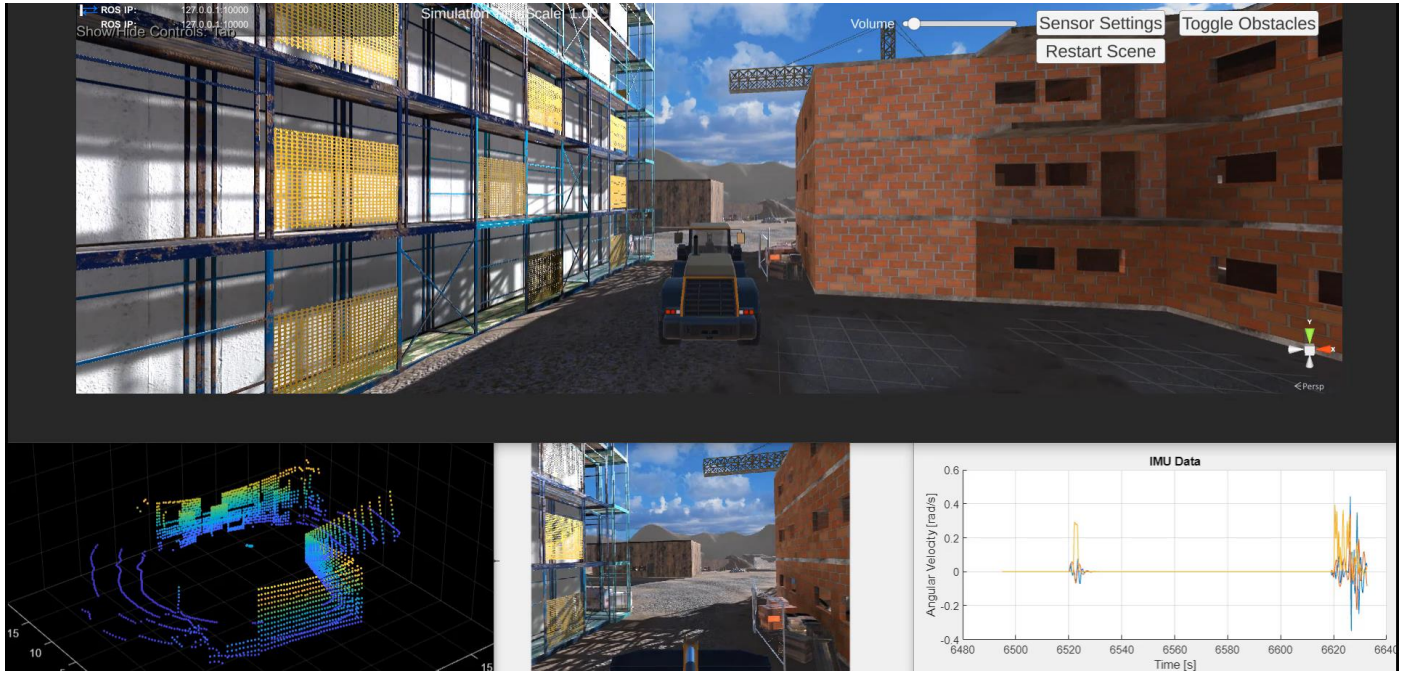


MathWorks Navigation Toolbox Example - https://www.mathworks.com/help/nav/ug/offroad-planning-on-digital-elevation-models.html

Using Sensors to Respond to the Environment with/without GPS

Basic Navigation (Moving from Point A to Point B)

- Requirements for Perception Systems
- Defining different Operational Design Domains (ODDs) for off-road scenarios
- Define sensor failure and edge cases – maintaining localization in case of loss of sensor data



Hauling a Load

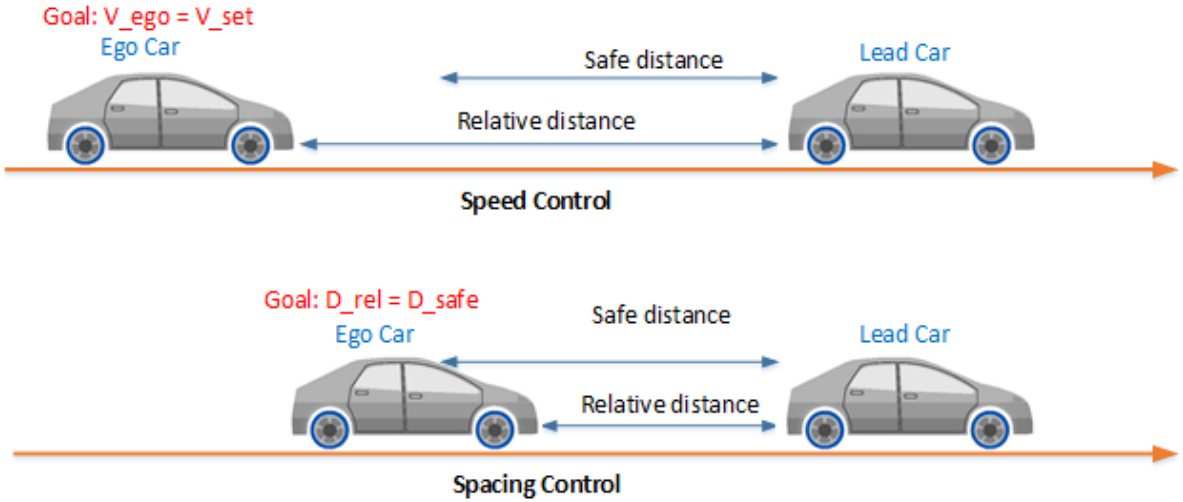
Basic Navigation (Moving from Point A to Point B)

- Define the impact of carrying a load on the vehicle's interaction with the terrain and impact on controller performance
- Assess whether adjustments in acceleration, braking, steering is required due to increased weight and altered center of gravity
- Assess slipping, tipping, sliding or immobilization
- Assess whether the vehicle can successfully reach the goal without rollover or loss of material while optimizing transportation time, fuel consumption, and tire wear.

Vehicle Interaction – Following a Lead Vehicle

Loading and Hauling

- Define speed and relative distance to be in optimal ranges
- The vehicle uses local sensor data to determine if the soil is soft such that the follower vehicle should deviate in its path sufficiently to avoid damage to the roadway or becoming stuck.

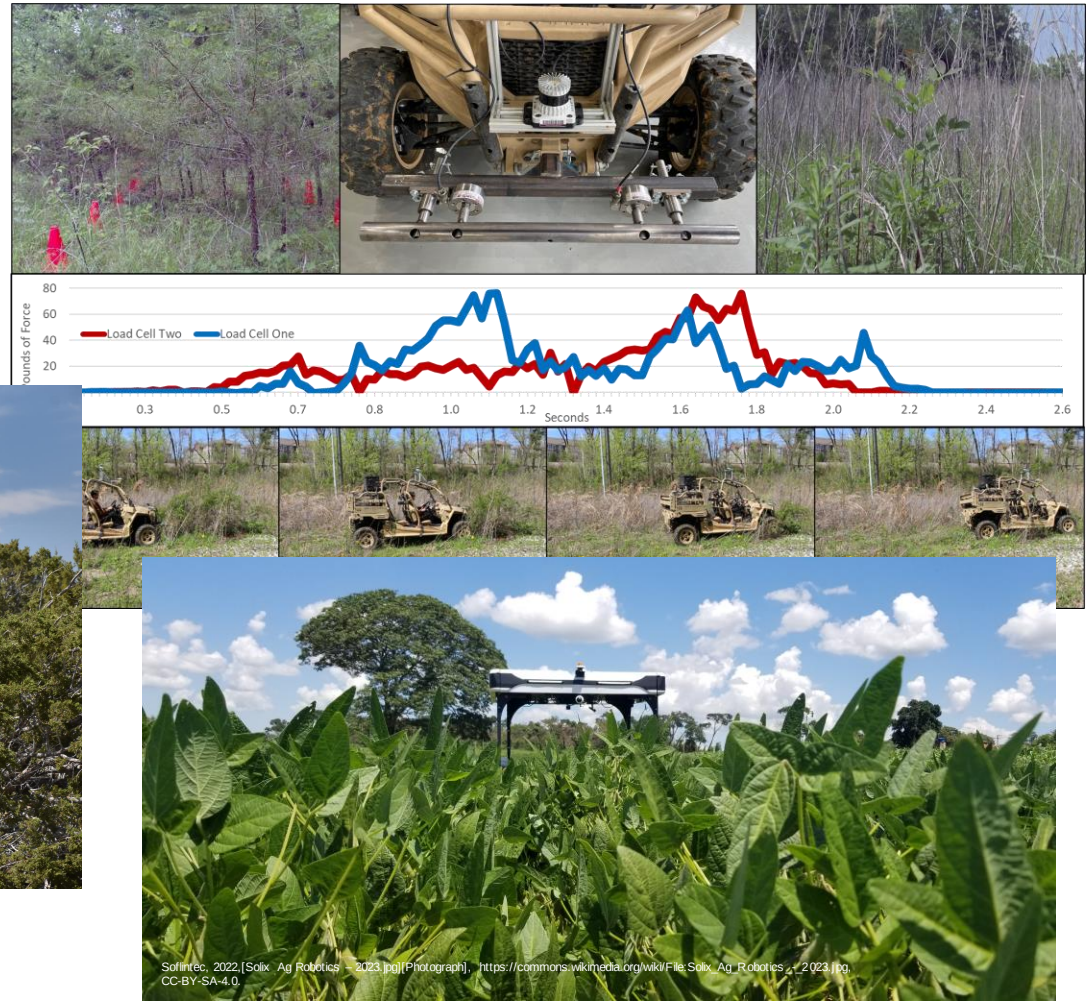


Dealing with Vegetation

- Many tasks require interaction with different levels of vegetation
  - Infrastructure inspection
  - Logging
  - Site clearing
  - Agriculture

- Effects on
  - Perception
  - Mobility
  - Tasks

- Object representation
- Physics

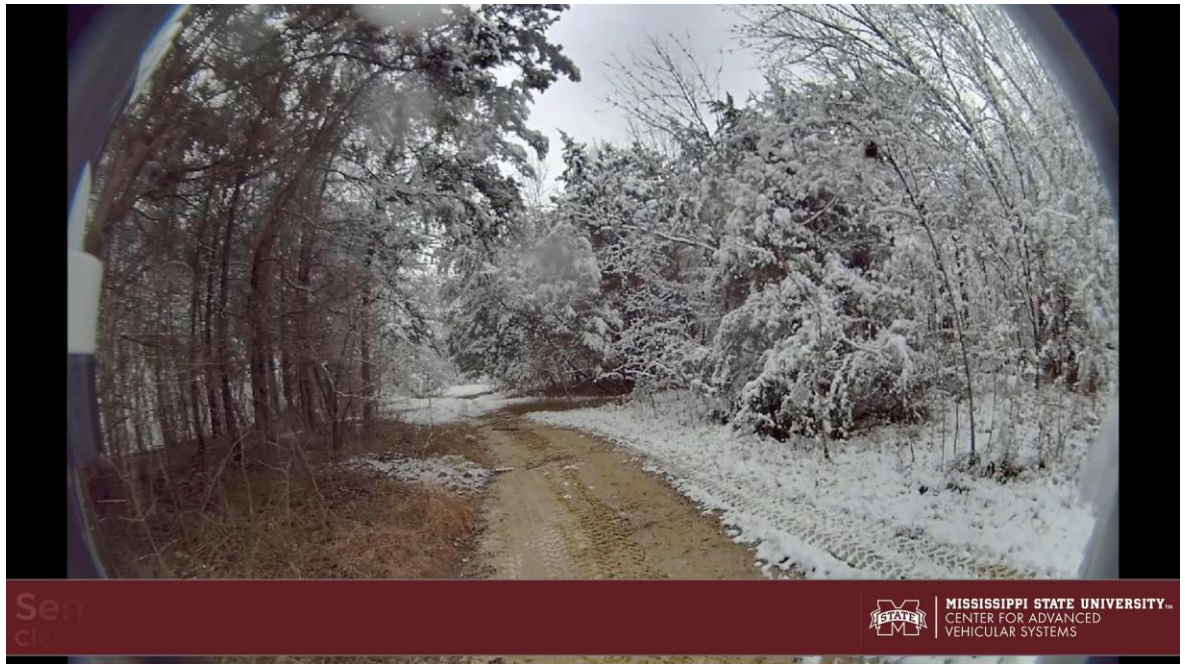


Kaibab National Forest, 2019.[Grassland Restoration 2019(48867911186).jpg][Photograph], https://commons.wikimedia.org/wiki/File:Grassland_Restoration_2019_(48867911186).jpg, CC-BY-SA-4.0.

