CRISIS MANAGEMENT IN URBAN TRANSPORT SYSTEMS

Navigating multiple risks and threats in times of global uncertainty

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tumi Transformative Urban Mobility Initiative

FOREWORD

The accelerated pace of multiple crises is confronting transport systems with unprecedented impacts. The strong variations in fuel supply and demand because of the COVID-19 pandemic or volatile energy prices coming along with military conflicts, show significant impacts on the transport sector and supply chains. Ever increasing extreme-whether events such as flooding and heatwaves, temporary blackouts or cyber-attacks impact the normal operation of public transport likewise.

The impacts of multiple shocks and crisis are putting passenger mobility, delivery of essential goods and production inputs, and basic urban services in danger. The sector needs to undergo a fundamental transformation not only to meet sustainable development and climate targets, but to maintain basic economic and social functions in the short- and long-run.

We observed during the pandemics, that cities with well-established cycling infrastructure have been coping impressively with the consequences of the pandemics, such as the need for social distancing. Mayor cities such as Bogotá, Mexico City or Berlin have been responding quickly by creating pop-up bike lanes, alleviating pressure from public transport for those who still needed to travel to keep up basic services.

Well established walking & cycling networks, policy-centric planning and decentralized distribution of goods are examples for a variety of policy and infrastructure measures contributing to the resilience of urban transport systems. More systemically, all relevant actors need to understand the impact of local and global risks on urban transport systems and prepare accordingly. Governments, municipalities, businesses, and transport operators worldwide are seeking guidance to reduce the dependency of their transport systems on fossil fuels, manage crisis and embark on the transition towards sustainability. Well established walking & cycling networks, policy-centric planning and decentralized distribution of goods are examples for a variety of policy and infrastructure measures contributing to the resilience of urban transport systems.

On behalf of the Federal Ministry of Economic Cooperation and Development (BMZ) under the Transformative Urban Mobility Initiative (TUMI) we initiated this study in 2022. We wanted to identify strategies for dealing with fuel-related crisis (which affected countries worldwide at the time). During the literature research, we noticed a huge lack of accessible guidance for decision-makers and professionals. Soon, we saw the need for a more systematic approach to dealing with multiple risks and threats.

With this publication, we propose a conceptual framework for crisis management and highlight proven measures already being implemented by cities and transport operators worldwide. Our aim is to strengthen the capacity of decision-makers and professionals, particularly in developing and emerging economies, to build more resilient, inclusive, and sustainable urban transport systems.

We invite you to explore and apply these insights in your specific context!

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1 CONTEXT

Crises in the transport sector – the panorama

Transport systems have been confronted by multiple crises in the last years, such as the COVID-19 pandemic, armed conflicts, and the climate emergency or blackouts, with unprecedented impacts. Due to its reliance on fossil fuels, which covered more than 90% of the sector's energy demand in 2020, the strong variations in fuel supply and demand because of the pandemic, and the volatile energy prices after Russia's attack on Ukraine hit urban transport systems hard. As a result of these multiple crises at an accelerated pace and an expected prolonged energy market volatility, the resilience of transport systems needs to be increased.

Nonetheless, the transport sector is facing further challenges: being responsible for more than a quarter of the energy-related greenhouse gases, with the fastest growing fuel consumption of all sectors, the transport sector needs to decarbonise and undergo a profound transformation to respond to the climate crisis. On the other hand, more and more climate risks are expected to materialise in the next years, affecting also transport infrastructure.

But how can decision makers, transport operators and logistics companies prepare for crises, manage them, and build resilience? This study based on research and expert interviews outlines measures and strategies how to respond to crises based on a management framework, how to prepare for short- and long-term actions, and how to mitigate impacts.

Fossil-fuel dependency of transport systems and the consequences

Global crises have led, inter alia to increasing volatility in fuel markets, with far-reaching consequences for the transport sector, which is still heavily dependent on fossil fuels. According to the International Energy Agency (IEA), transport is responsible for almost 60% of global oil consumption[1].

In 2020, the COVID-19 pandemic reduced mobility demand due to lockdowns, which resulted in a significant slowdown of the global oil demand. This led to a demand shock and oversupply, triggering a sharp decline in oil prices as shown Figure 1, even reaching negative values for the first time in history.

1 IEA - World Energy Outlook 2022

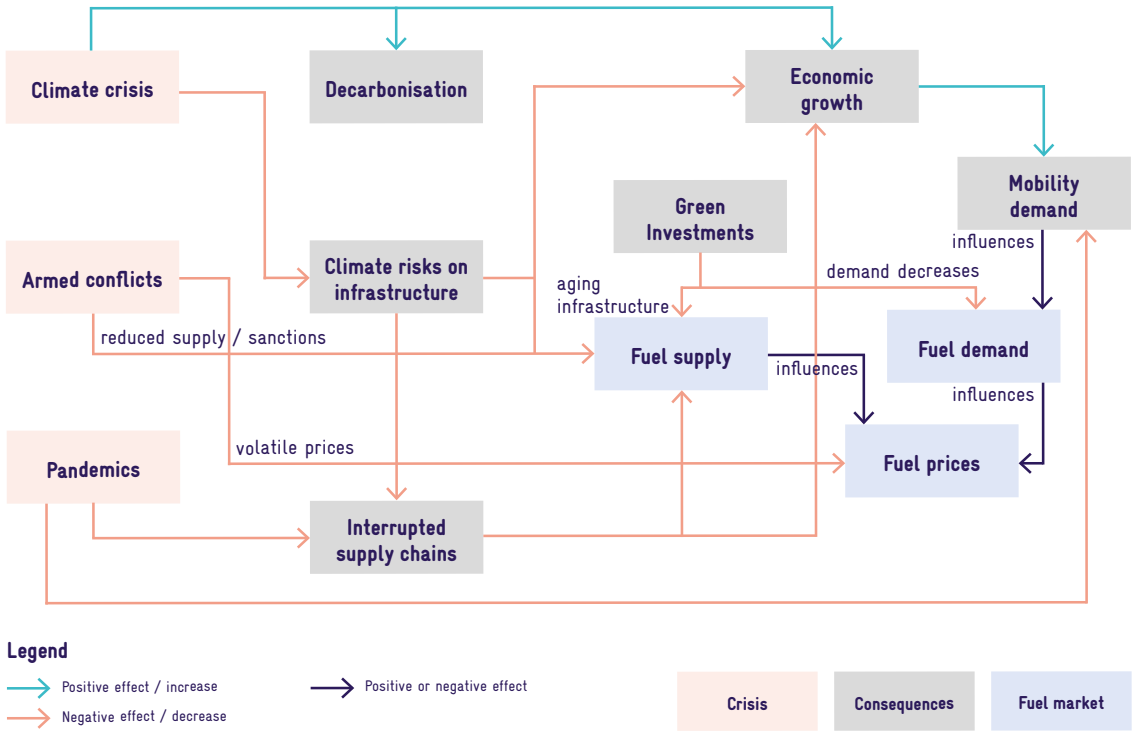
Figure 1 West Texas Intermediate Crude Oil Prices (Source: Macrotrends)

OPEC countries therefore decided to cut oil production, to firm up the prices. Furthermore, the pandemic interrupted supply chains, with negative impacts for economic growth and freight costs. However, in 2021, as containment measures were eased and the recovery from the pandemic began, global oil demand started to rebound, resulting in increasing fuel prices.

When Russia started its attack on Ukraine on 24th February 2022, the overlapping impacts of both crises became apparent. Due to the reduced OPEC production, oil inventories were diminishing, and as a reaction to Russia's aggression against Ukraine the international community implemented import sanctions, to reduce the country's trade profit, considering that Russia had been the largest exporter of fossil fuels worldwide. These circumstances destabilised global energy markets, with highly volatile energy prices. To alleviate the situation, in April 2022, countries belonging to the IEA decided to release emergency reserves. This action brought some temporary calm to the markets, and prices have returned to the pre-conflict-level.

However, it is important to note that in the upcoming years, we can still expect significant shocks in the fossil fuel industry. These shocks can arise from ongoing international conflicts, increased global economic interdependence, changing demand as we transition to a low-carbon economy, and natural disasters, inter alia caused by the climate crisis. In part, the impacts of crisis may also overlap and have opposite effects: while efforts for decarbonisation of the transport sector can spur economic growth, a delay in doing so might also increase the risk of an economic shock in the future and add further climate risks on infrastructure. Thus, decarbonisation can lead to a dilemma for oil-producing countries, as many countries and investors find it difficult to invest in new oil production facilities that may remain idle. In addition, aging infrastructure might not keep up at the short notice with current demands and become less productive over time as more repairs will be necessary – therefore increasing the probability for further supply shortcomings and prices shocks.

Figure 2 Consequences of crisis on fuel markets



In developing and emerging economies, the impact of sudden shifts in oil supply and prices is particularly challenging. Limited financial resources and inadequate infrastructure make it difficult to handle increased transport costs and absorb price hikes for essential goods. These circumstances can lead to fuel shortages and higher prices, which have significant consequences for businesses and the population. Access to education and job opportunities may be compromised, posing additional difficulties.

Moreover, the rising population and income levels in developing and emerging countries are driving a greater need for transport. By 2050, it is projected that non-OECD countries will experience a 2.4-fold increase in urban passenger travel, resulting in a surge in energy demand. This trend could worsen the vulnerability of these countries to sudden fuel price shocks if they do not reduce their reliance on fossil fuels.

In the face of multiple crises and the anticipated volatility of energy markets, it becomes imperative for urban transport systems to enhance their resilience. To navigate these challenges effectively, it is crucial to incorporate crisis management and prevention strategies as part of a broader transformation of the transport sector. This transformation should encompass efforts to decarbonize and adapt to the impacts of climate change. By embracing these strategies, we can pave the way for a more resilient future.

