



AUGMENTED CCAM

ACCAM Prioritised PDI Support Classification Schema
ACCAM Infrastructure Readiness Tool
ACCAM Infrastructure Support Tools

Augmenting and Evaluating the Physical and
Digital Infrastructure for CCAM deployment

...there are still some Open Questions

- Which are the **priority PDI requirements and adaptations** for different **mixed traffic application contexts, transport modes and CCAM readiness**?
- Which are the **most cost-efficient technological paths** to exploit existing and emerging PDI to support near future CCAM **ensuring the safety and efficiency of the transport network** as a whole?
- Which are the **concerned adopters in each case and how can we reflect the varying governance and operational models** in a service operational framework to be beneficial for all actors on technological and economic grounds?
- **How can we put in place a “no-regret” process for decision making** before proceeding to investments?

About AUGMENTED CCAM

AIMS to understand, harmonise and evaluate in an augmented manner, adapted and novel support concepts of Physical, Digital and Communication (PDI) infrastructure, to advance its readiness for large scale deployment of CCAM solutions for all.

13 Key PDI enabled solutions to develop & validate aiming at:

- ✓ extending Connected Automated Vehicles (CAVs) Operational Design Domain (ODD)
- ✓ an advanced functionality for the connected vehicles and cooperation with non-connected vehicles/users
- ✓ TRL6-7 at the end of the project

UC1: Emergency Vehicle Approaching
 UC2: Equipped Vulnerable Road Users (VRUs) Protection
 UC3: Non-equipped VRU protection
 UC4: Traffic Management Optimisation based on Vehicle Probe Data from CCAM
 UC5: Localisation of Assets and CCAM vehicles
 UC6: Minimum Risk Manoeuvre (MRM)
 UC7: Optimised Logistic Operation of AVs
 UC8: Insertion
 UC9: Temporary Road Works
 UC10: Insertion
 UC11: Emergency Vehicle Approaching
 UC12: UAV-based Non-Equipped VRU Protection
 UC13: Road workers in the field

ACCAM PDI Support Classification Schema & Tools

- **AUGMENTED CCAM** (or ACCAM) - Augmenting and Evaluating the Physical and Digital Infrastructure for CCAM deployment
- **Innovation Action**
- **Duration:** 40 months
- **Start date:** 1st Sep 2022
- **27 beneficiaries** from **13 European countries**
- **Coordinator:** FEHRL
- **Technical & Innovation Manager:** CERTH/HIT

4 Key Blocks approach



Multi-layered evaluation in physical & virtual test beds

- **7 physical test sites in 3 European Cities** [France, Latvia, Spain]
- **Confined areas & urban, rural and highway open traffic contexts**
- **Interconnecting field trials, AV and driving simulators, Digital Twins, microscopic traffic simulation & macroscopic traffic modelling**
- **With 9 CAVs & 10 more CVs**
- **Running from 20km/h to 100km/h**
- **Under all weather conditions**



ACCAM PDI Support Classification Schema

Why?

- CCAM has the potential to improve **road safety**, **reduce congestion** and **enhance global network efficiency**.
- One of the main constraints that is preventing large implementation of CCAM services is the **lack of PDI readiness** to support the implementation of CCAM.
- However, all needed upgrades and investments cannot be addressed simultaneously because of high costs.
- **Road operators lack tools** that help them prioritise their actions according to their infrastructure and their own needs.
- This leads to **ineffective investments, fragmentation and delays in CCAM integration**.

For whom?



Road operators and
public authorities



Researchers and EU-
funded Innovation
Projects



Policy makers and
Regulatory Bodies



CCAM stakeholders

ACCAM PDI Support Classification Schema

How? - Workstream

1. **Exploration & Definition of Context:** What the Schema should look like – Studying past work done – What is missing - Key terminology.
2. **Creation of PDI Registry:** Reference basis for schema – Which are the elements that contribute to the extension of ODD, including all known and near-future services and ACCAM services.

