C-ITS Roadmap for European cities

CIMEC Deliverable D3.3b: Roadmap Summary

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Cooperative ITS for Mobility in European Cities

www.cimec-project.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653637

Deliverable No.		D3.3b	
Workpackage No.	WP3	Workpackage Title	Deployment Roadmap
Task No.	T3.3	Task Title	Final Roadmap
Date of preparation of this version:		21/12/2016	
Authors:		Mark Cartwright, Leslie Knoop	
Status (F: final; D: draft; RD: revised draft):		D	
File Name:		CIMEC-D3.3b Final Roadmap v1.0 - Summary.docx	
Version:		0.1	
Task start date and duration		01/12/2016 – 01/04/2017	

Revision History

Version No.	Date	Details
0.1	21/12/2016	First draft (based on Draft Roadmap, D3.2)

TABLE OF CONTENTS

1. Introduction: about the Roadmap 4
   1.1. Project context 4
   1.2. Nature of the Roadmap 4
2. Context and state of the art 5
   2.1. What cities want 5
   2.2. The nature of C-ITS 6
   2.3. Potential value of C-ITS 6
   2.4. C-ITS design choices 7
   2.5. Externalities 8
   2.6. The supply market 8
   2.7. Standards and their take-up 9
3. How cities could benefit from C-ITS 10
   3.1. Use cases 10
   3.2. Categorising C-ITS 10
   3.3. Key choices: the city's strategy 12
   3.4. Procurement and implementation 14
4. The wider context 15
   4.1. Legal developments 15
   4.2. Private sector developments 15
   4.3. Developing the evidence base 15
   4.4. Funding support 16
   4.5. Implementation support 16

1. Introduction: about the Roadmap

1.1. Project context

This document has been produced under the CIMEC project, addressing "Cooperative ITS for Medium-sized European Cities".

CIMEC is a Coordination and Support Action (CSA) whose primary aims are to understand potential benefits and impacts of cooperative intelligent transport systems (C-ITS) on urban environments, since most of the work to date has been focussed heavily on the highways context. CIMEC runs from June 2015 to May 2017.

The main output of CIMEC is a "Roadmap for European cities", to be prepared, validated and disseminated towards the end of the project (project deliverable D3.3). This Roadmap Summary is a short form of the Roadmap, intended for use as both an introduction to the topic of city C-ITS, and as a shorter reference for people who do not need the full detail of the Roadmap.

1.2. Nature of the Roadmap

This document is not the first Roadmap that has been collated for C-ITS. It is, however, the first – as far as the project team is aware – that has been specifically brought together from the specific perspective of local roads networks, and the public administrations (referred to for simplicity as "cities" in this document) that are responsible for them.

Previous C-ITS Roadmaps have taken quite varied approaches. Some have attempted to describe a specific timeline. This Roadmap takes a broader view. It is intended, above all, to be an overview perspective on how the city C-ITS market is expected to develop in Europe: to provide a vision that European cities can collectively recognise and support, and that other stakeholder can benefit from in their political or commercial planning.

The Roadmap works through the following steps:

- The opening section describes the context and current state of the art: how cities work and where C-ITS might fit into this, as well as the current state of the supplier market.
- The middle section analyses specific functions that could provide tangible benefit to a city: specific "use cases", how to evaluate them for inclusion in the city's strategy, and how to formulate a coherent strategy.
- The final section explores how city C-ITS deployment will be affected by developments outside the control of cities and their supply chains, and implicitly sets a challenge to external stakeholders.

This summary covers each of these elements, but focussing particularly on the general implications for policy, rather than specific technical factors.

2. Context and state of the art

2.1. What cities want

European cities have many functions, and transport is only one in a battery of responsibilities that a city needs to juggle. Part of that juggle will include how to spend budget and in particular how to allocate budget to support policy goals which may not be set locally while still being mindful of local needs and local limits.

When considering transport policy within an individual city, a natural starting point would be to look at city geography, economy and demographics. A city which experiences a lot of snow might be expected to want very different things from a temperate or warm city. However, fundamentally, the city will want to make road users aware of adverse conditions on the roads. The specific conditions do not significantly change how technology might be used. For these reasons, CIMEC did not find that geographical factors had a major impact on city's approach to C-ITS.

