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City Resilience Development - Maturity Model

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European foreword

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Introduction

This CEN Workshop Agreement (CWA) is based on the results of the Smart Mature Resilience project (SMR). SMR project was initiated through the European Union's HORIZON 2020 framework programme, because European cities are facing an increasing frequency and intensity of hazards and disasters which are exacerbated by climate change and social issues. As Europe's cities continue to grow, there is an urgent need for far-reaching and holistic approaches to enhance their ability to resist, absorb, adapt to and recover from the potentially critical effects of hazards.

Today's high level of interconnectedness and interdependencies among cities and their systems may lead to cascading effects and crisis escalation from local level to regional, national or even international level. This is the main reason that cities should not be considered as isolated entities in the resilience building process. Building key resilient cities throughout Europe will create a strong resilience backbone for all of Europe, allowing cities to support each other in overcoming the challenges arising from the risks ahead.

The concept of the *European Resilience Backbone* consists of mutually supporting and networking cities. It enables the use of effective substitution processes in a crisis or disaster, for dealing with a lack of materials, technologies, human resources or capacities. Cities can be directly or indirectly affected by disasters. Indirect effects can arise from geographic proximity, through interdependencies or due to cascading effects, or even from facing the same class of major threats (e.g. sea level rise in Rotterdam and Vejle). Common approaches and collaborative arrangements could be the solution for facing disasters more efficiently. By sharing interests and responsibilities within formal and informal networks, and by taking a multi-level governance perspective, European cities can form a resilient "backbone" for Europe.

This CEN Workshop Agreement describes a Maturity Model, which presents a holistic approach where cities are not considered as isolated entities, but rather as interconnected and interdependent units. The Maturity Model is one of the five tools developed by the SMR project. Inputs from other European Union's HORIZON 2020 framework programme projects, like RESCCUE and Smart Resilience, were taken into account when developing this CWA.

CWA series - City Resilience Development

This CEN Workshop Agreement is part of the *City Resilience Development* series, which intends to support cities in becoming more resilient against various kinds of threats. The series consists of the following other two CWAs:

— CWA 17300 City Resilience Development – Operational Guidance;

— CWA 17302 City Resilience Development – Information Portal.

The CWA on Operational Guidance is the overarching document that refers to the *CWA 17301 City Resilience Development - Maturity Model*, *CWA 17302 City Resilience Development – Information Portal*, as well as to other supporting tools.

Goal

The Maturity Model is a strategic tool that provides a theoretical roadmap describing a possible resilience-building process for a city. It will enable cities to assess their current maturity stage and to identify the policies, which should be implemented in order for the city to evolve and move to the next maturity stage. The Maturity Model can be used to assess and re-asses a city's policies to diagnose the resilience maturity stage.

Cities have been performing specific actions towards resilience in different ways. Some of them have been working for several years on the concept of resilience while others have just started. Therefore, the requirements of the cities are not the same. In fact, a city that has been developing resilience-

building activities for several years will require different activities than a city that has just started the path of developing this concept. Thus, the end users of the Maturity Model can use the model, both to identify areas that need to be improved and to assess their corresponding maturity stage based on efforts already made in the resilience-building process. The policies of the Maturity Model can be compared to the policies and projects a city has already implemented or currently has in place to evaluate the level of resilience maturity.

Once a city has identified its corresponding maturity stage, the Maturity Model will help them through its policies to guide along their path in the resilience-building process considering their future resilience demands and capacities. Thus, the Maturity Model can be used to plan and implement a long-term resilience journey, which goal is to strengthen cities in dealing with shocks and long-term stresses.

The Maturity Model:

— helps cities to assess their current resilience maturity stage;

— helps cities prioritize resilience policy implementation actions according to the available funding;

— helps to attract new funding opportunities for specific measures;

— articulates the benefits and the added value of policies;

— helps cities to identify suitable policies to develop and implement resilience based on diagnosis and assessment;

— provides a point of reference for self-assessing the effectiveness of resilience developments; and

— is a useful component of strategic planning.

1 Scope

This CEN Workshop Agreement provides a framework for describing the ideal path in the resilience-building process of a city. This framework is based on the maturity stages through which a city should proceed.

This document is intended to be used by policy and decision-makers at city level and councilors working for resilience in their city, as well as by any other city stakeholders working on resilience (for example, but not limited to: critical infrastructure providers, service providers, emergency services, individuals, the media, non-governmental organizations, academic and research institutions as well as consultancies).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
best practice
action that increases the resilience level against an issue, according to specific indicators

3.2
cascading effect
failure in one system causes failures in another system

Note 1 to entry: This failure is due to interdependencies between different urban technical networks considered to be critical in the risk context.

3.3
case study
description of an actual situation, commonly involving a decision, a challenge, an opportunity, a problem or an issue

3.4
chronic stress
slow moving disasters that weaken the fabric of a city

EXAMPLE High unemployment, overtaxed or inefficient public transportation system, endemic violence or electric and water shortages.

3.5
city
local unit based on administrative boundaries within a metropolitan area

3.6
CITY
human settlement formed by a central area, neighborhoods and suburbs reciprocally connected but not necessarily coincident with administrative boundaries, and inclusive of all the city operators that play key roles in its functioning

3.7
city operator
organization that has the responsibility to deliver an ongoing operational service for the city

Note 1 to entry: A city operator can be a privately or publicly owned entity. City operators can be operating in just one city or in several cities; some could even be international enterprises. Non-governmental organizations (NGO) normally do not have a responsibility, even though the city depends on their existence and deliveries.

EXAMPLE Energy company, waste management, financial services.

3.8
city resilience
ability of a CITY or region to resist, absorb, adapt to and recover from acute shocks and chronic stresses to keep critical services functioning, and to monitor and learn from on-going processes through city and cross-regional collaboration, to increase adaptive abilities and strengthen preparedness by anticipating and appropriately responding to future challenges

3.9
climate change
change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer

[SOURCE: DIN SPEC 35810:2014-11, definition 3.2]

EXAMPLE Flooding, heat waves, cold waves, high winds, marine storm surges, sea level rise, drought, pest, wildfires or pollution.

3.10
crisis
unstable condition involving an impending abrupt or significant change that requires urgent attention and action to protect life, assets, property or the environment

[SOURCE: ISO 22300:2018-02, definition 3.59]

Note 1 to entry: Crises are related to stress situations that can evolve to emergencies.