Excerpt from PDI Registry – Elements highlighted in blue are new items proposed/developed within the ACCAM project

Element cluster	PDI element	PDI sub-element	PDI sub-sub-element	Type	Definition	Attributes	Sub-attribute
Traffic Control	Vertical Traffic Signs	Static traffic signs		Physical	Vertical traffic signs are signs placed along the roads that inform drivers of road conditions and restrictions or the possible direction of travel. They are source of information for a driver, which are designed to provide information at a glance. Based on ISO TS 14823, the types are: - Warning - Regulatory - Guidance - Public facilities - Ambient conditions - Road condition	Anomalies (A1) Visibility, machine readability (A2) Geometry (A6) Contextual information (A3)	Visibility obstacles (A2.1) Contrast (A2.2) Retroreflectivity (A2.3) Shape (A6.1)
		Temporary signs		Physical	The temporary signs and signals indicate temporary regulations or traffic management information. Based on ISO TS 14823, the types are: - Warning - Regulatory - Guidance - Public facilities - Ambient conditions - Road condition	(A1, A2, A3, A6) Operation duration (A4)	(A2.1, A2.3)
		Tunnel control signs		Physical	Physical traffic signs dedicated to control operation in tunnels	(A1, A2, A3, A4, A6)	(A2.1, A2.3)
		Dynamic signs		Physical	Dynamic traffic signs are electronic traffic signs that can display different messages depending on the situation. They can detect speed limits, no-overtaking signs, and other road signs and display this information to the driver. Based on ISO TS 14823, the types are: - Warning - Regulatory - Guidance - Public facilities - Ambient conditions - Road condition	(A1, A2, A3, A4)	(A2.1)
		Traffic signs signing dedicated lanes for automated vehicles		Physical	Traffic signs dedicated to AVs control of operation	(A1, A2, A3, A6)	
		Road works signage on pavement - work vehicles - channelling devices		Physical	Alternative ways to sign up road works (through vertical and horizontal traffic signs, cones/channelling devices, road works vehicles)		

7 fields for 10 clusters of elements [64 PDI elements & 154 sub-elements]

- **Fields:** (1) PDI element, (2) PDI sub-elements, (3) PDI sub-sub-element, (4) Type (Physical, physical context – as perceived by driver/road user, Digital – Service/Digital Info output, Digital enabler, Communication enabler), (5) Definition, (6) Attributes and (7) Sub-attributes.
- **Clusters:** (1) Traffic Control/Management, (2) Road infrastructure, (3) Weather conditions, (4) Illumination conditions, (5) Road pavement/Surface conditions, (6) Traffic conditions, (7) Surrounding traffic, (8) Digital services, (9) Communication enablers and (10) Digital enablers.

3. **Mapping of PDI Registry elements to find the relationships between physical elements and their digital counterparts**, as an intermediate step between the PDI Registry and the PDI Classification Schema.