Sofiintec, 2022.[Solix_Ag_Robotics_-_2023.jpg][Photograph], https://commons.wikimedia.org/wiki/File:Solix_Ag_Robotics_-_2023.jpg, CC-BY-SA-4.0.

Dealing with Environmental Effects

- Effect of weather and environmental conditions such as rain, fog, dust, snow, etc. on vehicle's perception and mobility

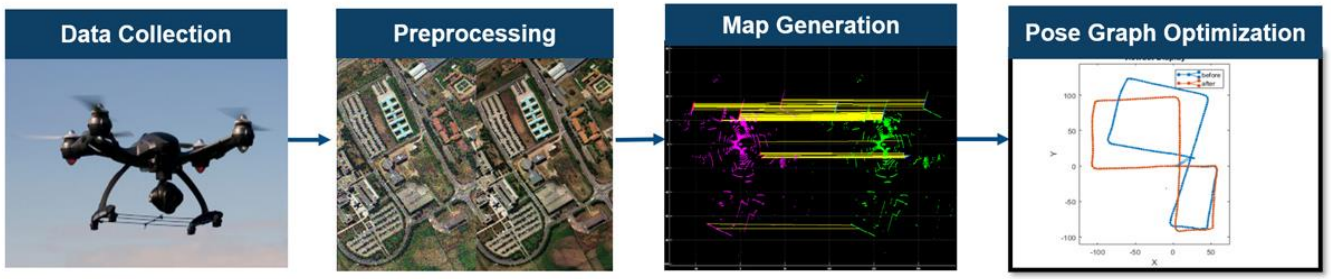


Interacting with Traffic

- Define traffic negotiations
- Requires simulation of the second agent
- Define constraints such as traversable space and width for the vehicle

Video courtesy of Mathworks.

Incorporating Drones – Ground-Air Teaming

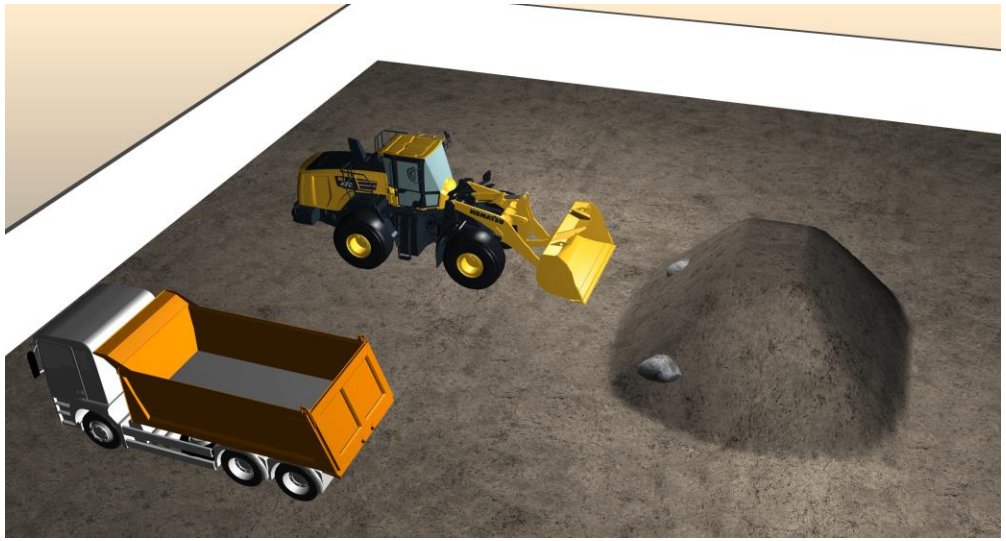


Loading and Unloading Material

Vehicle Interaction

- Define ability to position the vehicle next to the hauler, to manipulate the material, and to load the hauler
- Define ability to successfully load the hauler in an optimal time without tipping or colliding with the hauler
- Requires simulation of the hauler, models of articulating arms and buckets
- Requires simulation of the manipulation of the material

Loading the Vehicle

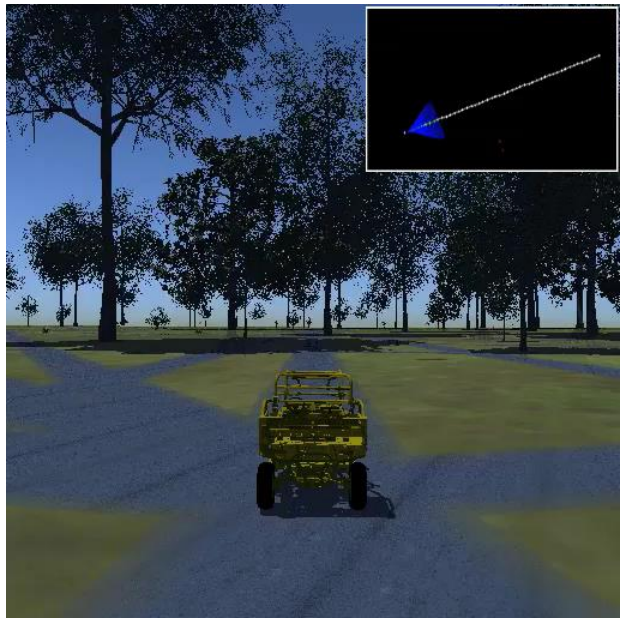


Video courtesy of Algoryx.

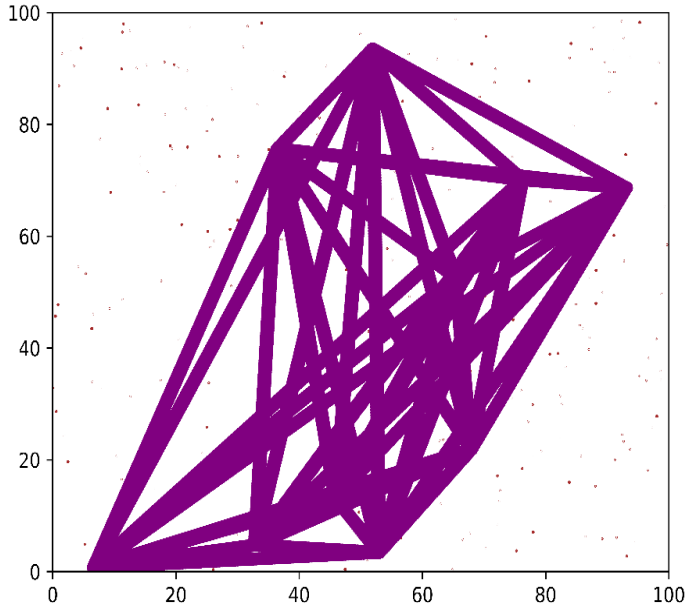
Evaluating Fuel Efficiency

- Site development and management
  - Evaluate fuel use
  - Determine optimal placement of depots, consider different power options (gas, diesel, electric, hybrid, etc.)
  - Fleet management and task assignment

- Environmental effects on vehicle powertrain and fuel efficiency
  - Travel on slopes, soft soils



Video courtesy of Mississippi State University. .



Scenarios

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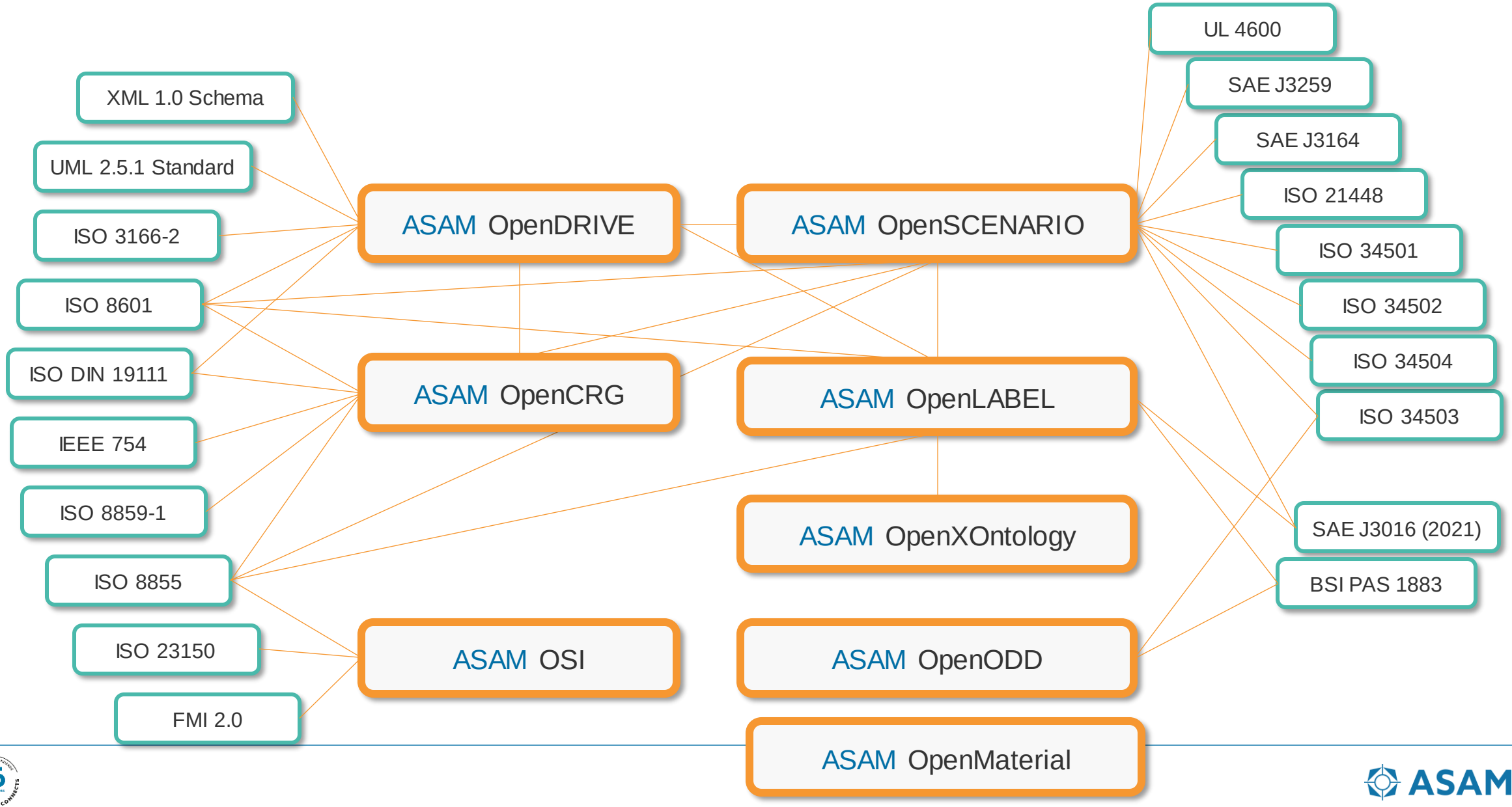
Exercising the Standards