EXAMPLE Terrorists holding employees hostage.

3.11
crisis management
holistic management process that identifies potential impacts that threaten an organization and provides a framework for building resilience, with the capability for an effective response that safeguards the interests of the organization's key interested parties, reputation, brand and value-creating activities, as well as effectively restoring operational capabilities

[SOURCE: ISO 22300:2018-02, definition 3.60]

3.12
critical infrastructure
system, service or asset, which can be physical or virtual

Note 1 to entry: Critical infrastructures are complex socio-technical systems in which the components are particularly interdependent. Interdependencies also exist between different critical infrastructures. All these interactions may imply many failures caused by cascading effects in the risk context. Critical infrastructures are

vital for the welfare of society, since a disruption and its cascading effects can have a negative impact on the health, security, safety and economic well-being of citizens and on the effective functioning of the government.

EXAMPLE Critical infrastructure failures could be transportation disruptions, blackouts, water supply unavailability, drainage insufficiency, gas shortages, chemical or nuclear accidents and telecommunication troubles.

3.13
disaster
situation where widespread human, material, economic or environmental losses have occurred which exceeded the ability of the affected organization, community or society to respond and recover using its own resources

[SOURCE: ISO 22300:2018-02, definition 3.69]

Note 1 to entry: Crisis with a bad ending.

EXAMPLE Employees killed in a terrorist hostage situation.

3.14
emergency
unforeseen or unplanned situation, which has life-threatening or extreme loss implications and requires immediate attention that is directly given

[SOURCE: modified ISO 22300:2018-02, definition 3.77]

EXAMPLE Child falls into a fast running river.

3.15
hazard
source of potential harm

[SOURCE: ISO 22300:2018-02, definition 3.99]

Note 1 to entry: A hazard poses no risk, if there is no exposure to that hazard.

Note 2 to entry: A natural hazard is a sub category of a hazard.

3.16
indicator
description of how to measure an issue

EXAMPLE A backup generator's capability under different conditions.

Note 1 to entry: Any type of indicator could be appropriate for measuring an issue: yes/no questions, scales etc. depending on the issue.

3.17
issue
general term that refers to anything that the stakeholder assesses as important in order to be resilient against threats

Note 1 to entry: An issue asks the question of what is important.

EXAMPLE A backup generator's or even a power station's capability to provide electricity on demand. An issue can be a capability, factor, condition, function, action or capacity.

3.18
lagging indicator
form of reactive monitoring, requiring the reporting and investigation of specific incidents and events to identify weaknesses in that system

Note 1 to entry: Lagging indicators show when a desired outcome has failed, or has not been achieved.

3.19
leading indicator
form of active monitoring focused on a few critical risk control systems to ensure their continued effectiveness

Note 1 to entry: Leading indicators require a routine systematic check that key actions or activities are undertaken as intended. They can be considered as measures of processes or inputs, which are essential for the delivery of the desired outcome.

3.20
local government
government unit having a local sphere of competence

3.21
maturity
level of gain after a maturation period

3.22
policy
set of recommendations/activities related to a particular purpose

3.23
resilience cycle
sequence of resisting, absorbing, adapting to and recovering from acute shocks and chronic stresses

3.24
resilience action plan
detailed plan outlining actions needed to reach one or more resilience goals

3.25
resilience strategy
plan to achieve a long-term or overall resilience objective

[SOURCE: modified ISO 9000:2015-09, definition 3.5.12]

3.26
risk
event that is expected to create a stress or shock to the system of interest often thought of in terms of the extent of its impact and the probability of occurrence

EXAMPLE A city is subject to unacceptable increases in air pollution, loneliness among the elderly or an increased number of elderly suffering from dementia.

3.27
risk register
tool to briefly describe or name each identified risk and record the impact (or consequence) if the event occurs, and the probability or likelihood of its occurrence

Note 1 to entry: The risk score or risk rating for each risk is the multiplication of probability and impact.

3.28
risk assessment
overall process of risk identification, risk analysis and risk evaluation

[SOURCE: ISO 22300:2018-02, definition 3.203]

3.29
risk scenario
portfolio of risk events that are causally linked, sometimes creating a vicious cycle where the scenario is self-sustaining

EXAMPLE Portfolio of risks: Families are increasingly living far away from one another leading to isolation risks of the elderly and/or breakdown of the family structure causing isolation and loneliness.

EXAMPLE Vicious cycle: Health services face an intolerable pressure, which means there is an inability to deliver basic healthcare. The rising health inequalities lead to an increase in health problems for those in poverty.

3.30
shock
sudden event that is not periodic and which threatens a city and requires immediate attention that cannot be given directly

EXAMPLE Earthquakes, floods, disease outbreaks and terrorist attacks.

3.31
social issues
problems that affect a substantial number of entities within a society

EXAMPLE Social unrest, elderly population, social cohesion, social alienation, inequalities, community integration, health, immigration, organized crimes or terrorism.

3.32
stakeholder
person, group or organization with an interest (stake) in the behavior, decisions, and policies of the city – stakeholders presume they may be affected by these, and they may have the power to affect them

EXAMPLE Local, regional and national government, European policymakers, emergency services, critical infrastructure providers, public-private partnerships, non-governmental organizations, volunteers, media, citizens, international organizations, academic and scientific entities.

3.33
threat
potential cause of an unwanted incident, which can result in harm to individuals, a system or organization, the environment or the community

[SOURCE: ISO 22300:2018-02, definition 3.259]

EXAMPLE Breakdown of sewage system.

4 Factors that influence shocks and chronic stresses of cities

The following characteristics should be considered during the implementation of the Maturity Model, especially in terms of the policies.

— *Government*: Key element in the resilience-building process of a city. It should guarantee the delivery of services and resources responding to shocks as well as chronic stresses and provide security. The government is in charge of implementing new legislation and regulation to promote the resilience-building process.

— *Population*: Different aspects relating to population should be considered. Population density in an urban area makes cities especially vulnerable to the impacts of shocks and chronic stresses. For example, the number of people and critical services affected due to a power blackout is significantly greater in cities than in rural areas.

  The average age of citizens, the percentage of the economically active population, percentage of citizens with higher education, and percentage of immigrants are also relevant indicators to consider in order to give detail to the Maturity Model since they provide information about the current and future challenges of the city.