ACCAM PDI Support Classification Schema

How? - Workstream

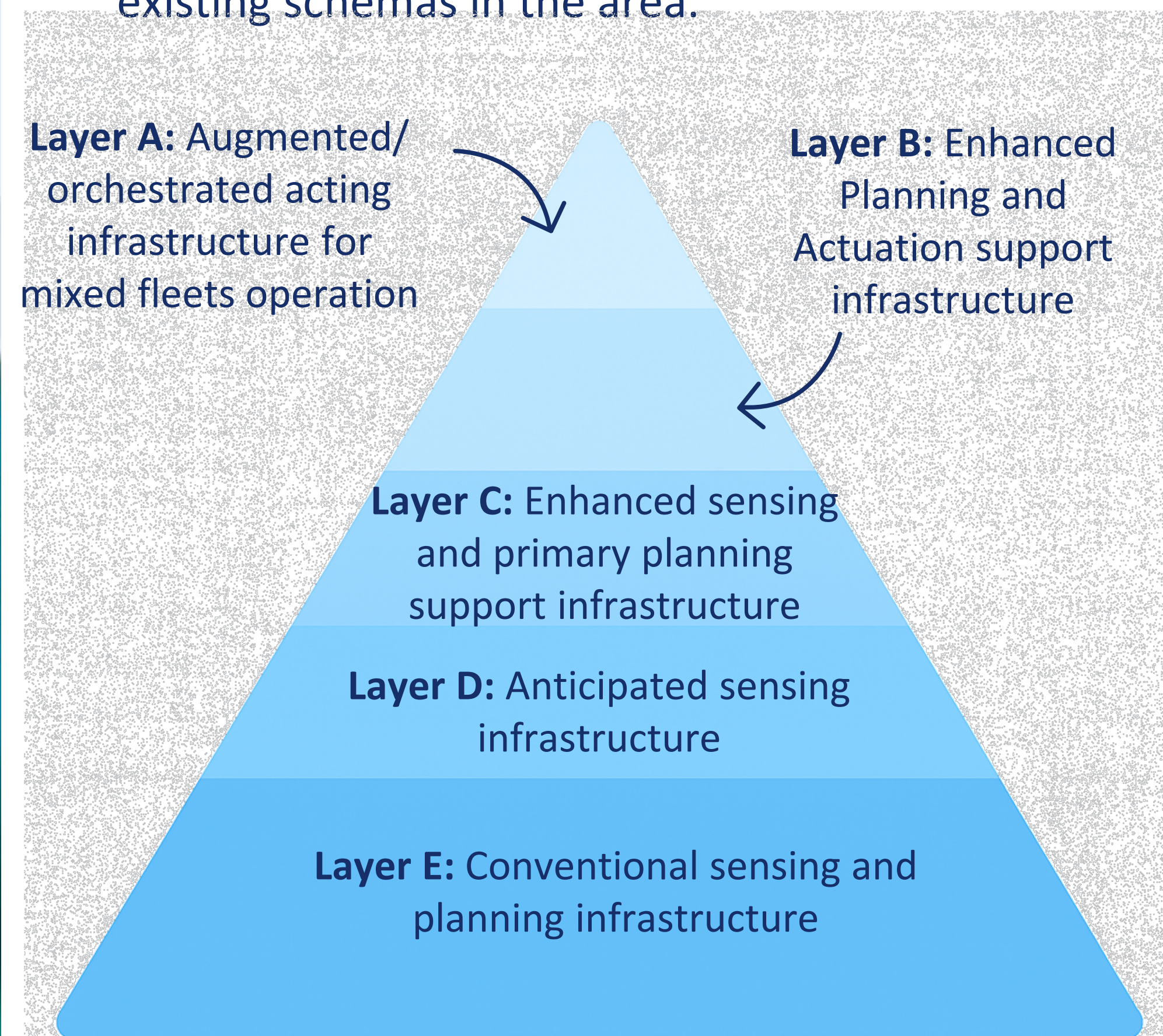
4. **Schema construction** - Final result is the consolidated ACCAM PDI Support Classification Shema, featuring the use and impact of **81 PDI support elements (of varying complexity; from lower end components to higher end services)**.

Layer E: Conventional sensing and planning infrastructure							
PI		DCI			Summary of PDI support/impact for each vehicle cluster functionality/ODD	Requirements for assuming infrastructure support	Key restrictions
Element [Registry]	Addressed vehicle cohorts & requirements	Element – DCI output/services [Registry]	Digital & communication enablers	Addressed vehicle cohorts & requirements			
Lane width [Road infrastructure]	☒ Conventional: Sufficient and standards-abiding lane width is a crucial factor for traffic safety. ☒ Connected & Cooperative: As above. ☒ L1-L3 automated: As above. In addition, specifically for AVs, inappropriate lane width can lead to disengagements. ☒ L4-L5 automated: As above.				Lane width adherence to standards, regulations and specific thresholds specifically for the operation of automated functions is crucial for safe driving in mixed Traffic conditions. Change on lane width could pose safety-related challenges even in	• Lane width should adhere to standards and regulations for hte smooth operation of all vehicles. Specifically, for AVs and assistance functions (i.e. LKA, LDW), and to minimize number of disengagements, the lane width should be higher than 2,72m – defined as the “critical lane width” as the same probability of automatic and human lateral control	

ACCAM PDI Support Classification Schema

Key principles of built-up

1. 5 escalating layers of PDI readiness, to be aligning and be comparable with existing schemas in the area.



