H2020-DSR-4-2014

PANDEM

Pandemic Risk and Emergency Management

DRAFT

D6.1 Specification and validation of demonstration concepts

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Project website: www.pandem.eu.com

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EXECUTIVE SUMMARY

Pandemic Risk and Emergency Management, PANDEM, is a Coordination and Support action funded by the Horizon 2020 Secure Societies Programme under the topic: Crisis management: Feasibility study for strengthening capacity-building for health and security protection in case of large-scale pandemics – Phase I Demo.

The objective of PANDEM was to assess current best practice and identify important gaps and innovative solutions in technologies, systems and capacity in the areas of surveillance, communications and governance, at Member State, EU and global levels. There was a particular focus on enhancing the capacity of EU Member States to collaborate on cross border risk assessment, response and recovery. With consortium experts from the health, communications, information technology, security, defence, legal and crisis management fields, the project investigated how key sectors in pandemic management can collaborate more effectively in order to prepare for and respond to the next pandemic.

The objectives of this report (D6.1) are to summarise the outputs of PANDEM Phase I Work Packages to date and describe, specify and validate the innovative concepts to be proposed for Phase II.

Building on advances in information technology, training methods, and effective risk communications, planning and governance, the proposed PHASE II Demonstration Strands address the three key domains where the Project has identified innovative solutions.

- **STRAND 1 - Governance, Planning and Communications:** Advance planning and engagement that builds trust and resilience
- **STRAND 2 - Situational Awareness and Decision Support:** State of the art surveillance, detection and prediction tools that support effective decision making
- **STRAND 3 - Workforce Mapping, Training and Networking**: enhanced knowledge sharing and immersive multi-sectoral learning, cross-sectoral simulation exercises and networking that maximises operational preparedness and response.

Each of the 13 demonstration concepts proposed is described in terms of the gap identified, description of solution/concept identified, outputs and impact. The solutions proposed will in many cases be closely linked and cross cutting. The plan for phase II will be to carry out targeted research to advance knowledge and practice in key areas, leverage advances in information technology and utilise advanced training, learning and knowledge sharing methodologies. The next steps will be to define a roadmap and implementation plan for a Phase II Demonstration project (D6.2).

1. PANDEM: BACKGROUND

Large scale epidemics pose a threat to the European Union (EU) due to the convergence of risk factors driving the emergence, amplification and dissemination of pathogens with pandemic potential.

Recent experiences with the Ebola outbreak in West Africa, the H1N1 pandemic, and ongoing Zika virus and Yellow Fever outbreaks demonstrate the threat posed by these emerging diseases on EU Member States and their citizens.

Protecting the health and security of citizens in the EU, in the face of these pandemic threats requires a coherent response driven by effective pandemic risk management.

In response to this challenge, the EU is funding research on building capacity in Member States. This research is also looking at investigating ways how the EU and Member States can be supported to implement EU Decision 1082 which provides new legislation to streamline and strengthen EU capacities to respond effectively to serious cross border threats to health.

The European Commission identified the three core areas of surveillance, communications and governance for which capacity building is required to strengthen pandemic management.

Pandemic Risk and Emergency Management, PANDEM, is a Coordination and Support action funded by the Horizon 2020 Secure Societies Programme under the topic: Crisis management: Feasibility study for strengthening capacity-building for health and security protection in case of large-scale pandemics – Phase I Demo.

With consortium experts from the health, communications, information technology, security, defence, legal and crisis management fields, the project is investigating how key sectors in pandemic management can collaborate more effectively in order to prepare for and respond to the next pandemic. The project is also assessing recent developments in information and communication technologies to support and improve inter-sectoral cooperation for pandemic management.

2. PANDEM: OBJECTIVES

The objective of PANDEM is to identify important gaps and innovative solutions in technologies, systems and capacity in the areas of surveillance, communications and governance, at Member State, EU and global levels. There is a particular focus on enhancing the capacity of EU Member States to collaborate on cross border risk assessment, response and recovery.

The project's specific objectives are to:

- Review and assess current best practice pandemic preparedness and response tools, systems and practice at national, EU and global level in priority areas
    - Risk assessment surveillance
    - Communication and public information
    - Governance and legal frameworks.
- Identify major gaps, improvement needs and priority research questions for pandemic management.
- Identify potential solutions for improved technologies, systems and capacity that would lead to better pandemic management, more efficient use of resources and better cross border risk assessment, response and recovery.
- Set the foundation for a multi-disciplinary, inter-sectoral network of experts in the EU and globally to improve pandemic management.
- Contribute to the reduction of health, socio-economic and security consequences of future pandemics to be better prepared at regional, national, EU and global level.

3. PURPOSE AND OBJECTIVES OF REPORT D6.1

1. Summarise the work and outputs of PANDEM Work Packages to date
2. Describe, specify and validate these innovative concepts in terms of:
    a. Gap identified
    b. Description of solution/innovative concept Identified
    c. Outputs
    d. Impact.

4. PANDEM: SUMMARY OF OUTPUTS

PANDEMs work was carried out by a multi-sectoral consortium which engaged in a range of analysis, research and outreach activities organised in a coordinated group of Work Packages.

The three core Work Packages (WP2-4) focused on examining best practice, identifying gaps and identifying potential solutions in the areas of:

- SURVEILLANCE (Threat Analysis, Risk Assessment and Surveillance)
- COMMUNICATIONS (Communications and Public Information)
- GOVERNANCE (Governance and Legal Frameworks).