What is important is how it can contribute to the city transport policy, and this is remarkably consistent across Europe. The four almost-universal policy goals are:

- To reduce congestion
- To improve the environment – specifically regarding air pollution
- To maintain safety on the network
- To promote excellent public transport (partly to support the above goals)

To achieve these goals, a city will need to ensure it spends its limited budget most effectively and efficiently. Technology may have a role, but before a city invests in technology, it needs to be convinced that it:

- is available and meets the specification;
- will do the job better than another (cheaper) solution;
- is well tested to achieve the outcome desired;
- is well tested to be safe in the context;
- is a price which is manageable within the budget;
- will integrate with legacy systems; and
- is future-proofed against obsolescence.

Getting the technology that's right for a city may have plenty of internal hurdles to overcome as well. Technology development is done by suppliers, but it needs to meet the needs of the city. It is easy to be enthusiastic about what is possible without sufficiently considering what is necessary, practical and cost effective. Understanding the technology is hard for people who are policy driven rather than technically minded. Changes in personnel and inconsistent levels of expertise may also contribute to problems in achieving a holistic approach to transport technology acquisition.

2.2. The nature of C-ITS

The general aim of C-ITS – *cooperative* ITS – is that, by having access to data from others, each stakeholder in the activity of transport will be able to make better decisions that they could if they just relied on their own data.

The term C-ITS therefore covers a very wide range of technical concepts, and many do *not* involve any investment by cities. For instance, one class of C-ITS is the so-called V2V concept, which involve the direct communication between vehicles: for example, if one vehicle could send a "braking" message to the vehicle behind, this could be used to help prevent a collision (e.g. by automatically activating its brakes much more quickly than the driver could react).

Another class of C-ITS, termed V2I, involves links between vehicle and "infrastructure", which generally covers systems owned and operated by the manager of the road network. For instance, many V2I services envisage direct communications between vehicles and traffic signals. These concepts are much more likely to involve cities.

Both V2V and V2I services include a wide variety of specific functions and mechanisms, some of which are relatively well understood and some of which are still very vague. In addition, there are other C-ITS concepts – for example, a vehicle could communicate with pedestrians, perhaps to alert a blind person to an approaching vehicle.

Within the systems community, there is a lot of detailed discussion on the technical aspects of C-ITS, and in the development of associated standards. By contrast, cities will be primarily interested in functionality, i.e. what can be done with the data that has been obtained using C-ITS. While there has been some exploration of these areas, they are much less well developed than the technical aspects. From the city perspective, this knowledge gap represents a serious challenge.

2.3. Potential value of C-ITS

The focus of a city will be firmly on *outcomes*, i.e. how different kinds of C-ITS might result in real-world changes to traffic and travel. The value of a C-ITS project can and must be evaluated primarily with this metric.

The best evidence, where available, would be a robust quantification of policy benefits which can be directly linked to specific C-ITS solutions: *lower accident rate*, *improved air quality*, etc. This information does not exist and may be very difficult to gain even in the long term, as the effect of C-ITS will be difficult to disentangle from other changes.

Accordingly there is more focus on the direct improvements claimed for C-ITS, such as *road users have better information on the presence of nearby VRUs*. This kind of metric is more likely to be objectively measurable, although at present the amount of reliable data is still very limited. However, better information does not equate to better driving, and there may even be negative consequences – for example, emissions rise, road wear increases or traffic flow breaks down.

CIMEC's research with cities identified the following *activity areas* – i.e. interventions which might benefit from C-ITS support. In no particular order:

- Multimodal traffic and transport management
- Information exchange
- Individual traffic management
- In-vehicle signalling
- Management of urban freight
- Management of electric vehicles
- Management of traffic lights
- Parking management
- Incident management
- Air pollution
- Support for vulnerable road users
- Car sharing
- Autonomous driving

2.4. C-ITS design choices

Technically, the two key alternatives are to use *short range* or *long range* communications channels (or indeed a mixture of both). The technical characteristics of the different channels make one or the other better suited for different services. For instance:

- Local comms are suited to management of "hotspots" like junctions, but less suited to network monitoring or broadcast information.
- Wide area comms services are, at present, much more prone to delays and interruptions. Services that require near-instantaneous response – such as collision detection and automated braking – may therefore prefer local comms.
- Local comms services require new pieces of roadside equipment; however, the comms services themselves are free. Conversely, wide area comms require very little infrastructure but impose an ongoing revenue cost.