— *Geographical location*: The location of a city can influence the probability of suffering certain type of shocks and chronic stresses. For example, San Sebastian is a coastal city with propensity for huge waves and consequently wave damage and flooding. Rome on the other hand is more likely to suffer the effects of an earthquake because of its location not far from a seismically active area.

— *Economic situation*: Local governments that invest in public infrastructure, planning systems, and support for employment growth can increase their resilience significantly, thus improving long-term investment prospects. On the other hand, cities in developing countries face higher chances of suffering shocks and chronic stresses due to their relative lack of resources for ensuring social welfare, enhancing the quality of infrastructures and adapting them to deal with these events. Indicators such as the unemployment rate, local gross domestic product, investments in research and innovation, and the budget the local government manages, makes it possible to analyze the economic situation of a city.

— *Quality of life/social cohesion*: This is the capacity of a society to ensure the welfare of all its members, minimizing disparities and avoiding polarization. The strength of the relationship between citizens is an indicator of how well communities will adapt when a shock occurs. In those situations, citizens cooperate to achieve a shared well-being. It is also important to build social cohesion when living with communities from a variety of cultures, ethnicities, languages and abilities. The influence of immigration on social cohesion is one of the challenges for Europe's future. The successful integration of immigrants is a prerequisite for social cohesion and economic progress. Indicators such as crime rate, poverty and integration programs among others are also crucial measurements to assess the quality of life of a city.

— *Quality of infrastructures*: Guaranteeing a high level of performance of the facilities that are critical to citizens' health and welfare is crucial for dealing with shocks and chronic stresses. Concrete actions should be implemented towards promoting investments in quality infrastructures to increase their redundancy, reliability and flexibility. Apart from critical services, the overall city infrastructure should be able to withstand a shock or should be easily restored if it is damaged during a shock. The city's urban planning should define measures to adapt the infrastructures located in particularly vulnerable areas and to build new infrastructures using nature-based solutions and technologies that can minimize the effect of shocks. An example of nature-based solutions can be found in Copenhagen, where recreational areas are used as flood prevention.

5 General

The aim of the Maturity Model is to provide a tool for reflection and guidance on the resilience-building process of cities, which will enable them to compile an analysis of their current status. It is primarily

designed to assist local governments in assessing their current maturity stage and to identify future resilience demands and capacities needed to advance to a more mature level.

The Maturity Model defines five incremental stages, which guide local governments through the ideal path for building city resilience: Starting, Moderate, Advanced, Robust, and Vertebrate. Each of these maturity stages includes a description of the objectives of each stage, the stakeholders actively involved in each maturity stage, and a list of policies that should be followed in order to achieve the objectives defined in that maturity stage. Furthermore, the identification of indicators for assessing each maturity stage is described. An overview of the content of the Maturity Model is given in Figure 1.

User of this CWA should first familiarize themselves with the resilience dimensions and sub-dimensions, and then apply the policies corresponding to the current maturity stage of the city. The policies can be viewed as recommendations, which are categorized according to the four resilience dimensions. Each resilience dimension is split into several sub-dimensions that group policies.

Indicators are to be developed and used to assess the maturity stage within the city when facing shocks and chronic stresses. The indicators are associated with the different resilience dimensions and sub-dimensions, thus supporting the identification of the maturity stage. They later help to identify gaps between planned and actual states as policies are implemented.

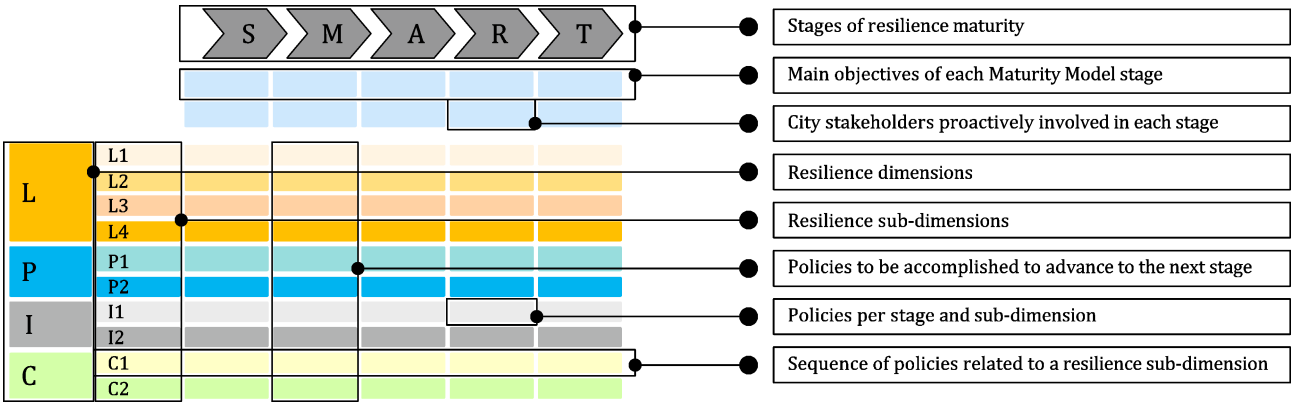

Figure 1 — Overview of the Maturity Model

The Maturity Model consists of four resilience dimensions:

1) Leadership and Governance (L);

2) Preparedness (P);

3) Infrastructure and Resources (I) and

4) Cooperation (C).

Each resilience dimension is split into several sub-dimensions with different policies. These sub-dimensions help cities visualize their maturity stage in these predetermined sub-areas, as cities can be at different maturity stages in different dimensions and sub-dimensions.

As shown in Figure 2, resilience development is a cross-dimensional and continuous learning process. The city stakeholders acquire knowledge, behaviors, skills, values, preferences and understanding of infrastructures, preparedness, leadership and cooperation that will help to improve the level of resilience, optimize the use of resources and avoid repeating previous mistakes. Learning is best achieved through the monitoring of past events and on-going processes to make predictions about future needs.

