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Abbreviations

Abbreviation	Explanation
ANE	Anemone Technology
CACC	Cooperative Adaptive Cruise Control
C-ITS	Cooperative Intelligent Transport Systems and Services
CAM	Cooperative Awareness Message
CBTC	Communication-Based Train Control
CODECS	Cooperative ITS Deployment Coordination Support
D	Deliverable
DAB+	Digital Audio Broadcasting
ETSI	European Telecommunications Standards Institute
EU	European Union
GLOSA	Green Light Optimised Speed Advisory
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
Hz	Hertz
I2V	Infrastructure-to-vehicle communication
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
ITS	Intelligent Transport Systems and Services
ITS-G5	European standard for ad-hoc dedicated short range communication of vehicles among each other (V2V) and with ITS stations in traffic infrastructure (V2I)
ITSAN	ITS automotive nord GmbH
PC	PaulsConsultancy
PDA	Personal Digital Assistant
PT	Public Transport
PTW	Powered Two-Wheelers
RLAN	Radio Local Area Network
RSU	Road Side Unit
SPaT	Signal Phase and Timing
T	Task
TR	Technical Report

Abbreviation	Explanation
TTG	Time to Green
UWB	Ultra-wideband
V2I	Vehicle-to-infrastructure-communication
V2V	Vehicle-to-vehicle-communication
V2X	Vehicle-to-x-communication
VRU	Vulnerable Road User
VW	Volkswagen AG
WiFi	Wireless Fidelity
WP	Work Package

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Executive Summary

The present report records the Workshop D3.1 Perspectives in functional roadmapping of the H2020 Coordination and Support Action CODECS (**CO**operative ITS **DE**ployment **C**oordination **S**upport). The Workshop belongs to CODECS' activities on aligning implementation roadmaps to ensure a concerted C-ITS roll-out across Europe (work package 3).

The workshop objectives were defined in discussing potential future C-ITS use cases which have been in the primary focus of the automotive industry who pushed the early development in C-ITS. Through an interactive workshop, the CODECS-team aimed at getting stakeholders' feedback on potential use cases on top of safety-related V2V use cases and V2I use cases settled in motorway scenarios which are part of current road maps for Day 1.

The workshop was held at 17 February 2016 at the Ministry of Transport in Prague, Czech Republic, and attended by 23 stakeholders from ten European countries (Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, Germany, Norway, Romania and The Netherlands). After a general introduction of Day 1 services, ITS technologies and their potential to support Day 1 + applications, as well as current industrial-driven roadmaps, the participants where split in three working groups. They created ideas for future use cases benefiting especially 1. Public Transport (PT), 2. Vulnerable Road Users (VRUs), and 3. non-safety related services.

The results of the workshop will slip into the use case roadmap to be developed within the CODECS WP 3 in the oncoming project months.

1. Introduction

The Coordination and Support Action CODECS pursues the high-level objectives of

- coordinating initial activities for cooperative Intelligent Transport Systems and Services (C-ITS) deployment in the different hot spots across Europe
- aligning implementation road maps especially with regard to the use cases served by vehicle-to-vehicle and vehicle-to-infrastructure communication
- giving strategy coordination support for a concerted, area-covering C-ITS roll-out and
- raising the awareness for the idea of cooperative road traffic and its benefits to the end-users.

For fulfilling these targets, CODECS relies on building-up and maintaining a tight stakeholder network. The profound stakeholder relationship management is essential to encourage their active cooperation and commitment to the project.

To ensure involvement of relevant stakeholders in the elaboration of well aligned roadmaps, a workshop on functional roadmapping was organised on 17 February in Prague, Czech Republic. The purpose of the workshop was to get input from stakeholders for some areas that have not necessarily been the key focus in the early work on C-ITS which was primarily driven by the automotive industry.

The principal initiative of the automotive industry for the early development of C-ITS, in cooperation with some national road operators, has led to a primary focus on V2V safety use cases and V2I use cases primarily centred around the motorway scenarios. This picture is clear when looking at. e. g. the C-ITS Deployment Platform's final report that has identified Day 1 use cases as shown in Table 1.

