Discussion within the European ITS Committee on

Cross-border testing

Version history

V0	10-10-2017	First draft as preparation for the 15th meeting of the ITS committee
V1	13-11-2017	Detailed draft distributed prior to the 16th meeting of the ITS Committee
V2	24-11-2017	Update / simplification of the methodology based on outcome of the 16th ITS Committee meeting on 16-11-2017
V3	01-02-2018	Preliminary conclusions and results of analysis of all three matrices
V4	09-02-2018	Included comments from 19th ITS Committee meeting on 08-02-2018
V5	20-02-2018	Included written comments post the 19th ITS Committee meeting
V6	31/05/2018	Included initial conclusions from workshops, organised alongside the ITS Committee, to consult with industry and other stakeholders

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Overall context

During the second High Level Member State Dialogue that took place on 14 and 15 September 2017 in Frankfurt (M), Member States called upon the European Commission to establish in close cooperation with Member States and industry a Task Force for the development of a European methodological approach for cooperation on cross-border testing of Connected and Automated Driving, addressing a number of specific issues[1]:

Elaboration of the issues mentioned in the Action Plan

During the 15th meeting of the ITS Committee a first discussion took place on a possible methodology to tackling the issue of cross-border testing in the field of Cooperative, Connected and Automated Mobility. A first summary draft was presented and discussed.

The summary below is a slightly modified version, in line with the outcome of the discussions during the 15th meeting.

<table>
<tr><th>A - WHAT WE WANT TO TEST</th><th>B – COOPERATION ELEMENTS</th></tr>
<tr><td>1. Which use cases:
• MS and COM plans / policy priorities for transport and future mobility
• Ongoing or planned H2020 projects
• Input from GEAR2030 & C-ITS platform (e.g. WG Urban, WG Enhanced TM)
• Industry / private sector input (e.g. ERTRAC)
2. Need to breakdown use cases in functionalities (e.g. stop safe in case of malfunction)?
3. Prioritise use cases / functionalities
• Short vs long-term feasibility
• Expected benefits and impacts (road safety, efficiency, social inclusion, driving time/rest periods, design of road infrastructure etc.)
4. Identify different testing levels per use case (e.g. prototype testing, small test fleet, close to market pre-deployment)
5. Identify prerequisites and enablers for testing:
• Legal framework (e.g. higher levels of automation, liability, data</td><td>To make progress we need to ensure various (cross-border) testing activities re-inforce each other, results can be compared and end-results can be transferred to other regions, other driving environments and across borders, offering seamless CCAM operations and user experiences. This involves two different sets of activities:
1. Implementing a framework for the exchange of knowledge, experience and data including a coordinated evaluation structure. This includes a common set of KPI's to be used for the impact assessment of (cross-border) tests in order to facilitate the comparison of results and extrapolation of results to other not-yet tested sites.
2. Mapping of all elements required for interoperability, in the short-term for enabling cross-border testing and in the long-term for avoiding fragmentation and stimulating large-scale deployment of CCAM.</td></tr>
</table>

[1] http://www.bmvi.de/SharedDocs/EN/Documents/DG/action-plan-automated-and-connected-driving.pdf?__blob=publicationFile

A - WHAT WE WANT TO TEST	B – COOPERATION ELEMENTS
management) • Availability of infrastructure support (incl. connectivity requirements) • Suitable test sites (e.g. support CCAM with cross-border Traffic Management Plans, cross-border testbeds such as the Luxembourg – Franco – German concept) • Allocation of responsibilities of industry, Member States, European Commission and other stakeholders	

C – CROSS-BORDER COOPERATION ON TESTING
• Identify all areas requiring increased cross-border cooperation, these include: i. Elements coming from the technical and non-technical enablers for priority use cases ii. KPIs as part of a framework for the exchange of knowledge (e.g. assess performance improvement of road safety, traffic efficiency, the public transport system, freight operations, etc.) iii. Elements needed for ensuring (technical) interoperability • Propose recommendations on how to further develop this cooperation

D - AMBITION LEVEL / SHARED OBJECTIVES
Establish a European roadmap with short and long-term targets for testing and deployment of CCAM and its integration in both existing traffic and new mobility systems.

In the following chapters we will detail the various elements of the methodology further and start preparing for the collection of the data that will drive the discussion forward.

This document focuses primarily on part A at this stage however some additional details have already been provided for the other parts as well.

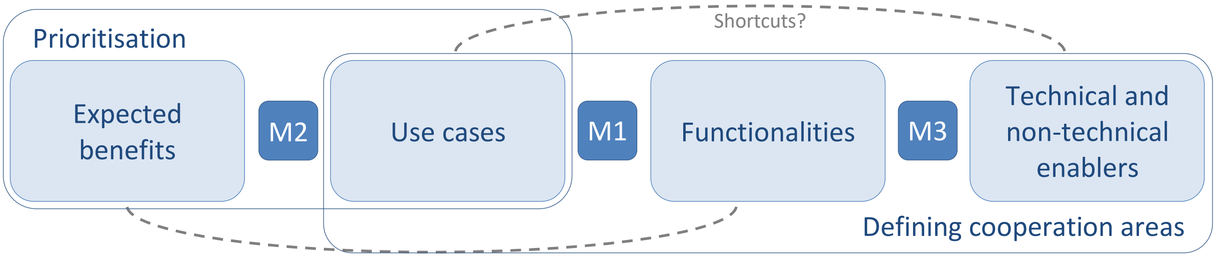
A. WHAT DO WE WANT TO TEST?

