Offroad Concept Proposal Content

Daniel Carruth, PhD
Mississippi State University

Mihir Acharya
Mathworks

2023-09-14
Virtual Proposal Workshop

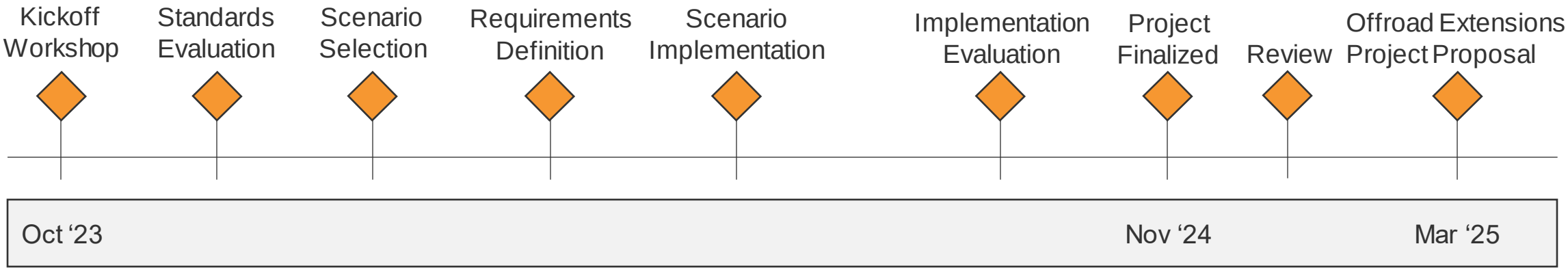
ASAM OpenX Standards in Offroad Applications Concept Project

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

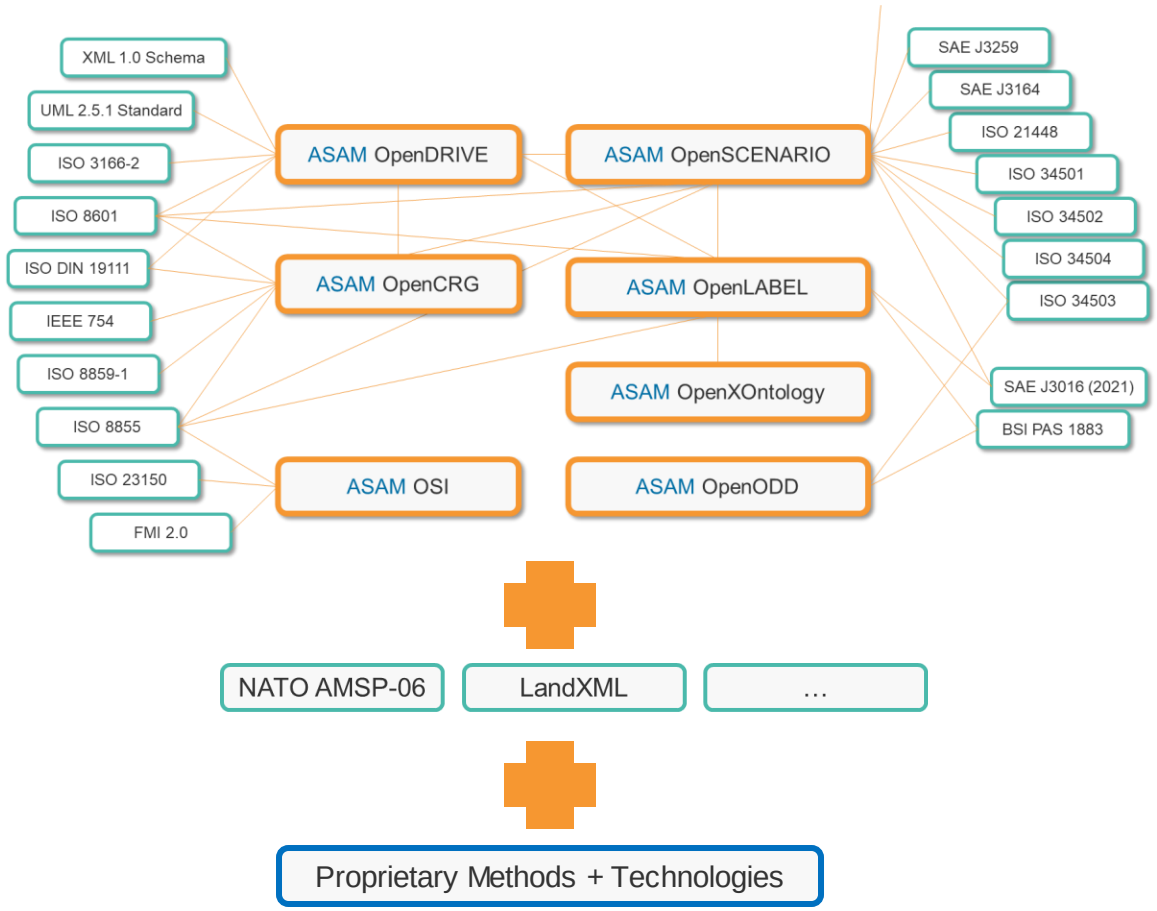
- Importance of offroad applications
- Lack of awareness of use cases
- Similarity in toolchains but limited statement of requirements
- Unique requirements
- Goals – support for multiple domains, function
- Leverage examples to exercise standards -
- Find gaps
- Develop a proposal