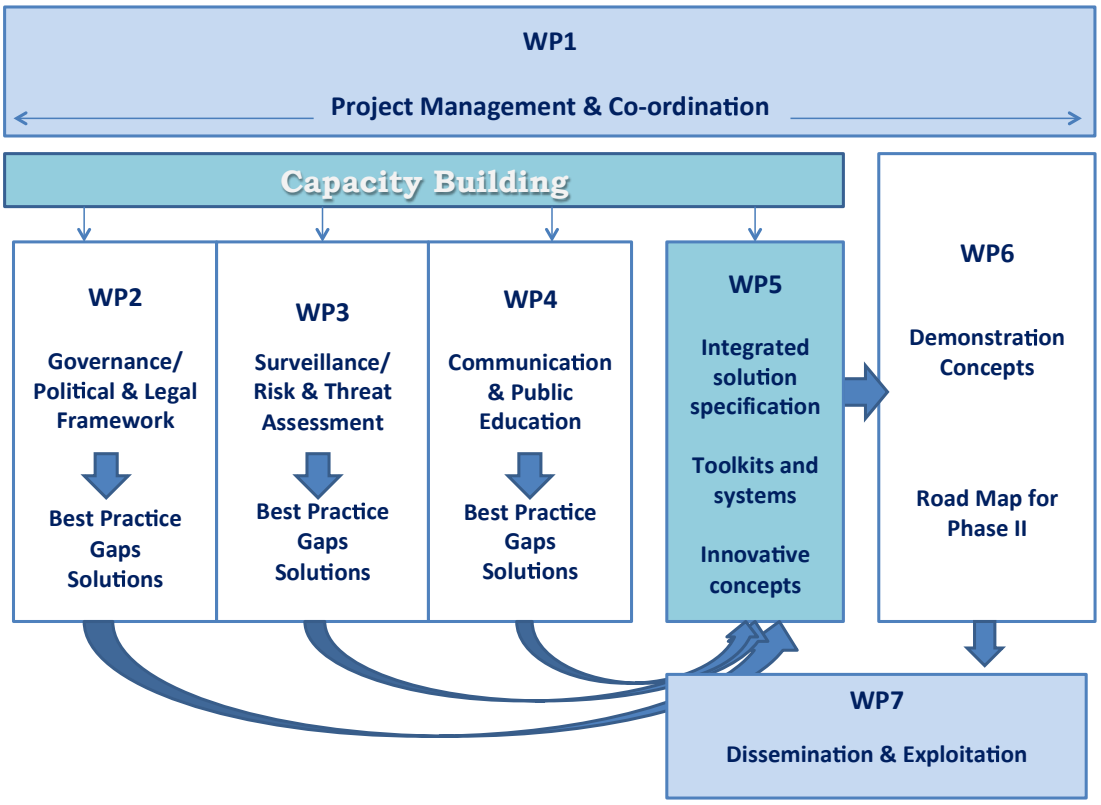

Figure 1: PANDEM Organisation and Relationships between Work Packages

4.1 WP 2 Threat Analysis, Risk Assessment & Surveillance

D2.1 Threat Analysis And Scenarios: conducted a comprehensive threat analysis and developed pandemic scenarios for use by all work packages to identify gaps, needs and suggestions as potential demonstrator concepts.

D2.2 Analysis Of Current Systems, Practices & Technologies For Risk Assessment & Surveillance And Research Needs: assessed the current systems and practices for surveillance and risk assessment at national, EU and global level to identify good practices for pandemic preparedness and response by case studies.

D2.3 Review of Diagnostic Technologies: reviewed the current diagnostic technologies and identified requirements for future innovative solutions.

4.2 WP 3: Communication & Public Information

D3.1 Identification/Mapping of Key Stakeholders and Users: identified key stakeholders in pandemic risk management.

D3.2 Review of EU and Global Initiatives and Research Projects/S&T Initiatives: produced a comprehensive review of relevant EU and global initiatives including science & technology research projects relevant to the pandemic demonstration project.

D3.3 Review of Best Practices, Inventory and Analysis Of Digital and Social Media Tools and Research Needs: assessed best practices in communication that have previously been used in preparing for, and responding to earlier epidemics and pandemics.

4.3 WP 4 Governance & Legal Frameworks

D4.1 Review Of Policy and Legal Frameworks: Examined existing key legal and policy frameworks at global, European and national levels with the aim of identifying commonalities, disconnects and priority challenges for future research

D4.2 Review and Analysis of Ethical and Human Rights Issues: Reviewed and analysed ethical and human rights issues in relation to pandemic preparedness and presents the current status and then identify gaps and priority challenges for the European Union

D4.3 Identification of Knowledge, Capability and Capacity Gaps, Priorities and Candidate Solutions for Pandemic Governance: Built on the research conducted for D4.1 and D4.2 by providing a synthesis on knowledge, capability and capacity gaps, priorities and candidate solutions to strengthen pandemic governance in the EU.

4.4 WP 5: Gaps, Needs and Solutions

The outputs of Work Packages 2, 3 and 4 were used in the Work Package 5 process to develop:

- An Integrated Gap Analysis (D5.2)
- An Integrated Solutions Specification (D5.3)
- A Research and Training Needs Report (D5.4)

The Integrated Gap Analysis (D5.2) distilled and integrated the outputs of the PANDEM Workshop (D5.1) and WP2-4 in terms of best practice, gaps identified and innovation and research needs. Ongoing work in other projects were reviewed, to enable PANDEM to build on and support previous and ongoing efforts. The effectiveness and impact of preparedness and response to past epidemics and pandemics by national governments and the EU were assessed including lessons learned. Based on these findings, a matrix was developed by all consortium partners which presents the current gaps and proposes solutions to address these gaps.

The Integrated Solutions Specification (D5.3) prioritises eight key areas of pandemic management at EU level that can be addressed by properly leveraging current and emerging ICT technologies. These included the development of an interactive resource modelling tool, an integrated predictive modelling tool, decision-support/data visualisation tool, diagnostic tools and innovative training technologies. The preliminary specifications of these tools were also provided which would be further specified, validated and developed as demonstrator concepts in D6.2 and D6.3 (Phase II Demo concepts & Roadmap).