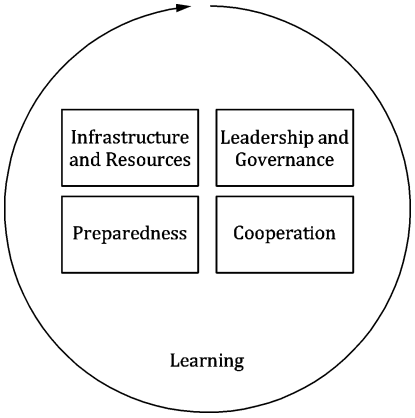

Figure 2 — Resilience is a continuous learning process

To support knowledge acquisition, learning processes and reflection activities, the local government should develop a set of case studies to illustrate best practices about the policies that have been implemented. A template for developing case studies is provided in Annex A.

6 Resilience dimensions and sub-dimensions

6.1 Dimension 1 - Leadership and Governance

The first dimension *Leadership and Governance (L)* affects the decision-making process of the local government. Commitment by the local government to a resilience culture, values and vision is essential for promoting effective strategies, inclusive decision-making and the engagement of relevant city stakeholders. All government levels are to develop an organizational culture of enthusiasm for challenge, agility, flexibility, adaptive capacity and innovation.

This dimension also involves the concept of multi-level governance, which requires the understanding of dynamic interrelationships within and between different levels of governance and government. The transfer of competencies upwards to supra-national organizations and downwards to sub-national authorities transformed both the structure and capacity of national governments. Within this dimension, three sub-dimensions are considered.

— *Municipality, cross-sectorial and multi-governance collaboration (L1)*: This sub-dimension includes all plans related to the activities the city conducts to establish collaboration on topics related to resilience within the different departments of the municipality, between different sectors and between different governmental bodies.

— *Legislation development and refinement (L2)*: This sub-dimension includes all plans related to the development of laws and procedures that help formalize the city's resilience-building process.

— *Learning culture (learning and dissemination) (L3)*: This sub-dimension includes all plans related to the fostering of resilience culture among different city stakeholders, as well as improving the learning process within the city.

— *Resilience action plan development (L4)*: This sub-dimension includes all the actions regarding the development of the resilience action plan.

6.2 Dimension 2 - Preparedness

Preparedness (P) refers to the anticipation of future needs and the adaptation of city functions. Preparedness is to be developed at all levels of society, from individuals and communities to leaders

and governments. It also includes being prepared for the unexpected, by increasing flexibility and the cities adaptive capacity and skills. Within this dimension, two sub-dimensions are to be considered.

— *Diagnosis and Assessment (P1)*: This sub-dimension includes plans regarding the systems and methodologies that are to be used to monitor and assess the implementation of the resilience action plan.

— *Education and Training (P2)*: This includes all the activities that are to be carried out to inform, educate and train city stakeholders. Activities to refine and disseminate the training programs are also considered.

6.3 Dimension 3 - Infrastructure and Resources

The city infrastructure shall be sufficiently robust in order to resist and absorb hazards through the preservation and restoration of its essential functions. This involves redundancy, risk management and continuous work on reducing vulnerabilities, in addition to the deployment of resources. The resources include all assets, people, skills, information, technology (including plant and equipment), premises (including nature-based solutions), supplies and information (whether electronic or not) that an organization has to have available to use, when needed, to operate and meet its objectives. Within this dimension, two sub-dimensions are considered.

— *Reliability of critical infrastructures and their interdependencies (I1)*: This sub-dimension includes all plans and capacities that help to increase the overall reliability, redundancy and adaptability of critical infrastructures.

— *Resources for building resilience and responding (I2)*: This sub-dimension includes all plans and capacities related to the allocation of resources to build up city resilience and improve the quality of crisis response.

6.4 Dimension 4 - Cooperation

Cooperation (C) refers to working or acting together for a common purpose or benefit. Cooperation is to be developed within the city and at a cross-regional level. The necessary stakeholders across city and regional sectors including European cities are to be considered. Cooperation shall also be developed at community level involving different stakeholders such as volunteer groups and citizens that exhibit an ability to self-organize. Within this dimension, two sub-dimensions are to be considered.

— *Development of partnerships with city stakeholders (C1)*: The different stakeholders within a city are to take part in the city resilience-building process. Therefore, the municipal authority shall carry out policies to set up collaboration partnerships and agreements with the city stakeholders and involve them in participative, learning and decision-making processes.

— *Involvement in resilience networks of cities (C2)*: Cities shall be aware and collaborate with other cities in order to contribute to its own as well as the overall resilience level. The municipal authority of a city shall establish alliances within networks of cities. This participation will allow the city to identify best practices, receive help and learn from other cities about the resilience-building process.

7 Maturity stage 1 - Starting

7.1 Description

In the starting stage, the crisis management of a local government is based on risk assessment without having an integrated approach towards multiple-hazards. Therefore, the risk assessment is fragmented and incomplete regarding hazards. Because critical infrastructure providers operate independently of

each other, there is a need for greater organization and cooperation among them. This is especially important in times of emergency when a disruption to one critical infrastructure can have cascading effects across other infrastructures. Against this background, a local government starts to identify and implement measures to improve critical infrastructures' reliability and robustness.

In this stage the local government has begun developing resilience policies; however, there is no coordination between the different activities conducted by different departments and there is no specific budget in the local government related to city resilience. There is no common strategy among the local government departments. Additionally, the stakeholders involved and sectors outside the local government also work independently.

In this context, the local government develops an integrated resilience action plan with common practices and approaches. A resilience strategy is included in the city's agenda at a strategic level. By this means, the local government makes the resilience strategy central to the municipality plan although the resilience action plan is still focused on dealing with shocks without considering chronic stresses.

The local government also carries out risk assessment to anticipate failures and mitigate risks as an input for the resilience action plan. A risk register shall be used to evaluate impact and probability of individual risks, which helps to develop risk mitigation strategies for high priority risks.

At this stage, the city's borders limit the resilience action plan. Therefore, collaboration with sub-urban or regional stakeholders is limited.

Characteristics of the starting stage

— lack of integrated approach towards multiple-hazards

— incomplete risk assessment

— incipient policies for resilience development

— focused on government

— local government is not part of larger networks

— incipient community involvement and public-private cooperation

— limited funding or no budget for resilience

7.2 Stakeholders

— *Local Government*: At this point, the local government acts proactively leading the resilience-building process. Its role is crucial since it integrates the actions developed independently by different municipal departments and stakeholders into a common strategy and communicates it so that everybody involved in the process has the same understanding about its objectives.

