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NATO AVT-341

Mobility Assessment Methods and Tools for Autonomous Military Ground Systems

Paramsothy Jayakumar
Co-Chair

Sibiu, Romania
23-27 May 2022



Background / Motivation

Autonomous ground systems are a key part of the future military strategy for many NATO Nations. In the race to field these systems, there is still a lack of understanding of the capabilities and reliability of these systems.

Towards Automation

- For ground vehicles it means using this technology to:
 - *Augmenting human capability through multi-sensing*
 - *Providing to human operator a legitimate unmanned and intelligent team support*
 - *Proactively analysing the theatre of operation to provide relevant strategical options*
 - *Ultimately being able to replace human perception and decision making through automation*
- Need to define and implement clear assessment procedure as:
 - *Current autonomy software does not address off-road or unstructured environments*
 - *Rely heavily on pre-loaded street maps and GPS*
 - *Limited or no integrated autonomy capabilities with various available M&S software*
 - *No available military scenarios for running simulations*
 - *No incorporation of military autonomous vehicles into military scenarios*

Mission

❖ *what do we want to accomplish?*

- Establish a mobility assessment framework purposely designed to consider the specific underlying requirements of off-road mobility of military autonomous ground vehicles.
- Demonstrate evaluation of autonomous mobility in integrated autonomy and mobility M&S tools within realistic and relevant scenarios.
- Focus research efforts at solving autonomous mobility capability gaps.
- Develop NATO STANAG.

Roadmap

- ❖ *how are we going to accomplish our goals?*
- Conduct interviews to confirm stakeholder requirements.
- Design a complete military relevant scenario.
- Implement the designed scenario in M&S tools to include environments, vehicles, sensors, and autonomy algorithms.
- Develop tests, metrics, and verification and validation (V&V) process.
- Conduct mini-CDTs and collect data.

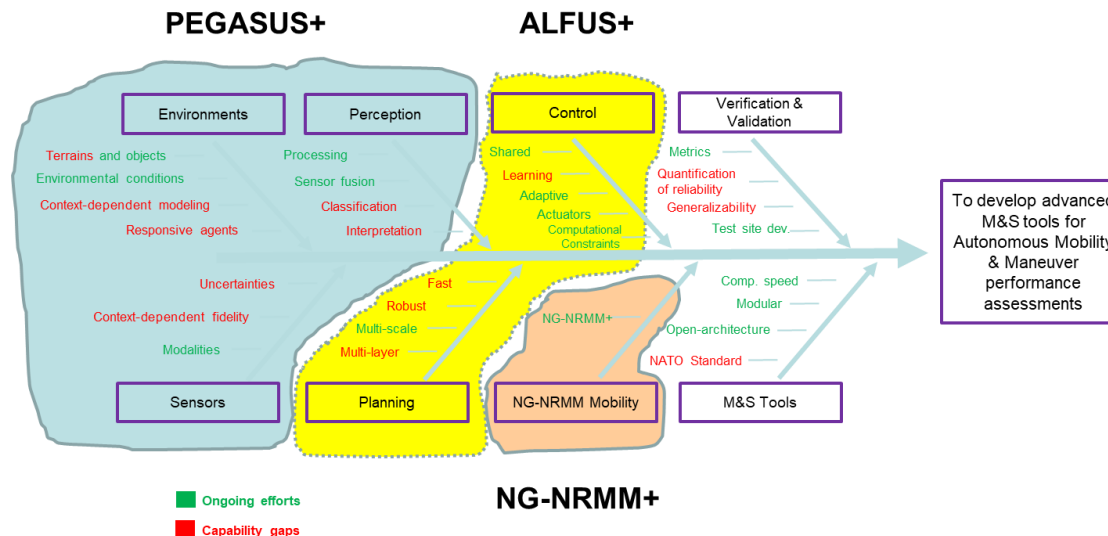
Roadmap

- ❖ *how are we going to accomplish our goals?*
- In a regular interval, conduct a series of demonstrations of a prescribed mission scenario that demonstrate capabilities and reveal gaps of autonomous mobility M&S.
- In a regular interval, develop and update accordingly to our findings, a series of draft NATO standards for autonomous mobility M&S of military AGVs beginning with the requirements developed by ET-194.