The Research and Training needs reports (D5.4) consolidated research findings from WP 2-4 and identified where further research is required focusing on research necessary to support effective cross-sectoral and transnational coordination and collaboration. Opportunities were identified for capacity building/training, e-learning, serious gaming, multi-sectoral exercises and networking especially where greater standardization/predictability in risk assessment/management are required for cross-border response.

See Table 1 for a summary of PANDEM Work Package outputs.

Table 1. PANDEM Work Package Outputs 2-5			
Work Package 2 **Surveillance**	D2,1	Threat analysis and scenarios.	Conducted a comprehensive threat analysis and developed pandemic scenarios for use by all work packages to identify gaps, needs and suggestions as potential demonstrator concepts.
	D2.2	Analysis of current systems, practices & technologies for risk assessment & surveillance and research needs	Assessed the current systems and practices for surveillance and risk assessment at national, EU and global level to identify good practices for pandemic preparedness and response by case studies.
	D2.3	Review of diagnostic technologies	Reviewed the current diagnostic technologies and identified requirements for future innovative solutions.
Work Package 3: **Communications**	D3.1	Identification/mapping of key stakeholders and users	Identified key stakeholders in pandemic risk management.
	D3.2	Review of EU and global initiatives and research projects/s&t initiatives	Produced a comprehensive review of relevant EU and global initiatives including science & technology research projects relevant to the pandemic demonstration project.
	D3.3	Review of best practice, inventory of digital/social media for communications and analysis of current systems and technologies	Assessed best practices in communication that have previously been used in preparing for, and responding to earlier epidemics and pandemics.
Work Package 4: **Governance**	D4.1	Review of policy and legal frameworks	Examined existing key legal and policy frameworks at global, European and national levels with the aim of identifying commonalities, disconnects and priority challenges for future research
	D4.2	Review and analysis of ethical and human rights issues	Reviewed and analysed ethical and human rights issues in relation to pandemic preparedness and presents the current status and then identify gaps and priority challenges for the European Union
	D4.3	Identification of knowledge, capability and capacity gaps, priorities and candidate solutions for pandemic governance	Built on the research conducted for D4.1 and D4.2 by providing a synthesis on knowledge, capability and capacity gaps, priorities and candidate solutions to strengthen pandemic governance in the EU..
Work Package 5: **Gaps, Needs and Solutions**	D5.1	Workshop to identify needs and innovations to strengthen pandemic surveillance, communications and governance	Gathered external experts and PANDEM consortium members to discuss the current good best practice, gaps, user needs as well as the research and innovation needed in the PANDEM areas of Surveillance, Communications and Governance
	D5.2	Integrated Gap Analysis	Distilled and integrated the outputs of the PANDEM Workshop (D5.1) and WP2-4 in terms of best practice, gaps identified and innovation/research needs. Ongoing work in other projects were reviewed to enable PANDEM to build on and support previous/ongpoing efforts. Assesed the effectiveness/impact of preparedness and response to past epidemics/pandemics by national governments and the EU including lessons learned. Based on these findings, a matrix was developed by all consortium partners which examines the current gaps and proposes solutions to address these gaps.
	D5.3	Integrated solutions specification	Presented eight key areas of pandemic management at EU level that can be addressed by properly leveraging contemporary and upcoming ICT techniques. These included the development of an interactive resource modelling tool, an integrated predictive modelling tool, decision-support/data visualisation tool, diagnostic tools, innovative training technologies, and. The preliminary specifications of these tools were also provided which would be further specified, validated and developed as demonstrator concepts in D6.2 and D6.3 (Phase II Demo concepts & Roadmap)
	D5.4	Priorities for research and training	Consolidated research findings from WP 2-4 and identified where further research is required focusing on research necessary to support effective cross-sectoral and transnational coordination and collaboration. Identified opportunities for capacity building/training, e-learning, serious gaming, multisectoral excercises and networking especially where more standardization/predictability in risk assessment/management are required for cross-border response.

5. DESCRIPTION OF DEMONSTRATION STRANDS AND CONCEPTS

PANDEM Phase I looked at the current systems and tools across three domains of surveillance, communications and governance, identifying gaps and improvement needs as well as innovative solutions to fill those gaps.

A follow-on Phase II project will focus on demonstrating a number of innovative solutions. These solutions involve improving knowledge through targeted research and the development of specific tools, architecture and systems that will be implemented and validated (Figure. 2).

