



# Lessons learned and recommendations

Marleen Venken - Hogeschool PXL

October 2024



Co-funded by  
the European Union

[www.c-roads.eu](http://www.c-roads.eu)

# Lessons learned and recommendations

1

## Data Accuracy

Prioritise data accuracy and continuous map updates for reliable C-ITS operations.

2

## Collaboration

Facilitate seamless collaboration and trust establishment among stakeholders.

3

## Networked Ecosystem

Foster a networked C-ITS ecosystem with a long-term vision for advanced applications.

4

## Continuously develop, improve and expand C-road standards

Introduce C-Roads standards for truck access regulations, ensuring consistency and interoperability.

5

## User-Centric Design

Embrace user-centric design with cultural sensitivity, considering diverse user needs and attitudes.

6

## Feedback Mechanisms

Implement continuous user feedback and reporting mechanisms for ongoing system improvement.



# The ideal mobility ecosystem

Marleen Venken - Hogeschool PXL

October 2024



Co-funded by  
the European Union

[www.c-roads.eu](http://www.c-roads.eu)

# The future of transportation: A connected mobility ecosystem

Imagine a future where vehicles, infrastructure, and road users communicate seamlessly, creating a symphony of data and intelligence.

This is the vision of a connected mobility ecosystem.



# The foundation:

## Robust and secure platform

- Data integrity
- Confidentiality
- Overall system resilience
- Safeguards against cyber threats and unauthorised access

## Universal connectivity and standardisation

- Seamless communication and data exchange among vehicles, infrastructure, and road users is essential for real-time information sharing.
- Standardised communication protocols and universal connectivity

# Enhanced perception through connectivity

## Individual sensor limitations

Individual sensors, like cameras or radar, have limited range and can be affected by weather or obstacles.

## Collective awareness

By sharing real-time information from multiple sensors, connected vehicles can see further and react more quickly to hazards.

# Predictive capabilities and digital twins

## Digital twin ecosystem

A digital twin serves as a virtual representation of the physical ecosystem. This digital replica allows for data analysis, simulation, and prediction.

## AI-powered insights

AI algorithms analyse data from the digital twin to identify patterns and predict future events. These insights enable proactive adjustments.

## Proactive safety measures

With its computational power and ability to make adjustments, the digital twin proactively protects physical world elements, much like a guardian angel.

# Trust and identity management

## Trust labels

- issued by a trusted authority
- serve as digital certificates verifying the authenticity and trustworthiness of vehicles, infrastructure, and other participants
- act as digital passports

## Trust framework

- establishes clear rules and guidelines for interactions within the ecosystem
- outlines mechanisms for managing trust
- resolving conflicts
- ensuring fairness in data sharing and decision-making processes



# Collaboration for ecosystem development

1

## Government partnerships

Governments provide:

- the regulatory framework,
- infrastructure support
  - funding
- promoting public awareness
- addressing ethical and legal considerations

2

## Research institutions

Research institutions push:

- the boundaries of innovation,
- developing new technologies, algorithms, and communication protocols

3

## Private sector developers

Private sector developers bring:

- their expertise in engineering, design, and manufacturing to create the connected vehicles, infrastructure, and software applications
- making C-ITS solutions commercially viable

# A human-centred approach: Privacy, security, and accessibility



### Data privacy

- Anonymisation
- Pseudonymisation of personal data
- Individuals should be informed about the data being collected
- This promotes a culture of trust



### Robust security

- Strong security measures to protect the integrity and confidentiality of the data
- Including encryption, authentication, and access controls
- This ensures the secure operation of connected vehicles and infrastructure



### Universal accessibility

- Inclusive and accessible to all
- Universal design principles ensure that C-ITS solutions are usable by everyone, regardless of their abilities or disabilities.
- This approach promotes equity

# Addressing legal and ethical considerations

1

## Updated regulations

- Existing regulations need to be updated
- New regulations may need to be developed concerning data privacy, cybersecurity, liability, and the use of autonomous vehicles

2

## Ethical dilemmas

- Autonomous systems present ethical dilemmas, such as collision avoidance scenarios where the system must make split-second decisions with potentially life-altering consequences.
- Establishing clear ethical guidelines for these scenarios is essential

3

## Defining liability and accountability

- Accidents involving C-ITS technology raise questions of liability and accountability
- Legal framework that balances the roles of drivers, manufacturers, and infrastructure providers

# (Technical) challenges for implementation

## 1

### Communication Protocols

Protocols for real-time data exchange between elements.  
These protocols must be reliable, secure, and scalable.