Among those use cases which the C-ITS Platform identified as Day 1 use cases, the first eleven relate to V2V safety or motorway uses cases. The remaining three are related to urban scenarios. However, despite the C-ITS Platform has identified these as Day 1 services, not all the necessary technology aspects have been standardised yet, e. g. the transport protocol to carry the information about the Signal Phase and Timing (SPaT) and the associated intersection Maps are currently under standardisation.

□	Day 1 Services			Bundle
1	Emergency electronic brake light	V2V	Safety	1
2	Emergency vehicle approaching	V2V	Safety	1
3	Slow or stationary vehicle(s)	V2V	Safety	1
4	Traffic jam ahead warning	V2V	Safety	1
5	Hazardous location notification	V2I	Motorway	2
6	Road works warning	V2I	Motorway	2
7	Weather conditions	V2I	Motorway	2
8	In-vehicle signage	V2I	Motorway	2
9	In-vehicle speed limits	V2I	Motorway	2
10	Probe vehicle data	V2I	Motorway	2
11	Shockwave damping	V2I	Motorway	2
12	GLOSA / Time To Green (TTG)	V2I	Urban	3
13	Signal violation/Intersection safety	V2I	Urban	3
14	Traffic signal priority request by designated vehicles	V2I	Urban	3

Table 1: List of Day 1 services identified by the EU C-ITS Deployment Platform (see [1])

Against this background, the focus of the CODECS-workshop was chosen to be on areas which in the past have received less attention, and as such, the CODECS-Team selected the following three:

- Public Transport (PT)
- Vulnerable Road Users (VRUs)
- Non Safety

The workshop itself consisted first of a general introduction of Day 1 use cases listed by the C-ITS Deployment Platform given by Niels Andersen (Anemone Technology), to set the scene and bring participants on an equal footing. After the introduction, a short overview on the technologies for C-ITS was provided (see section 2), followed by an introduction to V2X Roadmaps beyond Day 1 (see chapter 3).

After this plenary part the workshop participants were split in three parallel sessions, with each of them elaborating potential uses cases in one of the three chosen focus areas. The results of the parallel sessions were afterwards presented in the final session of the workshop.

2. ITS technologies

In order to facilitate the workshop discussion of future C-ITS use cases, a quick introduction to the technology aspects of ITS was provided by Paul Spaanderman (PaulsConsultancy BV). As indicated the early developments for C-ITS were primarily driven by the automotive industry, and looked at safety related use cases. When a broader range of use cases needs to be supported, this introduces some additional technical challenges:

- Can't be handled by ONE COMMUNICATION TECHNOLOGY!
- Growth of applications leads to INCREASE OF DATA transfer!
- New applications require HIGH LOCATION ACCURACY!
- New applications require NEW TYPE(s) OF DATA EXCHANGE!

2.1. Communication technologies

In summary, no single communication technology provides coverage for all ITS applications and the associated business models. Their requirements vary from short range broadcast type communication to wide area point-to-point communication. Further, it is important to note that no communication technology can guaranty uninterruptible communication for all ITS applications. All in all, this leads to the conclusion that a combination of different communication technologies is required, in other words, hybrid communication is needed.

Therefore, it can be expected that the communication for Day 2 applications and use cases will be able to use the following communication types:

- ITS-G5 for short-range safety critical and dynamic traffic management.
- CELLULAR technologies for general safety warnings and none safety.
- Potentially extended with: DAB+, RLAN, Bluetooth, UWB or ZigBee

2.2. Increase in amount of data to transfer

The amount of safety related applications is growing. With the amount of active applications, also the demand for data transfer increases. For instance, for cooperative adaptive cruise control (C-ACC) and platooning, the CAM rate will increase with a factor of about 3 to 30 Hz. Also the ascending security requirements will cause a significant increase in data rate while the amount of installed systems will have influence as well.

Early knowledge build-up within various projects indicates that the full set of ITS bands needs to become designated for prioritised use of ITS-G5.