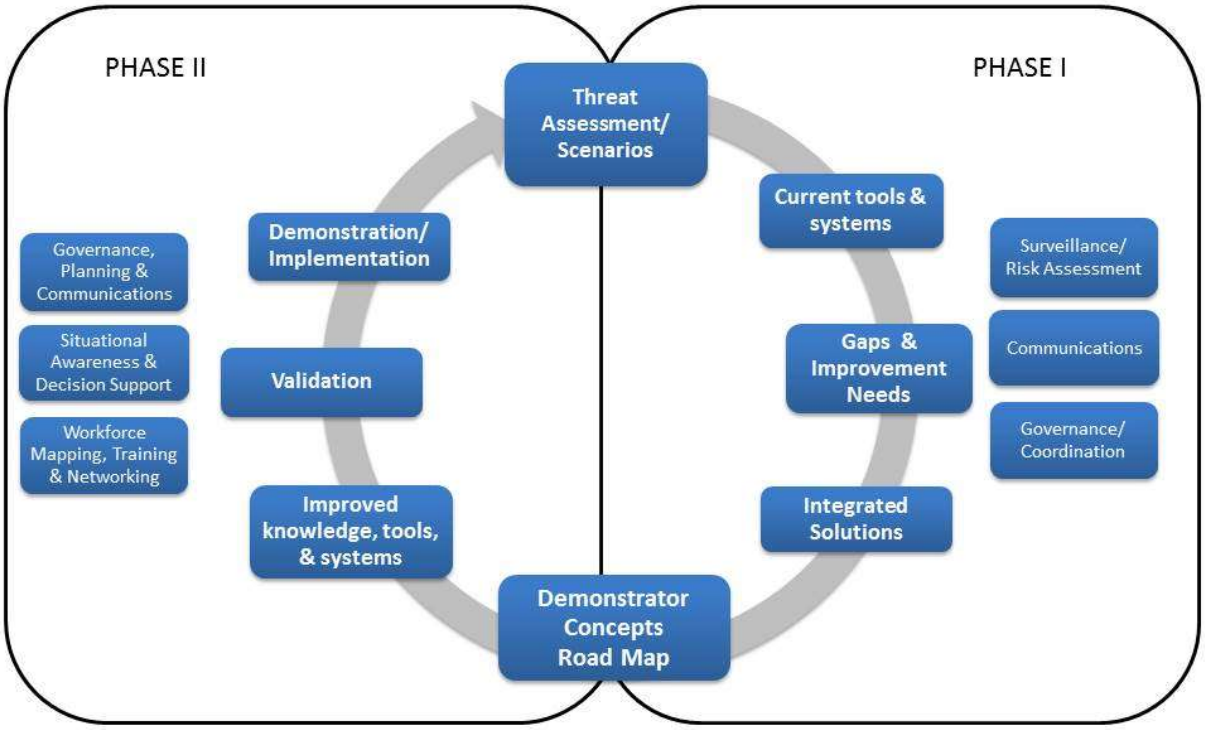

Figure 2: PANDEM: How Phase I Links with Phase II

Building on advances in information technology, training methods, and understanding of effective risk communications, planning and governance, the proposed PHASE II Demonstration Strands address the three key domains where the Project has identified innovative solutions (Figure 3):

- **STRAND 1 - Governance, Planning and Communications:** Advance planning and engagement that builds trust and resilience

- **STRAND 2 - Situational Awareness and Decision Support:** State of the art surveillance, detection and prediction tools that support effective decision making
- **STRAND 3 - Workforce Capacity, Training and Networking**: enhanced knowledge sharing and immersive multi-sectoral learning, cross-sectoral simulation exercises and networking that maximises operational preparedness and response.

The strands are not mutually exclusive and the solutions proposed will in many cases be closely linked and cross cutting and will:

- Carry out targeted research to advance knowledge and practice in key areas
- Leverage advances in Information Technology
- Utilise advanced training, learning and knowledge sharing methodologies.

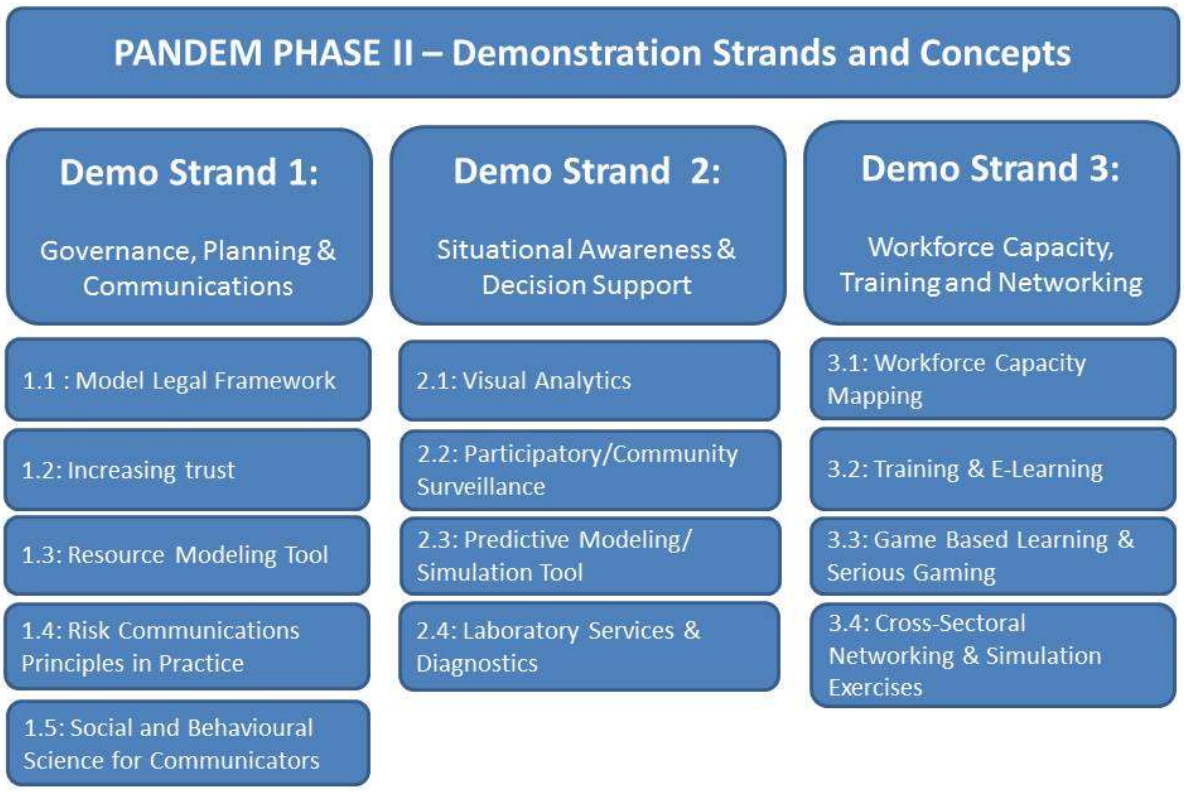

Figure 3 PANDEM Phase II: Demonstration Strands and Concepts

5.1 DEMONSTRATION STRAND 1: GOVERNANCE, PLANNING AND COMMUNICATIONS

The objective of this Demonstration Strand is strong legal and policy frameworks linked to advanced pandemic planning and resource modelling, with effective communications that build public trust and result in effective community engagement.