ACCAM PDI Support Classification Schema & Tools

2. Address all key vehicle cohorts, classifying them in 4 clusters:



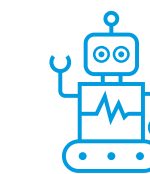
Conventional



SAE L1 – L3
Automated



Cooperative and
connected (non-
automated)



SAE L4 – L5
Automated

3. Explicitly identifying which are the **Physical Infrastructure (PI) elements** and which are the **Digital and Communication Infrastructure (DCI) elements** and how they impact each vehicle cohort and why.
4. Making it vehicle explicit by following overall the “**Sense – Plan – Act**” principle of CAVs and defining if and which are the specific requirements from their side to assume this support.



ACCAM PDI Support Classification Schema



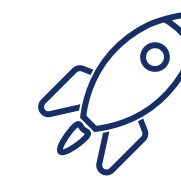
Liaison to past work

- ✓ Consideration of **relevant previous works** were (SAE, ISAD, PIARC, CCAM Platform WG 3, CRCS...)
- ✓ Alignment with **Layering of other relevant schemas**.
- ✓ Liaison to CCAM Partnership matrix in relation to the mapping of the **Physical and Digital infra** equivalents.



Value added

- ✓ Consolidation and leverage of **all ends of infrastructure, both Physical and Digital**.
- ✓ It is **vehicle-centric**, it specifies how PDI can support the “**Sense – Plan – Act**” axes.
- ✓ **Fulfils gaps** of other schemas, integrating the definition of the specific layering of **HD maps and Digital Twins**.



What is new?

- ✓ ACCAM has positioned its **final Layer** to aim at an **orchestrated transport operation of mixed traffic** encompassing all types of users.
- ✓ The ACCAM schema goes into detail for the **expected support of each PDI element and on each vehicle cohort**, identifying requirements and restrictions from both ends.
- ✓ ACCAM proceeded with the **prioritization of the PDI elements**.