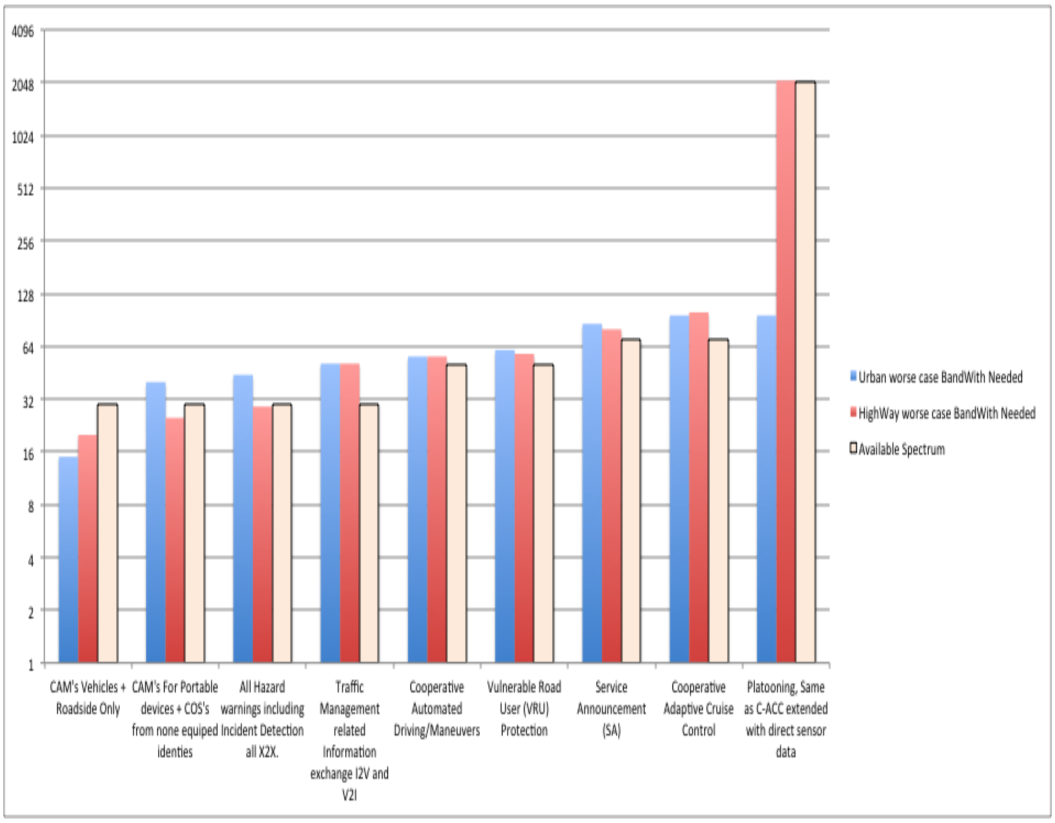

Figure 1: Estimated bandwidth needs for different types of use cases (see [2])

2.3. Requirements for positioning

Positioning can be split in two parts: one is the absolute position, and the second the relative position, e.g. relative to other traffic participants. For the absolute positioning for Day 1 GNSS systems are expected to provide 2 to 7 metre precision and 95% availability. For Day 2 and beyond it is expected that some use cases will need precision of 0.2 metres and a 99.99 % availability which currently is not feasible when basing the location on GNSS systems. This means that other technologies need to be used to improve the accuracy, examples of such technologies studied in the H2020 project HIGHTS are:

- ***Utilise existing ranging technologies***
  Using UWB, Short Range, ZigBee, ext Generation Positioning in IEEE 802.11 physical layer technologies to extend the GNSS precision
- ***Utilise location information exchange between stations***
  Exchange of Geolocation information of objects between stations. Where objects can be the station itself but also objects recognised by a station. Non-static stations (vehicles) to benefit from static stations higher Geolocation precision knowledge
- ***Utilise multi sensor Algorithm & Systems calculation***
  Use integration of GNSS-based positioning solutions with V2I, V2V and V2IoT (Vehicle-to-IoT) multi-hop localisation techniques. Bayesian inference and non-Bayesian solutions including (GNSS, WiFi networks, ITS-G5, vehicular sensors, etc.), dynamic map extensions at facility layer: enhanced freshness and interoperability

3. Roadmaps

In order to facilitate the workshop discussions of use cases, an introduction to some of the industry's guiding principles for V2X roadmaps was provided by Teodor Buburuzan (Volkswagen AG).

For the automotive industry the main principles are

- to focus on information exchange (between traffic participants)
- to cooperate on providing information that is clearly defined, e.g. in standards, over a commonly agreed air interface, with localised dissemination patterns, receivable for all traffic participants
- to ensure that the provided information pieces build on top of each other to gradually increase the overall information available for the potential applications.