— *Emergency Services and Critical Infrastructure Providers*: Both collaborate with the local government to guarantee the provision of basic services as well as an adequate response in case of emergencies. Nevertheless, collaboration among critical service providers and emergency services need to be improved as these services operate independently. At this point, the role of critical infrastructure providers is reactive to accomplish the local government and emergency services requests, conducting joint emergency drills to meet minimum mandatory requirements.

7.3 Policies

Table 1 gives an overview of the policies, which should be taken into account in the starting stage of the maturity model.

Table 1 — Policies in the starting stage of the Maturity Model

Resilience dimension	Sub-dimension	Policy
Leadership and Governance	(L1) Municipality, cross-sectorial and multi-governance collaboration	— (L1S1) Establish a working team responsible for resilience in the city. — (L1S2) Integrate resilience into visions, policies and strategies for city development plans.
	(L3) Learning culture (learning and dissemination)	— (L3S1) Develop a strategy to create a resilience culture.
	(L4) Resilience action plan development	— (L4S1) Identify city requirements regarding the resilience-building process.
Preparedness	(P1) Diagnosis and Assessment	— (P1S1) Assess and manage a wide range of risks. — (P1S2) List and prioritize critical services and assets. — (P1S3) List existing plans and response mechanisms and guidelines for shocks and chronic stresses.
	(P2) Education and Training	— (P2S1) Conduct training and arrange emergency drills with the emergency teams and critical infrastructure providers. — (P2S2) Inform citizens about volunteering opportunities in the local community. — (P2S3) Develop a common understanding of the resilience approach among stakeholders.
Infrastructure and Resources	(I1) Reliability of critical infrastructures and their interdependences	— (I1S1) Develop cooperation/collaboration agreements between the local government and critical infrastructure operators. — (I1S2) Develop plans to monitor critical infrastructures' functionality. — (I1S3) Develop contingency plans for critical infrastructures.
	(I2) Resources for building resilience and responding	— (I2S1) Assess current initiatives and funding opportunities for the development of resilience. — (I2S2) Develop a list of the currently available physical resources for response. — (I2S3) Deploy a disaster relief fund for emergencies.
Cooperation	(C1) Development of partnerships with city stakeholders	— (C1S1) Map relevant stakeholders to develop the resilience action plan. — (C1S2) Develop a public website with emergency information. — (C1S3) Establish a cooperation plan with emergency service providers.

8 Maturity stage 2 - Moderate

8.1 Description

In the moderate stage, the risk assessment with regard to hazards affecting critical infrastructures is operationalized in cooperation with critical infrastructure providers in order to deliver essential services in case of a crisis or emergency, defining measures to rapidly "bounce back" to the previous level of functioning.

The resilience action plan includes policies to be prepared and respond to shocks and chronic stresses.

The local government uses an approach to risk assessment using a risk register to reflect on interdependencies between risks. The identification of policies, which can manage a number of risks in a risk area and which allows the local government to pay attention to "bouncing back" from both shocks and chronic stresses, is needed.

The local government sets up an organizational structure to manage the resilience action plan and deploy resources for its development.

The local government shall start monitoring the implementation of the policies included in the resilience action plan using control measures, although there is a lack of a formalized resilience management process.

A communication strategy that will scale up resilience-building efforts has been set up. The local government carries out initiatives such as events and training activities to increase the awareness level of the different stakeholders to foster a resilience culture among them.

The local government starts the development of a multi-governance approach.

Regarding collaboration, the local government recognizes the importance of networks and communication platforms for the engagement of stakeholders and knowledge sharing. At this stage, the local government and emergency services use the communication platform internally. Moreover, the local government starts planning for networking with other local governments at regional level with regard to resilience and sustainability.

Characteristics of the moderate stage

— risk assessment operationalized in cooperation with critical infrastructure providers

— implementation of resilience policies using effective control mechanisms

— creation of a position/department/committee for coordinating resilience development

— plans to improve cooperation among all stakeholders

— local government recognizes the relevance of a multi-governance approach

— networking with other local governments

— establishment and use of a communication platform

— holding events to increase stakeholders' awareness

8.2 Stakeholders

— *Local Government*: The local government is aware of the importance of creating public-private partnerships to help communities become more resilient in addition to increasing the efficiency and effectiveness of the resilience-building process. Consequently, the local government

communicates the resilience strategy to public and private companies asking them for their commitment and active involvement.

— *Emergency Services and Critical Infrastructure Providers*: Collaboration with the local government takes places on a regular basis. The local government's commitment fosters the partnerships between critical infrastructure providers and emergency services to conduct joint training exercises regularly. The interdependencies among the different critical services are integrated into a common long-term resilience plan for the city.

— *Regional Government*: The regional government begins to be involved in the resilience-building process and collaborates with the local government in the development of the city resilience action plan.

— *Public-Private Partnerships*: Initial efforts are undertaken by the local government to involve public and private companies in the resilience-building efforts.

— *Volunteers and NGOs*: Both are involved in training programs and emergency exercises with emergency services and critical infrastructure providers. The local government is a key driver in this process informing citizens about the volunteering opportunities and supporting them.

8.3 Policies

Table 2 gives an overview of the policies, which should be taken into account in the moderate stage of the maturity model.

Table 2 — Policies in the moderate stage of the Maturity Model

Resilience dimension	Sub-dimension	Policy
Leadership and Governance	(L1) Municipality, cross-sectorial and multi-governance collaboration	— (L1M1) Establish a resilience position, department or committee as well as a cross-departmental coordination board and procedures. — (L1M2) Align, integrate and connect the resilience action plan with regional plans. — (L1M3) Adopt climate change adaptation/ mitigation actions. — (L1M4) Promote equality of access to services and basic infrastructures to vulnerable sectors of society.
	(L2) Legislation development and refinement	— (L2M1) Outline the multi-level governance approach to be used in the resilience-building process.
	(L3) Learning culture (learning and dissemination)	— (L3M1) Promote a culture of resilience. — (L3M2) Review best practices to deal with shocks and chronic stresses used in different sectors and other cities.
	(L4) Resilience action plan development	— (L4M1) Develop a resilience action plan to respond to shocks and chronic stresses.
reparedness	(P1) Diagnosis and Assessment	— (P1M1) Take account of interdependencies between risks when assessing and managing risk.
	(P2) Education and Training	— (P2M1) Conduct training and arrange emergency drills including volunteers.
Infrastructure and Resources	(I1) Reliability of critical infrastructures and their interdependences	— (I1M1) Identify interdependencies of critical services at local level. — (I1M2) Develop periodic maintenance procedures for critical infrastructures. — (I1M3) Develop measures to increase critical infrastructure redundancy and reliability. — (I1M4) Implement monitoring systems for identifying risk, shocks and chronic stresses. — (I1M5) Carry out audits of critical infrastructure operators.
	(I2) Resources for building resilience and responding	— (I2M1) Include the resilience action plan in the local government budget. — (I2M2) Promote resources/tool sharing among critical infrastructure operators within the region during crises.