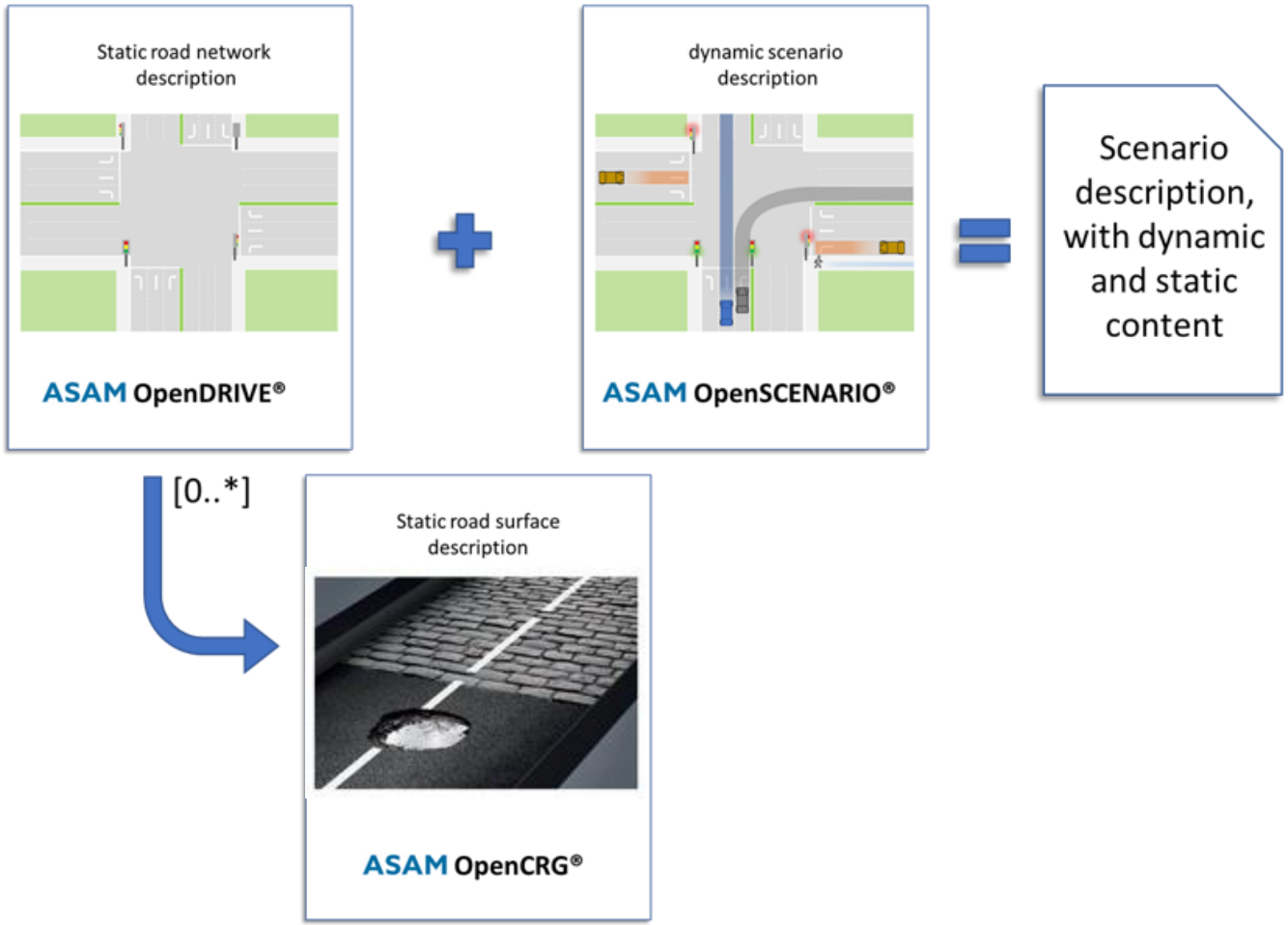
Finding Gaps in Current Standards

Interconnected Standards



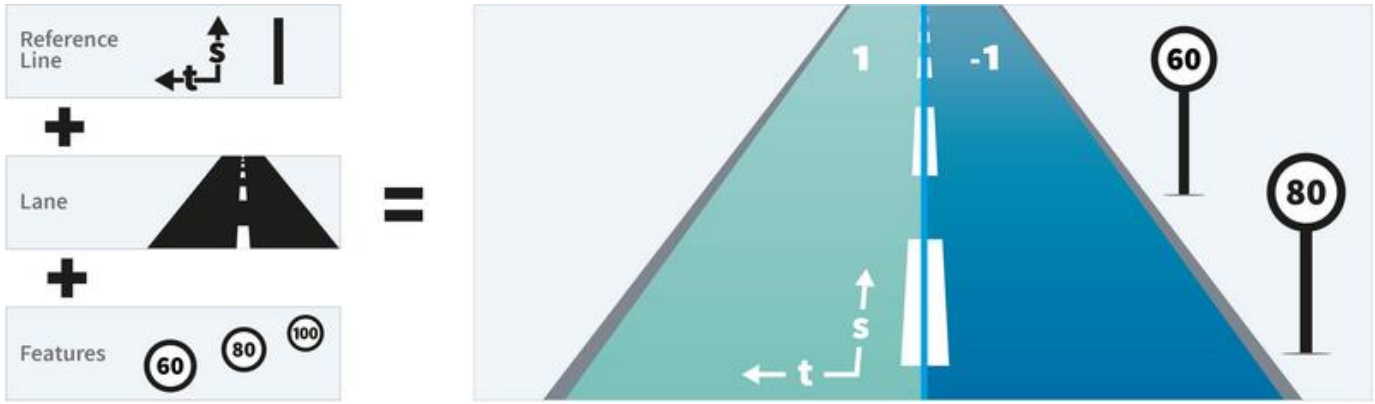
ASAM OpenDRIVE + OpenCRG + OpenSCENARIO

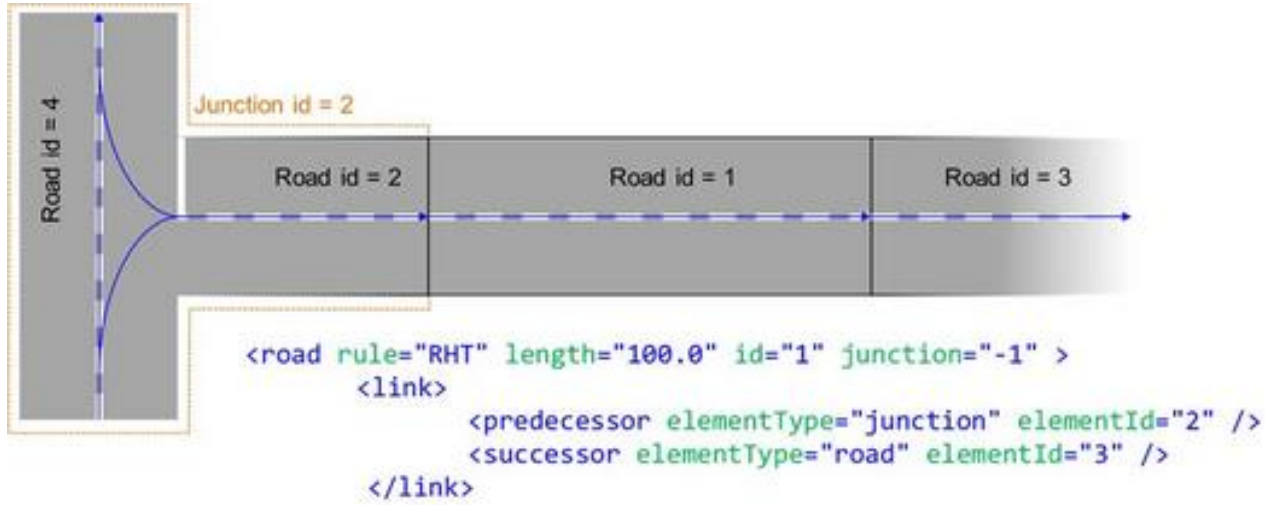
Defining the Environment and the Scenario