This section identified five steps to find the necessary links between the expected benefits and drivers of the (transport) policy, the targeted use cases, the required functionalities and the enablers of CCAM. This is illustrated below and should be understood as follows:

- Increased cross-border cooperation on testing is assumed to primarily take place at the level of the technical and non-technical enablers (i.e. the cooperation areas)

- Prioritisation of these enablers will be done based on the expected (societal) benefits of CCAM and the main policy drivers (transport, digital, industrial, environmental, etc.)

- To link the enablers with the benefits however we need two intermediate steps (the use cases and the functionalities) and thus three matrices (M1, M2 and M3)



- Some shortcuts might exist, for example some functionalities might be implemented as stand-alone features and be associated with benefits in their own right. Alternatively, some use cases might ask for specific enablers without the need for intermediate functionalities. We will need to decide how to handle these shortcuts as they arise, however they are not expected to complicate the end goal, which is the determination and prioritisation of enablers for CCAM.

This process should result in:

- An agreed, common list of (preferred) use-cases and the associated functionalities to test in order to enable deployment across borders, brands, transport modes and road networks.
- Identifying all technical and non-technical enablers of testing that require increased cross-border cooperation.

In the following subchapters we will further detail the five steps described under "A" above, including a first draft of elements that are expected to play a role in each step. In each subchapter a list of questions (or actions) has been added detailing the type of feedback that is requested, as well as an analysis of the different elements and relationships / matrices.

Note: It is expected that some of the already proposed elements will shift from one table or matrix to the other. Depending on point of view or context, some of these elements could be seen either as a detailed use case or as functionality; similarly, a functionality could also be listed as an enabler. This does not facilitate the exercise – obvious items may appear to be missing when they are in fact "hiding" in a different matrix – but this is to be expected in a field which is at the same time evolving rapidly and, for the time being, raising more questions than answers.

A1: Which use cases?

This question is needed to understand what it is we are talking about exactly when addressing CCAM use cases. Some further discussion might be needed on clarifying what is meant by a "use case". In the tables below they essentially refer to different geographical settings and automation levels but one could for example also take the different business models into account.

Firstly, all use cases are grouped in the following **3 categories**:

1. Private transport
2. Collective transport
3. Freight & Truck

Note: the "network" category has been removed and the use cases listed thereunder have been moved to functionalities and / or enablers. If other examples of use cases that don't fit the remaining three categories are proposed, this category can of course be revived, possible using a better name.

Next, the following **use cases** have been identified (for the full up-to-date list see Excel file in annex):

Cat	Use case	SAE	Detailed use case
Private Transport	Parking	4	Parking Garage Pilot
			Automated Valet Parking
	Urban	3	Traffic Jam Chauffeur
		4	Urban Pilot
	Sub-urban	4	Suburban Pilot
	Highway	3	Highway Chauffeur
		4	Highway Autopilot including Highway Convoy
	Everywhere	5	Autonomous private vehicles on public roads
	Other?	*?*	*?*

Cat	Use case	SAE	Detailed use case
Collective Transport	Dedicated (private) Roads	4	Personal Rapid Transit / automated shuttles
	Public Roads	2	Urban bus assist
		3	Automated bus chauffeur
		4	Personal Rapid Transit / automated shuttles
		4	Automated buses in mixed traffic
		5	Fully automated urban vehicle
	Shared mobility solutions	?	Ride / vehicle sharing for persons
	Last mile service freight	?	?
	Other?	*?*	*Examples: individual PODs, VRU vehicles*

Cat	Use case	SAE	Detailed use case
Freight & Truck	Platooning (multi brand)	2	Automated truck platooning
		4	Highway pilot platooning
	Highly automated freight vehicles	4	Other than platooning, e.g. logistics operations
	High-way applications	3	Traffic Jam Chauffeur
		3	Highway Jam Chauffeur
		4	Highly Automated Trucks
	Everywhere	5	Fully automated freight vehicles
	Other?	*?*	*?*

Support questions for the Excel file in annex:

- Do you agree with the grouping into three categories (if not provide an alternative)?
- Do you have any comment regarding the already defined (detailed) use cases?
- Would you like to propose other (detailed) use cases?

Analysis Use Cases

The grouping into three categories appears to be accepted by all, and the proposed use cases themselves were widely accepted too. However, when no clear detailed use case was provided no benefits were linked either, these use cases were thus removed from further analysis.

To avoid confusion it would still be useful to further clarify the different use cases at a later stage, making sure they are well understood and the differences between them are unambiguous. The use case "ride / vehicle sharing for persons" in particular was not clearly defined, and thus received significantly less feedback in the matrix. The introduction of shuttles into an urban environment could indeed happen on public, dedicated or semi-dedicated lanes / roads but the distinction between these was not truly clear to all in the context of this exercise. This however did not introduce a major problem into the analysis as the difference would largely be focussing on the level of infrastructure support and thus ease of implementation, whilst the benefits are largely considered equal.