Vision

❖ *what will this work lead to in the long term?*

- Spur research and development of M&S technologies for AGV off-road mobility performance assessment
- M&S tools organically integrate autonomy and mobility capabilities



Stakeholders

❖ *whom do we serve?*

- Designer/Developer of military autonomous ground vehicles
- Procurement Analysts
- Operational Analysts who support soldiers with assessment

Stakeholders' Requirements

❖ *how do we serve them?*

- The developed and validated assessment framework based on M&S technologies should enable mobility assessment of current AGV designs and potential AGV concepts in military missions from now to 10-year perspective.
- The developed assessment framework should be scalable and upgradable enabling it to keep up with technological developments and potential integration of all autonomy levels.
- Developed NATO STANAG should promote interoperability across NATO nations.

PBM Expectations

- Are we making progress against the *Roadmap*?
- Are we succeeding in communicating with the members?
- Is everyone contributing towards the goals?
- Is everyone nationally appointed?

Technical Team

Co-Chair: Paramsothy Jayakumar (USA)

Co-Chair: Johannes Anderson (Sweden)

Co-Chair: Arnold Free (Canada)

Panel Mentor: David Gorsich (USA)

Technical Evaluator: Bogdan Epureanu (USA)

Turkey:

AKALIN, Ozgen

KUTLUAY, Emir

Denmark: BALLING, Ole

Germany:

HOENLINGER, Michael

KLUGE, Torsten

ROESER, Dennis

SIEDEL, Maximilian

Chile: HUGHES, Ian

South Africa:

MODUNGWA, Dithoto

NKOSI, Phumlane

REINECKE, Johann David

Estonia: NOORMA, Mart

Romania: ROSCA, Petru

Czech Republic: RYBANSKY, Marian

United Kingdom:

NEEDHAM, Joseph

STIRRAT, Dan

SUTTIE, William

ZAGORECKI, Adam

Poland:

GLOWKA, Jakub

WRONA, Jozef

Netherlands: den BREEJEN, Eric

Norway: THORESEN, Marius

Canada:

HUANG, Wei

TEICHMANN, Marek

Italy: BERARDI, Cinzia

France: CHERMAK, Lounis

USA:

ABELEV, Andrei

ALGER, Russell

BRADLEY, Scott

CARRUTH, Daniel

CHOI, Kyung

COMPERE, Marc

ERSAL, Tulga

EWING, Jordan

FRANKENSTEIN, Susan

GAUL, Nick

HODGDON, Taylor

JAIN, Abhinandan

KANIARZ, John

LAMM, Ryan

MARTIN, Dave

McCULLOUGH, Michael

METCALF, Phil

MISKO, Samuel

OOMMEN, Thomas

PARKER, Michael

PULLEY, Reid

REINERMAN-JONES, Lauren

SERBAN, Radu

VANTSEVICH, Vladimir

WASFY, Hatem

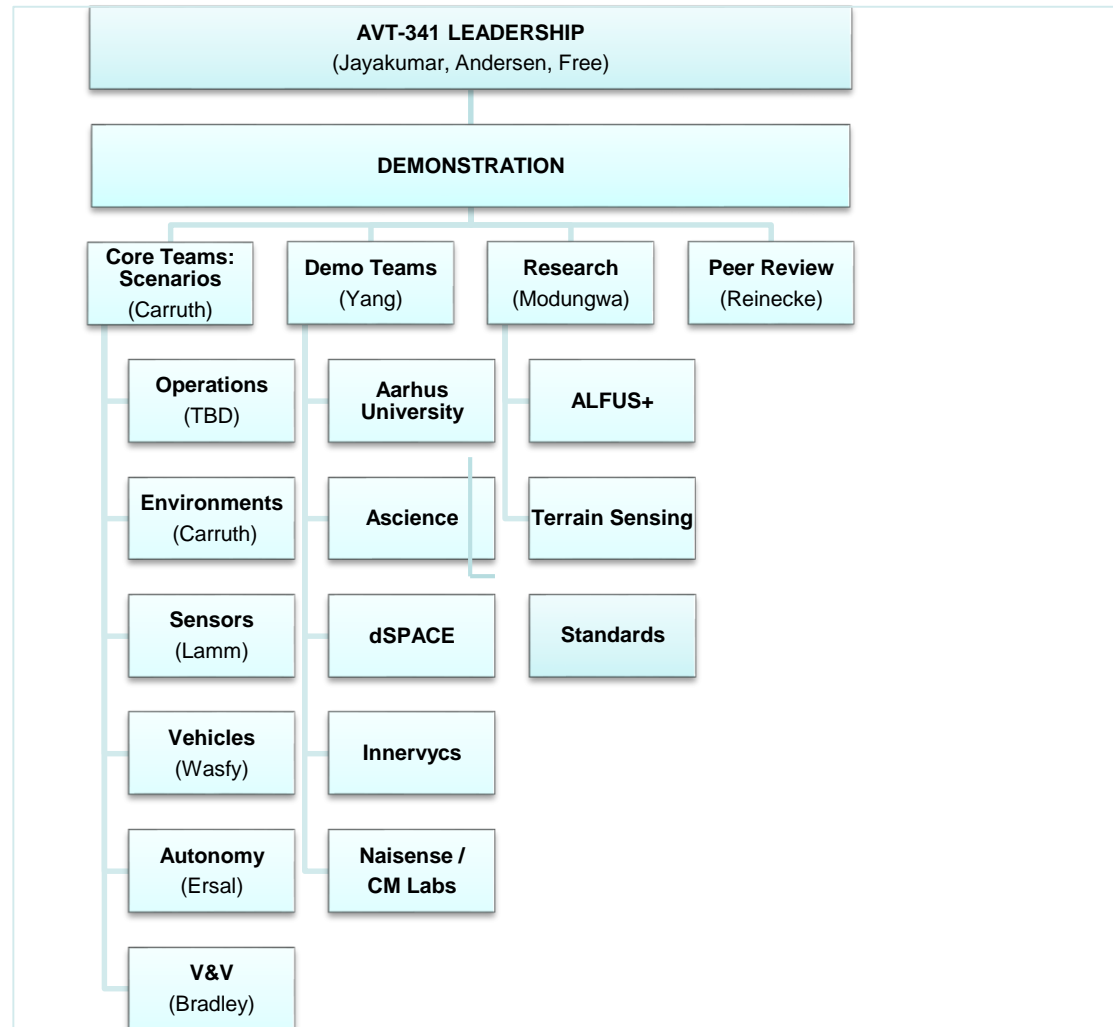
WASFY, Tamer

WILLIAMS, Ryan

YANG, Xiaobo

Number of Nations = 17
Number of Members = 57

Team Structure

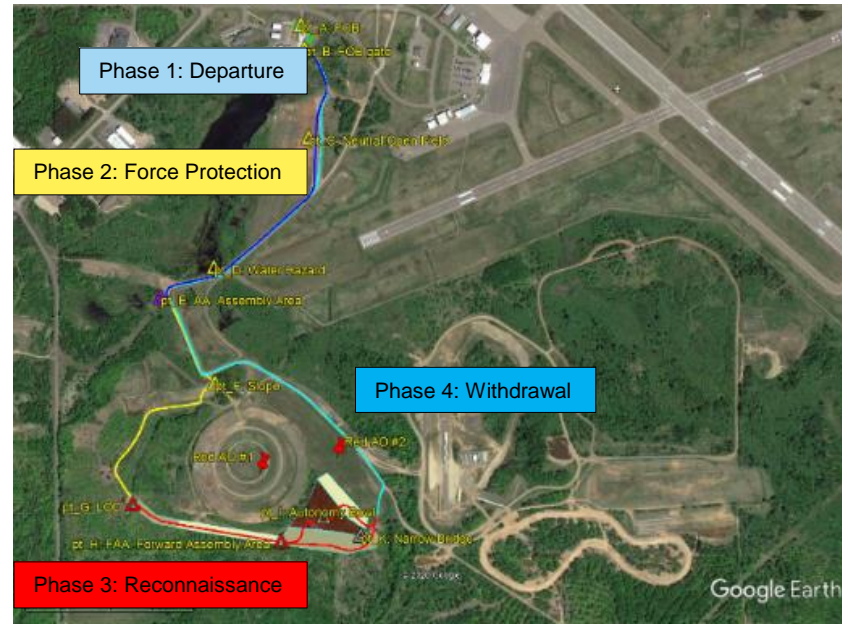


Actual Status

Status Against Roadmap

- Surveyed stakeholder requirements through a designed questionnaire.
- Designed a complete military relevant scenario of a “Loyal Wingman.”
- Implement the designed scenario in M&S tools.
- Develop tests, metrics, and verification and validation (V&V) process.
- Conduct mini-CDTs and collect data.
- *Develop NATO standards beginning with the requirements developed by ET-194.*