ASAM OpenDRIVE

Defining the Environment and the Scenario



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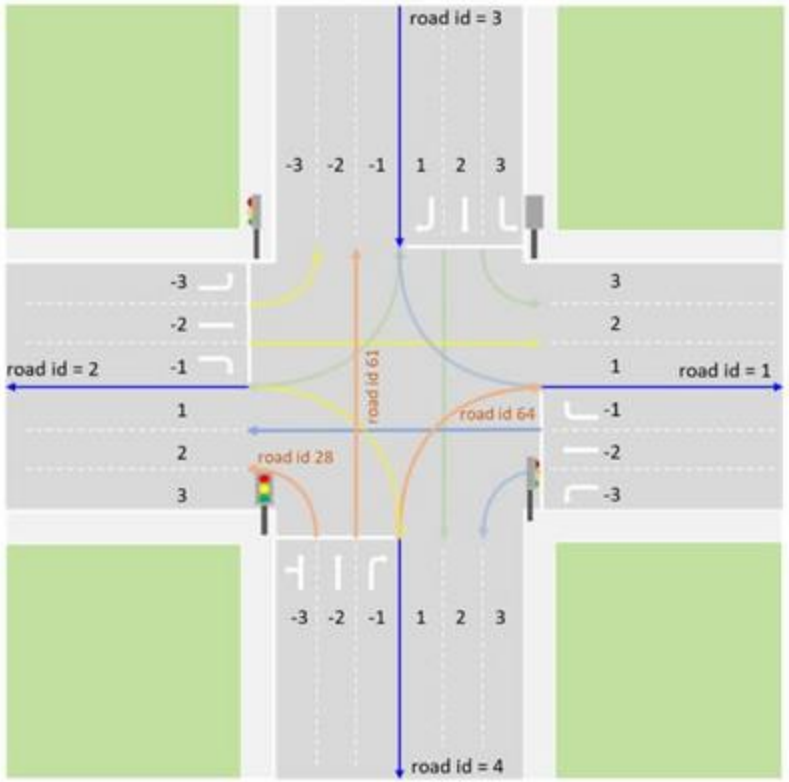
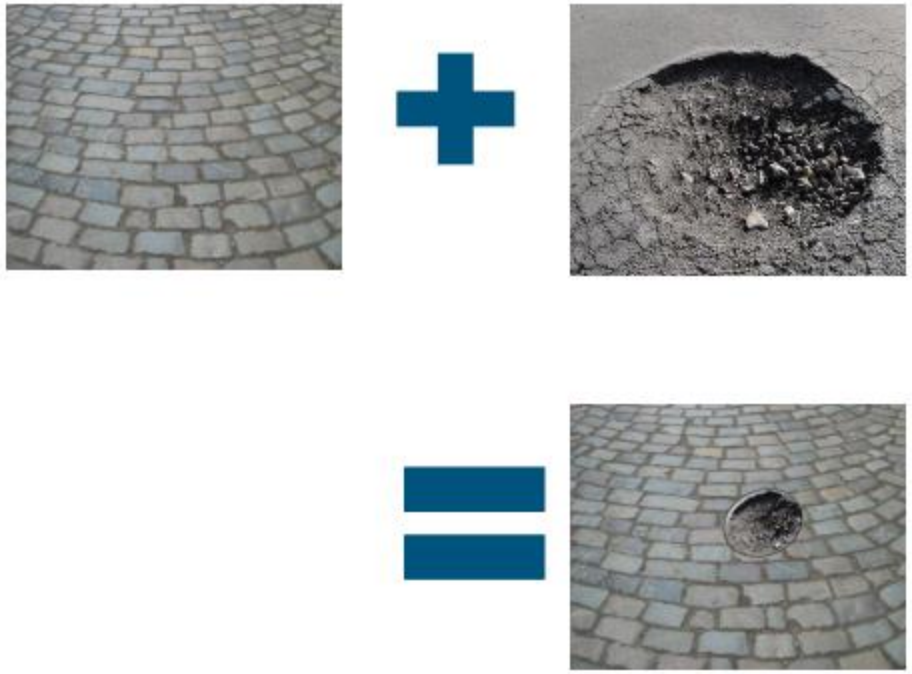
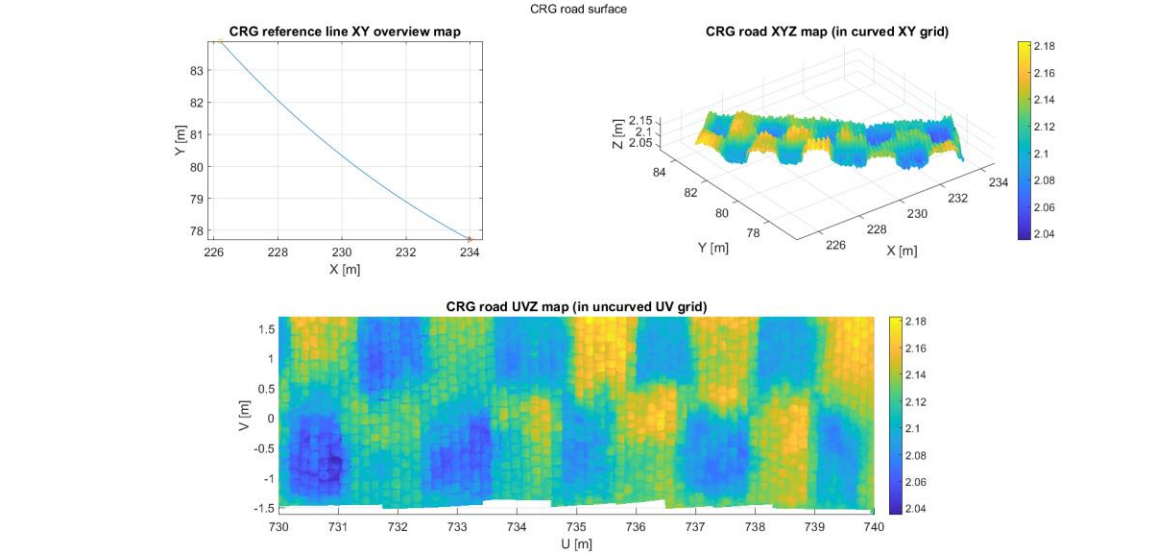
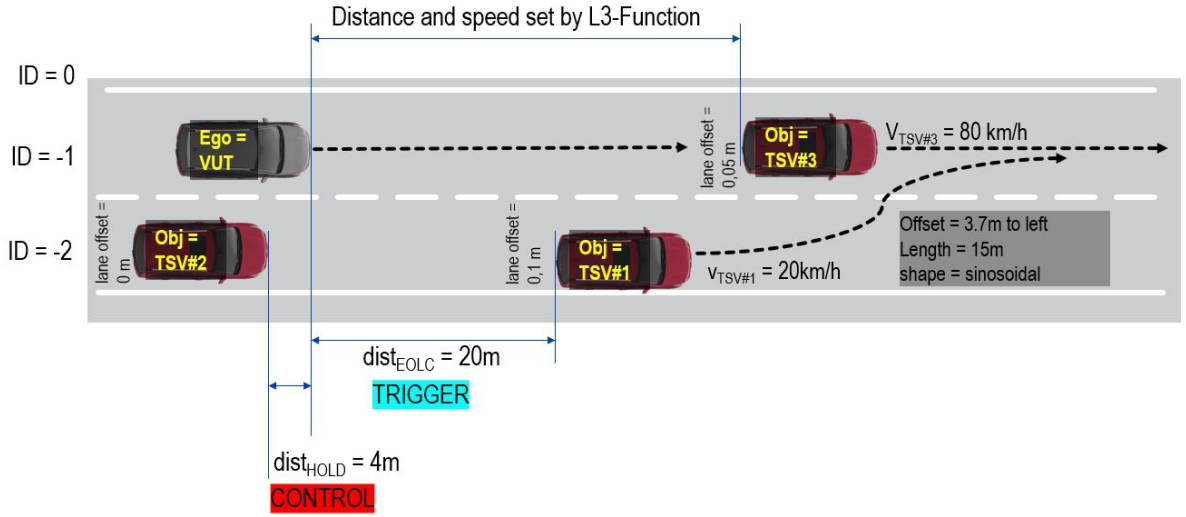


ASAM OpenCRG



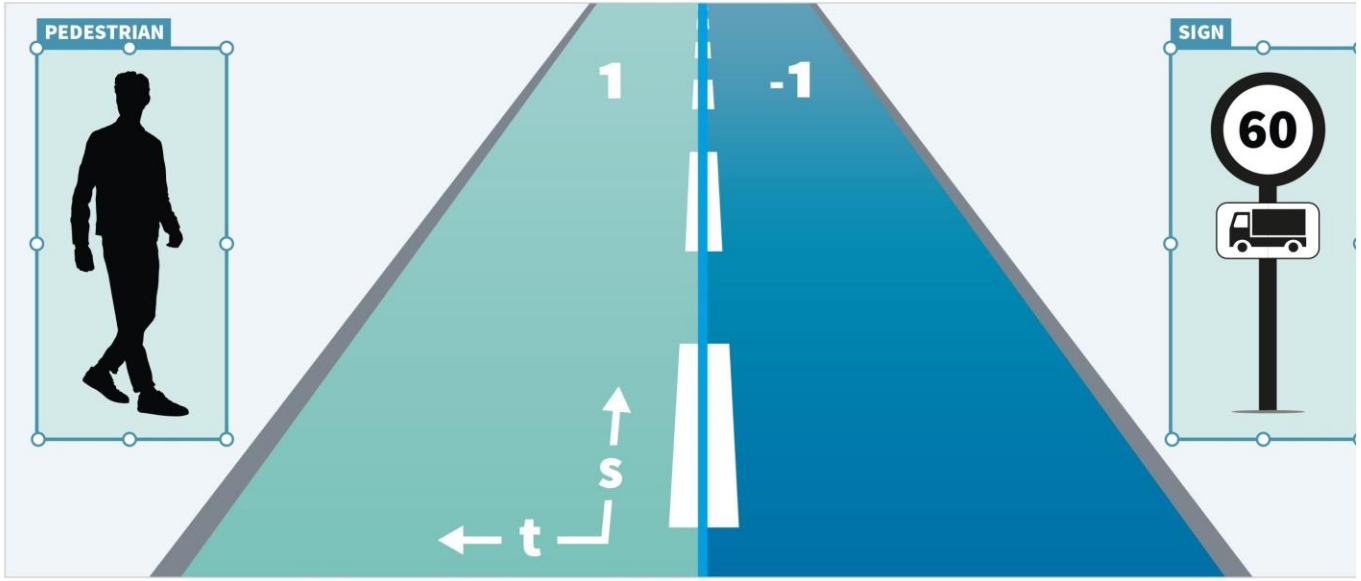


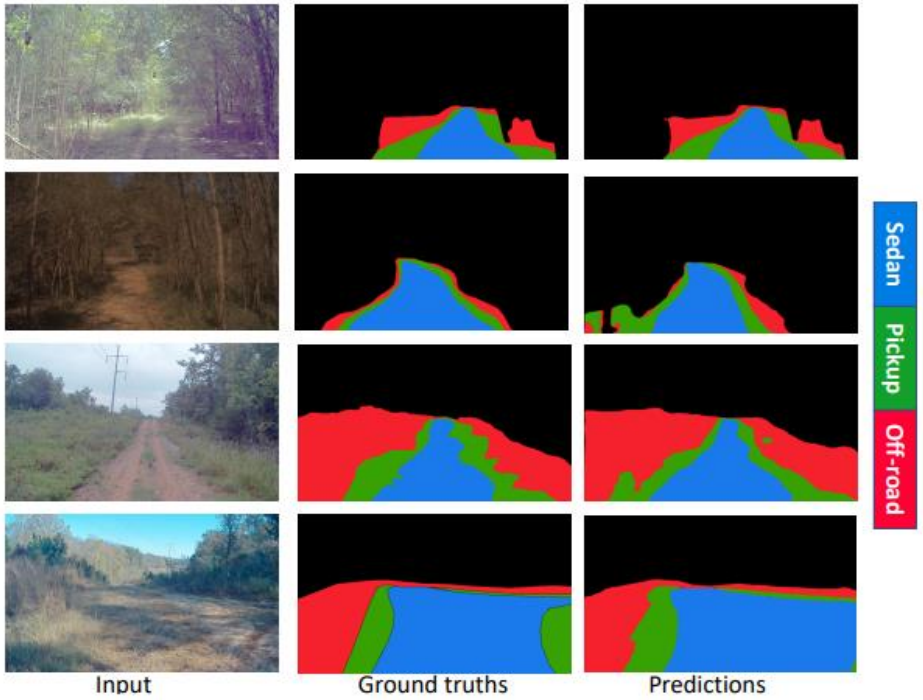
ASAM OpenSCENARIO



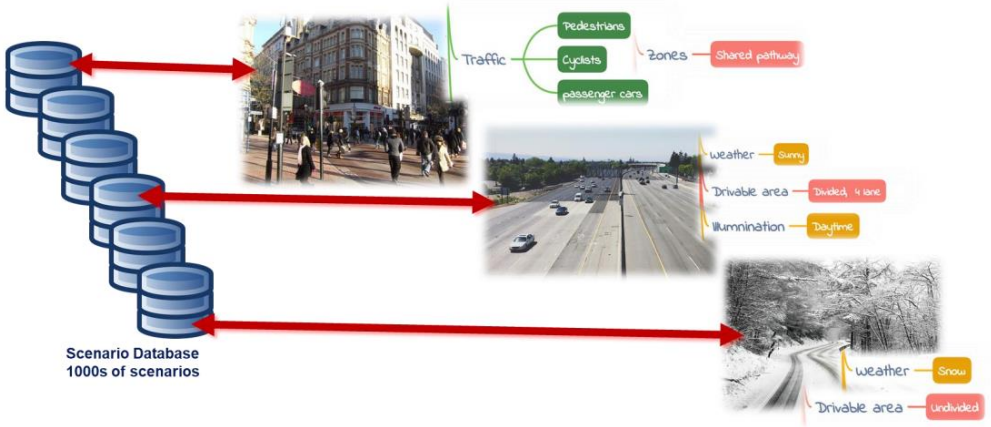

```
scenario sut.my__scenario:
    car1: vehicle
    car2: vehicle

    do serial:
        phase1: car1.drive(duration: 24s) with:
            speed([40kph..80kph], at: end)
            lane([2..4])
        phase2: car1.drive(duration: 24s) with:
            speed([70kph..60kph], at: end)
```