Other remarks focussed on the fact the use case focussed on larger vehicles (4 passengers and higher) where we could also consider smaller / individual vehicles targeting Vulnerable Road Users (e.g. PODs or even motorcycles).

A2: Which Functionalities?

All use cases face several and often common issues and problems or require certain functionalities in order to function. Furthermore, these functionalities are far more specific than the use cases and can therefore more easily be linked to technical solutions and / or non-technical enablers (this is the second intermediate step described above). As stated before some of these functionalities could be implemented as stand-alone services, in other words some discussion is expected on whether some of these elements are functionalities, detailed use cases or even use cases. Already identified functionalities include (non-exhaustive, for the full list see Excel file in annex):

- Respecting static / dynamic traffic rules and traffic lights (e.g. entering one-way street)
- Identifying suitability of automation mode and / or automation level
- Accurate / reliable positioning (e.g. adverse weather)
- Handling complex or missing lane markings (e.g. Toll plaza traffic)
- (severe) Incident detection (e.g. end of traffic jam)
- Passing construction sites
- Stop safe in case of malfunction
- Lane changing / merging
- Entering / exiting highways
- Handling complex intersections
- Avoiding collision risk

Support questions for the Excel file in annex:

- Do you have comments regarding the already defined functionalities?
- Would you like to propose other functionalities?
- Please map the functionalities to the use cases ⇒ **First Matrix** (M1 - see attached Excel file)

Analysis Functionalities vs Use Cases

Respecting traffic rules is an obvious and essential functionality for all automated vehicles; however additional thinking is required in splitting up this task into distinct problems and technical challenges. As such some proposed to simplify the functionalities where others proposed to add some, e.g. distinguish between dynamic and traffic rules, are traffic lights a separate functionality, do we add a functionality on respecting (police) enforcement commands, etc.

Support for persons with reduced mobility was proposed as an additional functionality. The possibilities offered by driverless vehicles for persons with reduced mobility are indeed already recognised in the benefit social inclusion. This follows directly from the removal of the driver and could thus be considered a benefit of all driverless vehicles. Additionally, one could consider the modification of vehicles specifically addressing access to the vehicle. The latter however would not necessarily be an "automation" functionality. Concluding, at this stage of the analysis the extra functionality was not added but bringing added mobility to all (including persons with reduced mobility) is a clear benefit of CCAM and this can be taken into account when designing future test campaigns.

Functionality	COUNT
Avoiding collision risk	9,0
Accurate / reliable positioning (e.g. adverse weather)	9,0
Stop safe in case of malfunction	8,7
Respecting static traffic rules (e.g. entering one-way street)	8,4
Incident detection (e.g. end of traffic jam)	8,3
Handling complex or missing lane markings (e.g. Toll plaza traffic)	8,2
Passing construction sites	8,2
Lane changing / merging	8,0
Advanced traffic management	7,8
Respecting dynamic traffic rules (e.g. variable speed limits)	7,8
Identifying suitability of automation mode and / or automation level	7,6
Respecting traffic lights	7,4
Handling complex intersections	7,0
Interacting with Vulnerable Road Users	6,6
Entering / exiting highways	5,7
Intermodal integration	4,4

When comparing use case vs functionalities (see above – the table shows how many times each functionality was linked to a use case, sorted descending based on the average value of all expert replies) we find a many-to-many relationship, in other words most functionalities are applicable to most use cases. This should not be a big surprise, the top two functionalities "avoiding collision" and "accurate positioning", are clearly common to all automation use cases, even when they might receive different practical solutions depending on where they are deployed.

Exceptions are "Entering / exiting highways" and "intermodal integration", which got less answers as they are more closely linked to specific use cases.

Cat	SAE	Detailed use case	AVG
Private	5	Autonomous private vehicles on public roads	10,31
Private	4	Urban Pilot	9,94
Private	4	Highway Autopilot	9,75
Private	4	Suburban Pilot	9,56
Freight	5	Fully automated freight vehicles	9,56
Freight	4	Highly Automated Trucks	9,44
Private	4	Highway Convoy	8,88
Private	3	Highway Chauffeur	8,50
Freight	4	Highway pilot platooning	8,25
Private	3	Traffic Jam Chauffeur	8,13
Freight	4	Other than platooning, e.g. logistics operations	7,94
Public	5	Fully automated urban vehicle	7,63
Public	4	Automated buses in mixed traffic	7,50
Freight	3	Traffic Jam Chauffeur	7,38
Freight	3	Highway Jam Chauffeur	7,31
Public	4	Automated shuttles (public roads)	7,19
Freight	2	Automated truck platooning	6,69
Public	3	Automated bus chauffeur	6,44
Public	4	Automated shuttles (dedicated roads)	6,06
Public	2	Urban bus assist	5,94
Private		Automated Valet Parking	4,44
Public	?	Ride / vehicle sharing for persons	4,44
Private	4	Parking Garage Pilot	4,25

We see the same relationship when looking at the table above (showing for each use case how many functionalities were linked to them – again averaged over all expert replies and sorted descending). We can derive some additional preliminary conclusions from this table:

- Higher SAE levels (predictably) require more functionalities
- Parking and ride sharing use cases require considerably less functionalities
- Reduced need for functionalities of collective use cases is likely due to missing input data

A3: Prioritise use cases / functionalities

For any meaningful prioritisation we need to evaluate the potential impact, (societal) benefits and timeliness of the proposed CCAM use cases (and / or functionalities, see comment on shortcuts earlier). The H2020 coordination and support action CARTRE[2] used the following three categories to evaluate the activity level or purpose of the work in ongoing and planned research and innovation projects:

1. Technical
2. Non-technical
3. Expected benefits

Using this classification as a basis brings the added advantage of being able to easily compare the conclusions from the ITS committee on cross-border testing with already ongoing or planned research and innovation activities. In this step we will concentrate on the category "expected benefits", the other two will become relevant in a later step.