The proposed demonstrator concepts (DC) under this Strand include:

- Model legal framework for pandemic response
- Increasing trust in governmental and public health institutions
- Resource modelling decision-support tool
- Risk communications principles in practice
- Social and behavioural science for communications.

DEMO CONCEPT 1.1 MODEL LEGAL FRAMEWORK FOR PANDEMIC RESPONSE

BACKGROUND/JUSTIFICATION

Importance of national legal frameworks: Sound governance is central to pandemic management. The International Health Regulations 2005 (IHR) and EU Decision 1082/13 are the key international legal instruments governing pandemic management. They require Member States to develop national plans and invite states to establish national legal frameworks to support compliance with this international legislation. The first Core Capacity required for the IHR is that "Legislation, laws, regulation, administrative requirements, policies or other government instruments in place are sufficient for implementation of the IHR". The principle of national sovereignty means that states may design the legal framework they choose but the strongest instrument of pandemic governance is national legislation.

Legislation is transparent (in the public domain), binding and enforceable. It sets out in the strongest possible form a national commitment to action, defines clearly the actions to be implemented, and, in so doing, defines tangible measures for evaluation. Legislation is a key tool in the armoury for better compliance, transparency and accountability.

National legislation has another valuable purpose. Although described as legally binding, the IHR has no enforcement mechanism. National laws which encompass the terms of the IHR or, in Europe, Decision 1082/13 should enable better compliance and enforcement at local level.

GAP IDENTIFIED

Many countries do now have plans in place, which can include controversial, but sometimes necessary measures such as rationing of resources, enforced isolation or quarantine, or seizure of goods and property. However, PANDEM found that many of the national plans were not supported by national laws. This corresponded with the findings of a previous EU funded research project: PHLawFlu, which in 2010 found that there was "a fragmented legal landscape to support pandemic policy measures" with many states not having enacted domestic laws to underpin key measures such as quarantine or requisition of premises.

This inadequate legal underpinning can lead to an incoherent response across Member States and some current legislation may be outdated and/or in breach of the European Convention on Human Rights.

SOLUTION CONCEPT

The principle of national sovereignty is clearly important and EU treaties specifically exclude any aim to harmonise legislation. Nevertheless, Member States should be encouraged to enact national legislation which meets international obligations, is transparent and ethical. Such legislation should be consistent with scientific evidence and respect individual human rights.

Both WHO and the EU produced model national plans to assist countries in drafting their own national plans for pandemic preparedness and response. These set out measures to include, stating which should be "Essential" and which are "Desirable". The WHO Regional Office for Europe and the ECDC have also held a number of joint workshops to assist Member States in drafting plans. A similar approach using a model act would be a useful guide for Member States.

A WP4 Case Study reviewed the Model State Emergency Health Powers Act in the US. This is model legislation drafted following 9/11 and which has since been adopted in whole or part by 34 US states. The development of model national legislation for a public health emergency could be beneficial for EU Member States, although it would be challenging because of the difference in legal systems and historical and socio-economic contexts across the EU Member States.

Creating a model act would require a number of preliminary steps. First it would be necessary to map and then evaluate (individually and comparatively) existing national legislation to prepare for and respond to pandemics.

Designing a model act would require collaboration and input from lawyers in all EU Member States. This would require a certain level of training and knowledge in public health law.

Although challenging, the collaborative process of creating a model act would be beneficial in raising understanding of issues and sharing of best practices.

OUTPUTS

1. Capacity building in public health law as a result of training across Member States;
2. Data collection: Comprehensive mapping and comparative evaluation of national pandemic legislation in Member States;
3. Greater understanding and cooperation between representatives of Member States through discussion of the terms of a model act;
4. A model act to provide guidance to Member States for creating national pandemic legislation.

IMPACT

If adopted into national legislation, a model act would help to ensure measures which were coherent, coordinated and transparent across states. Member States could use or adapt measures in the model framework to their own country context for cultural and social acceptability, while also being enforceable. International frameworks would be adopted into national legislation. The measures would be evidence-based, reflecting current scientific knowledge, and they would incorporate consideration of ethical issues and protection of human rights.

There would be greater clarity of response within and across Member States, providing legal authority and safeguards to both public health authorities and individual citizens.

DEMO CONCEPT 1.2 TRUST IN GOVERNMENTAL AND PUBLIC HEALTH INSTITUTIONS

BACKGROUND/JUSTIFICATION

Public trust in governmental and public health institutions is critical to effective management of a public health emergency. Measures to prepare and respond to a pandemic need the support, cooperation and understanding of the public, particularly those which involve restrictions on individual rights for “the common good”.

Where there is a lack of trust, the public may act in ways which are unhelpful, or even positively harmful. They may also panic.

At the two PANDEM workshops in February and September 2016, attendees commented on a perceived lack of public trust in governmental and public health institutions. This had been vividly demonstrated in initial local responses to the Ebola outbreak. The current political environment also suggests a lack of trust in long-standing institutions and norms. Perceptions of competence, truthfulness and goodwill may be fragile and easily lost, particularly in an age of ubiquitous social media.

Public distrust in public health recommendations has already been seen in a lowering of vaccination rates. There is a real risk that it could undermine an effective pandemic response.

While important, understanding what creates and drives "trust" is difficult because it is a complex concept which is difficult to measure or control. This makes it challenging to take appropriate measures to respond to a loss of trust.

SOLUTION CONCEPT

Research would examine public trust at a number of levels: individual-individual, individual-community, individual-institution (public health, government, regional institutions, global institutions). It would take a mixed-methods approach, including but not limited to analysis of:

- literature reviews of existing academic research;
- key informant interviews with experts from several disciplines, e.g. anthropology, risk management, economics, law, business, management;
- surveys and interrogation of existing data, e.g. use of social media, vaccine uptake.