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

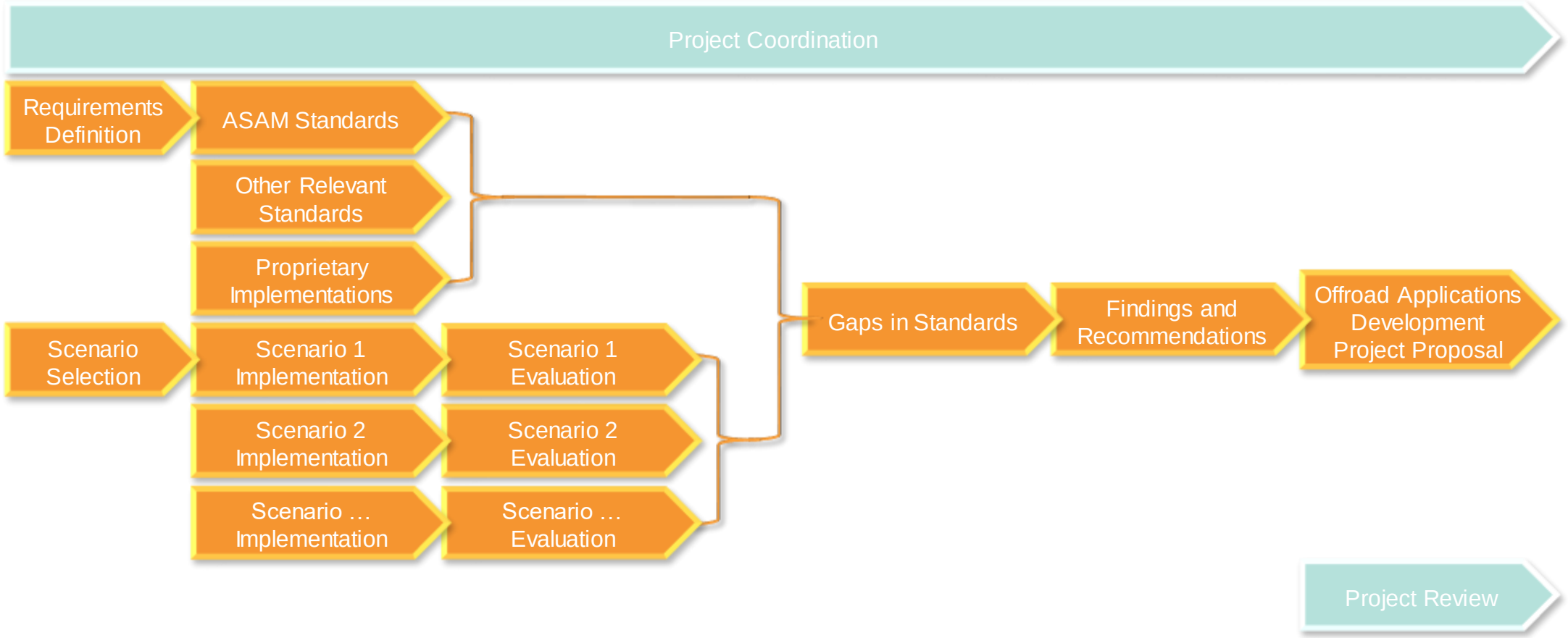
WP ID	Title	Resources
	Project Coordination	
1	Evaluate Existing Offroad Data Standards or Formats	
2	Implement 'Following a Path' example scenario	
3	Implement 'Finding a Path' example scenario	
4	Implement 'Carrying a Load' example scenario	
5	Implement 'Using sensors to respond to the environment' 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																	
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																	

* 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

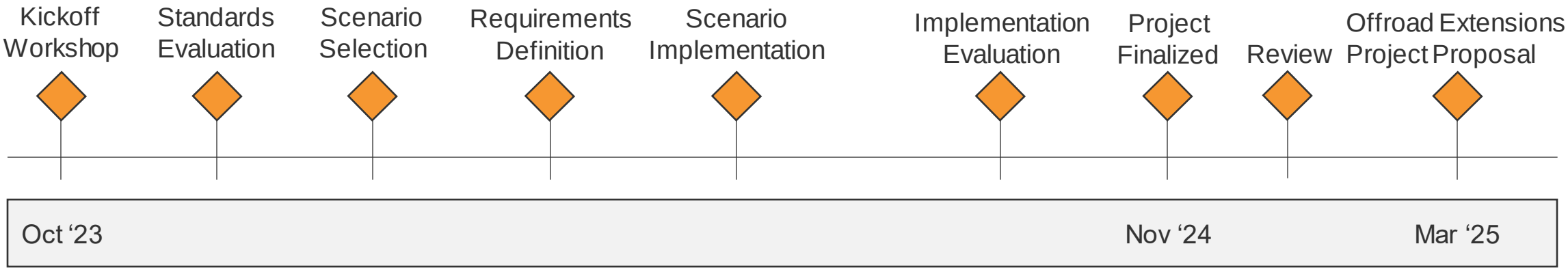
Offroad Applications Concept Project

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