## 3

### Scalability

Designing a scalable system: The infrastructure must be able to handle the massive amount of data generated by connected vehicles and infrastructure without compromising performance or security.

## 2

### AI Algorithms

AI algorithms for perception, prediction, and decision-making. These algorithms must be robust, reliable, and able to handle complex scenarios in real-time.

## 4

### Ethical Implications

Addressing the ethical implications of autonomous systems, such as liability and fairness.  
Clear guidelines and regulations need to be developed.



# User-centric implementation strategy

Marleen Venken - Hogeschool PXL

October 2024



Co-funded by  
the European Union

[www.c-roads.eu](http://www.c-roads.eu)

# A toolkit for municipalities:

## 7 essential steps for user-centric C-ITS implementation



# 7 essential steps for user-centric C-ITS implementation

BEFORE

DURING

AFTER

**Step 1**: Decision

**Step 2**: Design &  
implementation

**Step 3**: New role

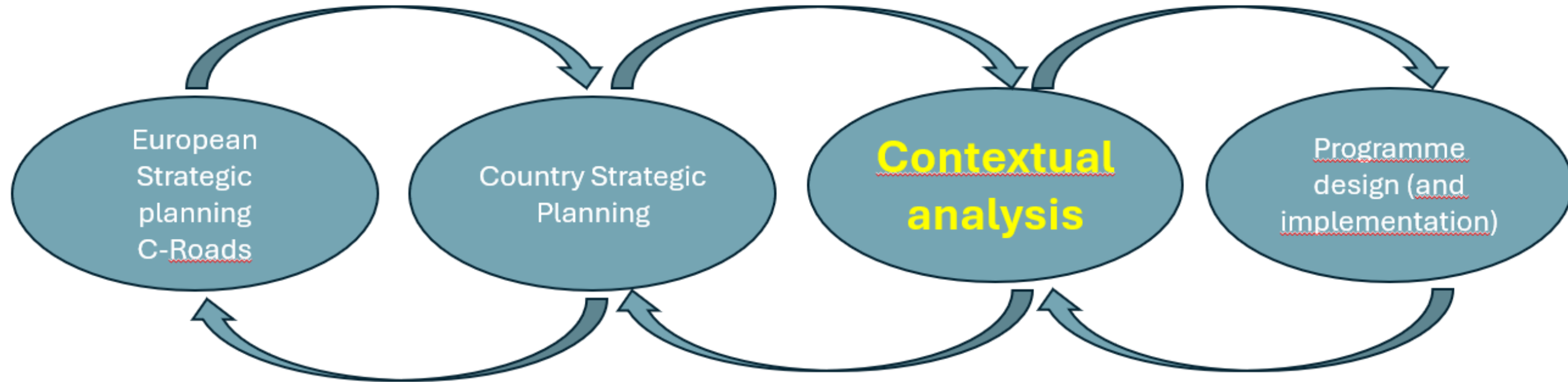
**Step 4**: Adoption &  
regulatory aspects