OUTPUTS

1. A multilevel analysis of the changing pattern of trust within and across societies in Europe;
2. Development of a "public health trust metric" and Monitoring Tool which could be used at any time, not just during an outbreak. This could interface with proposed demo concept 1.4 on risk communications principles in practice.

IMPACT

Analysis will provide greater understanding and enable more informed decision making at policy level. Greater public trust and cooperation will make a public health response more effective and ethically acceptable. There will be less risk of public panic which can undermine measures to respond to a pandemic.

DEMO CONCEPT 1.3 RESOURCE PLANNING – Resource Modelling Tool and Simulator

BACKGROUND/JUSTIFICATION

A key challenge for pandemic planning in Member States (MS) is to have the capacity to assess the resilience of their health system to cope with the demands brought on by the emergence of a new infectious agent, and to plan in an optimal manner to minimize adverse health and security outcomes. The acquisition and deployment of health system resources is a crucial activity for mitigating the impact of a pandemic, where key resources include vaccines, anti-virals, health care professionals, hospital beds, intensive care unit beds, surge capacity, and ventilators.

GAP IDENTIFIED

Member States (MS) are often unsure about the availability of health system resources, and their potential demand during a pandemic situation. There is a requirement for flexible interactive planning solutions that can be deployed at MS level, where these systems can integrate with existing health information systems to obtain resource availability, and then identify the health system demands that a pandemic can place on a MS.

SOLUTION CONCEPT

In order to provide an insight into, and a validation of, the requirements of a resource modelling solution, the PANDEM project demonstrator (PANDEM-CAP) architecture shown in Figure 4. This shows important aspects of a resource planning solution. At the core of PANDEM-CAP is a simulation and resource modelling engine that can extrapolate a range of pandemic scenarios that could impact a Member State, where impacts such as the severity of the pathogen and the likely transmission parameters are captured. Allied to this is data on demographics and core health system resources, and the resources that impact on population health and security. PANDEM-CAP will build on existing work done by the EU funded AsiaFlu Cap which was led by one of the PANDEM partners, LSHTM.

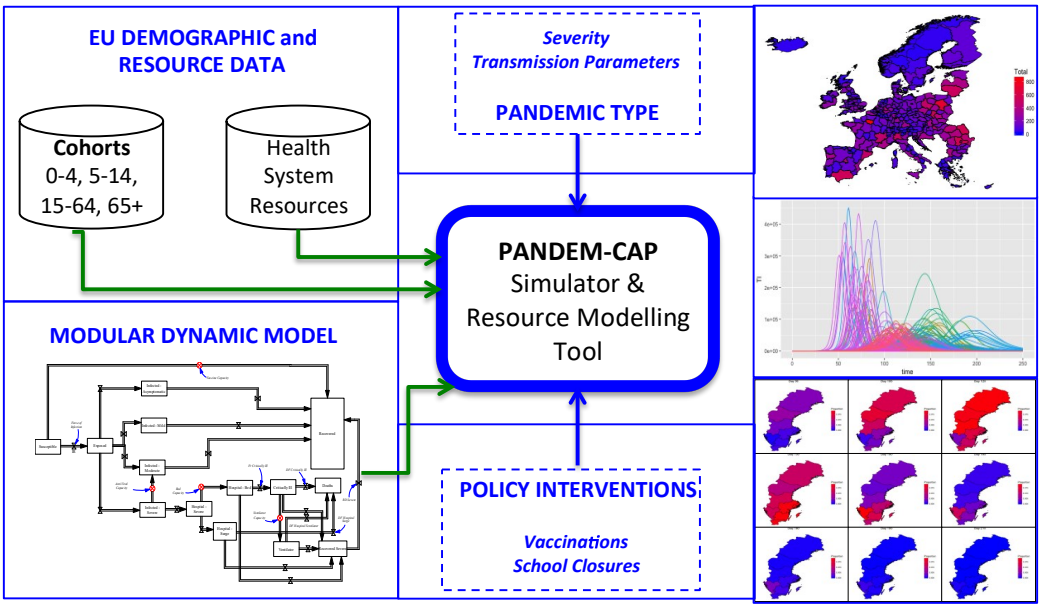

Figure 4: An exploratory transmission dynamics, interventions and resource demand model

The key elements of PANDEM-CAP are now summarised.

(1) The Dynamic Model

The dynamic model informing PANDEM-CAP is shown in Figure 5, and is an extension of the SEIR structure (Susceptible-Exposed-Infected-Recovered). It is divided out into four cohorts (00-04, 05-14, 15-64 and 65+). The infected cohort is further divided into four compartments, each reflecting a possible impact of the pathogen (asymptomatic, mild, moderate and severe). Severe cases are hospitalized, and their flow within a hospital scenario is dictated by the availability of resources. Resource availability also determines health outcomes, with higher mortality rates applied to patients in surge capacity care. Anti-viral resources can also be applied to severe patients, with a fraction of these becoming mildly infected, and thus avoiding the hospitalisation route.