METHODOLOGY OF THE STUDY

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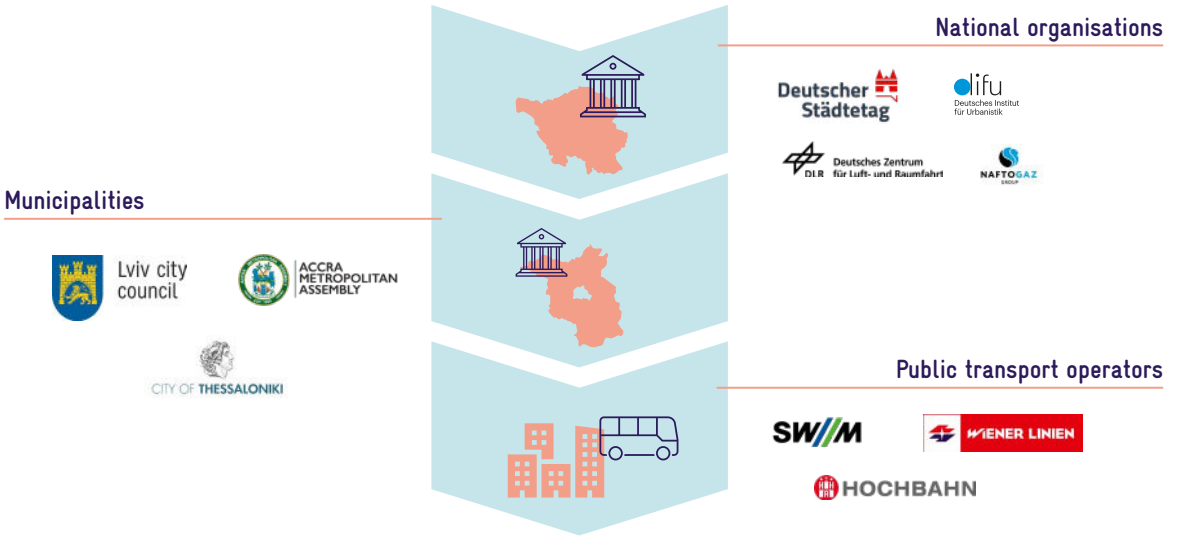
The purpose of this study is to provide practical guidance and strategies for dealing with crises in urban transport systems. To ensure resilience in the event of crises, actors need to understand the impact of specific local and global risks on urban transport systems better and prepare accordingly. In order to provide recommendations on how to respond to crises, how to prepare for mid-term scenarios, and how to build more resilient transport systems in the long term, a qualitative research and expert interviews were conducted.

The qualitative research involved a systematic review of existing literature on fossil fuel dependency in the urban transport sector, including underlying trends and existing crisis management approaches and measures. The research served as a guide for the selection of suitable interview participants and the development of the interview questions.

Expert interviews were conducted with actors of urban transport system from different countries, including national organisations, municipalities, and public transport operators (See Figure 3). The selection of the experts was based on their experience and expertise in the field of urban transport and crisis management.

Figure 3 Overview of the interview partners

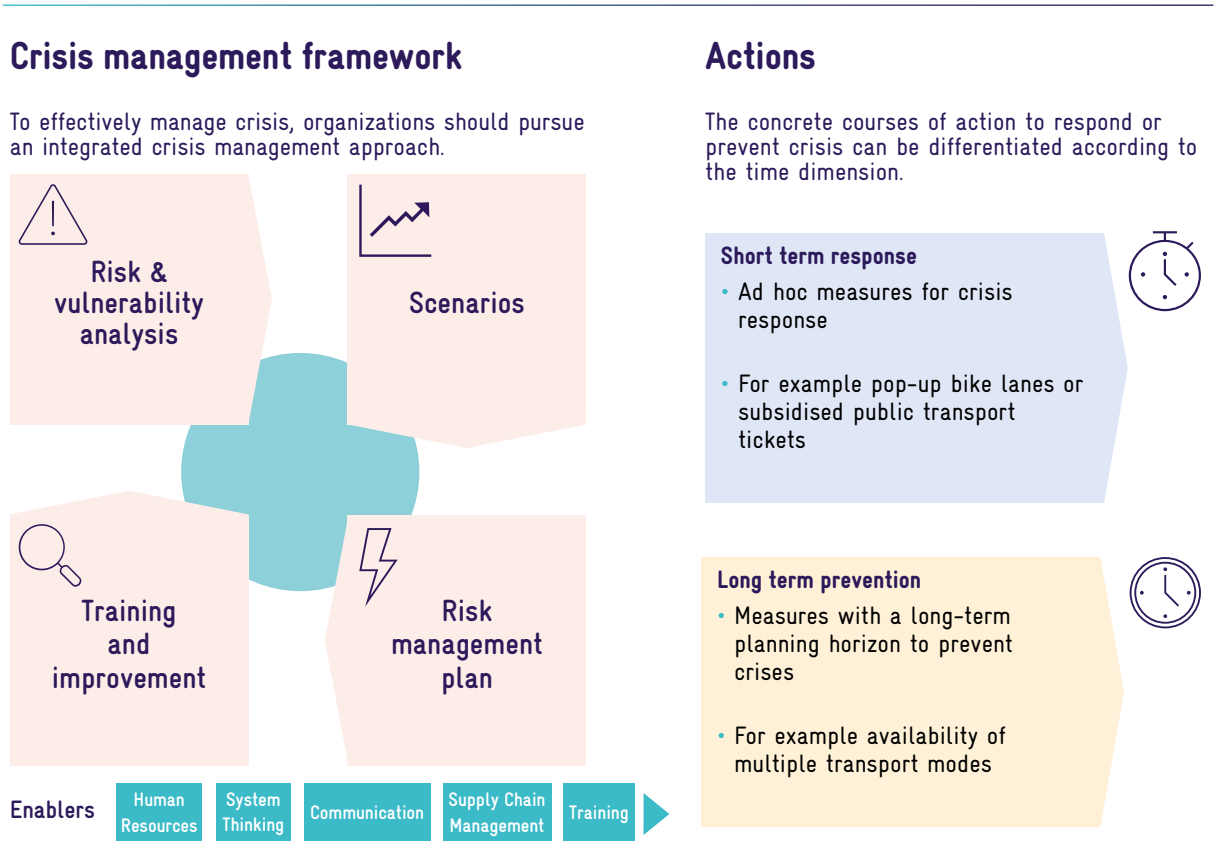


The interviews were carried out using a semi-structured interview protocol. This approach allowed for a flexible interview format that enabled interviewees to present their perspectives and experiences on crisis management while assuring that all essential areas were covered. The questionnaire was divided into a general part addressing the degree of preparedness for crises as well as existing learning experiences and a specific part which was designed to gather information on concrete measures for crisis management, including strategies to reduce fossil fuel dependency and increase the resilience of urban transport systems. The interviews were conducted via video conferences, with a duration of 60 minutes to 90 minutes. Some interview partners provided additional complementary material.

The derived recommendations from the expert interviews and the literature research were categorised into three dimensions within the scope of the study (see Figure 4):

- **Crisis management framework:** The dimension subsumes recommendations for action that enable organizations to deal appropriately with crises and build resilience. This includes for example identifying potential risks and vulnerabilities, developing crisis plans and training staff.
- **Short term response:** Practical guidelines within this category refer to short-term measures that can be taken promptly in the event of a crisis. These include short-term prioritization measures such as giving priority to public transport in the supply of fossil fuels.
- **Long term prevention:** The recommendations in this dimension aim to improve the resilience of urban transport systems. This includes strategic medium- to long-term approaches to minimize the impact of potential crises.

Figure 4 Crisis management framework and actions



DEALING WITH CRISIS IN URBAN TRANSPORT SYSTEMS

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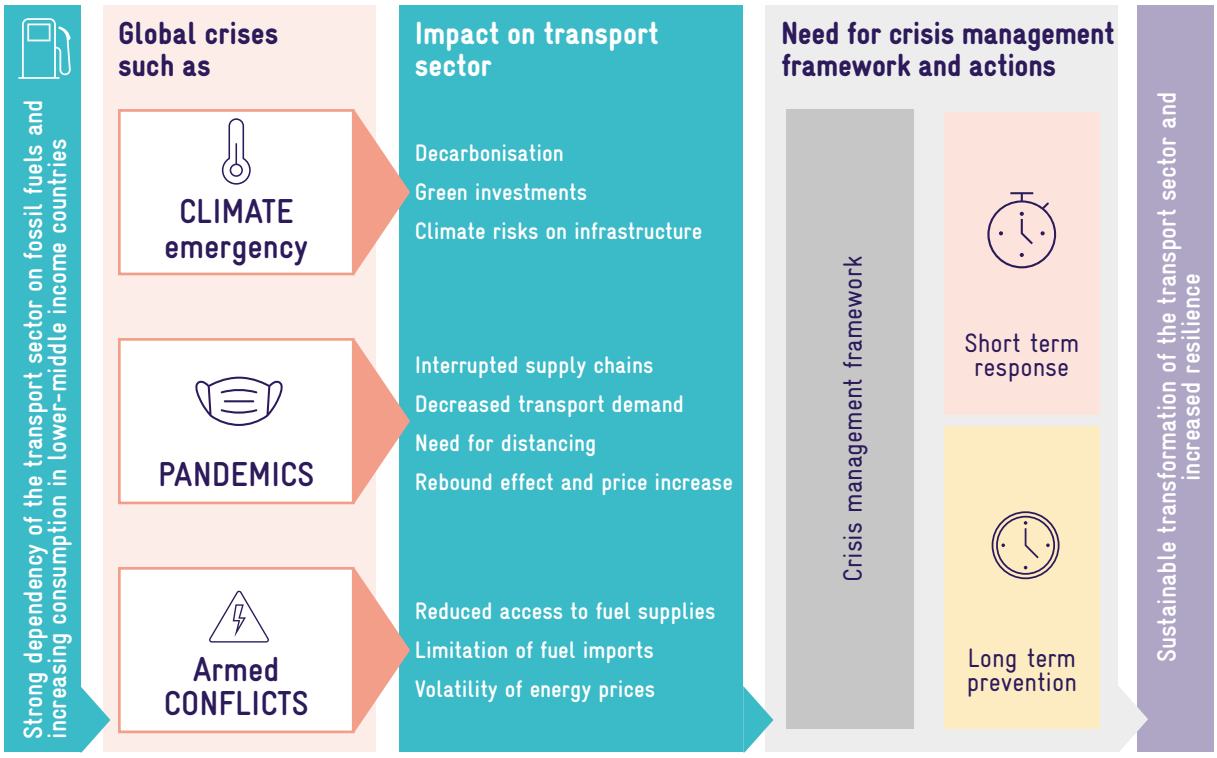
Figure 5 Context of crisis on urban transport systems



3.1 Crisis management framework

Comprehensive crisis management frameworks aim at preventing or mitigating the damage a crisis can inflict on a transport system. Due to the uniqueness of crisis, organisational structures for coordination, communication systems and a scalable crisis management need to be set up to allow for fast and flexible responses.

To effectively manage crises, organizations should pursue an integrated crisis management approach with four steps that builds on human resources, information systems, communication, supply chain management, training, and organisational structures as enablers to respond effectively to a crisis.