Prioritisation can then be done based on how many of the expected benefits or positive impacts are addressed by a specific use case, and possibly to what extent they are addressed.

Support questions for the Excel file in annex:

- Do you have comments regarding the already defined expected benefits (e.g. should some be rephrased, split or more detailed)?
- Would you like to propose other / new expected benefits?
- Please map the expected benefits to the use cases (and / or functionalities) ⇒ **Second Matrix** (M2 - see attached Excel file)

Analysis Use Cases vs Benefits

It was noted that not all benefits were as easily understood, for example "social inclusion" has at least two components, accessibility and affordability, and "Labour market effects" should not be mixed with "working conditions". It was also proposed to simplify the exercise and try to limit ourselves to (or smaller list of) primary benefits of CCAM. At the same time it was agreed by all that it is not possible to compare benefits directly, e.g. how do you choose between or attach (different) importance to road safety and social inclusion? Other possible overlaps were found in "public health", which could be seen as to share elements with both "road safety" and "emissions".

Nevertheless, despite these limitations analysis shows that there was largely sufficient feedback to come up with consistent conclusions and "average out" the un-clarities.

When looking at the different benefits in isolation (meaning not yet showing the link with the use cases, see table below), and sorted descending on their average score we see:

- "Safety" is the considered to be the key benefit ⇒ it received most answers, the highest score and the lowest deviation
- "Comfort", "congestion", "emissions", "personal mobility" and "public health" follow closely with slightly lower scores
- "Vehicle OPEX", "jobs", "social inclusion", "land use", "road OPEX" and "modal shift" all received lower scores and higher deviation

[2] CARTRE is a Coordination and Support Action (financed under H2020) to accelerate development and deployment of automated road transport by increasing market and policy certainties. Starting date: 01/10/2016, Duration: 24 Months, Total funding: 3 M€, 36 direct partners from 9 EU MS, Coordinator ERTICO – ITS Europe, see https://connectedautomateddriving.eu/about-us/cartre/

- "Public health" received least answers ⇒ as mentioned above, this is likely because this benefit was not clearly enough defined
- "Vehicle OPEX" is only relevant for highly automated freight / collective use cases
- "Jobs appears" related to “jams”
- "Social inclusion" and "land use" are only relevant for shuttles and SAE Level 5 use cases
- "Road OPEX" positively linked to freight services (only)
- "Modal shift" positive for collective, neutral for private and negative for freight use cases

Benefit	COUNT	AVG	DEV
Safety	9,5	1,2	0,5
Comfort Journey quality	8,2	0,9	0,6
Network Efficiency / Congestion	7,0	0,9	0,6
Energy / Emissions	8,0	0,9	0,8
Personal Mobility	6,9	0,7	0,7
Public health	4,5	0,6	0,7
Vehicle operation costs	7,9	0,4	1,1
Labour market effects	7,7	0,4	1,0
Social inclusion	5,7	0,4	0,7
Urban planning / land use	6,3	0,3	0,8
Road operation costs	6,4	0,2	1,1
Travel behaviour (modal shift)	8,0	0,1	1,0

Next, we look at the full matrix (use case vs benefits, sorted descending by the average score of all benefits – see table below).