There are options based on different business architectures. This area is also (for obvious reasons) in its infancy and few clear directions can be seen; however, several potential solutions have emerged during the course of CIMEC research, including the following:

- The city providing its C-ITS services directly to the road user, using its own technology.
- The city works with a specialist external entity, which provides the direct connection to vehicles– a national/regional service, a fleet owner, a vehicle manufacturer, or a specialist distributor of in-vehicle equipment (like TomTom).
- The city uses a third party to provide services to road users, but collects data directly from them. For instance, the city could publish its network data as open data, and rely on developer innovation to construct solutions (such as mobile apps).
- The city sources vehicle data from a data aggregator (perhaps bought-in from a fleet owner), but then provides information back to vehicles through other channels (e.g. broadcast).

The choice here will depend not only on the C-ITS service being considered, but also on the city's general policy on its role and business relationships with third parties.

2.5. Externalities

The opportunities of C-ITS represent a change for cities; but at the same time there are several other changes which involve both transport and technology, and which are widely seen as being much more significant and fundamental. City officers will need to consider C-ITS in the context of these other changes, which include:

- The rise of personal technology such as smartphones, and of "intelligent mobility".
- The expected emergence of increasingly automated vehicles.
- Smart cities and the Internet of Things.

For example, the link between road user and vehicle is currently under question with service concepts such as Mobility as a Service (MaaS). While buses and trams will still be politically supported, cities may be ambitious to support these newer paradigms. However, MaaS drives policy towards city-to-*traveller* services rather than city-to-*vehicle* services.

These changes can be expected to affect C-ITS directly. Many V2I services can be addressed through smartphones etc., rather than vehicle-mounted systems. Indeed, the boundary between the two is quite blurred for many applications: for example, identical services for (say) a "roadworks ahead" warning could be provided through a web page displayable both on a dashboard-positioned smartphone and on a vehicle-mounted instrument.

The externalities are both a challenge and an opportunity for C-ITS. A challenge, because C-ITS need to find their place within this much larger picture; but an opportunity, because C-ITS could be an excellent testbed for cities to explore these wider issues in the relatively contained context of transport.

2.6. The supply market

The C-ITS market is a sub-set of the overall ITS market. It is not new, but is still not widely deployed in either the urban or the inter-urban environments.

The ITS supply market is not uniform across Europe – most suppliers have a local national or regional focus – and this is reflected too for C-ITS. Some evidence of the geographical distribution of suppliers appeared in the CIMEC information gathering process.

Six general groups of supplier can be distinguished, as follows:

- Infrastructure-based suppliers, who provide conventional ITS solutions such as traffic light controllers, ANPR, etc. to public road authorities.
- Automotive Original Equipment Manufacturers (OEMs), who sell cars that become safer, more efficient and connected for added-value non-safety services.

- Automation suppliers, who provide transport solutions such as parking solutions for installation within (and integration with) autonomous or automated vehicles.
- Communication-based suppliers, who provide communication modules with software or hardware to public road authorities and/or the automotive industry, etc.
- V2X-specialists, who focus mainly on cooperative solutions, components and products, and sell them to public road authorities and the automotive industry, etc.
- Providers of traffic and traveller information services, who work on acquiring data and providing data-based services, or who manufacture navigation systems, or both.

CIMEC conducted an industry survey to determine the readiness of suppliers in providing city-relevant C-ITS. Overall, the responses confirm that the development of C-ITS within the industry is still at an early stage. Mature and effective solutions, products and components are therefore likely to take some time to emerge.

Among suppliers of all types, most see C-ITS as a technological potential, either to improve their existing ITS-services, or to enable new services such as “intersection safety warning systems”. In addition, suppliers regard C-ITS as an enabler for automated connected driving. However, that doesn’t mean all ITS suppliers are investing heavily in C-ITS development. Many suppliers seem to be waiting for a much smaller number of “key suppliers” to act.

The impression is of a very divided market. The substantial presence of large companies suggests that the existing ITS-market still retains a strong interest in delivering the next, cooperative, steps. But the substantial number of smaller companies – more niche, perhaps built around specific innovations – suggests a dynamic market.

2.7. Standards and their take-up

Standards can have a significant impact on the effectiveness of ITS, provided they are well-designed, managed openly and impartially, and are well supported by market products.

With the rapidly growing digitisation of all aspects of traffic and transport management, ITS standards play an increasingly important role in system effectiveness. This is likely to be even more important with C-ITS, because of the need for reliable and compatible connections between cities and vehicles.