1. The first step for cities, transport operators and businesses is to identify potential risks, that in the event of local or global crisis impede the normal functioning of transport systems, such as fossil fuel supply disruptions, price fluctuations, or environmental disasters. In addition, vulnerability analysis is conducted to identify weaknesses of the transport system.
2. After the risks and weaknesses of the transport system are identified, the next step is to perform a scenario analysis to determine how these threats might develop during a crisis. Within this analysis, the severity, likelihood, and impact on the transport system of each scenario is assessed.
3. This output is then used to develop a risk management plans with staff structures, responsibilities, and communication plans to address the identified vulnerabilities. For each identified scenario specific action are tailored.
4. In subsequent steps, an organisational structure with clear responsibilities needs to be set up and a crisis-resistant communication system with dedicated communication protocols is established to ensure effective communication between all stakeholders and enable a proper cooperation.

Depending on the actor and crisis management maturity level, the crisis management framework may include Business Continuity Management (BCM) with emergency plans and crisis training, robust procurement, collaborative crisis management, resilience departments in municipalities and knowledge exchange between stakeholders.

3.2 Short term response

Crisis management frameworks always have a short-term scope to alleviate crisis consequences. The main goal is to reduce the negative effects of a crisis, such as disruptions to the transport system, economic losses, and social instability. The possible measures can be clustered in supply side measures and demand side measures.

Typical supply side measures that governments might implement are subsidies such as fuel discounts or reduced public transport fares, price controls, fuel prioritisation for public transport and emergency services, and the release of emergency reserves to ensure that essential services and industries continue to function. Subsidies may temporarily soften the effect of the crisis but can have adverse impacts as they are increasing the demand despite of supply shortages. They can therefore have an impact on competition and trade by distorting market signals, which can lead to inefficiencies, price alterations, and lack of incentives. Subsidies also imply opportunity costs of public funds, which could be used alternatively for long term investments in resilience. Thus, subsidies for fossil fuels can inhibit the expansion of sustainable energy sources, as companies see no need to perform a fast transition. Lastly, incentives to build new fossil fuel infrastructure can have locked in effects and refrain countries from decarbonising.

Furthermore, governments can implement measures to reduce the demand for fossil fuels. These measures include the implementation of pop up bike lanes to promote active mobility as well as measures such as public transport fare reduction to encourage people to switch from private motorized transport to public transport.

In March 2022, the International Energy Agency (IEA) published the following 10-point plan to reduce oil consumption in the transport sector within a rapid 4-month action approach:

1. Reduce speed limits on highways by at least 10 km/h
2. Work from home up to three days a week where possible
3. Car-free Sundays in cities
4. Make the use of public transport cheaper and incentivise micro-mobility, walking and cycling
5. Alternate private car access to roads in large cities
6. Increase car sharing and adopt practices to reduce fuel use
7. Promote efficient driving for freight trucks and delivery of goods
8. Using high-speed and night trains instead of planes where possible
9. Avoid business air travel where alternative options exist
10. Reinforce the adoption of electric and more efficient vehicles

The report and infographic are available under the following link in several languages: **https://www.iea.org/reports/a-10-point-plan-to-cut-oil-use**

It's important to note that the response measures to a fossil fuel crisis depend on the severity and duration of the crisis, as well as the specific country or region where the crisis is occurring.

3.3 Long term prevention

Crisis management frameworks aim at making urban transport systems more resilient towards different sorts of crisis by implementing system-wide transformative actions. In contrast to the crisis response, this approach is more strategic and requires a long-term perspective as well as a commitment to ongoing innovation and adaptation. All stakeholders must continually monitor the effectiveness of their crisis prevention measures and be willing to adjust their strategies as needed in response to changing circumstances and emerging risks. This preventive approach enables serious consequences to be mitigated.

The long-term prevention measures identified in this study range from diversified energy supplies, increasing fuel storage capacities to sustainable urban mobility plans which promote active mobility and make urban transport systems more resilient to volatile fossil fuel prices in the long term. In addition, specific push measures are addressed to convince society to switch from private motorised transport to public transport. These include parking management schemes, unfavourable pricing, prioritisation, and the reallocation of road space in favour of public transport.

Other possible crisis prevention actions are electrification of bus fleet, diversifying energy supplies for transport, energy use optimisation of urban transport systems and public transport priority schemes.

THE WAY FORWARD – OVERVIEW OF MEASURES

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In the following chapter we provide an overview of a set of measures for crisis management in urban transport systems that can be taken to increase resilience and reliability of urban transport systems. Disruptions in urban transport system triggered by crises can lead to serious consequences, affecting the quality of life for citizens. Effective crisis handling is therefore essential to minimise negative impacts of potential crises and ensure a fast recovery.

The approach is structured into three dimensions:

1. Crisis Management Framework (see 4.1.)
2. Short-term response (see 4.2)
3. Long-term prevention (see 4.3)

The Crisis Management Framework is based on an organisational perspective and is complemented by short-term actions to respond to crises and long-term actions aimed at preventing them.

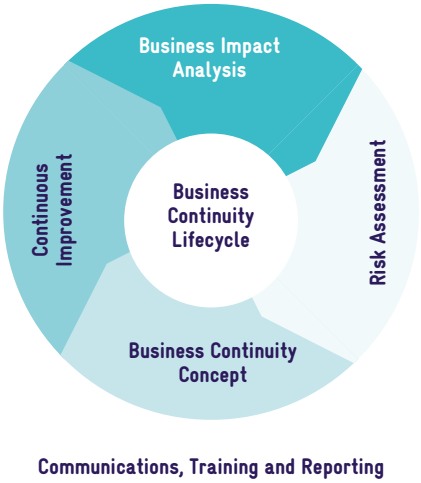
These measures have been developed based on expert interviews and additional research, with a focus on improving preparation, response, and management of transport-related crises. The chapter presents a range of approaches while raising no claim to completeness, including emergency planning and communication strategies, sustainable technologies, and active mobility concepts that can be taken to ensure the resilience of urban transport systems.

4.1 Establishing a crisis management framework

4.1.1 Business Continuity Management (BCM)

BCM is a management process that identifies potential threats and their impact on urban transport operations. By integrating several disciplines such as business impact analysis, risk assessment, business continuity concepts, and more, BCM provides a structured framework for building an enterprise's resilience with the ability to respond effectively to crisis that may endanger their operability. BCM is not limited to short-term responses to crises but should be part of an organization's longer-term corporate strategy. It involves the establishment, implementation, operation, monitoring, control, maintenance, and improvement of a

Figure 6 Business Continuity Lifecycle



Business Impact Analysis
- Identification of critical processes of the business
- Gathering of data to understand the system and dependencies
- Prioritisation and definition of criticality of business functions
- Definitions of recovery targets

Risk Assessment
- Identification of risks
- Assessment of risks based on likelihood and impact
- Evaluation of vulnerabilities of the transport system
- Grouping of risks and scenarios

Continuous Improvement
- Continuous improvement trough trainings and exercises
- Integration of concept into organisational structures to ensure functionality

Business Continuity Concept
- Development of strategies and emergency plans per function necessary to sustain operations, including a cost-benefit analysis
- Implementation of concept with sequences, tasks and responsibilities
- Set up of process organisation and communication channels

(Own illustration based on Carnegie Mellon University (2023))

management system that includes planning activities, allocation of responsibilities, various procedures, processes, and resources within the organisational structure of the enterprise. (Buganova et al. 2021, Tucker 2015)

Goal:

The purpose of Business Continuity Management is to prepare for, provide and maintain controls and capabilities for managing an organisation's overall ability to continue to operate during disruption due to an emergency.

Approach:

1. Plan: Establishment of business continuity policy, objectives, targets, and processes in accordance with the organisation values.
2. Do: Implementation of the identified processes, which includes putting in place preparedness, response, and mitigation programs, conducting risk and business impact analysis.
3. Check: The Checking stage involves monitoring and reviewing the implemented processes, identifying gaps, and determining the effectiveness of the continuity strategies and resources.
4. Act: In the Act stage, it is important to use the information gathered from the Checking stage to identify areas for improvement in the business continuity approach. This may involve modifying existing processes, developing new strategies and resources, providing additional training to personnel, or reallocating resources to better support the continuity plan.

Figure 6 illustrates the business continuity cycle based on key elements:

1. Business Impact Analysis: Identification of critical processes (e.g., staff management, resource management)
2. BCM-Risk analysis: Evaluation of risks and vulnerabilities (e.g., dependence on specific suppliers, new regulatory framework)
3. Business Continuity Concept: Strategies and measures for standardised emergency procedure
   - Development of specific emergency plans for scenarios with highest risk and impact on transport operations including
4. Improvement of BCM: Awareness through training and practice
   - Conducting the training program as well as embedding crisis management in operational routine

4.1.2 Crisis management

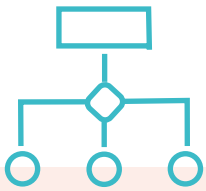
Crisis management is a process of crisis handling and preventing the occurrence of crisis and taking action to mitigate the damage a crisis can inflict on a transport system. A crisis can be defined as a situation of instability or danger with potential adverse impacts on society.

Due to the uniqueness of crisis, organisational structures for coordination, communication systems and a scalable crisis management should be set up to allow for flexible responses.

Figure 7 Fundamental components regarding functional crisis management

Crisis resistant communication

- Promptness (active and early)
  - Implementation of a communication network and standardised information processing
  - Establish clear line of communication between relevant stakeholders
- Truthfulness (factual, transparent)
  - Warning rules (external, internal) clearly regulated by dedicated organizations
- Comprehensibility (short, simple, straightforward, pictorial)
- Consistency (uniform, coordinated and continuous)



Organisational structure with clear responsibilities

- Crisis team is divided into individual staff sections with associated tasks
- Crisis Team Leader
  - Decision function
- Crisis Management Team
  - Specific competencies for the implementation of measures
- Selective engagement of consultants, if special knowledge is necessary
- Regulation of all aspects related to human resources

Crisis management with different escalation levels

- Crisis organisation (crisis team, task force, situation centre)
- Latent crisis phase report early warning systems
  - Existing concepts must be adapted with expected crisis scenario
- Acute crisis, alerts are sent to all authorities
  - Entire crisis team is ensured operationally and strategically
- Impact: local vs global
- Internal crisis vs. crisis for the entire municipality or region

Goal:

The goal of crisis management in urban transport systems is to ensure the functionality of the transport systems in case of a crisis and minimise negative impacts on the society.