**Step 5**: Procurement

**Step 6**: Up-to-date map

**Step 7**: Continuous  
measurement

## Step 1: The decision whether or not to implement C-ITS





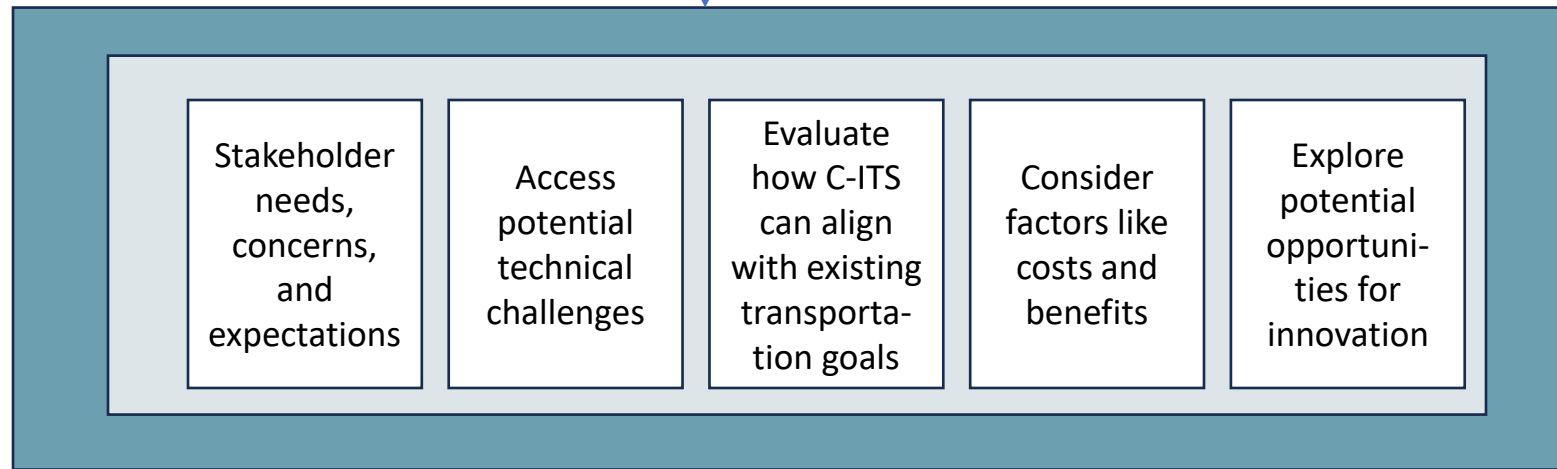
# Toolkit Step 1: Contextual analysis

## Define goals

- Define the boundaries of the area
- Set objectives

**Input:** collect data  
stakeholder interviews and surveys  
existing transportation plans and policies

## Contextual analysis



**Output:** synthesise information  
identify patterns and trends

## Blue print for the implementation

Model development: Create a visual representation of the local context with key relations

# 7 essential steps for user-centric C-ITS implementation

BEFORE

DURING

AFTER

**Step 1**: Decision

**Step 2**: Design &  
implementation

**Step 3**: New role

**Step 4**: Adoption &  
regulatory aspects

**Step 5**: Procurement

**Step 6**: Up-to-date map

**Step 7**: Continuous  
measurement

## Step 2: Design and implementation: A bottom-up approach

### Characteristics:

- involves various stakeholders, including citizens
- encourages experimentation and learning from mistakes

**Challenges** may include integration with outdated systems, data privacy and security, standardisation and interoperability, and stakeholder coordination.

### Operational models:

#### Living labs

Collaborative spaces for experimenting with C-ITS solutions in real-world settings.

#### Multi-stakeholder platforms

Forums for diverse groups to contribute ideas and feedback on C-ITS implementation.

#### Participatory budgeting

Give citizens the power to decide how to allocate public funds for C-ITS projects

#### Small scale pilot with iterative, agile development

Continuous refinement of C-ITS solutions based on user feedback and real-world performance.

## Step 3: The digital road manager: a new role

The digital road manager role demands a unique set of skills and expertise



### **Digital Infrastructure**

Expertise in managing and maintaining digital road systems.



### **Data Management**

Skills in handling large volumes of traffic and infrastructure data.



### **Security**

Knowledge of cybersecurity practices for protecting C-ITS systems.



### **Collaboration**

Ability to work with various stakeholders and technology partners.

# Step 4: Adoption and policy instruments

The Behaviour Change Wheel guide provides a theory-informed, evidence-based approach for designing context-appropriate interventions.

1

## Identify Behaviour

Determine the specific behaviour to change and target population.

2

## Diagnose

Use COM-B model to understand behaviour determinants.

## Behaviour change wheel

● Policy categories ● Intervention functions ● Sources of behaviour



## Step 4: Adoption and policy instruments

The Behaviour Change Wheel guide provides a theory-informed, evidence-based approach for designing context-appropriate interventions.