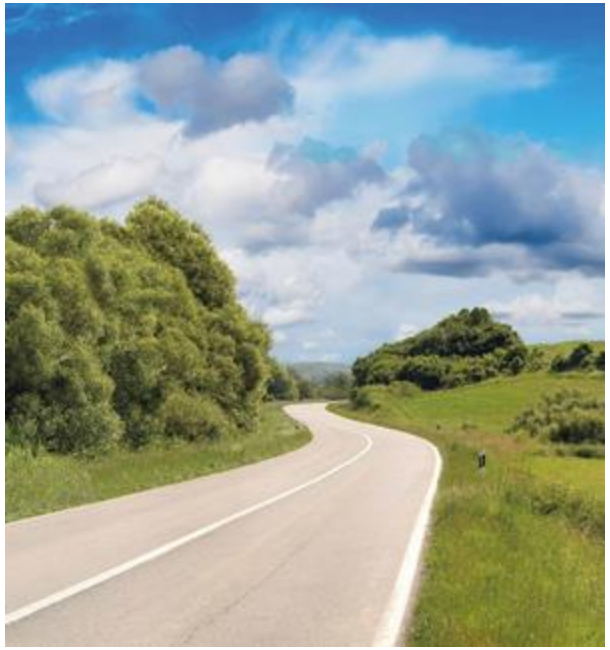
ASAM OpenLABEL





ASAM OpenODD

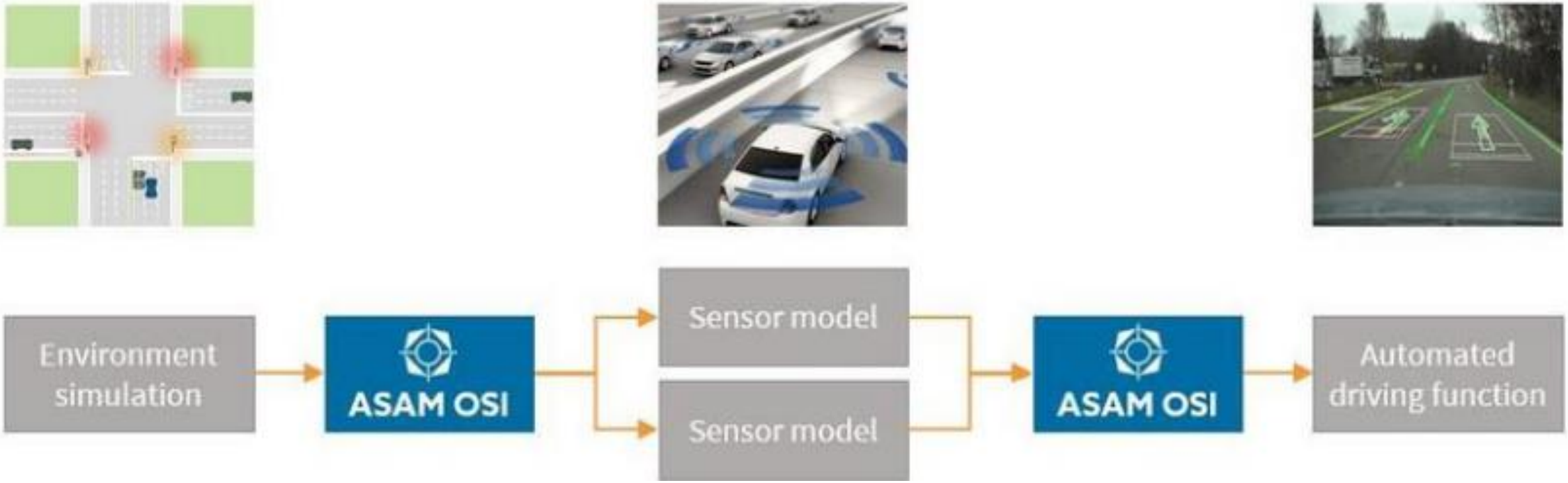


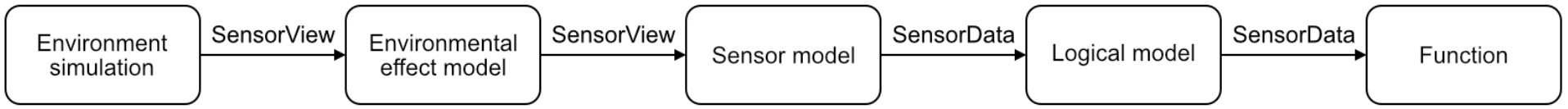


ODD Features

- Paved Road
- Right hand traffic
- Country Road
- No visibility limitation due to weather or time of day
- All possible traffic participants
- Animals
- …

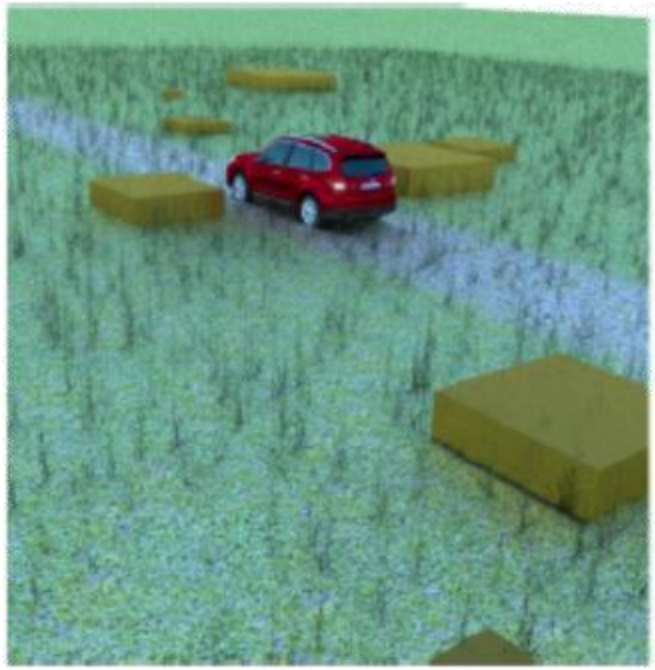
ASAM OSI Open Simulation Interface

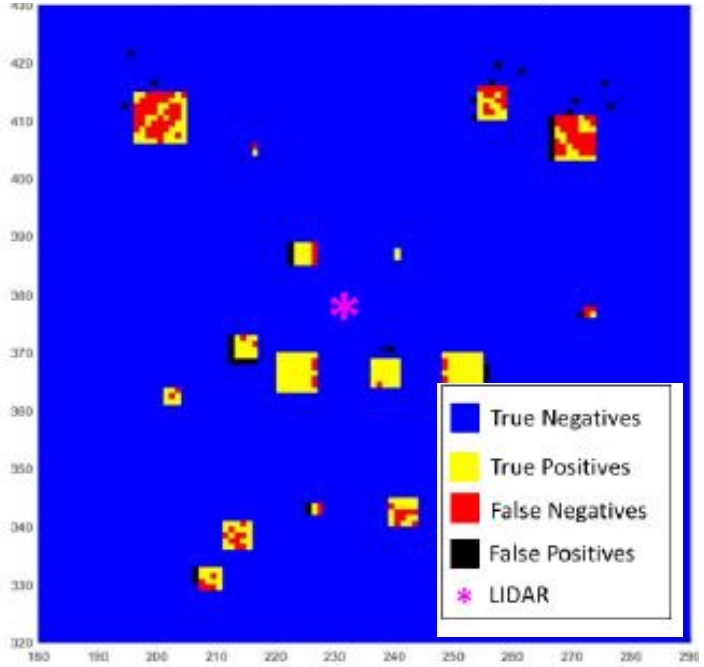




OpenMaterial

- Material measurement
- 3D Model structure
- Data structures
- OSI sensor view plugin





Existing Standards

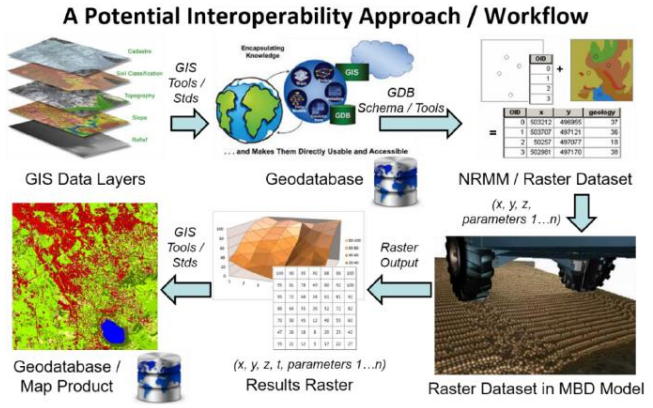
Terrain, drivable area, and materials

- Terrain, drivable area, and materials
  - Landxml 1.2 (infra model 4.0.4)
  - ASAM OpenCRG
  - ASAM OpenDRIVE
  - NATO AMSP-06

  - Algoryx agxTerrain implementation

NATO AMSP-06

- Addresses mobility modeling and simulation tools for military vehicle operations.
- Modernizes modeling and simulation for probabilistic mobility predictions of ground and amphibious vehicles.
- Enhances interoperability, portability, and extensibility of models.
- Addresses uncertainty quantification.
- Includes verification, validation, and benchmarking approaches.



- 24 attributes for describing soil characteristics.
- Representation of complex 3D terrain.
- Recommendations for 3D multibody dynamics modeling of vehicles.
- Description of environment requirements for modeling sensors for intelligent vehicles.

Existing Standards

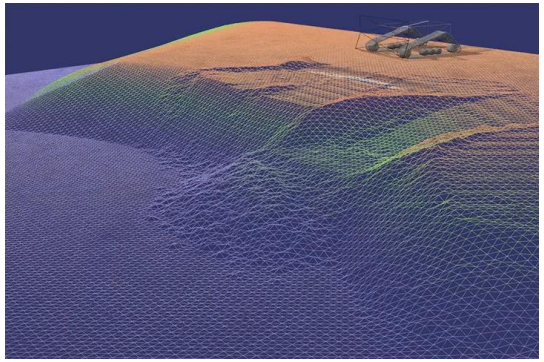
Terrain, drivable area, and materials

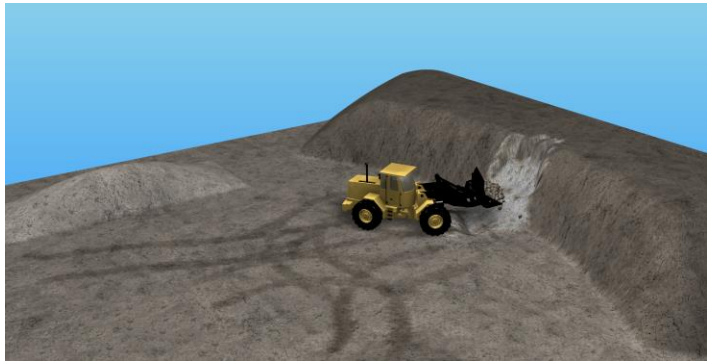
- Terrain, drivable area, and materials
  - Landxml 1.2 (infra model 4.0.4)
  - ASAM OpenCRG
  - ASAM OpenDRIVE
  - NATO AMSP-06

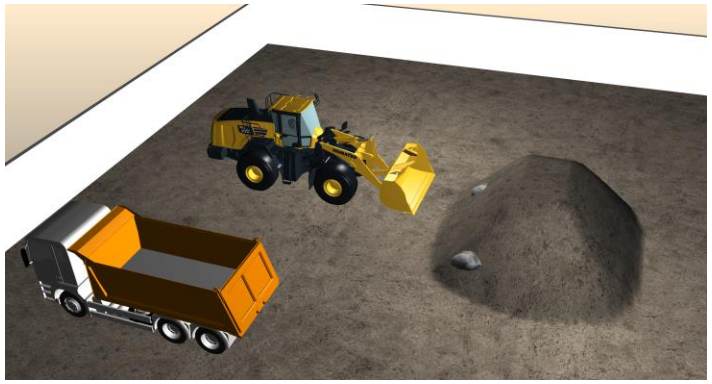
  - Algoryx agxTerrain implementation

Algoryx agxTerrain

- Algoryx's AGX Dynamics physics simulation toolkit.
- agxTerrain implements a deformable terrain model.
- Symmetric 3D grid data structure with overlapping surface height field.
- Supports digging, push/pull, and grading operations for bulldozing, wheel loading, excavation, etc.