Approach:

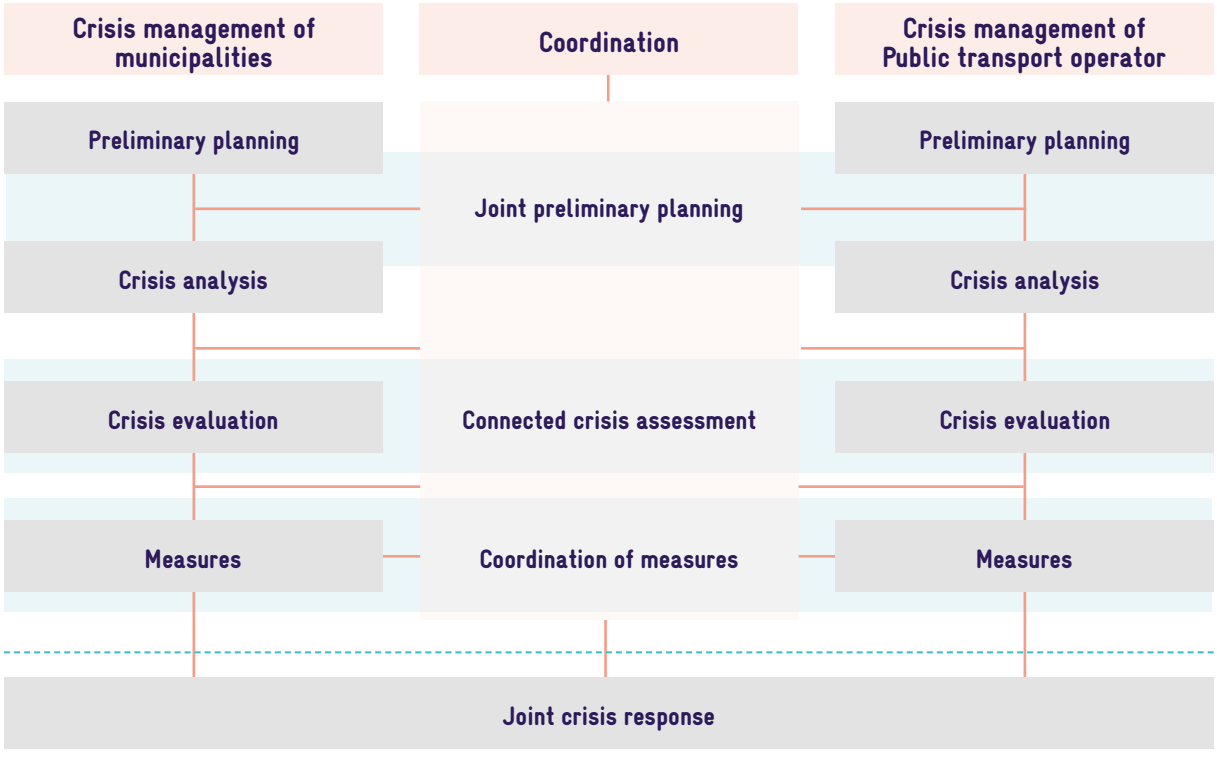
1. Comprehensive understanding of the potential risk and vulnerabilities of the transport system and its elements.
2. Development of response procedures to mitigate the impact of a crisis. This includes the implementation of a crisis-resistant communication system with established communication protocols that ensure effective communication between all stakeholders.
3. Establishment of an organisational structure with clear responsibilities for crisis management.

Regarding public transport systems, functional crisis management consists of three components: crisis-resistant communication, clear organisational structures, and responsibilities, and differentiated crisis management based on the escalation level of the crisis. The respective parts of the three components are shown in Figure 7.

4.1.3 Collaborative crisis management

Collaborative crisis management can be considered as an extension of the organisational crisis management and is usually initiated by the municipality. Within collaborative crisis management, multiple stakeholders such as municipalities, police, fire, emergency medical

Figure 8 Harmonization process in integrated crisis management



services, and community services work together to prepare for, respond to, and learn from a crisis.

Goal:

The goal of collaborative crisis management is to improve the overall effectiveness and efficiency of the crisis response by ensuring that all stakeholders work together in a coordinated and cohesive manner. In addition, the collaborative approach allows the expertise and resources of all stakeholders to be leveraged.

Approach:

1. Establish clear communication channels to ensure quick and efficient exchange during a crisis.
2. Develop joint response plans that define specific responsibilities for the different stakeholders.
3. Conduct regular training and exercises to identify vulnerabilities and potential for improvement in the collaborative crisis management approach.
4. Share information and resources to best prepare for potential crises and learn from individual experiences.

As part of the collaborative crisis management approach in urban transport systems, the crisis management of municipalities and urban transport operators is often linked. Thereby, the focus is on joint pre-planning, crisis assessment and coordination of measures in order to mitigate crises for the urban transport system in the best possible way (see Figure 8).

Excursus: Urban Resilience

Urban resilience is becoming more and more important in the face of a rapidly changing, connected, and urbanised world. Resilience generally refers to the ability to cope with and adapt to difficult situations and crises such as climate change, while urban resilience entails the capacity to effectively manage the multitude of risks and challenges that cities face.

To ensure urban resilience, cities must align their infrastructure, organisations, and policies. This means having the necessary economic, and social resources to prepare for, respond to, and recover from shocks and crises. Furthermore, cities should strive to build partnerships with other cities and regions to share best practices, resources, and solutions. By taking these measures, cities can strengthen their resilience and be better prepared to cope with future challenges.

In 2013, the Rockefeller Foundation developed a City Resilience Framework (See Figure 9) that can be used as a tool to capture and discuss the resilience strengths and weaknesses of cities. It is based on four dimensions that are essential to any city's urban resilience:

1. Health and wellbeing of individuals (people)
2. Urban systems and society (organisation)
3. Economy and society (organisation)
4. Leadership and strategy (knowledge)

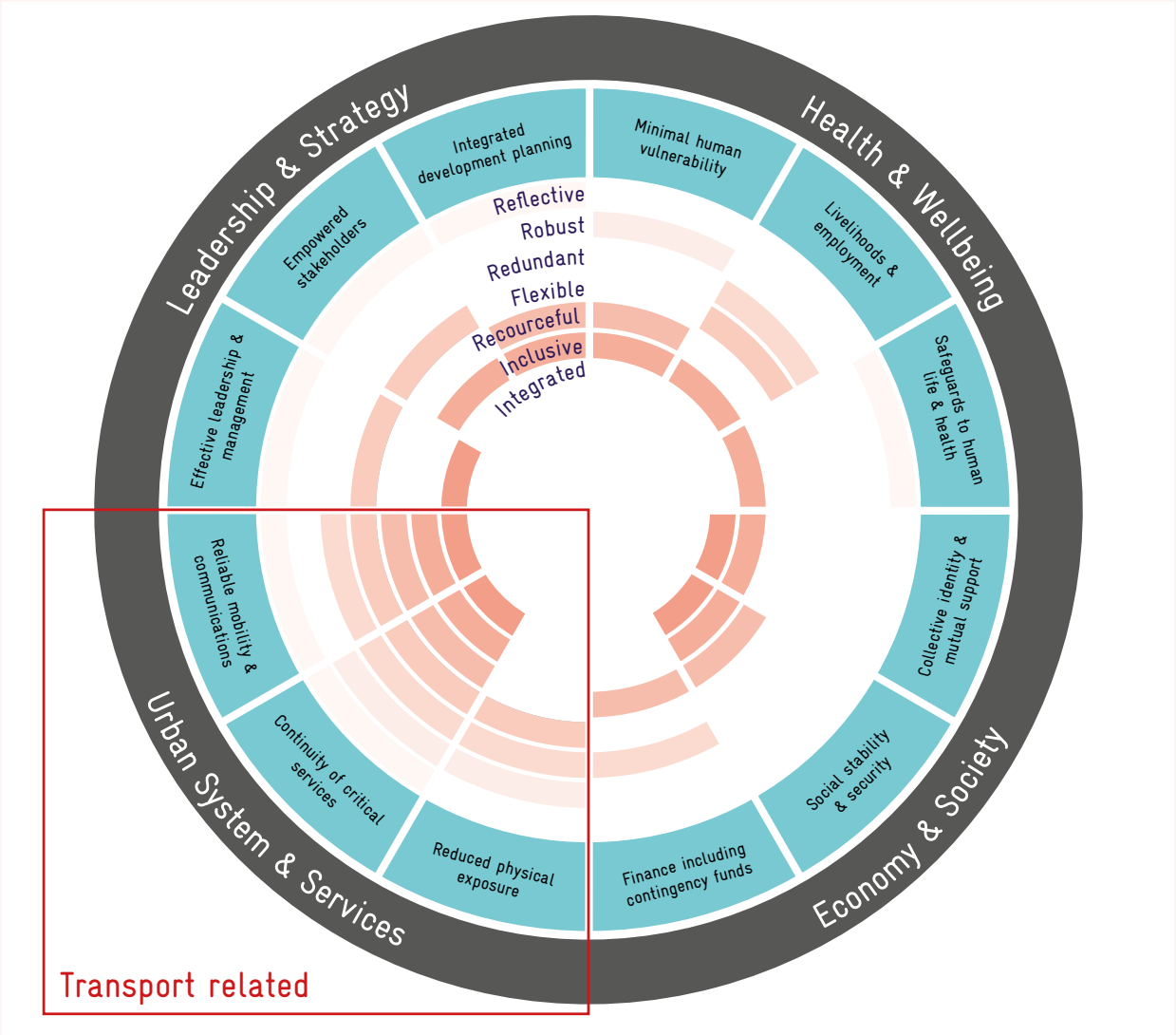
Each of the four dimensions is further defined by additional resilience factors. In the context of this study, primarily the urban system and services part is relevant, as it is directly related to urban transport systems. A resilient urban system is defined by the following qualities:

- **Reflective:** Reflective systems are adaptable to the constantly changing and uncertain nature of the world by continuously evolving and modifying their standards.
- **Robust:** Robust systems include well, constructed, and managed physical assets, so that they can withstand the effects of crises without significant damage or loss of function.

- **Redundant:** System redundancy refers to the purposeful creation of spare capacity within a system so that they can accommodate disruption, extreme pressures or increases in demand.
- **Flexible:** Flexibility means that systems have the ability to modify, adapt and transform themselves in reaction to varying situations and conditions.
- **Resourceful:** Resourcefulness refers to the capacity of individuals and organizations to quickly discover alternative methods to accomplish their objectives or satisfy their requirements in the face of a sudden or stressful event.
- **Inclusive:** Inclusion highlights the importance of involving and consulting a wide range of communities, including the most vulnerable groups, in decision-making processes.
- **Integrated:** Integration and alignment among urban systems ensure coherence in decision-making and guarantee that all investments are mutually reinforcing towards a shared objective.