1

### Identify Behaviour

Determine the specific behaviour to change and target population.

2

### Diagnose

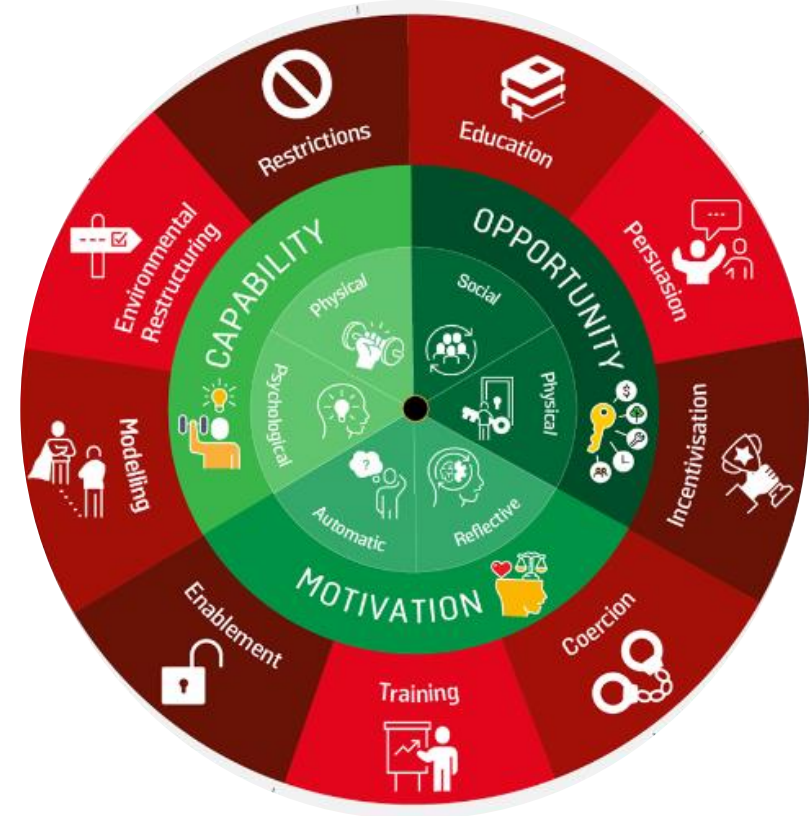
Use COM-B model to understand behaviour determinants.

3

### Choose Intervention

Select appropriate intervention function (e.g., education, persuasion).

Affordability  
Practicability  
Cost-Effectiveness  
Acceptability  
Safe



# Step 4: Adoption and policy instruments

The Behaviour Change Wheel guide provides a theory-informed, evidence-based approach for designing context-appropriate interventions.

1

## Identify Behaviour

Determine the specific behaviour to change and target population.

2













## Diagnose

Use COM-B model to understand behaviour determinants.

3

## Choose Intervention

Select appropriate intervention function (e.g., education, persuasion).

	 <b>Education:</b> Informing, explaining and showing <i>in order to</i> increase knowledge and understanding	 <b>Persuasion:</b> Highlighting, arguing, discussing, proposing, requesting, pleading or helping to imagine <i>in order to</i> influence attractiveness	 <b>Incentivation:</b> Introducing payment, some other extrinsic reward, or an expectation of a desired outcome, for a behaviour	 <b>Coercion:</b> Introducing a cost or expected negative outcome to prevent a behaviour or to induce someone to enact a behaviour	 <b>Training:</b> Demonstrating, supervising, providing feedback and supporting practice <i>in order to</i> improve mental or physical skills, or build habits	 <b>Restrictions:</b> Creating boundaries around what behaviours are and are not acceptable by setting rules	 <b>Environmental restructuring:</b> Introducing, removing or altering objects in the physical environment or shaping the social environment to prompt, facilitate or prevent behaviours	 <b>Modelling:</b> Providing examples of behaviour for people to aspire to or imitate	 <b>Enablement:</b> Providing or unproviding psychological, social or physical resources or treatments to support enactment of a behaviour
 <b>Physical capability</b>	✗	✗	✗	✗	✓	✗	✗	✗	✓
 <b>Mental capability</b>	✓	✗	✗	✗	✓	✗	✗	✗	✓
 <b>Physical opportunity</b>	✗	✗	✗	✗	✓	✓	✓	✗	✓
 <b>Social opportunity</b>	✗	✗	✗	✗	✗	✓	✓	✓	✓
 <b>Unconsciousness motivation</b>	✗	✓	✓	✓	✓	✗	✓	✓	✓
 <b>Reflective motivation</b>	✓	✓	✓	✓	✗	✗	✗	✗	✗