- *completed*
- *ongoing*
- *upcoming*

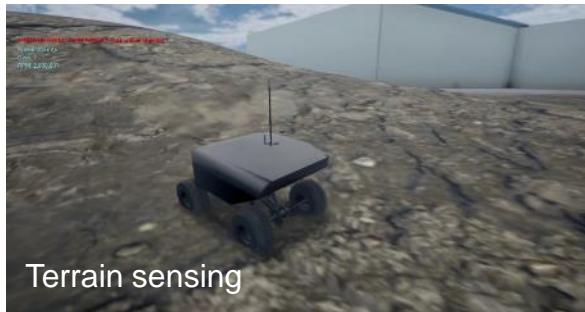


Actual Status

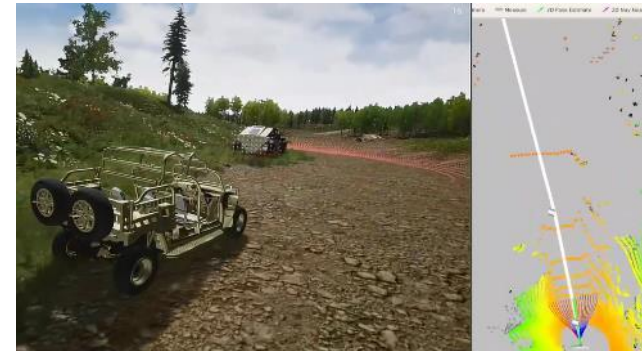
- Core teams on Operations, Environments, Sensors, Vehicles, Autonomy, and V&V are making progress, albeit unevenly.
- Autonomy development is progressing, and formalization of NATO (AVT-341) Autonomy Stack is to be decided at the 49th PBM.
- Currently five demo teams are participating in the demonstration exercise with little collaboration.
 - Consideration at the 49th PBM to merge demo teams to reduce risk and maximize collaboration
- The demo teams are progressing toward the development of autonomous mobility capability with a virtual demonstration at the 49th PBM, and further iterative demonstrations are planned through 2023.
- Challenges for a CDT are enormous. We will continue to evaluate our progress and determine the potential of a CDT to begin in 2024.
 - Currently are preparing mini-CDTs on specific AVT-341 topics such as sensor V&V, terrain sensing, autonomous planning and control, and UQ.

Actual Status

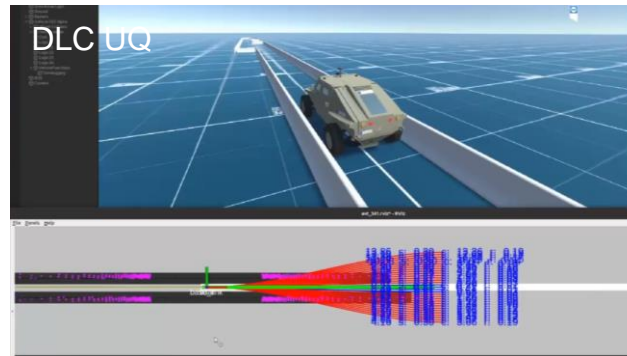
Innervycs



Ascience



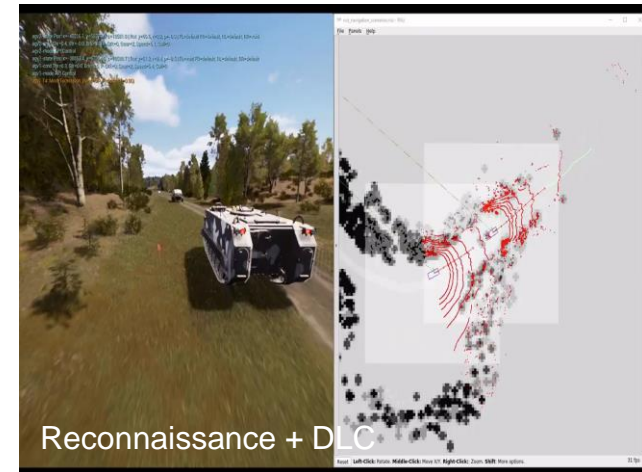
Aarhus Univ.