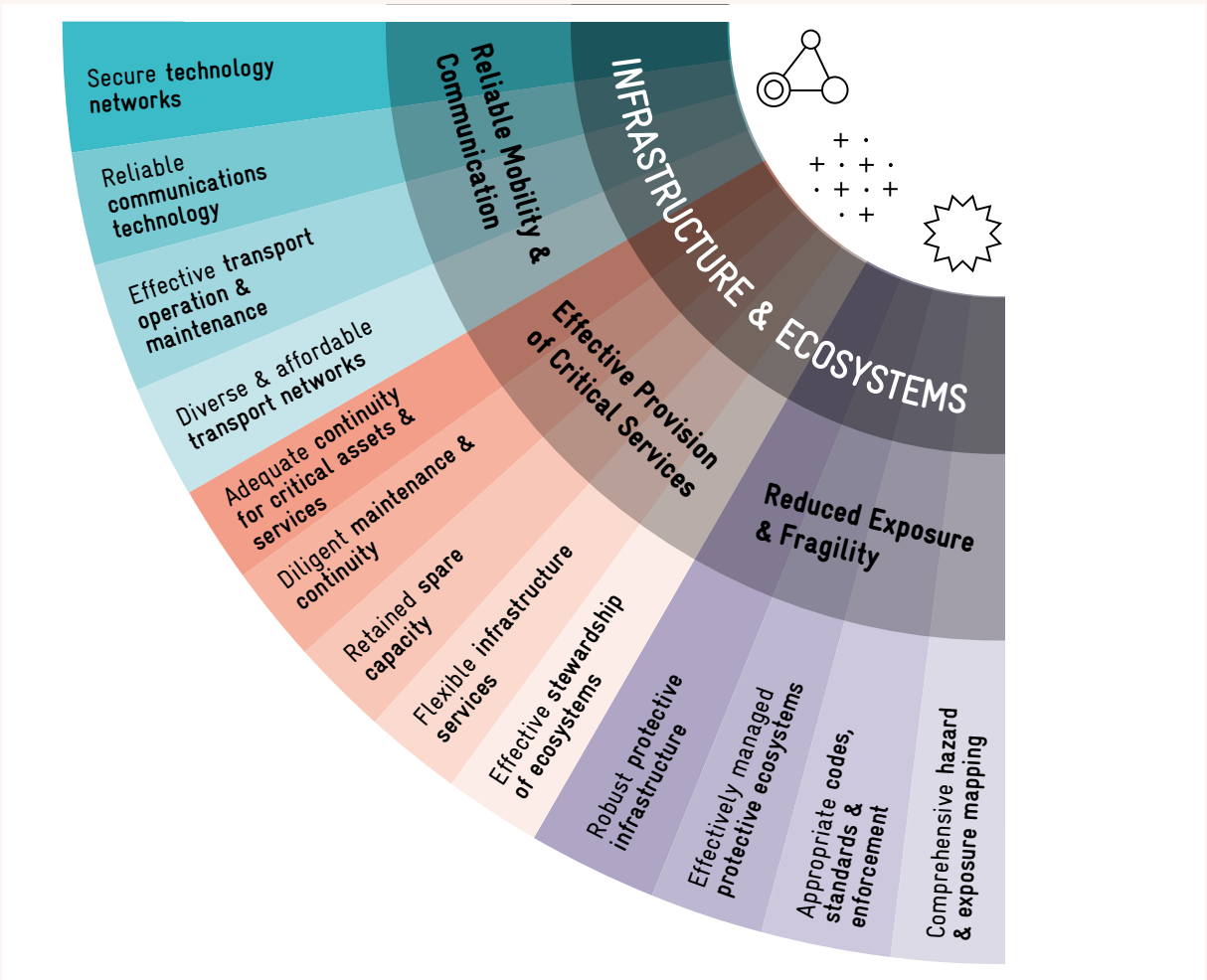
Reliable communications and mobility are enabled by diverse and affordable multi-modal transport systems and information and communication technology (ICT) networks, and contingency planning (See Figure 10).

Figure 9 City Resilience Framework (Rockefeller Foundation 2013)



- Diverse and affordable transport networks
  - Diverse and integrated transport networks, providing flexible and affordable travel around the city for all.
- Effective transport operation and maintenance
  - Effective management of the city's transport network to provide high quality, safe transport.
- Reliable communications technology
  - Effective and reliable communication systems that are accessible by all.
- Secure technology networks
  - Robust, effective mechanisms in place to protect the information and operational technology systems on which the city is dependent.

Figure 10 Transport related resilience components



4.2 Action: Short term response

In addition to the integrated crisis management approach that organisations should take to effectively manage crises, concrete actions are needed to respond to or avoid crises. Examples of short-term measures, with an immediate impact that can be implemented in short timeframe are presented in the following section.

Pop up bike lanes

Temporary bike lanes are a popular approach to promoting cycling in urban areas. They provide an alternative to fossil fuel-dependent transport modes without requiring extensive and costly building activities and can be implemented quickly. Pop-up bike lanes are designed to improve traffic safety on streets with inadequate bicycle infrastructure, reducing the risk of accidents and encouraging more people to cycle.

Goal:

The goal of pop-up bike lanes is to provide safe and accessible cycling infrastructure that promotes active mobility.

Approach:

1. Identification of suitable cycling routes with high demand and inadequate infrastructure or high potential for cycling in general
2. Assessment of current road layout to determine where redesignations are possible and expedient
3. Assessment of local requirements for the implementation of pop-up bike lanes
4. Ensuring fast and safe integration into the traffic network through temporary boundaries and coloured road markings
5. Testing the acceptance of the citizens towards the new bicycle infrastructure

The case of the City of Thessaloniki (one of the interview partners of this study) shows the importance of shifting to sustainable transport modes in terms of crisis resilience and is taking steps to promote them. To achieve this goal, the city plans to create a new cycling culture with infrastructure that increases the accessibility of this mode of transport. Currently, there is only a 2.5 km bike lane along the waterfront, with another 10 km of bike lanes limited to the administrative boundaries of the city of Thessaloniki. To expand the cycling infrastructure, a new urban cycling network will be designed that connects the different municipal cycling routes and has common specifications to ensure consistency and safety. In an initial phase, pop-up bike lanes have been introduced to test high-potential routes and to respond to the mobility crisis. (See Figure 11)

In addition to infrastructure improvements, a series of soft measures will be implemented to promote cycling as mode of commuting in the city. This will help reduce air pollution and carbon emissions and promote healthy and active lifestyles.

Fuel prioritisation schemes

During fuel supply shortages or distribution problems, fuel prioritisation schemes can be implemented to ensure that critical infrastructure such as public transport systems can maintain their operations. Public transport is often prioritised in fuel allocation because it is essential to maintaining basic mobility. Depending on the nature of the crisis and the availability of fuel resources, fuel prioritisation schemes may be implemented at national or local level. These schemes require collaboration among governments, fuel suppliers, and transport providers to ensure that fuel resources are allocated efficiently and equitably.

Goal:

Fuel prioritisation is intended to guarantee that critical infrastructures such as public transport systems remain able to operate in times of crisis. In this way, social and economic impacts can be minimised.

Figure 11 Case Study: Pop up bike lanes in Thessaloniki

Starting point Thessaloniki

Thessaloniki faces multiple crisis that have an impact on the urban transport system. Among the most severe crises are the financial and mobility crises.

- Financial Crisis
  - Greece has only slowly recovered from the financial crisis since 2008 and has a very strict budget for urban transport infrastructure.
- Mobility Crisis
  - The road network of the city is struggling with the increasing demand of individual motorised transport, and the high volume of cars on the roads has led to significant traffic problems.
  - Furthermore, the city is confronted with a high level of air pollution due to motorised transport.

CITY OF THESSALONIKI

Pop up bike lanes

One approach to compensating for the identified problems are short-term pop up bike lanes.

- Based on data analysis, traffic bottlenecks were identified. Derived from the results two pop up bike lanes were established
  - The goal was to promote cycling through improved infrastructure.
- In addition, Thessaloniki started multiple campaigns to promote cycling through awareness raising.
  - The focus was in particular on young people
  - Implementation of cycling maps and apps to improve usage of bicycle lanes
- Short-term implementation was possible due to the low intensity of costs for bicycle lanes and low bureaucratic hurdles

Approach:

1. Identification of critical infrastructures in the geographical area regarding resource supply or passenger transport
2. Assessment of fuel supply chains, including the sources of fuel, the transport networks, and the storage facilities.
3. Development of prioritisation criteria to determine which infrastructure should receive fuel supplies first during a crisis
4. Establishment of the concept for prioritisation based on defined prioritisation criteria

To be able to carry out the prioritisation of fuel, the following factors should be known:

- Which critical infrastructures exist in the reference area?
- What would be the impact of the failure of the basic service?
- Can the service be substituted?
- What is the time urgency of this failure?
- How are the critical infrastructures equipped with emergency generators and fuel?
- What self-provisioning (such as own gas stations or supply networks) can the state response rely on?
- What are the fuel requirements of the critical infrastructures?

Facilities and installations to be considered when prioritising the distribution of fuel:

- Fire brigade, rescue service, police, relief organisations, disaster control authorities
- Digital radio operators
- Hospitals and medical infrastructure
- Electricity, gas, water, wastewater companies
- Telecommunications network operators
- Basic service and infrastructure providers (livestock farms, ports)
- Facilities for supplying the population (food, etc.)
- Emergency shelters
- Public transport
- Public media
- Prisons

Definition of priority / core urban transport network in case of crisis

Priority or core urban transport network in the context of a crisis refer to the most critical transport corridors and routes that are necessary to maintain access to essential services and resources. This may include public transport systems, as well as emergency services.

Goal:

The goal of this measure is to ensure that the core urban transport network remains operational, allowing essential personnel and resources to reach their destinations.

Approach:

1. Conduct a transport needs assessment by analysing data (traffic volume, transport modes, critical infrastructure etc.)
2. Identify key routes for the urban transport system.
3. Coordination and agreement on system-relevant routes with other public transport operator and municipalities

Where to learn from?

- City Resilience Framework
https://www.rockefellerfoundation.org/wp-content/uploads/City-Resilience-Framework-2015.pdf
- Strategies of Crisis Management in Urban Transportation
https://maxwellsci.com/msproof.php?doi=rjaset.7.587
- Increasing the Resilience of Transport Enterprises through the Implementation of Risk Management and Continuity Management
https://reader.elsevier.com/reader/sd/pii/S2352146521005573?token=D65CABB3152ED2AC958BD1D6493570AA2E158C578B1D7FBD031CC4CE3A3DE5685FA347BFFC03F48133013B6696D8E033&originRegion=eu-west-1&originCreation=20230511123644
- Business Continuity from Preparedness to Recovery
https://www.sciencedirect.com/book/9780124200630/business-continuity-from-preparedness-to-recovery
- Avoiding the Failures of Collaborative Crisis Management
https://www.taylorfrancis.com/chapters/edit/10.4324/9780429244308-10/avoiding-failures-collaborative-crisis-management-charles-parker-bengt-sundelius

4.3 Action: long term prevention

Ideally actors should prevent the impact of crises by implementing long term actions, as they enable a mitigation of risks and allow for more time to manoeuvre and build resilience. Examples of long-term measures are presented in the following section.