# Step 4: Adoption and policy instruments

The Behaviour Change Wheel guide provides a theory-informed, evidence-based approach for designing context-appropriate interventions.

1

## Identify Behaviour

Determine the specific behaviour to change and target population.

2

## Diagnose

Use COM-B model to understand behaviour determinants.

3

## Choose Intervention

Select appropriate intervention function (e.g., education, persuasion).

4

## Select Policy

Choose policy options (e.g., legislation, regulation).





# Toolkit Step 4: Adoption and policy instruments

1

## Identify Behaviour

Determine the specific behaviour to change and target population.

2

## Diagnose

Use COM-B model to understand behaviour determinants.

3

















## Choose Intervention

Select appropriate intervention function (e.g., education, persuasion).

4

## Select Policy

Choose policy options (e.g., legislation, regulation).

	 <b>Communication / Marketing:</b> Using print media, correspondence, broadcast media and social media to present text and images and in some cases offering an opportunity for interaction	 <b>Legislation:</b> Enacting and enforcing laws	 <b>Service provision:</b> Providing staff and resources such as mobile applications to support and enforce behaviour change	 <b>Regulation:</b> Creating and applying rules with sanctions for breaking them, short of legislation or by organisations that do not have the power to legislate	 <b>Fiscal measures:</b> Using financial rules to provide incentives or disincentives	 <b>Guidelines:</b> Writing instructions and advice and mounting a campaign to get these accepted and put into practice	 <b>Environmental / social planning:</b> Using formal planning mechanisms to create supportive physical and social environments
 Education	✓	✓	✓	✓	✗	✓	✗
 Persuasion	✓	✓	✓	✓	✗	✓	✗
 Incentivation	✓	✓	✓	✓	✓	✓	✗
 Coercion	✓	✓	✓	✓	✓	✓	✗
 Training	✗	✓	✓	✓	✓	✓	✗
 Restriction	✗	✓	✗	✓	✗	✓	✗
 Environmental restructuring	✗	✓	✗	✓	✓	✓	✓
 Modelling	✓	✗	✓	✗	✗	✗	✗
 Enablement	✗	✓	✓	✓	✓	✓	✓



# Step 4: Adoption and policy instruments

The Behaviour Change Wheel guide provides a theory-informed, evidence-based approach for designing context-appropriate interventions.