Resilience dimension	Sub-dimension	Policy
Cooperation	(C1) Development of partnerships with city stakeholders	— (C1M1) Develop a stakeholder engagement plan defining roles and responsibilities. — (C1M2) Develop an internal communication platform for sharing information with different municipal departments and emergency services.
	(C2) Involvement in resilience networks of cities	— (C2M1) Establish alliances with cities facing similar risks.

9 Maturity stage 3 - Advanced

9.1 Description

In the advanced stage, the local government develops an operational resilience action plan with a holistic approach that integrates all sectors and stakeholders. The resilience action plan contains measures for increasing the flexibility of city infrastructures in order to deal with shocks and chronic stresses and to adapt to on-going circumstances. The resilience action plan implements a risk assessment, that includes measures to rapidly "bounce back" (maintaining the previous level of functioning) and "bounce forward" (taking opportunities as they come along to thrive under change).

The progress of the resilience action plan is monitored using leading and lagging indicators in order to assess the effectiveness and impact of the implemented policies.

The resilience action plan is continuously revised, taking identified non-compliances into consideration, and improved, including lessons learned and best practices obtained through regular debriefing sessions which facilitate a shared understanding, reflection and discussion.

Fostering community resilience as well as public and private cooperation is part of the resilience approach. The local government recognizes that there is a need for a shift from top-down city level to bottom-up initiatives in order to increase the engagement and mobilization of relevant stakeholders. Providing incentives for citizens and the private sector to offer solutions they can implement on a local level will strengthen social cohesion and support the goals of the resilience action plan. In this manner the local government changes its role, becoming a facilitator rather than having a central guiding policy role.

A multi-governance approach with a European dimension is included in the plans, but is not fully operationalized. The local government is a member of a major network of European cities with regard to resilience and sustainability.

Characteristics of the advanced stage

— develop a framework to manage and operationalize resilience

— monitor the resilience action plan using leading and lagging indicators

— continuous revision of the resilience action plan through debriefing sessions

— foster community resilience and private-public cooperation

— multi-governance approach with a European dimension, but not yet fully operationalized

— city member of a major European network

9.2 Stakeholders

— *Local Government, Emergency Services, Critical Infrastructure Providers, Regional Government, Public-Private Partnerships, Volunteers, and NGOs*: All are engaged in learning networks to improve the city resilience action plan.

— *Local Government*: Provides incentives for investments in research, development and innovation projects to test innovative ideas, methodologies and tools that address the challenges of the resilience-building process.

— *Public-Private Partnerships*: To improve collaboration with public and private companies, these companies are provided with incentives if they contribute to achieving the goals of the resilience action plan.

— *National Government*: Involved in the resilience-building process of the city to integrate and connect the resilience action plan with national plans.

— *Academic and Scientific Entities*: The contribution of academic and scientific entities is recognized at this stage. Partnerships are developed to identify methodologies to improve and evaluate the progress of the city resilience. The research carried out by academic and scientific entities is valuable in the development of new concepts and approaches, and in the assessment of their relevance to the resilience-building process.

— *Media*: The media is involved in the resilience-building process, and information is shared with them so that the actions of the resilience action plan can be disseminated to citizens. Media is used by the local government as a channel to communicate and disseminate the municipality strategy to citizens towards building resilience, increasing citizens' awareness and commitment to contributing in the resilience-building process.

— *Citizens*: At this stage, citizens are provided with the opportunity to provide input, suggestions and comments about the resilience-building process. Moreover, direct citizen involvement is a strategic shift in resilience-building process. Citizens contribute to increasing preparedness, and the response to and recovery from shocks and chronic stresses, since they are usually the first responders, already at the scene of a disaster as it occurs, and demonstrating a capability to deal with the emergency.

9.3 Policies

Table 3 gives an overview of the policies, which should be taken into account in the advanced stage of the maturity model.

Table 3 — Policies in the advanced stage of the Maturity Model

Resilience dimension	Sub-dimension	Policy
Leadership and Governance	(L1) Municipality, cross-sectorial and multi-governance collaboration	— (L1A1) Align, integrate and connect the resilience action plan with national plans. — (L1A2) Develop a plan for a multi-level governance approach involving the municipal, regional and national levels of governance.
	(L2) Legislation development and refinement	— (L2A1) Carry out certification processes to achieve conformity with national standards.
	(L3) Learning culture (learning and dissemination)	— (L3A1) Formalize the learning process and institutionalize regular debriefing meetings.
	(L4) Resilience action plan development	— (L4A1) Develop leading indicators for assessing the resilience action plan.
Preparedness	(P1) Diagnosis and Assessment	— (P1A1) Assess and prioritize risk scenarios and their implications through consideration of risk systemicity. For example using the *Risk Systemicity Questionnaire Tool*, which is further described in *CWA 17300 City Resilience Development – Operational Guidance*.
	(P2) Education and Training	— (P2A1) Provide training for citizens as well as public and private companies. — (P2A2) Conduct emergency drills at national level. — (P2A3) Develop education programs in schools about the resilience action plan. — (P2A4) Assess and refine training programs.
Infrastructure and Resources	(I1) Reliability of critical infrastructures and their interdependences	— (I1A1) Develop adaptability measures.
	(I2) Resources for building resilience and responding	— (I2A1) Promote and provide incentives for initiatives that contribute to building resilience. — (I2A2) Implement centralized control of coordination of critical resources and activities during shocks and chronic stresses. — (I2A3) Encourage stakeholders to have appropriate insurance coverage. — (I2A4) Promote and provide incentives for the development of sustainable urban infrastructures.