Electrification of bus fleets

Electric buses powered by batteries or catenaries can replace conventional busses and thus help to reduce the dependency from fossil fuels and lower greenhouse gas emissions:

- Zero Emissions: Electric buses produce zero tailpipe emissions. Unlike conventional buses that run on fossil fuels, electric buses do not emit harmful pollutants such as carbon dioxide (CO_2), nitrogen oxides (NO_X), and particulate matter into the atmosphere. This significant reduction in emissions helps mitigate climate change and improve air quality.
- Renewable Energy Integration: The charging with electricity from renewable energy sources further enhances the environmental benefits of e-buses. By utilising clean energy generated from solar, wind, or hydroelectric power, electric buses can operate based on local energy sources without relying on fossil fuels that often need to be imported.
- Energy Efficiency: E-buses are more energy-efficient compared to internal combustion engine buses. Electric motors are highly efficient in converting electrical energy into mechanical energy, resulting in less energy wastage during operation. This efficiency translates to reduced energy consumption and lower overall energy requirements, contributing to the saving of resources.
- Energy Diversification: Shifting to e-buses helps diversify the energy sources for public transport. By relying on electricity instead of fossil fuels, the dependency on often volatile oil reserves is reduced. This diversification increases energy security, mitigates the risks associated with fuel price fluctuations, and reduces vulnerability to fossil fuel supply disruptions.
- Redundancies and Grid Integration: When replacing fossil fuels with electricity, it is essential to consider the resilience of the energy grid. Ideally, the grid should draw power from a wide range of decentralized energy sources distributed across a broad geographic area (e.g., nationwide) to ensure continuity in the event of individual generator failures. Despite electrification efforts, some public transport operators (e.g. the Hamburger Hochbahn) maintain a backup fleet of internal combustion engine (ICE) buses to provide emergency support.

Goal:

The deployment of e-buses as a long-term mitigation measure has several goals: reduce the dependency from fossil fuels, diversify energy sources in public transport, reduce noise and emissions, and improve energy efficiency.

Approach:

For the deployment of e-buses, the following steps should be taken:

1. Feasibility Study to assess the viability of deploying e-buses. This study includes evaluating infrastructure requirements such as charging stations, assessing operational costs compared to diesel or gas buses, and analysing the energy supply capabilities.

2. Development of Project Plan: Once the feasibility study is completed, a project plan should be developed, outlining financing options, procurement strategies, charging infrastructure requirements, and maintenance considerations.

3. Financing: Due to the usually higher upfront costs of e-busses it is key to secure adequate financing. This may involve government grants, subsidies, loans, or partnerships with bus suppliers and utilities. The project plan should include a detailed financial analysis, budgeting for vehicle procurement, charging infrastructure installation, maintenance costs, and ongoing operational expenses.

4. Procurement of e-buses and charging infrastructure: The next step is to procure the e-buses and the necessary charging infrastructure. Therefore, the technical specifications and performance requirements need to de defined, the procurement process and tender need to be prepared, and the most suitable option chosen based on the established criteria. Simultaneously, charging infrastructure should be planned, determining the number and locations of charging stations, and coordinating the installation with suppliers.

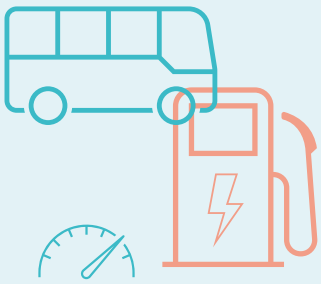
5. Training: Once the e-buses and charging infrastructure are in place, they need to be integrated into the existing transport system. Therefore schedules, routes, and maintenance procedures must be coordinated. Additionally, training programs should be implemented to educate drivers and maintenance staff.

Figure 12 E-bus projects in Thessaloniki and Hamburg

CITY OF THESSALONIKI

Implementation strategy
- Collaboration with bus operators for replacement of diesel busses
- Introduction of e-buses in the city centre
- Revision of the regulations on the implementation

Infrastructure
- Reduction of fossil fuel traffic by introducing low emissions zones



Vision
- Reduce air and noise pollution
- Climate change mitigation
- Decarbonisation

HOCHBAHN

Implementation strategy
- Optimised planning of routes for e-buses due to limited range
- Financial support by national government

Infrastructure
- Building new operating locations with equipment for electric buses
- Solar panels at bus depots
- Electrical grid connection to the charging facilities
- Intermediate charging for buses to increase range

If you're interested to learn more about E-Bus electrification, visit the TUMI E-Bus mission: https://transformative-mobility.org/focus-area/tumi-e-bus-mission/

Availability of multiple transport modes and infrastructure

Having a variety of transport modes based on different energy sources, including trams, metros, and diesel buses, enhances the resilience of transport systems by offering alternative options in case of disruptions. This reduces dependency on a single mode and increases overall capacity, providing passengers with more flexibility. Additionally, it is crucial to consider the development of infrastructure for active transport modes like walking and cycling, which are independent of energy and fossil fuels.

1. Fossil Fuel Price Shocks: In the event of fossil fuel price shocks or supply disruptions, transport systems that rely solely on one energy source, can be severely affected. However, by diversifying the energy sources through modes like trams, metros, and e-buses, the system becomes less vulnerable to price fluctuations. Electric-powered modes like e-buses can help reduce the dependency on fossil fuels and mitigate the impact of fuel price shocks. At the same time, it is important to also have vehicles which are not dependent on electricity, such as diesel or gas buses, to have a fallback option and be able to maintain basic services in case of a blackout.

2. Pandemics: During pandemics, public health measures may require reduced occupancy or physical distancing on public transport. Having a mix of transport modes allows for better distribution of passengers and reduces the risk of over-crowding. Cycling and walking provide individual mobility options that promote social distancing and minimise the spread of infectious diseases.

3. Armed Conflicts or Disruptions: Due to armed conflicts or service disruptions, certain transport modes or infrastructure may become inaccessible or damaged. Having a diversified system with multiple transport modes allows for more flexibility and adaptability. For example, if a certain route or mode is compromised, alternative modes like trams, metros, or bicycles can be utilized, ensuring continued transport services.

Goal:

The goal of providing several transport modes in the context of crisis prevention is to create redundancy and alternative options in the case of a disruption, provide flexibility and adaptability by offering more capacity and routes with a better accessibility and a more efficient distribution of passengers and goods, and to reduce the dependency on a single energy source. This contributes to the overall resilience of a transport systems and society, as access to employment, education, healthcare, and food can be ensured.

Approach

1. As a first step, the existing modes and infrastructure should be assessed according to vulnerabilities and interdependencies, including factors such as capacity, energy sources, and potential hazards and impacts of a disruption.

2. The next step is the identification of transport needs and development of transport plan, considering the identified vulnerabilities and taking into account population density, commuting patterns and accessibility.

3. Based on the identified needs and vulnerabilities, a concept needs to be developed how to ensure basic mobility and accessibility in the event of a crisis, by considering multiple transport modes. Public transport and active mobility options should be given priority to reduce dependency on private vehicles and promote sustainable and resilient transport. Of course, modes such as trams or metros require substantial investments and have long planning times. Therefore, the adjustment or addition of bus routes and dedicated infrastructure for cycling and walking can be implemented more easily to cover needs and vulnerabilities in the short term.

Pricing Schemes

Pricing schemes such as fossil fuel and emission taxes, or road tolls can be used as strategies to influence travel behaviour and encourage the use of more sustainable modes of transport. They also support a long-term reduction of fuel consumption.

Fossil fuel and emission taxes are levies imposed on the consumption or production of fossil fuels or the emissions of pollutants, which increase the cost of using these fuels or emitting pollutants, thereby providing an economic incentive to reduce their use or emissions. Road tolls are imposed on vehicles for the use of roads and can vary based on vehicle type, distance traveled, and time of day.

Goal:

The goal of pricing schemes is to influence travel behaviour and encourage the use of more sustainable transport modes by increasing the cost of using private vehicles or certain roads. By reducing fuel consumption and emissions, air quality can be improved, and congestion diminished. Importantly, the generated funds can also be used to invest in more resilient and environmentally friendly transport modes.

Approach

1. As a first step, objectives and scope of the pricing scheme should be defined, target road users identified, and potential impacts on different stakeholders assessed.

2. With the scope delimitated, the pricing mechanism such as a fuel tax, a congestion charge, or a distance-based road toll needs to be designed. Furthermore, the level of the pricing to achieve the desired behavioural change while considering its economic impact on different groups has to be determined.

3. As a next step, the legal and regulatory framework has to be formulated to enable the implementation of the pricing scheme, outlining the exemptions or rebates, as well as defining the governance framework to manage the implementation and enforcement of the scheme.

4. It is key to communicate the rationale and the objectives of the pricing scheme, as well as its benefits to the population, addressing concerns and ensuring transparency.

5. In order to implement and enforce the fuel tax, congestion charge, or road toll systems such as toll booths and cameras need to be installed and enforcement mechanisms put in place to ensure compliance.

4.4 Spotlight Naftogaz

Interview with Nataliya Boyko, Deputy chairperson of the Supervisory Board of Naftogaz Ukraine (April 2023)

How has Ukraine's energy sector prepared and reacted towards the Russian invasion?

"Ukraine has a huge power generation system, which was originally built as a flow to transport energy generated from nuclear stations to Europe. After the decision [taken in 2017] to disconnected Ukraine's network from Russian Federation and to connect it to Europe's system [originally planned for 2023], the idea was to make it a normal functioning system. The tricky moment with Russia's aggression in the electricity sphere was that Ukraine had prepared for a very high-level emergency scenario, but then the whole energy system was disconnected earlier planned as and worked in an island regime. This was very challenging at the beginning of the war, but Ukraine successfully managed to connect to the European Entso-E system and is now maintaining import-export relations. Regarding gas, Ukraine is still working as a transit country to Europe [Remark: When conducting the interview – at the time of publication, no more gas is being transited from Russia through Ukrainian pipelines] and has acknowledged early on that this is a political and not only commercial topic. The decision taken a couple of years ago not to buy Russian gas, but to buy it on the European market was very important and proved right, ensuring energy security. In the gas sector for each winter zero transit scenarios were prepared, coordinated under the Prime Minister."

What long-term implications do you see with respect to energy and fuel systems?