## Identify Behaviour

1 Determine the specific behaviour to change and target population.

## Diagnose

2 Use COM-B model to understand behaviour determinants.

## Choose Intervention

3 Select appropriate intervention function (e.g., education, persuasion).

## Select Policy

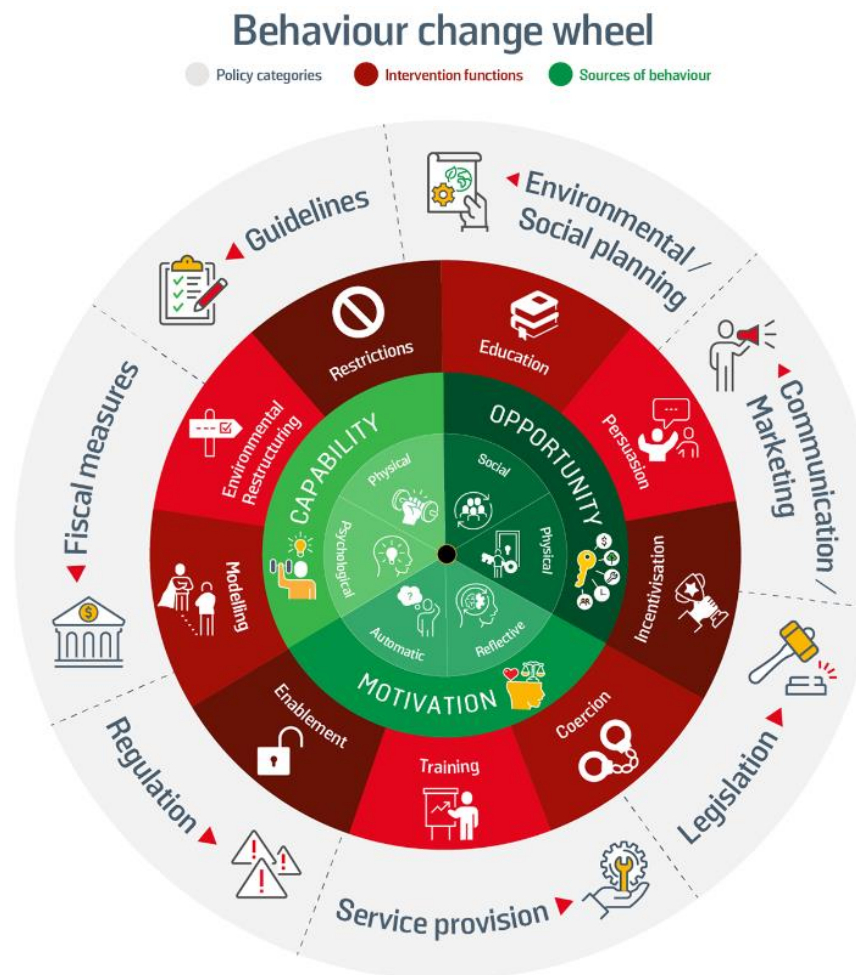
4 Choose policy options (e.g., legislation, regulation).

## Build Intervention

5 Develop the specific intervention strategy.

## Implement & Evaluate

6 Deploy the intervention and assess its effectiveness.



## Step 5: Procurement strategy

Local authorities can utilise their procurement power to stimulate the uptake of C-ITS solutions and services.

### Market Pull

By including C-ITS in procurement requirements, local authorities create demand for these technologies, encouraging development and innovation.

### Cost Reduction

Consolidating demand across multiple municipalities can lead to economies of scale, reducing the overall cost of C-ITS implementation.

### Innovation Stimulus

Strategic procurement can encourage providers to develop more advanced and efficient C-ITS solutions to meet specific municipal needs.

# 7 essential steps for user-centric C-ITS implementation

BEFORE

DURING

AFTER

**Step 1**: Decision

**Step 2**: Design &  
implementation

**Step 3**: New role

**Step 4**: Adoption &  
regulatory aspects

**Step 5**: Procurement

**Step 6**: Up-to-date map

**Step 7**: Continuous  
measurement

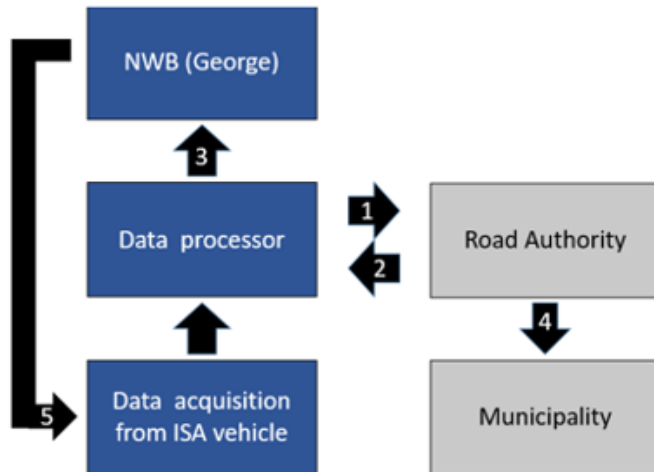
## Step 6 & 7: Keep the system up-to-date

1

2

### Up-to date digital map

- ISA data feedback loop



### Continuous stakeholder measurement

- Regular surveys
- Performance metrics
- Feedback channels
- Stakeholder meetings



# Thank you!

Marleen Venken - Hogeschool PXL  
marleen.venken@pxl.be

October 2024



Co-funded by  
the European Union

[www.c-roads.eu](http://www.c-roads.eu)