Scenario Evaluation

- Documentation of requirements driven by offroad application
- Evaluation of current ability to meet requirements with current standards
  - Able to meet requirement with current standard
  - Unable to meet requirement with current standards
  - Unable to demonstrate proprietary capability
  - When met, document the standard, method, and grade level of support
  - When not met, identify potential standard that could support, possible definitio
- Estimate overall level of support for offroad applications

<u>Unsupported requirements</u>
- Soft terrain – deep tracks deformation

<u>Possible solutions</u>
- Extend OpenDRIVE with 3D terrain elements and soil characteristics

OR
- New OpenTERRAIN or OpenOFFROAD standard

Requirement	Met?	Standard	
Modelling of navigation of heavy machinery on soft terrain (deep tracks)	N	NA	
Model vehicle perception as it traverses an offroad environment	Y	OSI	3
Model effects of terrain and soil properties on vehicle-terrain interaction and mobility/dynamics including loss of traction, slip	Y	OpenCRG	2
Overall Support	**66%**	**-**	**2.5**

Summary

- Introduce offroad applications
- Motivation for exploring usage of OpenX standards
- User stories for offroad applications
- Offroad features and requirements
- Proposed approach for concept project
- Discussed scenarios for evaluation
- Relationship to relevant standards
  - ASAM OpenX Standards
  - Other standards
- Evaluation approach

ASAM Development Process for Standards

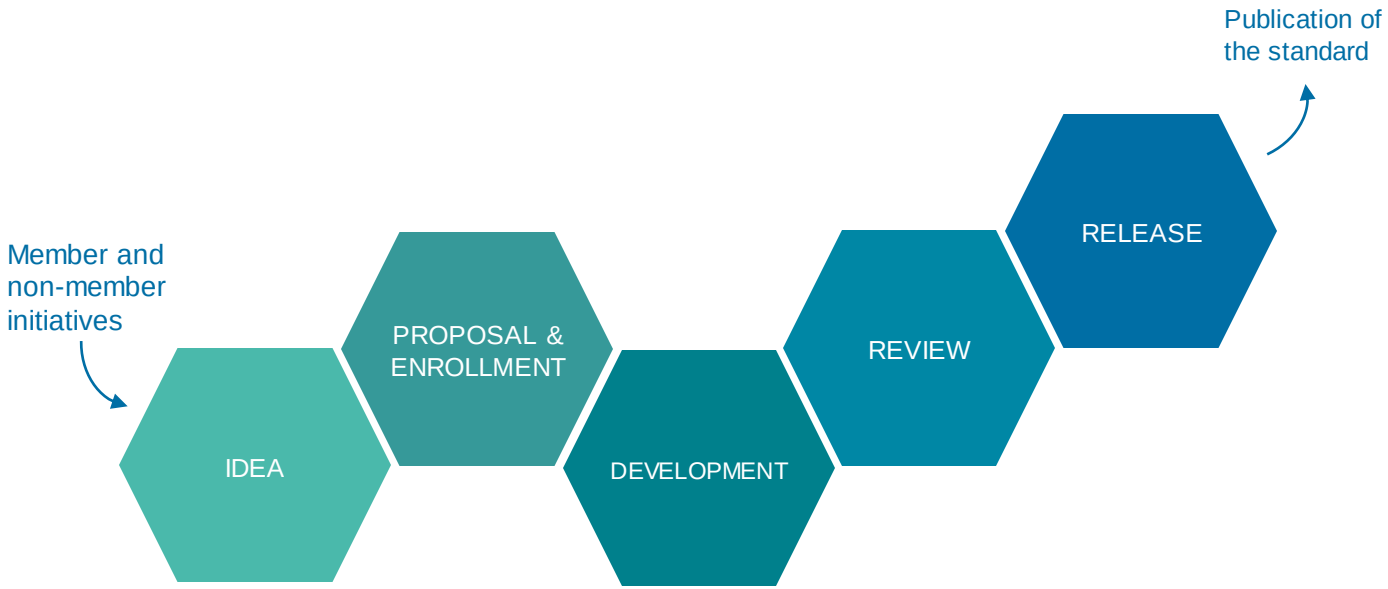
Matthäus Lang
ASAM e.V.

2023-09-14
Virtual Proposal Workshop

ASAM
Association for Standardization of Automation and Measuring Systems

ASAM Development Process for Standards

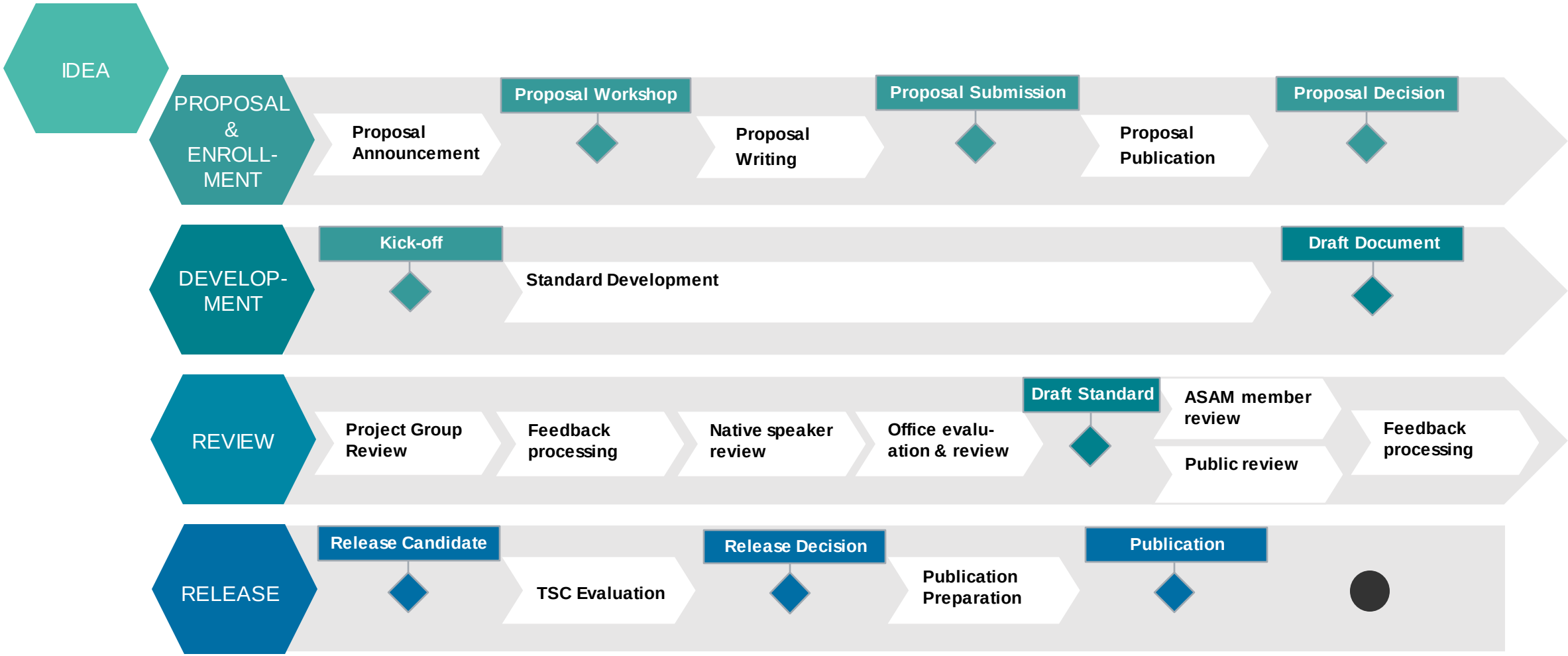
From the first idea to the publication of a standard



Guiding Principles:

- Member-driven
  Initiatives and decisions are taken by the member companies.
- Open exchange
  ASAM requests open exchange among all stakeholders.
- Domain expertise
  ASAM has a global network of domain experts to develop standards
- Flexible processes
  ASAM has lean yet flexible process structures leading to short development times
- Project support
  Experienced Technology Managers support the project groups

ASAM Development Process for Standards



ASAM Development Process for Standards

Goals of the Concept project development

- Understand how offroad applications can be built using current standards
- Identify gaps between current standards and requirements

Project Members

Task: Develop the standard as per project proposal and TSC decision.

- Provide use-cases, application & process knowledge and requirements.
- Provide technical expertise.
- May write parts of the standard and contribute other artefacts.
- Internal review of the standard and evaluation of the service provider work.

Project Leader

Task: Organizes and manages the work group.

- Sets the meeting agendas.
- Moderates work group meetings.
- Manages service provider(s).
- Represents the group towards the TSC and ASAM Office.
- Is elected by work group.

ASAM Development Process for Standards

Infrastructure

- A dedicated SharePoint Website will be available for the concept project
- Additional tools will be discussed and decided upon in the kick-off workshop

Work Packages

- The Work Packages will be finalized in the kick-off workshop as well as the assignees
- Some of the Packages might be changed or eliminated depending on the feedback of the participating project members

Roadmap

- The preliminary road map approved by the TSC will be subject to change during depending on the progress of the group work
- Possible project extension might be requested at a later date if required

Resource Commitment

- The main resource of any ASAM project are the participating members
- A possible secondary resource can be acquired through an approved budget for external support

Meeting Planning

- The rhythm of the group members meeting as well as the location will be discussed and decided upon in the kick-off workshop
- Every meeting should have a note taker for the meeting minutes

Usage of ASAM OpenX standards in Offroad Applications

BREAK
16:25 – 16:35 CEST

2023-09-14
Online

ASAM
Association for Standardization of Automation and Measuring Systems

Offroad Concept Proposal Content

Daniel Carruth, PhD
Mississippi State University

Mihir Acharya
Mathworks

2023-09-14
Virtual Proposal Workshop

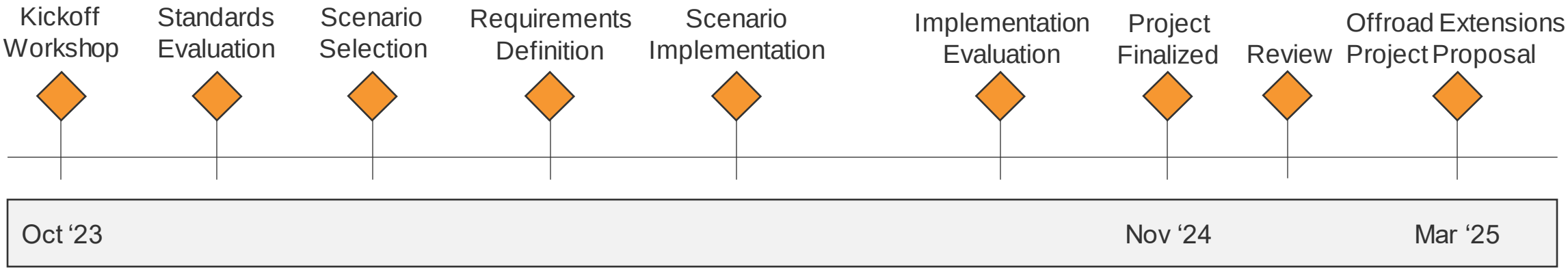
ASAM OpenX Standards in Offroad Applications Concept Project

Goals

- Select a set of example scenarios that represent use cases of interest
- Determine requirements
- Evaluate existing standards, standardization activities, and proprietary solutions to determine what, if any, new standard(s) are needed for offroad applications
- Exercise current standards by implementing example scenarios. Identify gaps in current standards ability to meet requirements. Document gaps across OpenX standards.

Deliverables

- Example scenario implementation and documentation of requirements and gaps.
- Create a concept document for OpenX Offroad Extensions.
- Offroad extension development project proposal.