"It is very important for us to make process work. Before the war Nafotgaz had taken a big loan on batteries and energy storages, solar panels and even hydrogen pilots, with very ambitious targets. Unfortunately, these resources are now used to buy transformer equipment to repair damaged infrastructure, which is very painful. Unfortunately, it was very easy to attack wind generation, so now almost all wind generation is stopped. However, nuclear generation was not attacked. Ukraine is now trying to be more decentralised, implementing projects at regional level with the possibility to work as small island regimes."

Which means of transport play an important role during war?

"I will be very frank, we survived because of the army, Ukrainian railways, energy specialists and municipality specialists. Ukrainian railways provided an incredible support to the state. Railways proved to be the safest and best way to manage all tasks, including the transport of people, but also special energy equipment, and supply of diesel. Funnily, they also started to be much more client oriented, serving really good coffee now."

4.5 Spotlight Transport Office Lviv

Interview with Orest Oleskiv, Head of Transport Office Lviv City Council (April 2023)

Can you tell us about the main challenges the urban transport system in Lviv faced because of the Russian attack on Ukraine and how you addressed them?

"As a consequence of the attack, we had to deal with multiple problems related to mobility, such as disrupted public transport services, fuel shortages, and damaged infrastructure. To overcome these issues, we adopted a pragmatic and reactive approach, prioritising essential routes for evacuation and critical infrastructure. Therefore, we adjusted our bus network to best address refugee flows, and we were forced to reduce our trip volume due to a driver shortage. Finding bus drivers was extremely difficult given the direct competition with the logistics sector, where significantly better salaries are paid. Furthermore, we quickly realised that parallel transport systems are of extreme advantage in a crisis situation. Through our bus, tram, and trolleybus network, we were able to continue transporting people to most neighbourhoods in Lviv despite numerous damages to the infrastructure."

How did Lviv manage to overcome the fuel crisis at the beginning of the war and ensure public transport services were operational?

"To address the fuel crisis, in May [2022] we prioritized fuel for buses, replaced buses with trolley buses and trams where possible. Electrically powered systems were a good fallback option at the time. Furthermore, special contracts were concluded between the gas stations and bus and logistics operators, giving them preference over private customers."

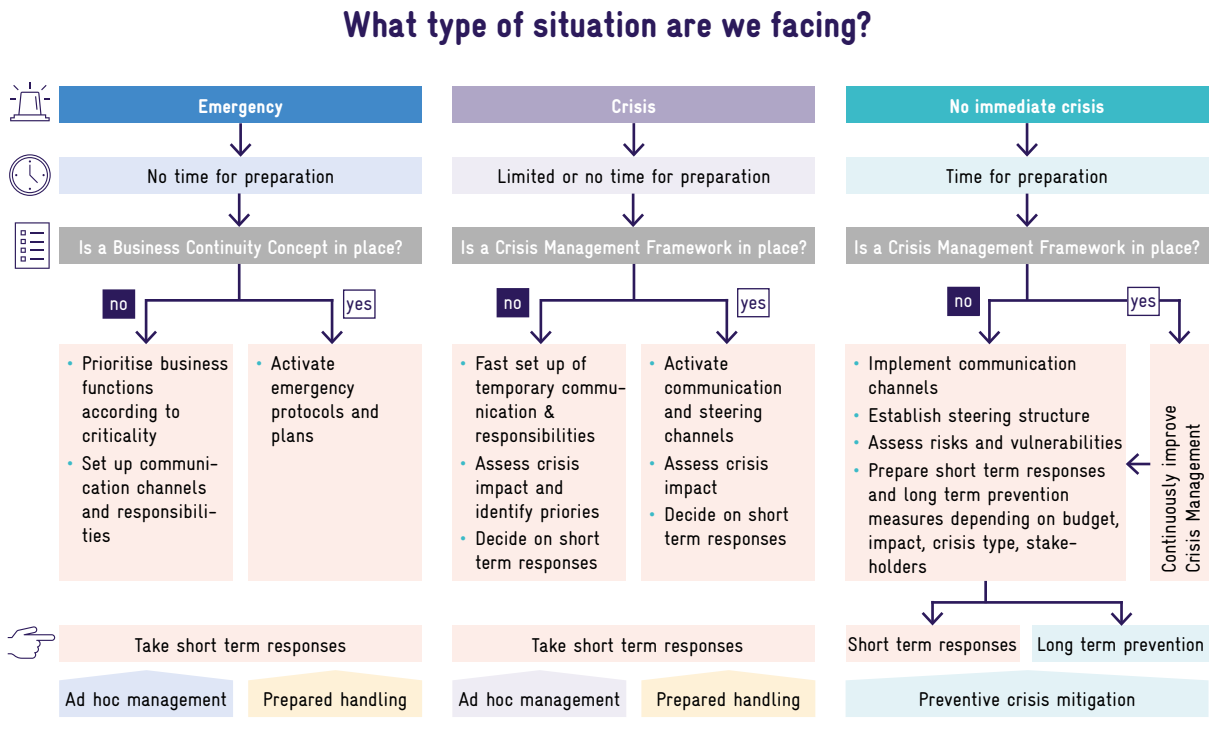
How is Lviv coordinating with other cities to deal with the crisis within the urban transport system?

"We are partnering with other cities to share ideas and best practices on crisis management. We received support from Copenhagen and other major cities in the form of free bicycles to ensure active mobility during the crisis. Moreover, Polish bus companies provided significant assistance with evacuations."

5 SYNTHESIS

The accelerated pace of multiple and overlapping crises, such as the climate emergency, pandemics, and Russia's aggression against Ukraine, are leading to higher volatility of fossil-fuel prices, interrupted supply chains and higher freight costs, which is putting passenger mobility, delivery of essential goods and access to basic services in danger. Price shocks and scarcity of fuel have a significant impact on businesses and the general population, limiting their ability to access markets, workplaces, and education. This situation poses a growing challenge for local and national governments, enterprises, and society, making it difficult to sustain essential functions. As a result, economic activities may cease, potentially leading to social unrest and even posing a threat to political stability. At the same time, the climate crisis is demanding urgent action. The transport sector needs to

Figure 13 Decision tree for crisis management and preparation



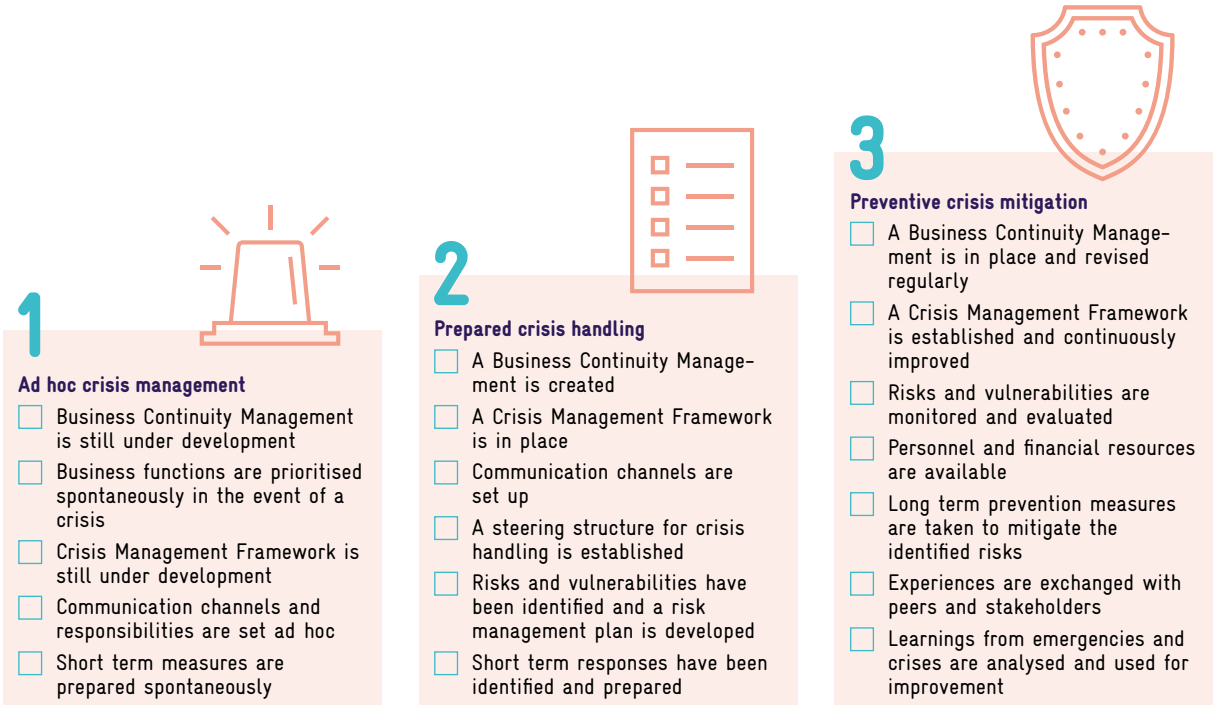
drastically reduce its greenhouse gas emissions, which still make up a quarter of the total energy related emissions worldwide.

Depending on the situation stakeholders are faced with, different courses of action are to be taken, as shown in Figure 13.

In emergency situations when an organisation's resources or processes fail, Business continuity concepts are crucial as they define protocols that can be activated for short-term actions. Without a pre-established Business Continuity Concept, functions must be prioritized based on criticality, and ad hoc communication channels, responsibilities, and measures must be set up, leading to critical delays. In contrast to emergencies, crises are typically unique and can be defined as a situation of instability or danger with potential adverse impacts on society, economy, and environment. In the event of a crisis, with limited or no time for preparation, a Management Framework is therefore fundamental. Existing communication channels and steering structures can be activated, who will regularly assess the impact of the crisis and decide on short term measures to be taken. If no Crisis Management Framework is in place, communication channels within the organisation and with other external stakeholders need to be set up fast and temporary responsibilities need to be defined, to then assess the crisis impact and prioritise short term actions. Ideally, a Crisis Management Framework is already established before an imminent crisis, as this allows a comprehensive risk and vulnerability assessment, and the according identification of possible short-term responses and the implementation of long-term prevention measures depending on the budget, vulnerabilities, possible impacts and stakeholders to be involved. Crisis Management is an iterative process, to be continuously verified and improved, integrating the learnings from past crises. If you want to assess the maturity of your organisations' crisis management, please have a look at the checklist in Figure 14.

The best way of preparing for crises is acting early on to reduce potential risks, lower the dependency of fossil-fuels and embark on a transformation towards sustainable mobility and resilience.