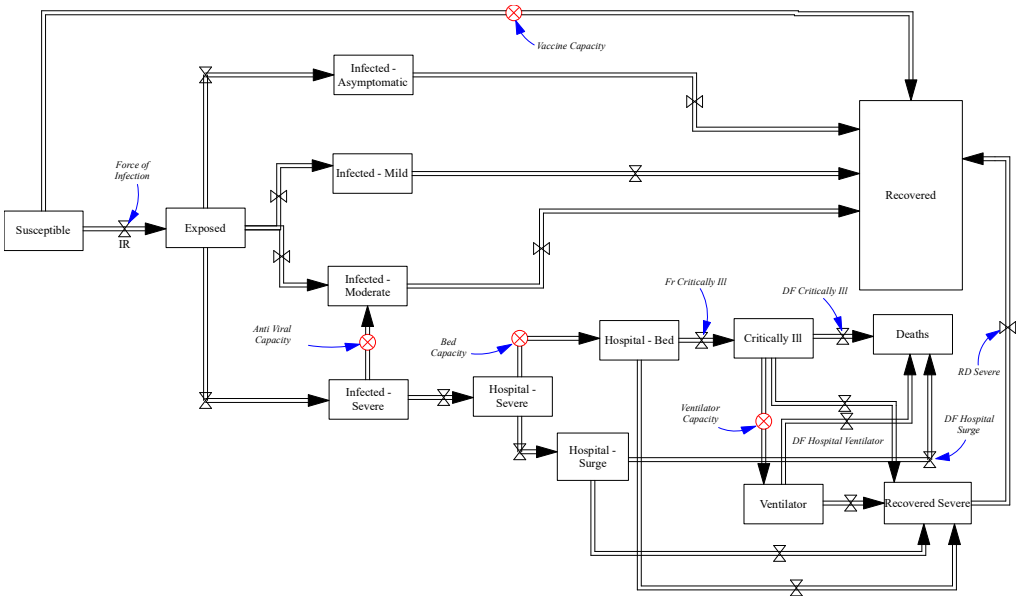

Figure 5: The multi-cohort transmission model, with identified resource constraints that impact health outcomes

The dynamic model also contains measures for assessing the impact of a pandemic on workforce absenteeism, and therefore it can provide an insight into business continuity challenges that arise during a prolonged pandemic. Absenteeism is calculated based on a number of factors, including:

- the number ill in the 15-64 cohort (factored by a ratio of how many people in that group are employed in the workforce), and
- the number of children that are sick (as this will mean higher number of parents would remain at home).

Furthermore, people who recover from severe illness take longer to return to the workforce, as the *Recovered Severe* compartment models those who have recovered, but are not yet well-enough to return to work.

The model also allows for school closures, and also can capture seasonality effects, where the infectivity of a pathogen can become further amplified during the winter months, as more people remain indoors, and so the probability of transmission increases.

(2) NUTS2 Data

PANDEM-CAP is based on the NUTS2 geographic divisions for the EU. Eurostat[1] provides an excellent source of demographic and health indicator data, and also provides mapping files for visualisation, for example, the NUTS2 divisions for the EU are shown in Figure 6.

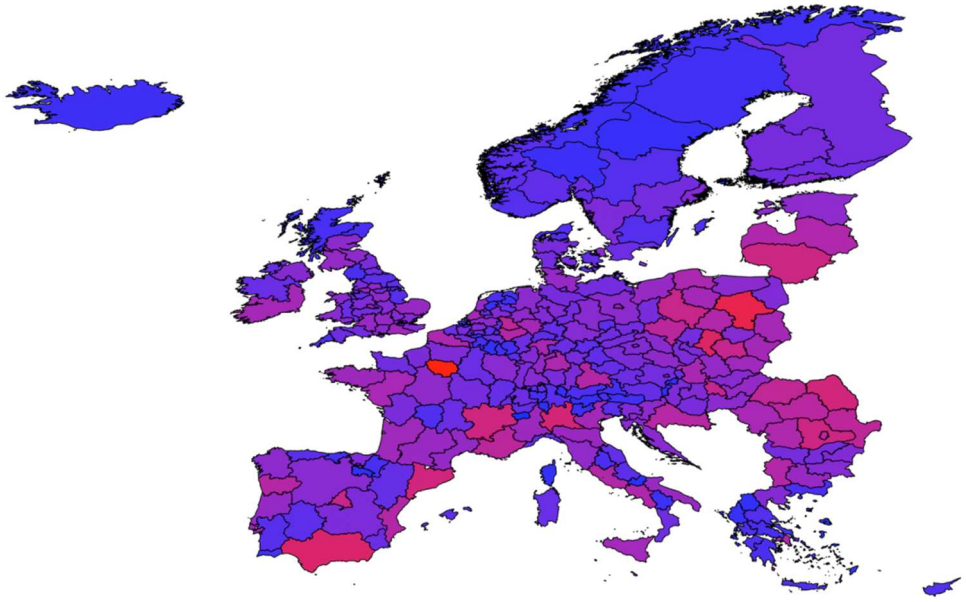

Figure 6: Visualisation of NUTS2 Regions for the EU.

Sample data extracted from the EU Portal is shown in Table 2, and this contains NUTS2 regions for Austria, along with each region's population by the relevant ECDC age cohorts. Estimates of health resources are also included with the number of hospital beds per hundred thousand, and the total number of hospital beds, which then is used to populate the model.

NUTS_ID	Population	Cohort 0-4	Cohort 5-14	Cohort 15-64	Cohort 65P	Beds Per Hundred Thousand	Beds
AT11	288178	12230	25984	190433	59531	607	1748
AT12	1635695	76966	160219	1077035	321475	701	11459
AT13	1794799	103092	164670	1223169	303868	793	14241
AT21	557047	24482	51197	366468	114900	877	4887
AT22	1220495	55191	108634	816393	240277	864	10542
AT31	1435335	73168	143546	961519	257102	710	10192
AT32	538102	27824	52864	360977	96437	953	5126
AT33	728435	37358	70661	493990	126426	703	5124
AT34	378175	20777	40803	253478	63117	594	2246

Table 2: Sample NUTS2 data for Austria's NUTS2 regions.

[1] http://ec.europa.eu/eurostat

(3) PANDEM-CAP Implementation

PANDEM-CAP is implemented in R, using a number of supporting R libraries, including:

- **deSolve**, an integral equation solver which runs each NUTS2 model as a set of stock and flow equations;
- **ggplot2**, used to visualise graphical output;
- **rgdal** and **regos** for mapping model output across NUTS2 regions;
- **RShiny**, which provides a web-based interface for the tool, and supports user-interaction and scenario generation.