In addition to the cooperation, it is essential for the automotive industry to keep the competitive element. This is done by allowing the actors to compete and capitalise on the information, meaning that each traffic participant can freely use the received information for their applications and, e. g., enhance automatic driving function.

Generally, the Day 1 of C-ITS can be considered as 'awareness driving', e.g. the traffic participants share status information, to allow others understanding the current status around them.

For the next phase, it is expected that the participants in addition to status data will also share the observations, e.g. the data from their sensors. This can be envisioned to allow providing information about traffic participants that are not themselves able to provide status information, e. g., because they are not C-ITS equipped. This second phase is often called 'sensing driving'.

Again building on top of the information provided it the first two phases, a third phase is envisaged to enable 'cooperative driving'. To allow that, it will be necessary to share intentions, e. g., the participants will inform the others about their intentions, such as lane changes, planned trajectories etc. The third phase will most likely be followed by a fourth phase that will allow the participants to make coordinated actions, e. g., forming platoons, coordinate lane merging etc. This phase is often called 'synchronised cooperative driving'. The next step after this will be moving towards accident-free driving, based on automated driving with optimised traffic flows.

4. Results of the Working Groups

4.1. Public Transport

As indicated in the introduction to the workshop the principal initiative of the automotive industry for the early development of C-ITS, in cooperation with some national road operators, has led to a primary focus on V2V safety use cases and V2I use cases primarily centred around the motorway scenario. When looking towards more urban scenarios the public transport plays an important role and thus it was important to discuss potential use in relation to public transport.

In the discussions it was noted that already today there are different systems in use to assist the operation of public transport. However, these systems are often proprietary, what often leads to the need for different systems in a vehicle. Therefore, there would be potential benefits of moving even some of those use cases to the same technology platform as the day one use cases.

During the workshop discussions the following use cases was identified

- BUS/Tram: Warning of the following actions:
    - Stopping
    - Starting
    - Turning left/right

- Tram warning (general)
- Tram interlocking control
- Blind spot detection (to avoid collisions with cycles and pedestrians)
- Localisation of vehicles
- Use of C-ITS to improve inter-modal transport
- Special needs passenger indication at stop (e.g. longer stop time for disabled persons to enter)
- Request for bus/tram to stop
- Fleet management e.g. for waste collection, public services etc.
- Vehicle management (at garage)
- ? Communication-Based Train Control (CBTC) for urban rail
- Priority at traffic lights/ Green Light Optimised Speed Advisory (GLOSA)
    - Known service, so why ETSI G5?
        - Some existing radio solutions are old and have doubtful quality
        - Synergy across services
        - Might replace other traffic sensors

4.2. Vulnerable Road Users

In the session on Vulnerable Road Users, the focus was towards what VRUs are and what kind of use cases the audience finds important to be supported. For this, the current knowledge and open questions were presented and discussed in a general open way.

4.2.1. What are Vulnerable Road Users?

It is clear for the audience that pedestrians and bicyclists are VRUs, but not that motorcycles also are VRUs. The current list, as captured in the draft ETSI standard TR 103 300, has been presented and discussed.

Figure 2: Recognised Vulnerable Road Users (see [2])

- Pedestrians (children, elderly, joggers)
- Wheelchairs users, prams
- Skaters, skateboards, segway
- Bikes and e-bikes, with speed limited to 25 km/h.

- High speed e-bikes, speed higher than 25 km/h, class L1e-A.
- Powered two-wheelers (PTW), mopeds (scooters), class L1e.
- PTW, motorcycles, class L3e.
- PTW, tricycles, class L2e, L4e and L5e, limited to 45 km/h.
- PTW, quadricycles, class L5e and L6e, limited to 45 km/h.

The common conclusion of the discussion was that in the first place all humans participating in road transportation, who have less protections then sitting in a car or truck, can be classified as VRUs. Some of the participants proposed to add animals as a VRU. Although this does not seem obvious, especially in the Northern countries this situation is rather common. Currently herds are GPS-tracked.