Cat	SAE	Detailed use case	AVG	Energy / Emission	Personal Mobility	Public health	Safety	Travel behavio	Comfort Journey	Network Efficienc	Urban planning	Labour market	Social inclusion	Vehicle operatio	Road operatio
Public	5	Fully automated urban vehicle	0,87	0,75	1,50	-0,17	1,50	0,67	1,22	1,00	1,13	-0,11	1,33	1,00	0,57
Public	4	Automated shuttles (dedicated roads)	0,84	1,00	1,40	0,40	1,30	1,10	1,00	0,75	0,43	0,25	1,25	1,00	0,25
Public	4	Automated buses in mixed traffic	0,82	0,78	1,00	0,80	1,45	1,00	1,00	0,88	0,71	0,43	0,75	0,90	0,14
Public	4	Automated shuttles (public roads)	0,82	1,00	1,30	0,60	1,40	0,90	1,10	0,88	1,00	0,00	0,75	0,75	0,14
Private	4	Suburban Pilot	0,76	0,67	1,30	0,60	1,64	0,20	1,20	1,14	0,75	0,71	0,63	0,13	0,14
Public	?	Ride / vehicle sharing for persons	0,74	0,88	1,44	0,20	0,57	1,00	0,63	1,57	1,13	0,38	1,11	-0,14	0,17
Private	4	Urban Pilot	0,74	0,56	1,30	0,60	1,73	0,20	1,30	1,11	0,63	0,71	0,50	0,13	0,14
Private	5	Autonomous private vehicles on public roads	0,71	0,67	1,50	0,17	1,36	-0,10	1,20	1,22	0,25	0,11	0,89	0,56	0,75
Freight	4	Highly Automated Trucks	0,69	1,44		1,00	1,55	-0,50	0,86	1,25	0,00	0,10		0,67	0,57
Freight	5	Fully automated freight vehicles	0,66	1,33		0,80	1,60	-0,50	0,67	0,86	0,57	0,11		0,56	0,63
Freight	4	Other than platooning, e.g. logistics operations	0,65	1,11		0,60	1,30	0,00		0,86	0,86	0,22		0,44	0,50
Public	3	Automated bus chauffeur	0,65	0,89	0,63	0,83	1,09	0,57	0,89	1,00	0,20	0,38	0,67	0,60	0,00
Private	4	Highway Autopilot	0,64	1,00	1,00	0,60	1,42	0,00	1,50	1,33	-0,14	0,29	0,33	0,22	0,14
Freight	4	Highway pilot platooning	0,62	1,33		0,80	1,20	-0,25	0,86	1,14	-0,33	0,33		0,56	0,57
Public	2	Urban bus assist	0,62	0,43	0,63	0,80	1,09	0,63	0,89	0,86	0,20	0,67	0,50	0,56	0,20
Private	4	Highway Convoy	0,60	1,30	1,00	0,80	0,91	0,00	1,20	1,50	-0,43	0,25	0,33	0,33	0,00
Private	3	Highway Chauffeur	0,59	0,80	0,78	0,80	1,27	0,00	1,09	1,11	0,14	0,38	0,33	0,22	0,14
Private	3	Traffic Jam Chauffeur	0,59	0,63	0,86	0,80	1,18	-0,25	1,09	1,22	0,33	0,75	0,17	0,13	0,17
Freight	3	Traffic Jam Chauffeur	0,57	1,00		0,80	1,20	-0,50	0,63	0,88	-0,20	0,75		0,56	0,57
Freight	3	Highway Jam Chauffeur	0,55	1,00		0,80	1,30	-0,50	0,63	0,88	-0,20	0,75		0,44	0,43
Freight	2	Automated truck platooning	0,52	1,25		0,80	1,00	-0,83	0,57	1,00	-0,33	0,78		0,50	0,43
Private		Automated Valet Parking	0,15	0,25	0,50	0,20	0,38	0,00	1,10	-0,50	0,14	0,63	-0,20	-0,50	-0,17
Private	4	Parking Garage Pilot	0,06	0,14	0,57	0,20	0,63	-0,13	1,00	-0,50	0,43	0,00	-0,20	-0,67	-0,80

Here we note that:

- Benefits increase with the SAE level, in other words higher levels of automation generate higher benefits (additionally, they also avoid some of the issues related to SAE level 3, particularly on the transition of control back from vehicle to human).

- Some functionalities were not relevant for some use case, created erroneous results and were thus remove from the analysis (see all white cases in the table above)
- The two parking use case received significantly lower scores and were only seen as beneficial for comfort
- Freight services scored lower on comfort, this could mean some kind of distinction is made between the comfort business case for private and professional drivers but as noted earlier this could also be linked to an overlap with "working conditions".
- Social inclusion is a benefit that is clearly linked to the highest SAE level only.
- Road operational cost was only (positively) linked to freight services.
- "Ride / vehicle sharing" was not clearly defined and as a separate use case and this created some confusion. It should rather be seen as part of flanking measures to make best possible use of future automated vehicles (e.g. by making sure they become part of collective use cases).

A4: Testing levels

With testing levels we mean for example prototype testing, small test fleet or close to market pre-deployment.

As the use-cases have already been largely split into different SAE levels this automatically creates a chronological order and closeness to market, generalising we could say:

- Level 3: more or less 2020
- Level 4: before 2030
- Level 5: between 2030 and arguably never, but we can approximate a L5 vehicle as a L4 vehicle that can drive in "most" or "all relevant" environments, rather than "all environments where a human could drive" and use 2050 as an upper limit (target for Vision Zero, i.e. NO road fatalities on European roads)

Agreement in the 17th ITS Committee to address testing levels at a later stage of the exercise, when addressing the ambition level for cross-border testing, if needed.

A5: Identify enabling conditions

The enabling conditions are the level at which increased cross-border cooperation is required. As such defining them is of vital importance in this exercise. Afterwards they will be linked to use cases and policy priorities and we can start formulating recommendations on how to achieve our goals on cross-border testing.

We can again use categories identified by CARTRE as a starting point (see point A3), namely all elements under the categories technical and non-technical (detailed descriptions are available in a background document provided by CARTRE, these should not be seen as limiting or not open for discussion as these definitions were established with a slightly different goal in mind, nevertheless this work forms an excellent starting point).