dSPACE



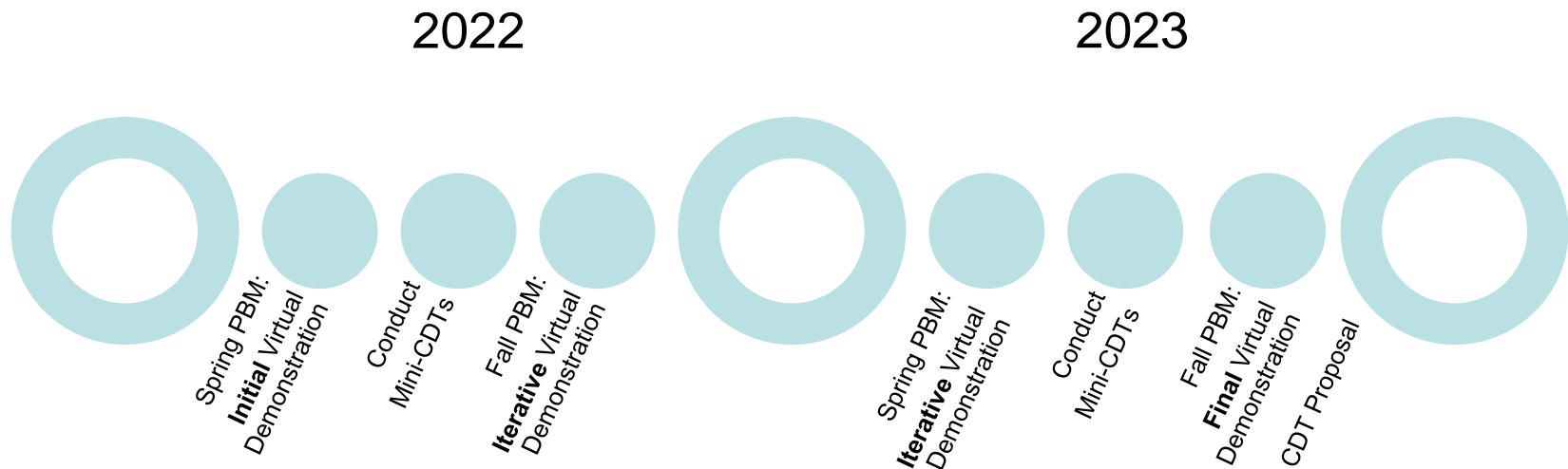
Naisense



Outlook

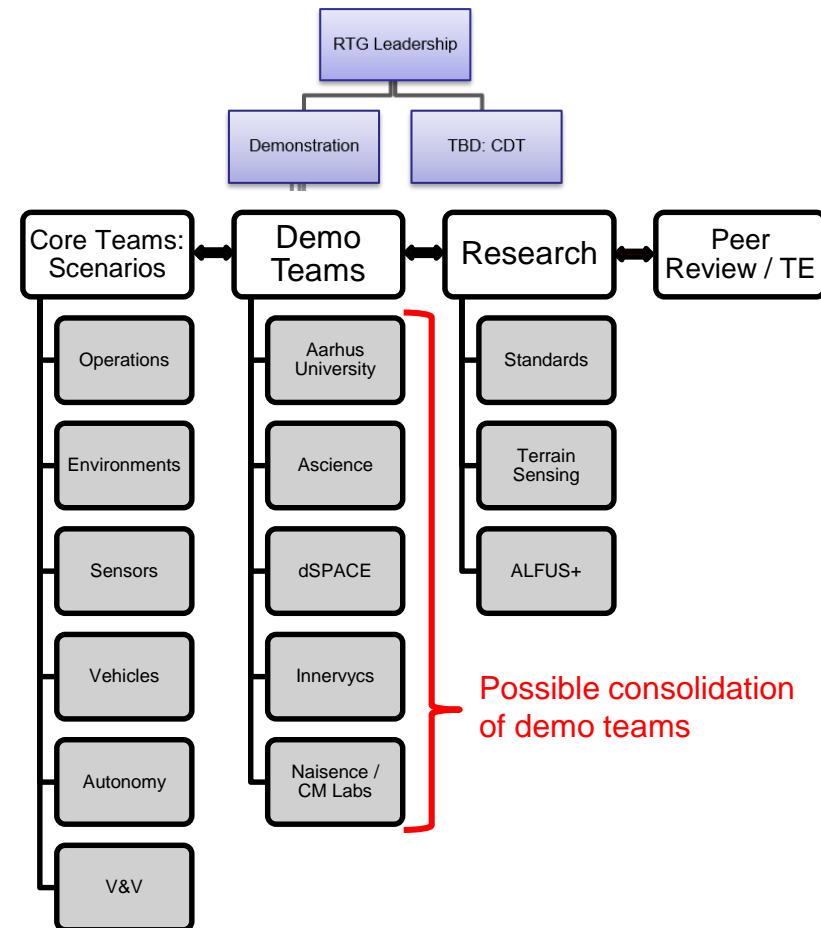
- **Roadmap**

- The iterative Virtual Prototyping will lead to a Virtual Demonstration of the Loyal Wingman scenario, and in general, Mobility of AGVs in military relevant scenarios.
- Prepare Cooperative Demonstration of Technology (CDT) proposal.
- Finally, develop NATO standards for autonomous mobility M&S of military ground vehicles.