Figure 14 Checklist for maturity assessment of crisis management



Furthermore, crisis preparation and prevention are cheaper than the potential consequences of not being able to respond properly. Preventive crisis management allows to increase the resilience of transport systems and lower the dependency on fossil fuels. Therefore, long-term strategic policies are needed, resources should be shifted towards more efficient and environmentally friendly energy sources, and supply chains should be diversified. In the interviews 5 key elements were identified to prepare and manage crises affecting the transport sector at an accelerated pace:

1. **Identification of vulnerabilities and risks:** To ensure the continuity of urban transport systems in the event of a crisis, the vulnerabilities and risks of the system must be identified, analysed, and ranked by priority.

2. **Set up of organisational structures and steering mechanisms:** Organisations need dedicated mechanisms for crisis management. Communication and clear internal responsibilities are key in a crisis. Furthermore, it is crucial to be able to react quickly and flexibly to the consequences of the crisis.

3. **Development of action plans and trainings:** To increase the level of preparation for crises, it is advisable to develop plans and perform regular trainings. In addition, an ongoing exchange with different stakeholders is valuable to benefit from learnings and integrate them into the crisis management systems.

4. **Collaboration with other stakeholders and exchange with peers:** Based on collaborative crisis management by municipalities, transport operators and public authorities, crises can be addressed holistically.

5. **Building resilience:** Urban planning strategies that build resilience trough redundancy, robustness, flexibility, reflectiveness and integration, and reduce fossil fuel dependency, may prevent or significantly mitigate crisis consequences for urban transport systems.

Transport systems that are prepared for crises will be better equipped to withstand the damaging effects, such as price shocks, interrupted supply chains and natural disasters due to climate change. Therefore, the costs associated with rebuilding and repairing are minimized, which allows for a greater allocation of upfront investments towards in sustainable and resilient transport systems with more room to manoeuvre in the event of a crisis.

To enhance resilience, it is crucial for actors to make systematic investments in long term measures. By taking proactive steps to strengthen transport systems and reduce their dependency on fossils fuels, the long-term benefits will outweigh the costs. This approach proves to be more cost-effective compared to addressing crises as they occur. By prioritising preparedness and resilience, we can ensure that our transport systems are robust and sustainable, and crises can be managed efficiently.

Glossary & Measures Catalogue

Emergency	An emergency is a damaging event in which an organisation's processes or resources do not operate as intended. The availability of the corresponding processes or resources cannot be restored within the required time.
Crisis	A crisis can be defined as a situation of instability or danger with potential adverse impacts on society, economy and environment. A crisis is typically unique and therefore frameworks rather than strict flow charts are required to deal with the consequences.
Crisis management framework	
Business continuity management in public transport systems	Business Continuity Management enables organizations to protect and sustain critical processes during a disruption due to an emergency.
Emergency plans	Emergency plans are comprehensive instructions on how to proceed in the event of an unforeseen interruption of operations. The central building blocks are how to communicate, how to operate emergency transport services and how to re-establish operations after the emergency.
Training	Development of an emergency training program by the transport operator in coordination with the authorities based on the business continuity strategy.
Crisis management in public transport systems	Crisis management is a process designed to prevent or mitigate the damage a crisis can inflict on a transport system. Due to the uniqueness of crisis, organisational structures for coordination, communication systems and a scalable crisis management should be set up to allow for flexible responses.
Risk management and vulnerability analysis	Risk Management requires identifying potential risks, assessing them and creating strategies to prevent or minimise these risks. Vulnerability analysis on the other hand involves identifying weaknesses of the transport system based on specific crisis scenarios.
Robust procurement systems	Robust procurement system allows to minimise the risks for resources shortages through the diversification of suppliers and long-term supplier management.
Collaborative crisis management	Collaborative crisis management can be defined as the collective efforts of multiple actors such as municipalities, police, fire workers, rescue services and municipal services in working across organisational boundaries, to prepare for, respond to, and learn from a crisis. A joint crisis management approach between involves a continuous exchange, with clearly defined communication channels.

Knowledge exchange between municipalities	To enhance the crisis management capabilities cities should engage in regular exchanges, conferences and working groups. These formats provide the opportunity for cities to share experiences, strategies and recommendations on crisis handling and learn form their peers.
Resilience departments in municipalities	To improve crisis preparedness, the establishment of a special resilience department in the municipality is supportive. This department should serve as an intermediary between the departments and other external stakeholders to take a coordinated approach on planning and implementing resilience measures for urban areas.
Short term response	
Pop-up bike lanes	Temporary bike lanes are a popular approach to promoting cycling in urban areas. They provide an alternative to fossil fuel-dependent transport modes without requiring extensive and costly building activities and can be implemented quickly. Pop-up bike lanes are designed to improve traffic safety on streets with inadequate bicycle infrastructure, reducing the risk of accidents and encouraging more people to cycle.
Fuel prioritisation schemes	In a crisis supply shortage and distribution problems can lead to a scarcity of fossil fuels. In order to maintain the operation of urban transport systems in such situations, priority schemes for critical infrastructures including public transport and transport operator are implemented.
Definition of priority / core urban transport network in case of crisis	Definition of priority / core urban transport network in case of crisis involves identifying the most critical transport corridors and routes that are necessary to maintain access to essential services and resources. This may involve prioritising routes that serve emergency housings and other critical facilities.
Public transport fare reduction	Subsidized public transport tickets are usually implemented by the government or other public institutions, with the aim of ensuring essential services, promoting the use of low carbon transport and reducing CO_2 emissions. The measure can take different forms, such as direct subsidies to public transport providers, general fare reductions or discounted tickets for specific groups (e.g. students, elderly, low-income individuals).
General fuel discount	A fuel discount is a reduction in the price of gasoline or other types of fuel that is directly or indirectly subsidised by the government. This type of discount is typically designed to provide relief to consumers who are facing high fuel prices due to market factors such as increased demand, supply disruptions or geopolitical tensions.

Long term prevention	
Improving the availability of fossil fuels through greater storage capacity	To become less dependent on fossil fuel imports and improve ad hoc availability, expanding fossil fuel storage capacity is a potential solution. By increasing storage capacity, National governments, urban transport and logistic operator can stockpile reserves for extended periods, ensuring a reliable supply of fossil fuels and greater energy security.
Electrification of bus fleet	With the deployment of e-buses conventional diesel buses can be replaced by powered by batteries or catenaries. The electrification of bus fleets has become a key concern for many cities and countries, as it helps to reduce air pollution and lower operating costs in the long term, as well as independence from fossil fuels.
Energy use optimisation	To optimise energy use, public transport operators can train their drivers in eco-driving. By driving at a steady speed, avoiding abrupt acceleration or braking, anticipating traffic flow, and maintaining appropriate tire pressure to reduce rolling resistance fuel costs can be reduced.
Availability of multiple transport modes and infrastructure	The availability of multiple transport modes based on different energy sources, such as trams, metros, and diesel busses increase the resilience of transport systems by providing redundant options with alternatives to swich if one mode is disrupted. In addition, the capacity is increased, passengers are more flexible and the dependency on a single mode is reduced.
Reallocation of road space towards public transport and active mobility	Reallocation of road space towards public transport and active mobility involves a paradigm shift in urban planning that prioritises people-centred mobility and sustainable transport options. This approach requires rethinking the traditional allocation of street space, with a focus on creating a more equitable and accessible transport network.
Public transport priority schemes	Public transport priority schemes aim to create a more efficient and reliable transit system that benefits passengers and cities. By providing dedicated lanes and priority signals to reduce travel time, improve traffic flow, optimizes energy usage and encourage greater use of public transport.
Sustainable Urban Mobility Plans	A sustainable urban mobility plan (SUMP) is a strategic plan that aims to provide a framework for developing and implementing sustainable transport policies and projects in urban areas. The plan takes into account the social, economic, and environmental aspects of transport, and seeks to provide accessible, safe, and efficient transport options that reduce reliance on cars and promote sustainable mobility modes such as public transport, cycling, walking, and shared mobility.

Parking management and Park & Ride concepts	Parking management refers to the management, regulation and pricing of parking space in city centres. It includes parking pricing policies that vary depending on the time of day or the duration of parking, parking guidance systems and parking enforcement. Park and ride facilities are typically located close to public transport hubs at the outskirts of city and are free or low-cost to encourage their use. The goal is to provide an alternative to driving to congested urban areas for commuters who don't have convenient access to public transport or cannot bike or walk.
Pricing schemes	By increasing the cost of using private vehicles or certain roads, pricing measures such as fossil fuel and emission taxes or road tolls can incentivise individuals and businesses reduce their consumption of fossil fuels and to adopt more sustainable transport modes.

Further resources on resilient urban transport systems

"How can transport authorities and operators navigate through multiple risks and threats at times of global crisis?"

Article (GIZ-TUMI)
https://transformative-mobility.org/multimedia/article-fossil-fuel-dependency/

"Adapting Urban Transport to Climate Change"

Publication (GIZ-SUTP Module 5f, contains numerous approaches for analyzing, identifying and implementation measures and case studies)
https://sutp.org/publications/sutp-module-5f-adapting-urban-transport-to-climate-change-ed-2/

"Integrating Climate Adaptation into Sustainable Urban Mobility Plans (SUMPs)"

Publication (Mobilise Your City)
https://www.mobiliseyourcity.net/integrating-climate-adaptation-sustainable-urban-mobility-plans-sumps

"Adaptation of urban mobility and the built environment to climate change: Nine principles for effective action"

Publication (Mobilise Your City)
https://www.mobiliseyourcity.net/sites/default/files/2025-03/Nine%20principles%20for%20effective%20adaptation%20of%20urban%20mobility%20and%20built%20environment%20-%20EN%20Clean_2.pdf

"Beat the Heat – A Quick Guide"

Short Publication (GIZ-TUMI)
https://transformative-mobility.org/multimedia/beat-the-heat-a-quick-guide/

"Cycling in the Heat: Overcoming Challenges and Promoting Sustainable Mobility"

Article (GIZ-TUMI)
https://transformative-mobility.org/cycling-in-the-heat-overcoming-challenges-and-promoting-sustainable-mobility/

"Nature Based Solutions (NBS) in the Transport Sector"

Article/Leaflet (GIZ-TUMI)
https://transformative-mobility.org/multimedia/nature-based-solutions-nbs-in-the-transport-sector/

"Data for Adaptation in Vietnam: Climate Proofing bus transport to flooding in Ho Chi Minh City"

Case Study (GIZ TUMI Lab)
Article: https://transformative-mobility.org/data-for-adaptation-in-vietnam-climate-proofing-bus-transport-to-flooding-in-ho-chi-minh-city/
Video: https://transformative-mobility.org/multimedia/tumi-lab-ho-chi-minh-city-climate-proofing-urban-buses-to-flooding/

"Urban floods and transport"

Upcoming short publication (GIZ-TUMI)

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