Support questions for the Excel file in annex:

- Do you have comments regarding the already defined technical and non-technical issues (e.g. should some be rephrased, split or more detailed)?
- Would you like to propose other / new technical and non-technical issues?
- Please map the technical and non-technical issues to the functionalities (and / or use cases) ⇒ **Third Matrix** (M3 - see attached Excel file)

Analysis Enablers vs Functionalities

High accuracy GNSS positioning was proposed as a technical enabler. This can discussed further if we can clarify the overlap with accurate and reliable positioning, which was already defined as a functionality and which would include GNSS positioning.

We start by looking at technical enablers in isolation (counting how many times each one was linked to a functionality and sorted descending) and find another many-to-many relation, in other words most technical enablers are supporting most functionalities.

The only notable exception is Electric Vehicles, where the relation is likely one-way, meaning Electric Vehicles would benefit from CCAM (e.g. by increasing efficiency and thus range) but CCAM would not necessarily benefit from EVs. Note that this lack of clear relation does not contradict that CCAM and EVs (or more accurately Alternative Fuels) can both be (independent) pillars from the Low Emission Mobility strategy.

Technical Enabler	COUNT
Maps & electronic horizon	8,6
Sensors Development	7,4
Short-range connectivity (V2V, V2I)	6,9
HMI	6,8
Cloud Connectivity	6,5
Road infrastructure	6,5
Decision and control incl. AI techniques	6,5
Functional safety	6,4
Big Data Collection	6,1
Integration into wider IoT ecosystem	5,1
Electric vehicles	1,4

All other enablers have a role to play and could be summarized into three categories:

- Position and navigate first ⇒ automated vehicles will need (HD) maps, sensors and V2V & V2I to (accurately) position themselves on the road, be aware of their environment and safely drive on the road network
- Infrastructure, functioning second ⇒ (external) support from infrastructure, whether from the road or cloud, coupled with AI, functional safety and good HMI (for drivers but also for other road users outside of the automated vehicle) form the second layer of technical enablers.
- (Other) data later ⇒ Big Data and Internet of Things are also important technical enablers but follow in third place (these data related enablers are labelled other – or wider – as the undisputed key enabler – Maps – can arguably be labelled data as well. The same can be said

about road infrastructure support, which can contain both physical as digital (i.e. data) elements).

Next we do the same exercise for non-technical enablers (counting again how many times each one was linked to a functionality and sorted descending) and find yet another many-to-many relation, in other words most non-technical enablers are supporting most functionalities. Cyber security is seen as the key enabler, though closely followed by standards and several other non-technical enablers.

Surprisingly we find that Privacy and Business models are NOT considered important enablers for these functionalities. This could be due to the – in many cases necessary – introduction of functionalities between the use cases and enablers. It does indeed make much more sense to link the business case to a use case and not a functionality. Similarly, all functionalities that do not rely on the exchange of (personal) data would not have an impact on privacy, but privacy could still be an essential component of an overall use case as that would need a myriad of functionalities, some of which do rely on the exchange of data.

non-Technical Enabler	COUNT
Cyber-security	7,4
Standards	7,2
Road users interaction	6,5
Collaboration	6,4
Liability	6,1
Data Gov & Exchange	6,1
Traffic Management	6,0
Mixed traffic	5,4
Regulations	5,3
Insurance	4,8
Methodology	4,8
Mandatory deployment of C-ITS	4,8
Business models	3,9
Privacy	2,9

CONCLUSIONS PART A

- The **top benefit** expected from automation, across all use cases and automation levels, **is road safety** (highest number of mentions, highest average score and lowest deviation).
- Other highly valued benefits can be catalogued under **traffic efficiency** (better comfort, less congestion, less emissions, better personal mobility and increased public health).
- From public authorities' point of view, the **top use cases** in terms of expected benefits **are all SAE level 4 or 5**, for both passenger and freight transport.
- Therefore, **when developing a cross-border testing roadmap, focus should be on SAE level 4 as the endpoint**[3], which can in the longer run expand to SAE level 5 by gradually increasing the operational domain of the SAE level 4 vehicles.
- From public interest point of view, the top priority use cases are **automated shuttles**, both on (semi-)dedicated and public roads **and busses**. Such vehicles are expected to transform

[3] This does not exclude lower SAE levels from this roadmap, it means that our goal is to reach SAE level 4 as quickly as possible and priority should be given to activities that help achieve this objective, including activities that don't focus on automation.

collective transport significantly, and should cover both urban and rural environments to cover personal mobility needs of all citizens.

- Both passenger and freight automation need to be accompanied by flanking measures to integrate them into the overall transport system and **ensure complementary with other modes**.
- From public authorities' point of view, **parking and highway use cases bring less benefits ⇒** to be investigated whether and how their development can contribute to accelerating development of the priority use cases.
- All (or most) functionalities have a role to play, though we can roughly distinguish between **3 groups of functionalities**:
    - Position and navigate ⇒ maps, sensors, V2V and V2I
    - Infrastructure support and functioning ⇒ roadside, cloud, AI, HMI
    - (other) data ⇒ big data, Internet of Things
- For the enablers, technical and non-technical, we also find that all (or most) have relevance.
- Thus, in order to make progress with functionalities and enablers, **additional prioritisation is needed** and will be based on:
    - Need for cross-border coordination, i.e. making sure harmonisation at EU level is sufficiently taken into account when implementing the different enablers.
    - Need for public sector intervention
    - Distinction between "must haves" and "nice to haves"
    - The current state of the art and feasibility in the short term
    - Urgency
    - Costs
- Road safety being the key benefit and V2V & V2I one of the key functionalities together confirm the premise of CCAM, and the need for Connectivity, Cooperative Intelligent Transport Systems and Automated Vehicles to converge.