4.2.2. What are possible additional VRU use cases?

As introduction, an initial set of basic use cases was presented and based on this in a brainstorming way additional ones of interest to the participants were specified. See for the presented use cases:

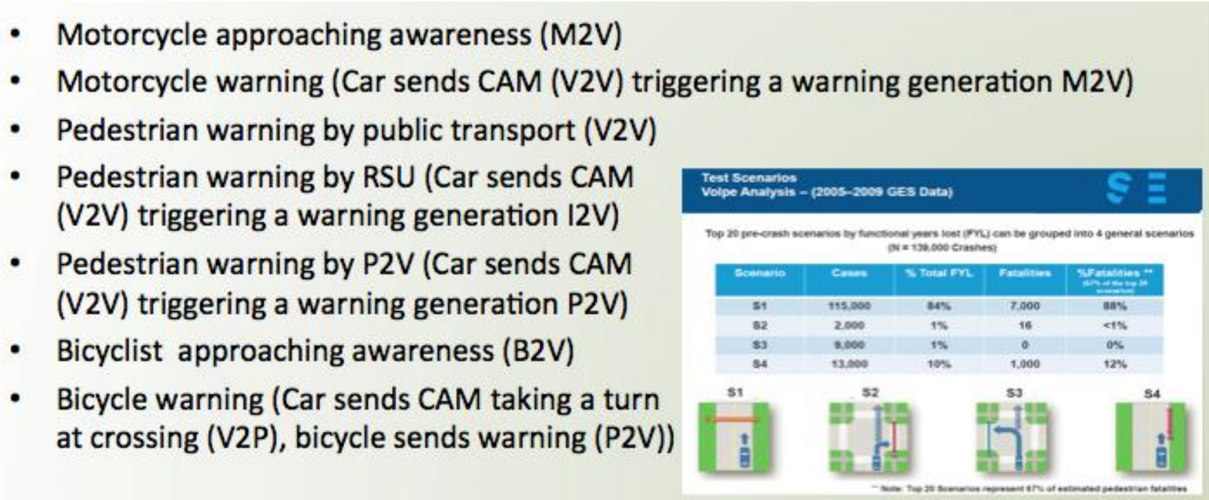

Figure 3: Estimated bandwidth needs for different types of use cases (see [2])

In a brainstorming session the following additional use cases have been identified:

- Recognised Public Transport (PT) oriented use cases (1)
  - Pedestrian crossing road in front of or rear of a bus while vehicles, or other VRUs, are passing by at bus stop
    - Bus detects pedestrian(s) crossing and warns passing road users for this event
    - Bus detects pedestrian(s) crossing and warns pedestrian(s) for passing road users in case they are there
  - Bus situation awareness for disabled (blind and others) at bus stop
    - Bus capabilities (wheelchair,...)
    - Which bus is stopping where (at a multi bus-line stop area)? Where to go and how much time left?
- Recognised PT oriented use cases (2)
  - Pedestrian crossing a road, in between the waiting area and physical location to get onto a bus, tram or trolley

- The bus, tram or trolley detects the availability of people who would like to get on the bus and sends out a warning to passing traffic at a stop (when there is other traffic)

- Virtual Pedestrian road crossing use case
  - At specific or non specific times, groups of people (including school classes of children) need to cross a road without any real pedestrian or cyclist crossing in the neighbourhood
  - Pedestrians or cyclists intending to cross have a device equipped to send out warnings and actively sends out the warning on initiative of the pedestrian or cyclist itself
  - A Road Side Unit (RSU) detects the pedestrians or cyclists intending to cross and sends out a warning to passing other road users. Detection could be done by a knob to push or by visual recognitions (camera or infrared)
- Bike lane change and unequal crossing use case(s) (1)
  - 'Bike approaching crossing'-warning
  - Bike sends out an awareness or a driver initiated warning at crossing.
  - RSU detects a bike and sends a 'bicycle approaching'-warning (could also send a car approaching warning).
  - Car CAM is detected by bike and bike application warns the bicyclist.
- Bike lane change and unequal crossing use case(s) (2)
  - Bike lane ends, bikes on normal road.
  - RSU detects a bike approaching and sends 'bicycle entering the road'-warning. RSU can also send a 'traffic at bike lane/road merge'-warning
  - Bicyclist indicates going onto normal road and sends a warning
- Other bicycle oriented use cases
  - Bicycle priority, GLOSA
    - Bicycle has beacon (sends awareness message)
    - Bicycle sends request for crossing (sends a request)
    - RSU sensors detect bicycle and provide 'time to green'-information to the bicycle(s)
  - Bicycle slippery road
    - Bicycle can receive slippery road information by cars passing by
    - Bicycles may detect slippery road themselves and provide related information to others
- Bike sharing service to include
  - With integrated PDA/mobile phone to provide
    - Commercial services including locations of interest
    - Public services such as tourism, public locations and events
    - Safety services such as
      - Static road situation awareness
      - Dynamic warnings such as described earlier in the slides
    - Including support for disabled like with limited hearing
- Bike CAM uplink to Cloud