Lack of standards is seen by both suppliers and cities as an important technical barrier/challenge to urban C-ITS deployment. Key suppliers are generally very active in standard development – while at the same time pursuing their own proprietary technical developments. (A separate CIMEC report has advised on the specific developments required within standards.)

3. How cities could benefit from C-ITS

3.1. Use cases

CIMEC identified a number of city-relevant C-ITS "use cases", through consultations with city authorities and stakeholders across Europe. Each is relevant to one or more of the key city policy goals: to improve **traffic efficiency**, to improve **traffic safety**, to improve the **environment**, or to improve **accessibility**:

- UC1: Individual routing of vehicles
- UC2: In-vehicle signs
- UC3: In-vehicle signal information
- UC4: Management of loading and unloading areas for freight vehicles
- UC5: Access control for heavy goods vehicles with dangerous goods
- UC6: Regulation of access to free lanes for electrical vehicles
- UC7: Green lights for police and emergency vehicles
- UC8: Traffic light management
- UC9: Green lights for public transport vehicles
- UC10: Green lights for cyclists
- UC11: Parking management
- UC12: Inform about incidents in the road network and access control to these areas
- UC13: Inform about emergencies in the road network and access control to these areas
- UC14: Dynamic access control for air quality management
- UC15: Speed enforcement around schools
- UC16: C-ITS services for vulnerable road users
- UC17: Pedestrians crossing in front of bus/tram
- UC18: Bike lane change and unusual crossing

Several additional activity areas were discussed where C-ITS might be relevant, but where a specific use case cannot yet be identified – either because there is no clear opportunity for systems, or because there is no clear role for cities. However, it is likely – given the early state of the market – that the list of city-relevant C-ITS use cases will expand over time.

3.2. Categorising C-ITS

In evaluating each potential use case, a city will need to decide whether the function is worthwhile and whether C-ITS provides the best way to implement it.

This primary factor in selecting a potential C-ITS project is, of course, the **benefit** that will arise from its delivery. Benefits models exist, although they can be complex, and using them effectively relies on accurate input assumptions. The key factors include considerations of:

- Who receives the benefit (e.g. all vehicles, buses only, specific vehicles, cyclists only)

- How widespread the benefit is (e.g. just at a single junction vs city-wide)
- How the benefit is valued (e.g. in monetary terms, in time saved, in accident reduction, or just in political kudos)
- Crucially, how robust the benefit estimate is (e.g. how much relevant, quantified evidence exists)

Costs are generally a lot easier to establish, if only by asking the market. As with benefits modelling, there are robust established methods, such as discounted cash flow, to estimate whole-life costs. Nevertheless, because C-ITS is still an emerging technology, and because of the complicating factors in understanding future transport, accurate costs for city C-ITS projects will be difficult to get exactly right, at least for the next few years.

For these reasons, it can be expected that cities will tend to start with:

- Small projects and pilots for particular functions.
- Incremental functionality, that can be implemented relatively easily with minimal change to roadside infrastructure.
- Projects with low personnel costs – services that require little operator involvement, and little engagement with road users (e.g. floating vehicle data).
- Low risk projects, where liability and claims are low. While safety-related C-ITS services offer some of the best potential value, they also carry the highest risk; services that are “informative” or “advisory” to road users will create less risk.

One of the key **challenges** of C-ITS is that it requires road users to be suitably equipped with matching technologies, and to ensure that they are used. However, the level of dependency, and the hurdle to road users becoming connected, varies greatly in terms of:

- Which users need to be equipped.
- How specialized and costly the user devices and/or applications are.
- What level of system management is expected of the road user.

Systems that focus on professional drivers, who are likely to have been trained and may have employment incentives to use the system, are therefore likely to be good starting points: public transport, freight, etc.

Many C-ITS implementations require information to be passed from the vehicle to other parties. Insofar as this could be regarded as **personal data**, there is a significant potential issue of data protection. In some parts of Europe this is a very problematic, not just legally but also culturally.

CIMEC identified five classes of personal data usage, applicable to different C-ITS services:

- Class 1: the vehicle provides no information to the city (i.e. receives only broadcast data).
- Class 2: the vehicle sends a completely anonymous message to the city.
- Class 3: the vehicle passes some basic information, such as current location, but with an identifier.
- Class 4: the vehicle passes information not just about itself but about its environment too.
- Class 5: the vehicle passes detailed information about its operation: speed, occupancy, emissions etc.