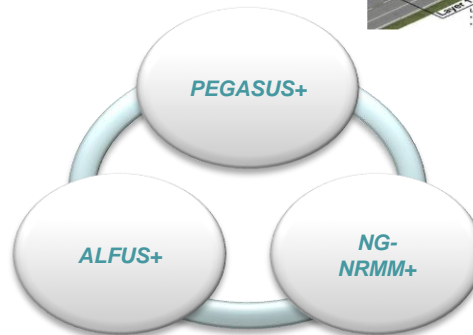
Expected Results

- Establishment of stakeholder requirements
- Development of M&S technologies for military AGV mobility through an iterative Virtual Demonstration effort articulated around 4 activities:
 - Scenarios
 - Demonstrators
 - Research
 - Peer Review / Technical Evaluator
- Development of a NATO autonomy software stack
- Conduct mini-CDTs
- Standardization of autonomous mobility assessment
- Assessment of Risks for achieving goals

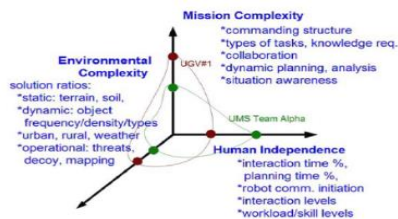


Impact Statements

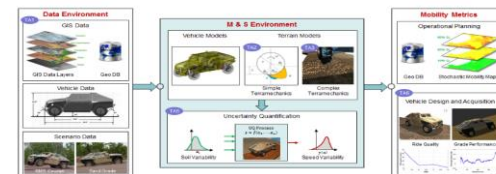
- Lay the ground work for a standardization procedure for assessing autonomous mobility performance through:
 - Mobility Standard (NG-NRMM+)
 - Autonomy Standard (ALFUS+)
 - Scenarios Standard (PEGASUS+)



Levels of Autonomy



Mobility



Impact and Exploitation: DOTMLPFI

- Provide critical S&T to NATO nations to perform tactical maneuvers and broader operations
- Provide strategic impact on autonomous military vehicle assessment capabilities
- Identify technology gaps through evaluation and demonstration of current capabilities
- Contribute an adaptable and interoperable mobility assessment framework and standards allowing for advancements in autonomy technology

PBM Agenda

Monday, 23 May 2022		Responsible Member
12:30-13:00	Opening ceremony	
14:00-15:30	Welcome, Introduction, AVT-341 & PBM Goals; Scenarios: Operations; Vehicles	Jay; MAJ Needham; Wasfy
16:00-17:30	Scenarios: Environments; UQ	Carruth; Gaul

Tuesday, 24 May 2022		Responsible Member
09:00-10:30	Scenarios: Sensors	Lamm
11:00-12:30	Scenarios: Autonomy	Ersal
12:30-13:00	Lunch	
14:00-15:30	Scenarios: V&V	Bradley
16:00-17:30	Mini-CDT	Andersen

Wednesday, 25 May 2022		Responsible Member
09:00-10:30	Demo Team: Ascience	Wasfy
11:00-12:30	Demo Team: dSPACE; Group Photo	Kluge; Serban
12:30-13:00	Lunch	
14:00-15:30	Demo Team: Naisence/CM Labs	Free
16:00-17:30	Demo Team: Innervycs	Hughes
18:30-21:30	Group Dinnner	Rosca

Thursday, 26 May 2022		Responsible Member
09:00-10:00	Demo Team: Aarhus University	Balling
10:00-10:30	Discussion	Jay
11:00-12:30	Scenarios: Autonomy	Ersal
12:30-13:00	Lunch	
14:00-15:30	Research Topics: Terrain Sensing, ALFUS+, STANREC/Final Report	Modungwa
16:00-17:30	Discussion	Jay

Friday, 27 May 2022		Responsible Member
09:00-10:30	Peer Review; Techncial Evaluator Feedback	Reinecke; Epureanu
11:00-12:30	Decisions: Core Teams Makeover, Demo Teams Consolidation, Member Participation	Co-Chairs
12:30-13:00	Lunch	