- Bicycle CAMs through mobile network to cloud and from there to Vehicles

4.3. Non Safety

Up until now the focus of direct communication between traffic participants was set on increasing the safety of individual participants. This can be clearly recognized from the envisioned Day 1 use cases, as well as from the future Day-2-3-4 use-cases which go towards fully-automatic driving. However, an area currently not considered that much is represented by the so called non-safety, or commercial applications. Especially in the future context of smart cities and smart infrastructure, a significant number of applications might be developed for increasing the comfort of the traffic participants.

- SmartCities
    - City-Profile installation (e.g. speed limitations, …) and Pay-per-Use-Transactions (payment information and operations which are city-specific)
        - City-Tolling (e.g. pay for using the city infrastructure, maybe through a pseudonym)
        - Parking (pay for using the parking infrastructure of a city, maybe also using pseudonyms)
        - „Attractions“ (download additional content from the city attractions)
    - Road-Quality-Measurements (provide feedback to the city about the quality of its infrastructure)
    - Pre-ordering/ reservations (e.g. DriveIn at McDonald’s, …)
- SmartHome
    - Use vehicles as energy sources (e.g. E-Vehicles can also provide energy to the smart home, or directly into the power-network if the economics speak for it)
    - Synchronise with other vehicles to intelligently use free garages/parking possibilities (when in vacation, the parking spot in front of the house can be made available to other traffic participants by the smart home)
- Gamification
    - Assurance reduction (be awarded ‘cooperative’ points by other traffic participants when being cooperative)
    - Emission-bonus/ payment (awarded/invoiced by cities for driving within a specific city-limit)
    - Intelligent green-phases (the traffic lights can dynamically adjust their pahses according to how many traffic participants require a specific green phase)

5. Conclusion

With the D3.1 Workshop Perspectives in functional roadmapping, the CODECS team succeeded in triggering an interactive discussion of potential future use cases enabled by V2X communication with international C-ITS stakeholders. The debate proved that also in the various stakeholders’ perspectives, there are assorted use cases benefitting Public Transport, VRUs and Non-Safety services which need to become an integral part of C-ITS future roadmaps. Looking across the use cases for Public Transport and Vulnerable Road User there is a clear synergy between the uses cases, and the integration of the Public Transport will not only provide benefit to the operation of the public transport but also provide benefits to vulnerable road users when they use public transport.

Some of the discussed use-cases were provided to the C2C_CC working group Roadmap and are currently considered for inclusion on their roadmaps. Especially the safety related use-cases requiring no change of the existing standards (e.g. (indirect) VRU warning through the school-bus warning) will most likely by added and enabled in future connected vehicles. With the Smart Cities topics becoming increasingly present, the C2C_CC will most likely also consider developing roadmaps for non-safety applications. An initial contribution towards this work is the list provided in section 4.3 which already includes several interesting use-cases for the automotive industry.

In terms of consolidation of stakeholder preferences and requirements, CODECS will include the list of use cases conceptualised by the workshop participants into its D3.2 Use case definition and stake-holder roles as well as D3.3 Initial harmonised use case roadmap.

ANNEX A: References

[1] European Commission DG Move C-ITS Platform Final Report, January 2016, http://ec.europa.eu/transport/themes/its/doc/c-its-platform-final-report-january-2016.pdf

[2] CODECS_Roadmap_Workshop_ITS_Technologies.pdf, presentation held by Paul Spaan-derman, http://www.codecs-project.eu/fileadmin/user_upload/pdfs/Workshop_Roadmap/CODECS_Roadmap_Workshop_ITS_Technologies.pdf