Resilience dimension	Sub-dimension	Policy
Cooperation	(C1) Development of partnerships with city stakeholders	— (C1A1) Align the objectives of the different stakeholders and set up a common understanding of resilience. — (C1A2) Develop formal partnerships between academic and scientific entities to improve the resilience-building process. — (C1A3) Undertake public consultations to receive feedback on the resilience action plan. — (C1A4) Develop a public platform to interact and communicate with stakeholders.
	(C2) Involvement in resilience networks of cities	— (C2A1) Join a major network of European cities. — (C2A2) Develop formal partnerships with regional stakeholders.

10 Maturity stage 4 - Robust

10.1 Description

All relevant stakeholders have been identified and were engaged in the development of the resilience action plan. Upon reaching this stage, the term CITY can be used (see definition Clause 3). Stakeholders are proactive and add value to resilience-building processes. They are also aware that resilience is a continual process and resilience is part of the daily thinking and acting.

The resilience action plan is monitored and assessed based on regularly collected information and the success and possible drawbacks of the process are reported, giving feedback for the resilience action plan revision process. The focus is on making the system and the community resilient and not placing sole responsibility on the individual employee and citizen. The resilience action plan is continuously improved and updated based on the feedback and suggestions received from the city stakeholders via consultations and participatory platforms.

The CITY is capable of "bouncing back" and "bouncing forward" from shocks and chronic stresses.

The CITY combines a participatory approach with local decision-making. The city administration and organization is flexible enough to adapt and evolve as the threat landscape continuously shifts. Local communities work as self-organized systems that can deal with uncertain situations.

The multi-governance approach with an international dimension is well-developed and operationalized.

The CITY participates in a variety of networks with regard to resilience and sustainability, has a proactive attitude, and encourages continuous learning, transferring knowledge and best practices to be prepared for any unknown events.

Characteristics of the robust stage

— engagement of all the stakeholders (CITY)

— stakeholders add value to the resilience-building process

— multi-governance approach well developed and operationalized

— city is member of a major network, has a proactive attitude and encourages continuous learning

— awareness about city resilience level

10.2 Stakeholders

— *Local Government, Emergency Services, Critical Infrastructure Providers, Regional Government, Public-Private Partnerships, Volunteers, NGOs, National Government, Media, Citizens, Academic and Scientific Entities*: All are actively involved in the development of the city's resilience. Feedback from and opinions of these stakeholders are taken into account for the implementation of the resilience action plan, and when making decisions about the progress of the city's resilience. At this stage, stakeholders recognize the importance of collaborating in the resilience-building process and perceive the benefits. In addition, they make a significant effort to learn and improve the resilience development by sharing lessons learned and engaging in multi-stakeholder discussions.

— *European Policymakers*: The involvement of European policymakers enables a common framework to be drawn up with guidelines for the collaboration among different countries and resource sharing in case of shocks and chronic stresses. The European policymakers also provide guidelines for helping critical infrastructure providers incorporate resilience-building programs addressed towards climate change, shocks and chronic stresses, and set up policies to overcome inequalities and promote well-being and cohesion.

10.3 Policies

Table 4 gives an overview of the policies, which should be taken into account in the robust stage of the maturity model.

Table 4 — Policies in the robust stage of the Maturity Model

Resilience dimension	Sub-dimension	Policy
Leadership and Governance	(L1) Municipality, cross-sectorial and multi-governance collaboration	— (L1R1) Align, integrate and connect the resilience action plan with regional, national and international resilience management guidelines.
	(L2) Legislation development and refinement	— (L2R1) Carry out certification processes to achieve conformity with international standards.
	(L3) Learning culture (learning and dissemination)	— (L3R1) Institutionalize learning processes within the municipality and other public entities.
	(L4) Resilience action plan development	— (L4R1) Assess and monitor the resilience action plan's efficiency periodically in order to continuously improve it.
Preparedness	(P1) Diagnosis and Assessment	— (P1R1) Undertake regular and long-term risk assessment with a focus on risk systemicity.
	(P2) Education and Training	— (P2R1) Establish a strong network of volunteers. — (P2R2) Conduct frequent joint training exercises with European cities.

Resilience dimension	Sub-dimension	Policy
Infrastructure and Resources	(I1) Reliability of critical infrastructures and their interdependences	— (I1R1) Identify interdependencies of critical services at international level.
	(I2) Resources for building resilience and responding	— (I2R1) Promote and provide incentives to stakeholders for investment in research, development and innovation projects regarding resilience. — (I2R2) Monitor an effective use of resources to ensure a sustainable resilience-building process.
Cooperation	(C1) Development of partnerships with city stakeholders	— (C1R1) Widen collaborative networks with stakeholders to reflect on and make decisions about the progress of the city resilience. — (C1R2) Arrange multi-stakeholder debriefing meetings. — (C1R3) Improve the public platform to enhance learning among city stakeholders.
	(C2) Involvement in resilience networks of cities	— (C2R1) Participate proactively in regional, national and international networks to promote initiatives, exchange experiences and learn.

11 Maturity stage 5 - Vertebrate

11.1 Description

In the vertebrate stage, the CITY enhances its resilience, being part of the regional, national and international resilience system and understanding that in order for the CITY to become resilient, the environment needs to be resilient as well. The CITY functions as a "vertebra" in the *European Resilience Backbone* and has an internalized resilience culture.

The resilience action plan is continuously improved based on lessons learned from past events. There is also a full integration of all known stakeholders in the resilience action plan, with a high level of participation of these stakeholders in the decision-making process. Communities are able to self-organize in order to help at times of crisis.

The CITY acts as a leader in international networks and participates in the definition of resilience standards. Actions implemented in the CITY are presented to third parties as best practices. The CITY is thus proactively supporting the development of resilience in other cities and regions, as it understands that coexisting in a more resilient environment makes the CITY itself more resilient.

Characteristics of the vertebrate stage

— CITY is part of an ecosystem that has to be resilient

— CITY acts as a vertebra in the *European Resilience Backbone*

— continuous improvement of the resilience action plan

— CITY is proactive in promoting resilience practices

11.2 Stakeholders

— *Local Government, Emergency Services, Critical Infrastructure Providers, Regional Government, Public-Private Partnerships, Volunteers, NGOs, National Government, Media, Citizens, Academic and Scientific Entities, European Policymakers*: All efforts are coordinated, integrated and aligned with the resilience action plan. Furthermore, stakeholders are regularly engaged in debriefing meetings, experiences, and lessons learned from these stakeholders are a useful input for improving the city resilience action plan. The CITY acts as tutor for the resilience-building process in other cities.