ASAM OpenX Standards in Offroad Applications Concept Project

Project Number	C_2023_3
Project name	ASAM OpenX Standards in Offroad Applications
Domain	Simulation
Impacted standard(s)	OpenCRG, OpenDRIVE, OpenLabel, OpenMaterial, OpenODD, OpenScenario, OSI, possible new standard(s)
Project type	Concept
Start date	01.11.2023
End date	28.02.2025
TSC submission	29.09.2023
Proposer(s)	Daniel Carruth (Mississippi State University), Mihir Acharya (Mathworks), Hugo Borjesson (Algoryx)
ASAM Office Responsible (OR)	Matthäus Lang
Initiating companies	Mississippi State University, Mathworks, Algoryx
ASAM funds	TBD
Backwards compatibility	N/A

Proposal Document

- Outline
  - Executive Summary
  - Overview
  - Technical Content
    - Approach
    - Domains
    - Scenarios
    - Modeling soft terrain
  - Use-Cases
    - Requirements
    - User Stories
  - Project Resources
  - Deliverables

If you'd like to review and contribute to the document, please contact:

Matthäus Lang
Technology Manager
ASAM e.V.
Phone: +49810270139083
Mobile: +491709213579
matthaeus.lang@asam.net

www.asam.net

Executive Summary

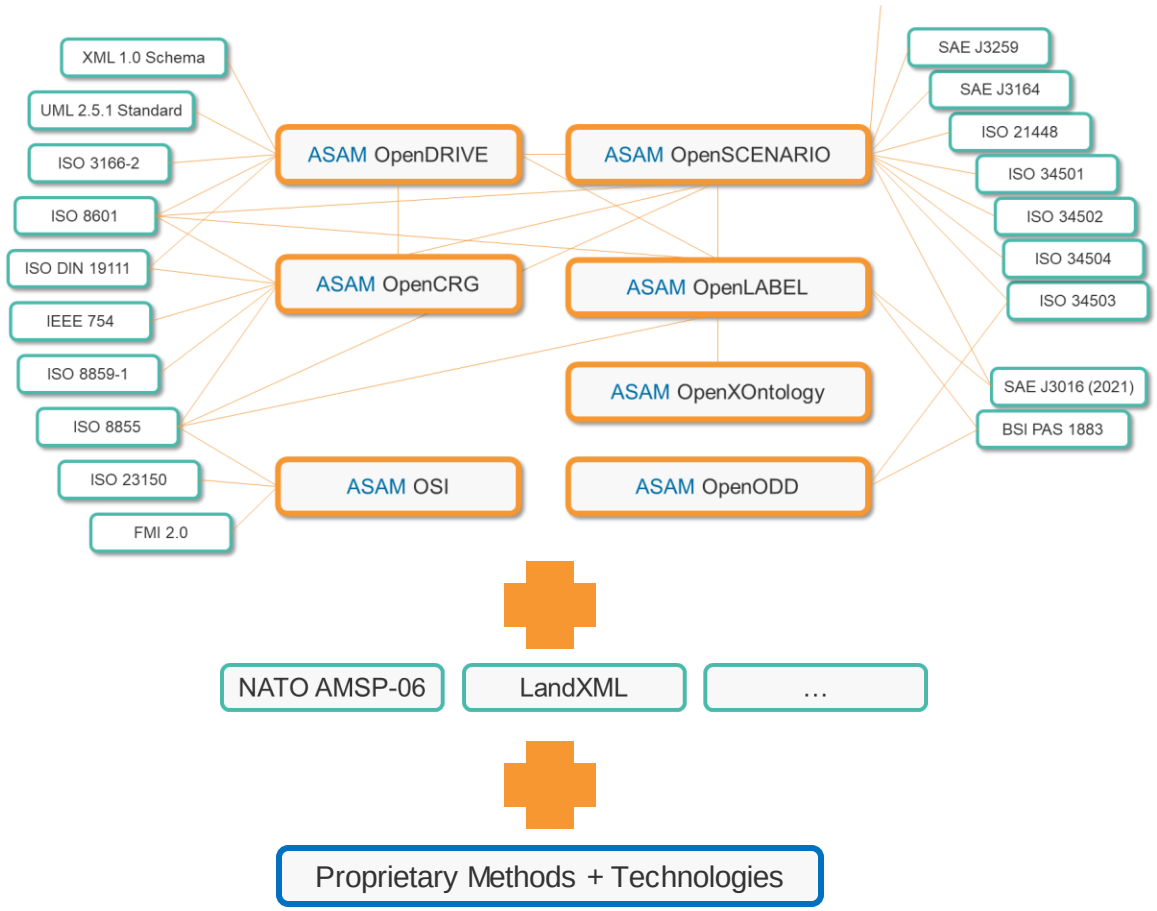
- Importance of offroad applications
- Lack of awareness of use cases
- Similarity in toolchains but limited statement of requirements
- Unique requirements
- Goals – support for multiple domains, function
- Leverage examples to exercise standards -
- Find gaps
- Develop a proposal

Motivation

- Industries involving landfill, construction, agriculture, and mining are developing highly automated driving functionality
- Significant overlap in their use cases with ASAM OpenX standards across on-road ADAS/AD
- However, there are unique requirements for simulating operations in offroad domains
- We want to support companies in these domains and prevent redundancy
- But, need to understand domain requirements and demonstrate the application of ASAM OpenX standards in these areas
- Experiences of concept project will lead to expansion of the use of ASAM OpenX standards
- Some aspects are likely to be beneficial for applications in on-road driving

Relations to Other Standards

- ASAM Standards
  - OpenCRG
  - OpenDRIVE
  - OpenLABEL
  - OpenMATERIAL
  - OpenODD
  - OpenSCENARIO
  - OSI
- Other Standards
  - NATO AMSP-06
  - Application Standards
    - Mining
    - Contruction
    - Work site management and traffic control
- Commercial Tool Systems
  - e.g., Algoryx



Developing Examples to Highlight Required Extensions

- Two primary operating modes of interest
  1. Navigation and interaction with complex, offroad environments
  2. Interactions with soil and material through implements

- Establish the potential operating domains and application areas:
  - Application Areas
    - Mining
    - Forestry
    - Agriculture
    - Construction
    - Military
    - Recreational

  - Operating Domains
    - Forests, Mountains, Deserts, Fields, …

Unique Requirements

Environments with complex structure

- On-trail driving
  - Similar to on-road driving
  - More varied road surfaces
  - More varied topography (washes, ruts, etc.)
  - Sharp inclines, sharp declines, sudden changes in elevation
  - Special driving regulation, prioritization of loaded vehicles
- Off-trail, cross-country navigation
  - Through a field (small diameter, dense but traversable vegetation)
  - Through woods (larger diameter, untraversable vegetation, canopy, range occlusion, no straight paths)
  - Rocky terrain (obstacles, changes in elevation)
- Terrain Conditions
  - Rough, uneven terrain
  - Varying terrain soil strength
  - Loose terrain (loose soil, gravel, slip)

Potential Topics Addressed by Extensions or New Standards

- Complex 3D terrain
- Representation of the subsurface
  - Soil strength, density, temperature, water content
- Surface materials
- Vehicle-terrain interaction
- Material dynamics
- Deformation
- Accumulation of material on vehicles
- Occlusion of sensors
- Representation of vegetation and other natural obstacles
  - Perception *and* mobility
- Weather conditions

Scenarios

Which scenarios to incorporate into the proposal?

- **Moving from Point A to Point B**
    1. Following a Path
    2. Finding a Path
    3. Carrying a Load
    4. Using Sensors to Respond to the Environment
    5. Navigating without GPS
- **Vehicle Interaction**
    6. Following a Lead Vehicle
    7. Dealing with Environmental Effects
    8. Interacting with Traffic
- **Load and Haul**
    9. Loading a Hauler - Hauler
    10. Loading a Hauler – Excavator
    11. Evaluating fuel efficiency

Use Cases

ID	Description	Relevant Scenario	Relevant Standard	Type
1	Modelling of navigation of heavy machinery on soft terrain (deep tracks)	1-3, 5, 6		Technical
2	Model vehicle perception and mobility and dynamics as it traverses an offroad environment	1, 3, 4, 6-8		Technical
3	Model effects of terrain and soil properties on vehicle-terrain interaction and mobility/dynamics including loss of traction, slip	1, 3, 6,		Technical
4	Model GPS sensor data accounting for effects of vehicle movement, terrain, and vegetation including loss of signal, multipath, etc.	1, 5		Technical
5	Model common sensors (e.g., LiDAR, EO camera, IR, radar, GPR, etc.) accounting for effects of vehicle movement, terrain, and vegetation including occlusion, material attribution, etc.	2, 6,		Technical
6	Represent objects with appropriate mesh and material attributions for common sensors	2, 4		Technical
7	Represent physics of objects for appropriate vehicle-object interactions	2, 4, 5		Technical
8	Represent vehicle loads including specification of type and volume of material being transported and estimating effects caused by the load including stability, traction, deformation of road surfaces, and maneuverability	3, 6, 9		Technical
9	Represent effects of adverse conditions (dust, standing water, mud, etc.) on terrain properties and on sensors (e.g., occlusions from dust clouds, water spray, water or mud on lenses, etc.)	7		Technical
10	Represent vehicle components relevant to VTI/mobility	1-3		Technical
11	Represent driveline/powertrain for the vehicle	1-3		Technical
12	Represent other vehicles acting appropriately in the offroad environment	6, 8		Technical
13	Incorporate fuel depot/charging stations (capacity, charge/refuel rate)	11		Technical
14	Tram systems (external power lines; temporary disconnect from power supply/charging)	11		Technical
15	Articulated effectors	9-10,		Technical

Use Cases

ID	Description	Relevant Scenario	Relevant Standard	Type
16	Model vehicle cooperation – specific positioning relative to each other	6, 8, 9-10		Technical
17	Model effects of terrain and soil properties on digging and moving soil	9-10		Technical
18	Estimate effects of vegetation on vehicle mobility	1, 2, 4, 7		Technical
19	Estimate effects of vegetation on sensors and perception			Technical
20	Generate prior information to the autonomy stack (e.g., simulate extraction of maps, etc. from previous drives, UAS, or other sources)	1		Technical
21	Extract sensing and mobility data for learning how to traverse terrain	1, 4, 6		Technical
22	Evaluate or optimize efficiency of vehicle systems in the operating environment	11		Business
23	Collecting performance data for benchmarking systems (e.g., specifying and recording various metrics for evaluating system performance)	All		Technical
24	Share and reuse offroad scenarios in a common format for shared understanding	All		Business

User Stories

ID	Description	Related Use Cases (IDs)
1	As a vehicle developer, I want to evaluate the performance of autonomous system components in an offroad environment to understand how the vehicle will act in such an operating environment. (Mobility Application)	
2	As a vehicle developer, I want to develop new capabilities and test the vehicle against offroad scenarios. I want to develop and test mechanical, electrical, hydraulic, and electro-mechanical systems.	
3	As an autonomy software developer, I create algorithms, software and supporting documentation for perception, planning and control of the vehicles and their support tools. I work with control engineers to investigate, test, and select software toolsets or hardware components and peripherals (programmable logic controllers, mobile computers, display/touch screens, etc.). I want to collect sensor and mobility data for training AI/ML models. I want to develop new algorithms and test the vehicle against offroad scenarios. I want to work with other engineers to investigate and test vendors' products.	
4	As a test engineer, I want to develop and evaluate detailed offroad test scenarios for both component and system level testing and validation.	
5	As a system integration engineer, I work in early planning stages and define the scope of projects. I am making decisions about interfaces between the systems. I create scenarios to help understand the requirements for systems. I create schematic representations of mechanical, electrical, hydraulic, and electro-mechanical systems and work with other disciplines to create the specifications that outline the control system logic necessary for haul truck functions.	
6	As a site manager, I manage and assess the application of vehicle systems on-site. I work with the environment, health, and safety teams and security teams to conduct regular risk assessments. I maintain a risk register and develop and implement risk mitigation plans. A digital twin of the site that can simulate scenarios will help me to understand site operations, assess risks, and predict the effectiveness of mitigation strategies.	