B. COOPERATION ELEMENTS

To be further developed; building on the CARTRE project, which already gave a brief presentation at the 17th ITS Committee. Industry will be invited to the ITS Committee following its February meeting. A lot of work on fostering cooperation has also been performed in the traffic management working group of the C-ITS platform[4]. Existing cross-border testbeds could also provide a presentation as to how they have organised themselves.

B1: …

B2: …

[4] https://ec.europa.eu/transport/sites/transport/files/2017-09-c-its-platform-final-report.pdf

C. Identify all areas requiring increased cross-border cooperation

To be further developed after completing part A, but using the three matrices we can in principle combine the questionnaire findings to come up with a list of high priority areas for the cross-border cooperation. It is likely to be based on the use cases, possibly in combination with the functionalities.
We will also identify all technical and non-technical enablers that require increased cross-border cooperation.
Additionally, the work developed in part B is expected to identify the key elements of a common evaluation framework. To implement such a framework and enable learning by doing across borders will surely lead to other areas in need of increased cooperation.

D. AMBITION LEVEL / SHARED OBJECTIVES

To be further developed, the main idea being that we build on the:

- Agreed, common list of (preferred) use-cases and the associated functionalities to test and enable deployment across borders, brands, transport modes and road networks.
- Increased cross-border cooperation on all defined areas.

And further elaborate by:

- Defining needs for additional cross-border testing, enabled by this increased cooperation.
- Performing a gap analysis of cross-border testing needs using already ongoing or planned test activities (such as L3-Pilot and ENSEMBLE, which will carry out large scale demonstrations with a cross-border dimension).
- Defining a European roadmap with short and long-term targets for testing and deployment of CCAM and its integration in both existing traffic and new mobility systems.
- Looking for synergies and complementarity with actions resulting from the Letter of Intent from Rome, fostering additional investments in infrastructure and on the vehicle-side.
- Linking with the ongoing work on the update of the STRIA roadmap on Connected and Automated Driving, scheduled to end December 2018.

E. Workshops with industry and other stakeholders

All work described in the previous chapters was based on discussions with Member State experts only and served to find a shared public sector view on cross-border testing in the field of Cooperative, Connected and Automated Mobility. From the beginning it was clear that the outcome and preliminary conclusions of this exercise would need to be cross-checked with a wider audience of industrial and other stakeholders. To this end several workshops were organised in which the Member State experts of the ITS Committee met with representatives from the automotive, motorcycle, ICT and telecom industry; road, transport and toll operators; cities; information service and public transport providers.

This was particularly useful to make progress on prioritisation of functionalities and enablers and better understanding the perceived needs for public sector intervention. To help structure the discussions another survey was conducted – this time with the wider audience of stakeholders and not the Member State experts – covering the functionalities, technical and non-technical enablers already defined in the first survey.

As agreed earlier (see conclusions Part A) the focus of the survey was on the following elements, is there or is it:

- A need for cooperation between MS?
- A need for Public Sector intervention?
- A Must have or Nice to have?
- Feasible in short term (max. 3 to 5 years)?
- Urgently required?
- Costs involved?

Analysis

In total 11 replies to the survey were submitted and used for the analysis, though (understandably) not all contributions covered all aspects (i.e. all functionalities and all enablers). Ideally we would have had even more but nevertheless this was deemed sufficient to formulate some conclusions to further advance this topic. As such this second survey also adds new insights to the conclusions already formulated in Part A.

Involved costs are very difficult to estimate using the limited (or lacking) descriptions of the various elements. Furthermore, no solutions were associated with the required functionalities or enablers, which is normal as these in many cases still need to be developed and tested. As a result, several respondents left the cost question blank or gave widely varying answers (in some cases low, medium and high were given for the same functionality). For further analysis, the cost question was thus not taken into account.

All other questions were used to prioritise the different elements of the survey using the following logic:

- A need for cooperation between MS? ⇒ should be answered by "YES"
- A need for Public Sector intervention? ⇒ should be answered by "YES"
- A Must have or Nice to have? ⇒ should be answered by "Must have"
- Feasible in short term (max. 3 to 5 years)? ⇒ should be answered by "YES"
- Urgently required? ⇒ should be answered by "YES"

All contributions that meet the above criteria point towards a clear focus area for this exercise and thus large-scale testing in the **short term**, meaning a **must-have** and **urgent** topic that requires **cross-border cooperation** and a **public sector intervention**.

Two important additional comments should be taken into account:

- Not ALL questions needed to be answered, in other words if one (or more) of the questions above was left blank and all remaining questions were answered as described above, the contribution was still considered relevant for the prioritisation exercise.
- When a functionality or enabler did not receive contributions as described above, one should not conclude this is of lower importance to the further development of CCAM. For example, it could simply mean that industry expects to solve this particular issue without help from the public sector. It might also mean it is not deemed feasible in the short term, likely making it a candidate for further research rather than large-scale testing in the short term.