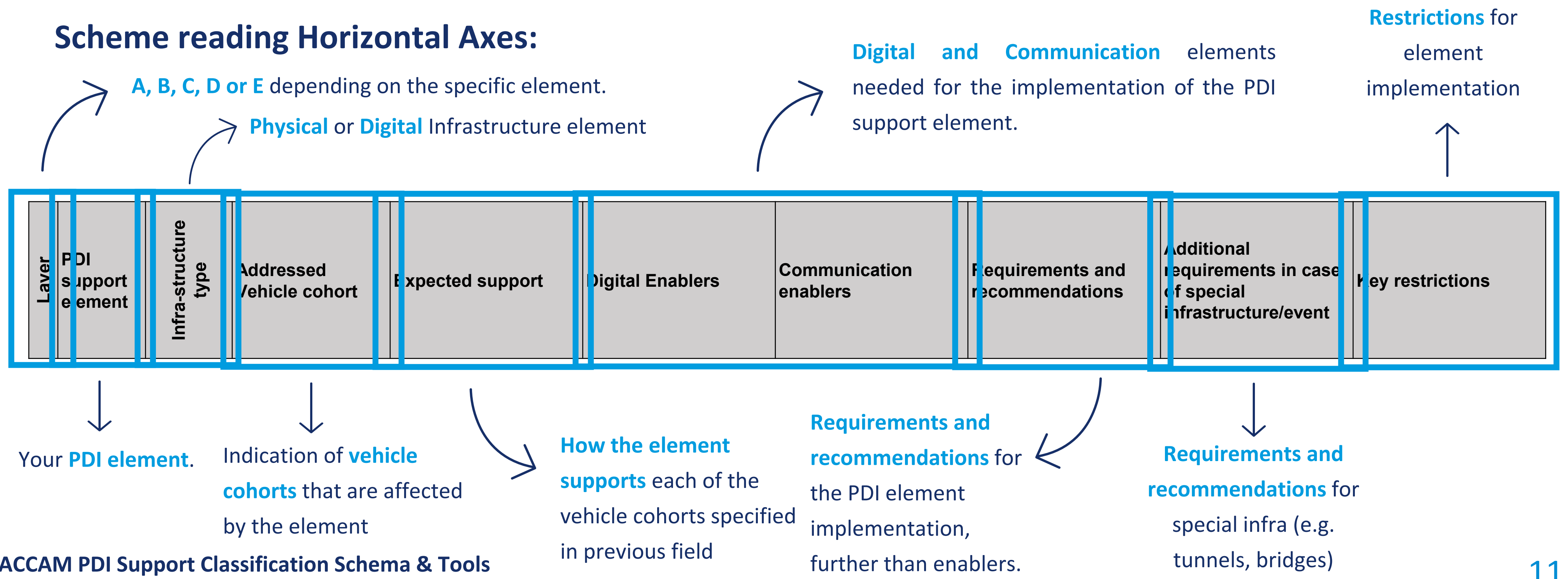
ACCAM PDI Support Classification Schema

How to read the ACCAM Schema

General structure:

- The schema includes **81 PDI support elements**, organized in the defined **escalating layers of infrastructure readiness for CCAM**.
- New elements/services targeted by AUGMENTED CCAM are highlighted in **green**.

Scheme reading Horizontal Axes:

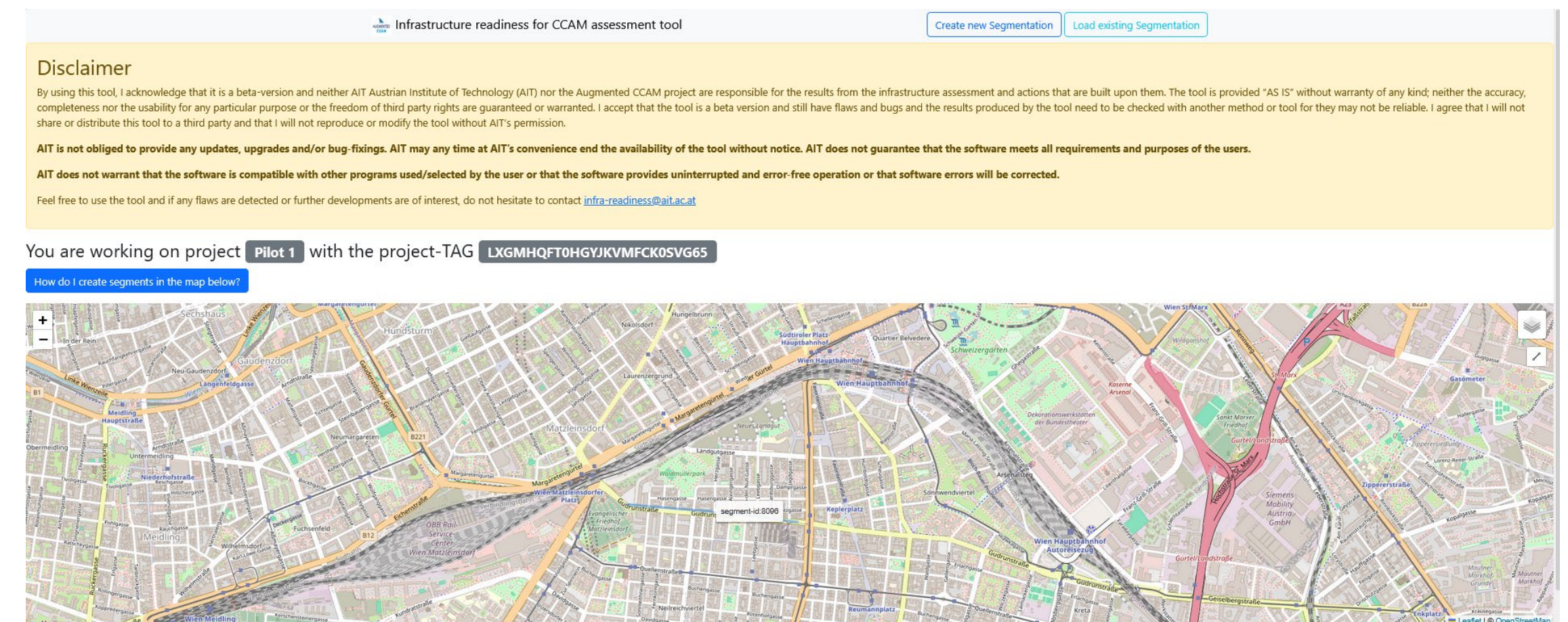


The Infrastructure readiness for CCAM assessment tool



<https://infra.ait.ac.at/infra-readiness-for-CCAM-tool>

- To be able to apply the ACCAM classification schema on roads
- Assessing the CCAM readiness of selected roads or road sections, at any instance and for various similar purposes. For example,
 - the current status of the infrastructure: prior to any adaptations, to also assist decision making,
 - after adaptations to cross-check the extent to which the CCAM readiness of the infrastructure has advanced.



Screenshot of the Infrastructure readiness for CCAM assessment tool

ACCAM Infrastructure Support Tools



<https://augmented-ccam.pragma-iot.com>

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Infrastructure Support Tools for CCAM

Prioritised Infrastructure Support Tool & ACCAM PDI Support Schema Enhancement

AUGMENTED CCAM offers digital tools to the CCAM community and, especially, to road operators, potential road infrastructure investors and mobility researchers, so as to get the most out of the classification schema and to contribute to its continuous update and improvement.

Plan your infrastructure for CCAM

Use our decision-making tool to prioritize your actions for improving and updating the infrastructure in order to support automated driving.

> USE THE TOOL

↓ DOWNLOAD THE MANUAL

Improve the ACCAM PDI Support Schema

Help us to improve the PDI classification schema by proposing changes to existing PDI elements or add new ones.

> USE THE TOOL

↓ DOWNLOAD THE MANUAL



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**AUGMENTED
CCAM**

- **Diverse Input Categories:** From vehicle cohorts to cost rates and special infrastructure recommendations, our tool is designed with precision to cater to all your planning needs.
- **In-depth Rating Systems:** Detailed scales for priority, safety, readiness for automation, and cost ensure you get an all-encompassing understanding.
- **Context-Specific Insights:** Whether you're interested in highways, rural, or urban areas, our tool provides nuanced insights to guide your infrastructure planning.
- **Comprehensive PDI Elements Overview:** A meticulous display of PDI elements – both physical and digital/communication, organised across incremental support layers for CCAM, ensures you have all the information at your fingertips.
- **User-Centric Design:** Filter results, view detailed insights, and explore the PDI registry and scheme, all from one central hub.

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ACCAM PDI Support Classification Schema & Tools

- **Examine & Identify:** Dive into the existing PDI support classification schema and spot opportunities for enhancement.
- **Edit or Add:** Modify existing PDI elements, comment on their classification or introduce new ones using our intuitive interface.
- **Collaborative Review:** Once you've made your suggestions, our dedicated AUGMENTED CCAM Committee springs into action, evaluating and refining your proposals.
- **Stay Updated:** As the schema evolves, stay in the loop with timely notifications on the status of your proposals.

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THANK YOU!



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