Where privacy is a big issue, Class 1 services are likely to be deployed earliest by cities. Where Class 2 or higher class services are available, the city has access to a data source that it can use to intervene actively, e.g. to change signal timings or road speed limits. And third party service providers may find it easier to deliver higher class services (e.g. companies with whom the road user already has a relationship), with the explicit and willing agreement of the road user.

The **political risk** for C-ITS is much higher than for most other ITS. Systems like traffic signals are "internal" projects and do not directly impinge on road users. C-ITS, of its nature, does – which may be another reason for cities preferring to work with known, limited fleets like buses, rather than with road users generally. Conversely, of course, a C-ITS project may be seen (and justified) as essentially a political project:

- If it shows the city is technologically advanced and forward-thinking ("smart").
- If it attracts high-profile visitors or inward investment.
- If the intervention is deliberate and targeted at, say, emissions management or disabled travellers.

3.3. Key choices: the city's strategy

The analysis presented above (and more fully in the main Roadmap) can be drawn together to help guide cities in their strategic planning for C-ITS. Each use case identified in section 3.1 was assessed against various tests, namely:

- The quality of the evidence of benefit.
- Technical feasibility and dependencies.
- Commercial feasibility and likely project cost.
- Utility to road users.
- Utility to city managers.
- Social issues, in particular privacy.

Generally, the services best suited to early consideration by the majority for cities were:

- UC9: public transport priority at traffic signals
- UC3: green light optimum speed advisory, especially for freight vehicles
- UC11: parking management
- Services that replace/enhance sensor networks: floating vehicle data (part of UC8)

Obviously local circumstances are critically important, and cannot be taken into account; so, this is not universal advice, and for individual cities, there may be good local reasons to indicate a different course of action.

With politicians and funders, a suitable **political strategy** could be set by:

- The desire to be seen as progressive, and a "beacon" for new technology
- The desire to maximise the city profile, and associated opportunities, in a particular transport area – say, freight (if there is a local port) or cycling (in a university city without too many hills)

- The simple desire to capture funding and support from a national or European programme

Technical strategy involves a choice of systems, processes and delivery mechanism. Existing ITS and commercial relationships will help determine the optimal architecture for the city, in terms of:

- What communications channels it uses (local or wide area) to get information from road users and provide information back to them
- What data it seeks to gather into roadside units (if any) or central systems, and where those central systems are deployed
- Which third parties it can usefully use as part of its overall system – perhaps central systems managed by neighbouring cities or commercial bus companies, perhaps long-term partnerships with communications companies

While the chosen architecture should not determine which services are to be offered in isolation, it is an important part of the planning process. A service which does not naturally fit within a practical city C-ITS architecture may be too risky, expensive or hard to sustain.

A practical **programme** that appropriately manages cost and risk will follow a path typical of any complex programme. Key pointers include:

- Think about phased implementations: don't try to do everything at once.
- First focus on relatively simple, low risk projects, even if they are relatively low priority. Apart from anything else, this will build valuable experience in working with the C-ITS architecture.
- Don't over-promise to the users of the system, or to local politicians.
- Be aware that you may have to change course part way through the programme, and try not to build any key component that is unchangeable.
- Don't leave the programme half finished, especially if the majority of benefits accrue only in the later stages.
- Make sure the budget profile is realistic. If you are at risk of political fluctuations over the 10-15 year timescale, try to get multi-party backing.

Strategy should be **validated with stakeholders**, both initially and as the programme is delivered. Cities are used to public consultation; however, by their nature C-ITS services are more interactive and may require a significantly greater level of coordination with users and potential users.

Different services will require engagement with different categories of road user, to different extents (obviously, bus priority measures will primarily involve bus operators more than general road users). In addition to these, coordination will be required with other stakeholders at a strategic level: national governments, local politicians, funding authorities, other specialist units within the city (e.g. air quality officers), OEMs for affected vehicles, electricity and communications services suppliers, emergency services, etc.

Of course, any staff involved in traffic management will also need to be regarded as stakeholders, especially if they have operational, enforcement or public-facing roles that are connected with the use of the C-ITS.

3.4. Procurement and implementation

The issues involved in procuring C-ITS infrastructure revolve around:

- Determining the appropriate commercial model
- Developing the specification requirements and evaluation criteria
- Managing any supplier competition, including responding to questions

These are not specific to C-ITS, but because of the unfamiliar challenges on technical design, business operation and so on – both within the city and within the supplier community – it may be challenging to ensure that the risks are kept under control during the process.