Doing this exercise revealed considerably less "positive" answers – following the logic described above - for the technical enablers, compared to the functionalities and non-technical enablers. This is most probably related to the note above, meaning that these are issues that may be critical for the development of CCAM but do not meet all criteria above, in particular the combined need for public sector intervention and cooperation between MS was far less often identified than for the other categories.

Analysis functionalities

The table below shows how many times each functionality was mentioned using all criteria defined above. That means that the highest count points to the functionalities worthy of prioritisation within the scope of this exercise (*note: in the tables below green means identified as a priority by 5 or more respondents, yellow means identified as a priority by 4 respondents)*.

	Count
Passing construction sites	7
Respecting traffic lights	7
Incident detection (e.g. end of traffic jam)	7
Respecting dynamic traffic rules (e.g. variable speed limits, police instructions)	6
Respecting static traffic rules (e.g. entering one-way street)	5
Stop safe in case of malfunction	5
Lane changing / merging	5
Entering / exiting highways	4
Identifying suitability of automation mode and / or automation level	4
Avoiding collision risk	4
Advanced traffic management	4
Accurate / reliable positioning (e.g. adverse weather)	4
Interacting with Vulnerable Road Users	4
Handling complex or missing lane markings (e.g. Toll plaza traffic)	3
Handling complex intersections	2
Integration with other (complementary) transport modes	1
Grand Total	**72**

First of all, we note that all functionalities meet the above criteria at least once, confirming once again that these functionalities are of a very horizontal nature and are all very relevant for CCAM.

However, clear differences can be noted in how often they were mentioned and 7 functionalities meet all criteria according to at least half of the respondents, including **passing construction sites**, **traffic lights** and **incidents**, **static** and **dynamic traffic rules**, **lane changing** and **stopping safe in case of malfunction**. A common element of these 7 functionalities is that they tackle elements that are volatile, dynamic and/or not predictable, with the exception of static traffic rules. Dealing with such situations is considerably more difficult, requires immediate reaction and could potentially generate a safety risk if not handled correctly.

Analysis technical enablers

The table below shows how many times each technical enabler was mentioned using all criteria defined above, which as stated earlier is far fewer than for the other categories (a total of 24, or three time less than the 72 “positive” answers for functionalities).

Two technical enablers were not even mentioned once; those are sensors development & integration into wider IoT system. Again, this does not mean these enablers should be considered as less important overall, but it does indicate they are not deemed a priority in the scope of this exercise.

	Count
Short-range connectivity (V2V, V2I)	5
Road Infrastructure	4
Functional safety	4
Maps & electronic horizon	3
Cloud Connectivity	2
Decision and control incl. AI techniques	2
Big Data Collection	2
HMI	1
Electric vehicles	1
Grand Total	**24**

One technical enabler sticks out as being most relevant for this exercise - **short-range connectivity** - closely followed by **Road Infrastructure** and **Functional safety**. These are of course also the enablers were collaboration between public and private sector is most needed.

Analysis non-technical enablers

As for the functionalities all non-technical enablers were mentioned at least once and no less than three new ones were proposed, one even by two different respondents, namely “mandatory training of drivers for SAE level 3 and 4 vehicles”. The other two were “centralised fleet management of automated vehicles” and “public acceptance”. In particular the latter appears a to be an oversight and might have gotten significantly more votes had it been included in the survey from the beginning.

	Count
Cyber-security	7
Regulations	6
Standards	6
Mixed traffic	6
Collaboration	5
Privacy	5
Data Gov & Exchange	4
Road users interaction	3
Traffic Management	3
Liability	3
Mandatory deployment of C-ITS	3
NEW - Mandatory training of drivers for levels 3 & 4 vehicles	2
Insurance	2
Methodology	1
Business models	1
NEW - Centralised fleet management of automated vehicles	1
NEW - Public acceptance	1
Grand Total	**59**

Top priorities include two topics that were already high on the C-ITS agenda, **cybersecurity** and **privacy**. Furthermore, **mixed traffic** is clearly identified as a priority and it is again confirmed that this topic cannot be solved by a single stakeholder, meaning it will require **collaboration**, but also **standards** and **regulation**. **Data governance and exchange** was only mentioned 4 times but this is a very wide topic, and answering the question would depend a lot on the type of data and who the exchanging parties are (e.g. two respondents did not consider this topic feasible in the short term).

CONCLUSIONS PART E:

- Involved **costs** are impossible to estimate without a more detailed description of the functionality / enabler and a general idea on the possible solution. As a result, the answers to these questions were not used in the prioritisation exercise. Obviously this does not mean cost (and economic sustainability and affordability, also for the end-user) will not be a determining factor in the success of CCAM.
- A combination of the answers to all other questions was used to determine priorities, in other words finding candidates for large-scale testing in the **short term**, meaning a **must-have** and **urgent** topic that requires **cross-border cooperation** and a **public sector intervention**
- **Seven functionalities** were identified by at least five respondents and can be considered priorities for testing
- **Three technical enablers** were identified by at least four respondents and can be considered priorities for testing
- **Six non-technical enablers** (seven if we include data) were identified by at least five respondents and can be considered priorities for testing. In addition, two new enablers came out of the survey that are good candidates for further consideration.