— *International Organizations*: Partnerships with international organizations, which lead and participate in research projects related to the improvement of resilience in different topics, can provide the CITY with an opportunity for networking with other cities and sharing knowledge and experiences.

EXAMPLE Examples of international organizations are the Rockefeller foundation and the United Nations Office for Disaster Risk Reduction (UNISDR).

11.3 Policies

Table 5 gives an overview of the policies, which should be taken into account in the vertebrate stage of the maturity model.

Table 5 — Policies in the vertebrate stage of the Maturity Model

Resilience dimension	Sub-dimension	Policy
Leadership and Governance	(L1) Municipality, cross-sectorial and multi-governance collaboration	— (L1T1) Support the development of other city resilience plans which are aligned, integrated and connected with regional, national and international resilience management guidelines.
	(L2) Legislation development and refinement	— (L2T1) Contribute to the development of standards on resilience guidelines and policies.
	(L3) Learning culture (learning and dissemination)	— (L3T1) Develop formal procedures for assessing the effectiveness of the learning process. — (L3T2) Participate in knowledge exchange programs and platforms with other cities, regions and countries.
	(L4) Resilience action plan development	— (L4T1) Share the CITY's expertise in the resilience action plan development with other cities that are about to start the resilience-building process.
Preparedness	(P1) Diagnosis and Assessment	— (P1T1) Assess the value added by CITY contributions to the resilience of other CITIES.
	(P2) Education and Training	— (P2T1) Develop training plans in cooperation with other CITIES. — (P2T2) Implement training activities with other CITIES. — (P2T3) Encourage autonomous activities that improve the resilience of the CITY.
Infrastructure and Resources	(I1) Reliability of critical infrastructures and their interdependences	— (I1T1) Encourage the continuous improvement of policies, to take advantage of any shock and chronic stress to "bounce forward", improve and re-design. — (I1T2) Apply big data approaches to analyze the information obtained.
	(I2) Resources for building resilience and responding	— (I2T1) Assess the impact of innovation in the resilience-building process. — (I2T2) Monitor the insurance level of stakeholders.
Cooperation	(C1) Development of partnerships with city stakeholders	— (C1T1) Enhance self-organization of cooperation among all stakeholders involved in resilience development. — (C1T2) Involve all stakeholders in the learning process.
	(C2) Involvement in resilience networks of cities	— (C2T1) Active involvement of local authorities and stakeholders in networks (local, national, European and international). — (C2T2) Encourage stakeholders to present their experience with the resilience-building process as reference for other cities and CITIES.

12 Indicators for the assessment of a city's resilience

12.1 Characteristics of indicators

Indicators help elaborate a description of city resilience. In order to have an efficient indicator-based solution, the selected indicators shall be independent, measurable (qualitative or quantitative data) and easily understandable to users. Additionally indicators shall be valid and reliable while also realistic and reasonable to measure. Furthermore, end users should be involved in the identification and selection of indicators.

The number of selected indicators and their hierarchical organization (aggregation) should be done in such a way that the number of indicators is sufficiently high to represent the resilience dimension well (adequate coverage) and at the same time, reasonably small in order to be usable (simplicity of use).

12.2 Examples of indicators

For the resilience dimension *(P2) Education and Training,* the following policies apply in the advanced maturity stage:

— (P2A1) Provide training for citizens as well as public and private companies;

— (P2A2) Conduct emergency drills at national level;

— (P2A3) Develop education programs in schools about the resilience action plan;

— (P2A4) Assess and refine the training programs.

For each particular case of the city resilience assessment, the respective indicators should be established. Examples of indicators with relation to the above policies are:

— (P2A1) What are the quality requirements for a companies' resilience program? [Scale];

— (P2A2) How long ago was the last national drill? [Number of years];

— (P2A3) What is the percentage of schools that have a resilience action plan program? [Percentage];

— (P2A4) Does a standardized training program exist? [Yes/No].

12.3 Adaption of indicators to support assessment of resilience maturity stage

Assigning values to the indicators provides a measurable understanding of the issues and thereby of the resilience dimensions. This process thus yields an aggregate value (resilience level) indicating the resilience at a given stage of the maturity model. This type of assessment can be done either by the city stakeholders directly (self-assessment) or by others, e.g. an appointed third party.

One method for performing the assessment is the establishment of (weighted) averages. In this case, weights are used, which the city stakeholders usually assign. These methods could then be adapted to the scale used for the indicators, e.g. some of the audit methods for indicator assessment often use scale indicator measurements with predefined answers corresponding to the scale points (e.g. zero at the scale representing a yes/no question or the case when something is completely missing). When assessing the quality of a plan on a scale from zero to five, for example, zero could mean that there is no plan or an unsystematic plan while five could indicate a well-implemented, existing plan.

12.4 Steps to assess a city's resilience

The steps below should be followed for each resilience dimension in order to assess resilience at each maturity stage:

1) Identify the issues arising from each sub-dimension.

2) Define indicators for each issue. Some indicators can be applied for a single phase of the resilience cycle, while others can be applied for several phases. Some indicators can be applied for a single stage of the maturity model and others can be applied for several stages.

3) Assign weights to each indicator according to the importance of what it measures, and assign values to each indicator.

4) Assess each indicator in each relevant resilience phase, resilience dimension and maturity stage.

5) Assess the resilience of the city within the Maturity Model according to the combined resilience level of all the dimensions.

Annex A
(informative)

Template for case studies to illustrate best practice implementation of the policies

A case study description should be one or two pages long and should contain visual support.

The following content should be included.

a) Case study name

b) Resilience dimension, sub-dimension and policy (e.g. L2R1) illustrated by this case study

c) Summary

- Short description of the case study.
- Word count: approximately 30

d) Relevant context

- Include context about the city, and other cities to which this case study could be of relevance.
- Word count: approximately 100

e) Aim

- Why was this project carried out? What was it trying to achieve?
- Word count: approximately 100

f) Approach

- How was the project carried out? What methods were used? Who was leading? Who was involved? How did they collaborate?
- Word count: approximately 100

g) Resources

- How was the project funded? How much did it cost? Were human resources required?
- Word count: approximately 30

h) Outcome

- What was achieved? Why is this project an example of best practice? What worked well? Lessons learned?
- Word count: approximately 100