Project Resources

- Number of Participants
- Number of Companies
- ASAM funds

- Work Package Features and Effort
- Project Plan
- Service Providers
- Company Commitments

Work Packages

WP ID	Title	Resources
	Project Coordination	
1	Evaluate Existing Offroad Data Standards or Formats	
2	Implement 'Following a Path' example scenario	
3	Implement 'Finding a Path' example scenario	
4	Implement 'Carrying a Load' example scenario	
5	Implement 'Using sensors to respond to the environment' example scenario	
6	Implement 'Navigating without GPS' example scenario	
7	Implement 'Following a Lead Vehicle' example scenario	
8	Implement 'Dealing with Environmental Effects' example scenario	
9	Implement 'Interacting with Traffic' example scenario	
10	Implement 'Loading a Hauler - Hauler' example scenario	
11	Implement 'Loading a Hauler - Excavator' example scenario	
12	Implement 'Evaluating fuel efficiency' example scenario	
13	Identify gaps and requirements for standard based on example scenario exercises	
14	Link gaps and requirements with ASAM standards	
15	Create concept document for offroad extensions	
16	Propose further development	
	Review	

Project Plan

WP ID	Title	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
	Project Coordination																	
1	Evaluate Existing Offroad Data Standards or Formats																	
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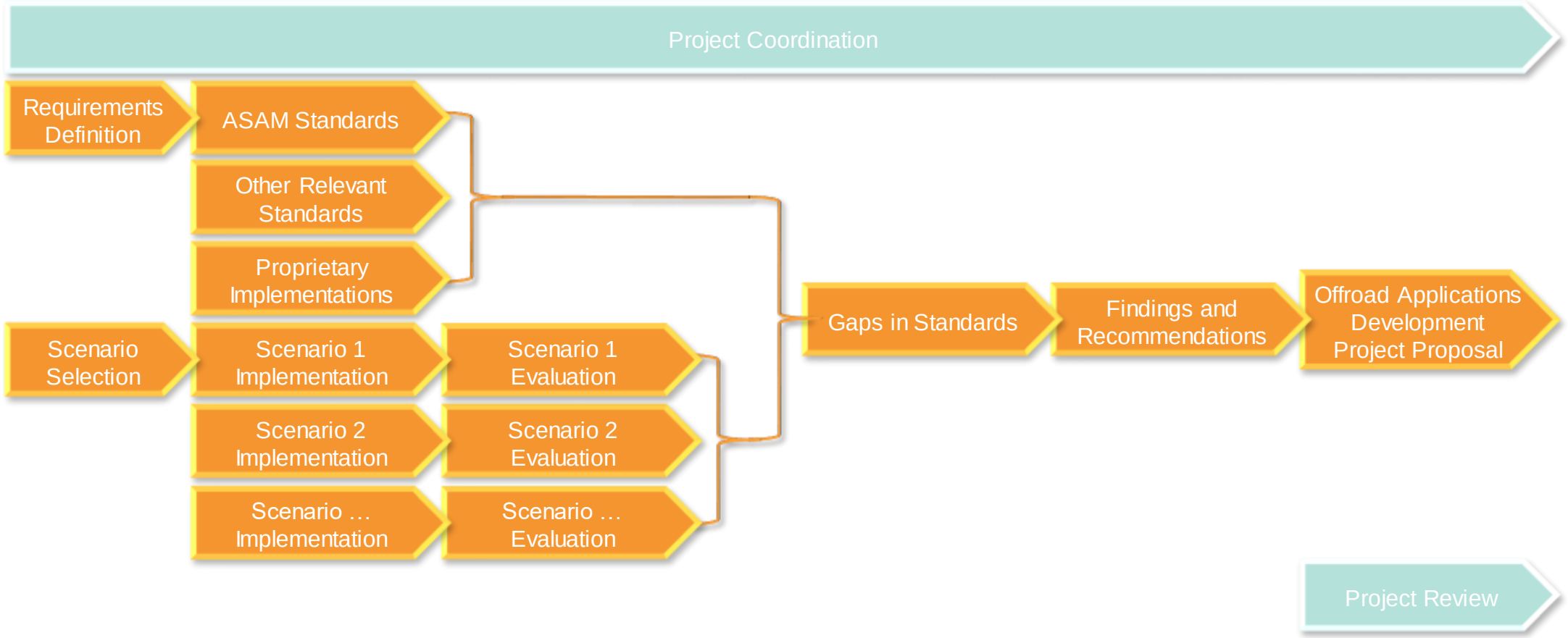
15	Create concept document for offroad extensions																	
16	Propose further development																	
	Review																	

* Based on full set of scenarios, expected to be revised following workshop.

Project Activities



Company Commitments

- 2 days per month (24 days for 12 month duration) per participant
- Participation in weekly meetings, F2F meetings, and offline preparation
- Concept project activities
  - Requirements development
  - Standards review and evaluation
  - Scenario development
  - Scenario implementation evaluation
  - Offroad applications project proposal development

Enrollment

- Personnel
  - Anyone with interest in offroad application areas
  - Expertise in the application areas
  - Expert in OpenX standards
  - Experts in other offroad standards
  - Developers and users of the modeling and simulation tools
  - Application developers

- We will need assistance:
  - Ensuring that our scenarios are relevant while remaining feasible
  - Exploring the capabilities of current standards, even bending the standards for novel applications
  - Personnel to help implement and evaluate the example scenarios

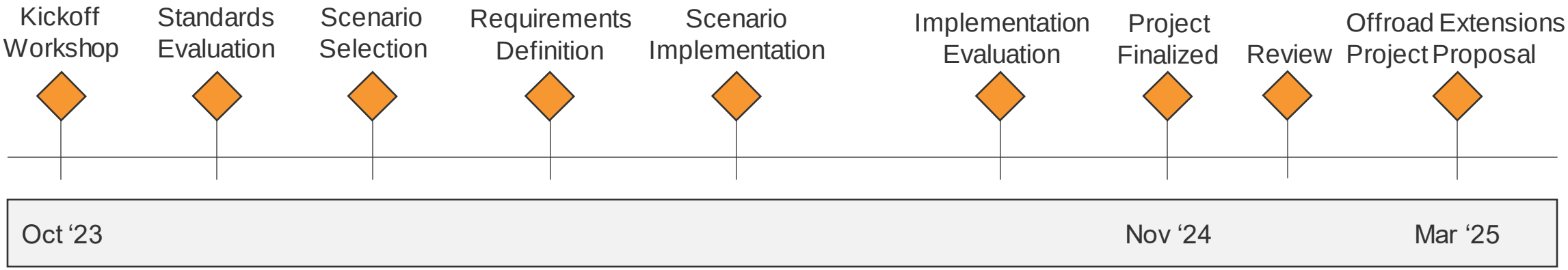
Offroad Applications Concept Project

Goals

- Select a set of example scenarios that represent use cases of interest
- Determine set of requirements
- Evaluate existing standards, standardization activities, and proprietary solutions to determine what, if any, new standard(s) are needed for offroad applications
- Exercise current standards by implementing example scenarios. Identify gaps in current standards ability to meet requirements. Document gaps across OpenX standards.

Deliverables

- Example scenario implementation and documentation.
- Create a concept document for extensions and/or standards for supporting offroad applications.
- Offroad extension development project proposal.



Deliverables

1. Example Scenario Implementation and Documentation
   - Abstract, logical and concrete descriptions of example scenarios
   - Documentation of requirements driven by offroad application
   - Evaluation of current ability to meet requirements with current standards
   - Estimate overall level of support from current standards for selected scenarios

2. Technical Report
   - Requirements for offroad applications
   - Relationship of existing standards to requirements
   - Proposed extensions to existing standards and, if needed, new standards

3. Proposal for an Offroad Extensions Development Project

Daniel Carruth
Associate Director
Center for Advanced Vehicular Systems
Mississippi State University
dwc2@cavs.msstate.edu
Linkedin: danielcarruth

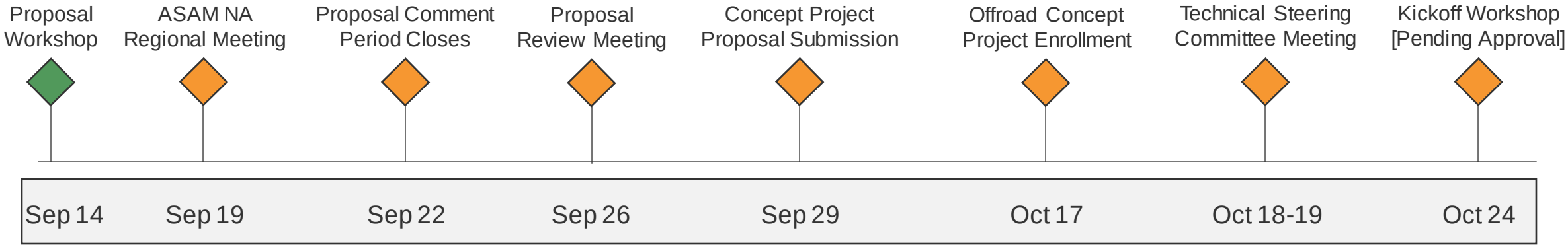
Mihir Acharya
Sr. Technical Product Manager
Robotics and Autonomous Systems
Mathworks
macharya@mathworks.com

Next Steps

Matthäus Lang
ASAM e.V.

2023-09-14
Virtual Proposal Workshop

Concept Project Proposal Timeline



Next Steps:

The ASAM Offroad Concept Discussion has successfully concluded with this workshop and will be replaced with the new Concept Project **ASAM** OpenX standards in Offroad Applications upon approval by the Technical Steering Committee next month. This will be followed by the Kick-off workshop which will be announced at a later date.

Draft proposal document is now available.
To join the ideation group and/or access the proposal document please contact:

Matthäus Lang
Technology Manager
ASAM e.V.
matthaeus.lang@asam.net

ASAM Regional Meeting North America

on: Sep 19, 2023 | 13:30 - 17:00 PDT (Pacific Daylight Time) UTC-7
at: Santa Clara Convention Center | Hybrid meeting
Room: Great America J
5001 Great America Pkwy
Santa Clara, CA 95054
United States

For the first time, ASAM is hosting the ASAM Regional Meeting in Santa Clara, CA. The meeting will be held in conjunction with the ADAS & Autonomous Vehicle Technology Expo California.

At the ASAM Regional Meeting, we connect with our North American community, introduce new ASAM activities and standards, and learn about the local community's requirements and concerns. This year, we are hosting this event in California to meet the car industry of the Silicon Valley.

Feel free to forward this event invitation to your colleagues, friends and clients. Membership is NOT required to attend.

Please register following the link below:
https://www.asam.net/conferences-events/detail/asam-regional-meeting-north-america/

Call for Participation

- Currently enrolling participants for the concept project
  - The Link for enrollment will be available shortly on the ASAM Website: www.asam.net
  - Open through Oct 17

- *Who should participate?*
  - Interest in offroad ground vehicle application areas
  - Expertise in application domains
  - Expertise across OpenX standards and other related standards
  - Developers and users of M&S tools
  - Ground vehicle developers

Immediate opportunities to participate:

- Provide comments on current draft proposal by Sep 22, 23:00 CEST
- Participate in current working group meetings on Sep 26
- Assist with reviewing and editing proposal for submission by Sep 29

To join please follow the provided link. For questions please contact:

Matthäus Lang
Technology Manager
ASAM e.V.
Phone: +49810270139083
Mobile: +491709213579
matthaeus.lang@asam.net

www.asam.net

Thank you for your attention!

Matthäus Lang
Technology Manager
ASAM e.V.
Altlaufstr. 40
85635 Höhenkirchen / Germany
Phone: +49810270139083
Mobile: +491709213579
matthaeus.lang@asam.net

www.asam.net

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R. Luck, 2011,[Caterpillar haul truck, Luminant Energy Kosse lignite mine][Photograph], https://www.flickr.com/photos/royluck/5556779421/, CC-BY-2.0.

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L. Burke, 2007, [Tractor in the mud – geograph.org.uk - 578481.jpg).jpg][Photograph], https://commons.wikimedia.org/wiki/File:Tractor_in_the_mud_-_geograph.org.uk_-_578481.jpg, CC-BY-SA-2.0.