The challenges continue after procurement and during the implementation phase. New ITS services are very often subject to unforeseen technical hitches, even where there is an off-the-shelf solution that "merely" needs to be connected in to existing facilities. For C-ITS, where solutions will be at least very new and possible still being developed post-procurement, the challenges are redoubled. Moreover, although the city may be able to afford some teething problems in integration with its own internal systems, integration with equipped road users (depending on the service) may need to be instantaneous, fully reliable and free of interruptions.

Once an ITS service is implemented, it needs to be maintained and (in some cases) actively operated, either by the city itself or by a third party. This applies, in particular, to any new C-ITS facility.

The different C-ITS services have different requirements for factors like acceptable time to repair, expected upgrade schedule, need for pro-active maintenance (to ensure adequate uptime) etc. All of these factors need to be taken into account during procurement, in order to ensure that the system as delivered can be maintained in an effective state.

In particular, it is a sad truth that – at any given time – many individual ITS devices belonging to European cities are non-functional, and awaiting repair. For budgetary reasons, this repair can often be postponed for a long time. Where there is a fallback position this may not be too much of a problem: for example, an adaptive signal controller can drop back to fixed time operation if a detector loop fails. For some C-ITS solutions, this level of loss and fallback may not be acceptable.

4. The wider context

4.1. Legal developments

European cities are subject to a wide range of legal obligations of two kinds:

- Duties that they need to fulfil
- Constraints and limitations that they must observe

At present, there are some general duties related to ITS that apply – directly or indirectly – to all European cities. However there are no current duties that compel them to implement C-ITS.

It is widely recognised that C-ITS is still an innovating area and not to be excessively constrained by regulation. However, this does mean that cities are unsure about what their obligations might be in the future, and this makes them cautious about investment.

Policymakers need to ensure that the legal environment is sufficiently clear, and sufficiently supportive, regarding both duties and constraints, in order to encourage appropriate, coherent C-ITS deployment.

4.2. Private sector developments

Cities cannot control the readiness of the market for C-ITS services. Whether they can plan practically a deployment will therefore depend on what progress is made in other sectors, particularly in the vehicle telematics industry.

At present there is little coherence among these industries. While European OEMs are now generally committing to have some form of C-ITS readiness in vehicles "from 2019", this is quite independent from development in (for example) the bus AVL market or the market for nav-aid apps. Some industries are wholly nascent – for example "telematics" for cyclists.

The pace of cities' C-ITS implementation will be strongly coupled to these other developments. Policymakers, in their promotion of a connected future, therefore need also to also consider these other areas when setting their expectations and designing interventions.

4.3. Developing the evidence base

A city's decision and planning to invest in C-ITS is likely to depend on the available evidence, in order to demonstrate that the planned investment is sustainable and cost-effective. Such evidence is limited at present, and it is easy for cities to dismiss the most C-ITS concepts as unjustifiable: having no proven benefit and being excessively risky.

It is beyond the ability of all but the largest cities to undertake speculative investment in C-ITS research on their own. Central authorities therefore have a critical role in gaining the necessary evidence. While this is already begun through programmes like Horizon 2020, it has to be a continuing process, and there will be a need for the foreseeable future to sustain, interpret and disseminate this evidence to cities.

4.4. Funding support

Some of the key risks that cities see with C-ITS are commercial ones: cities continue to feel their budgets are very tight, and see an inexorable rise in social costs with an ageing population, high unemployment, etc.

Some of these risks are cost-related: until supply market is more mature, and products more stable, long term costs are not very well understood. Other risks relate to the source of funding: not so much for the capital cost of equipment, but for the revenue costs of maintenance, operational services and staffing.

The provision of central funding support is a well-established approach to move innovations towards maturity. If cities believe that central funds might be made available for city C-ITS deployment, then they will be alert to those opportunities.

4.5. Implementation support

As well as the simple availability of cash, a second major concern is that cities do not have a clear technical view of what actual systems need to be put in place to deliver C-ITS effectively. While consultants can assist in this, they will also be on a learning curve as city C-ITS begin to be deployed.

In similar contexts, it has proven helpful to have a level of coordination to develop and promote good practice approaches: standard models for design, operation and integration. This may be delivered through a “centre of excellence”, a stakeholder network/forum, or a resource library – or a combination of the three.

This implementation support would best be organised to work with and through the established networks around Europe, including those that are predominantly city-focussed and those that are more technical.