Sample output from the R Studio workbench is shown in Figure 7. One of the variables of interest is a list known as output, which contains the simulation results for each NUTS2 region in the model, and the dimensions of this data frame are 251 observations (one for each day), by 188 variables (features), which contain the simulation results and the initial conditions of each simulation.

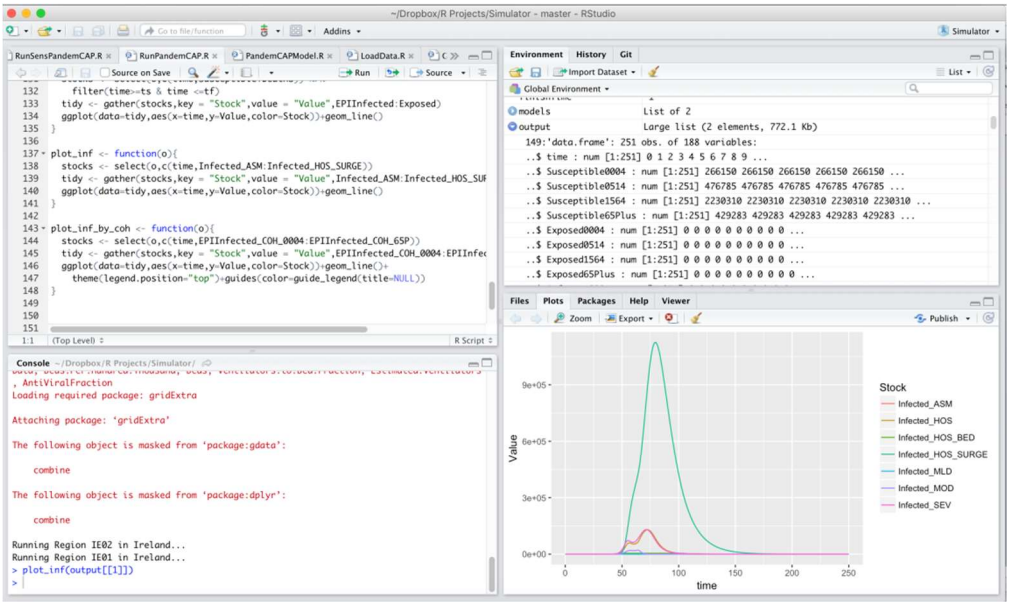

Figure 7: PANDEM-CAP as viewed through the R Studio Integrated Development Environment.

PANDEM-CAP can be parameterised for each run, so that many of the variables can be seeded with different initial conditions. This supports sensitivity analysis, and also regional variations within an overall MS model. These parameters are summarised in Table 3 and Table 4 (overleaf).

Parameter	Description
WAIFW Matrix (4x4)	Between-cohort transmission rates (Emilia Vynnycky and Richard White 2010)
Country	Country for the simulation run
GeoLabel	Geographic label for NUTS2 Region being simulated
Region	NUTS2 Region
SimulationDate	Date of the simulation run
InjectionDay	Day when patient zero arrives in NUTS2 region
InjectionAmount	Number of patient-zeros that arrive in the NUTS2 region
InjectionIndex	Cohort of Patient zero (1=Young, 2=Child, 3=Adult, 4=Elderly)
PropAsm	Proportion of population who will be asymptomatic
PropMild	Proportion of population who will have mild infection
PropMod	Proportion of population who will have moderate infection
PropSev	Proportion of population who will have severe infection
VaccinationDay	Day the vaccine is ready for production
VaccinationAmount	Number of Vaccines produced for a region
VaccinationDelay	Average delay for vaccines to reach the health system
Population	Total population of the region
Population_0004	Number in cohort 00-04
Population_0514	Number in cohort 05-14
Population_1564	Number in cohort 15-64
Population_65P	Number in cohort 65 Plus
Pr_Immune_0004	Proportion with prior immunity 00-04
Pr_Immune_0514	Proportion with prior immunity 05-15
Pr_Immune_1564	Proportion with prior immunity 15-64
Pr_Immune_65P	Proportion with prior immunity 65P
AVAmount	Number of antivirals available
AVSevModEff	Effectiveness of anti-viral treatment at early stage which impacts transition from Severe → Moderate
CloseSchools	Boolean flag to close schools
ReportingFraction	Estimate of how many people are reporting their symptoms to the healthcare system
CloseThreshold	Reported level per 100,000 at which schools are closed
CloseDuration	Length of time schools are closed for
ResAVMultiplier	Scenario multiplier which impacts the number of antivirals
ResVAccMultiplier	Scenario multiplier which impacts the number of vaccines
ResBedsMultiplier	Scenario multiplier which impacts the number of hospital beds
InfectivityMultiplier	Scenario multiplier which impacts the pathogen infectivity
SeasonalForcing	Parameter which can increase infectivity during winter months

Table 3: PANDEM-CAP parameters for simulation run (1/2)

Parameter	Description
HospitalBeds	Estimated Number of hospital beds in NUTS2 region.
Ventilators	Estimated Number of Ventilators in NUTS2 region.
HospitalBedsTxMod	Transmission modifier parameter for those infected in hospital beds
AverageRecoveryDelay	Average number of days for patient to become non-infectious
Vaccinate_0004	Boolean flag that controls whether or not 00-04 cohort is vaccinated
Vaccinate_0514	Boolean flag that controls whether or not 05-14 cohort is vaccinated
Vaccinate_1564	Boolean flag that controls whether or not 15-64 cohort is vaccinated
Vaccinate_65P	Boolean flag that controls whether or not 65P cohort is vaccinated
FRCriticallyIll	Fraction of severely ill who become critically ill
DFHospitalSurge	Death fraction for those in hospital surge capacity (this can model the impact of a reduced level of patient care due to system stresses)
DFHospitalVentilator	Fraction of deaths arising from those on a Ventilator
DFCriticallyIll	Fraction of deaths arising from those who are critically ill
SevereRecoveryDelay	Delay time for full recovery for those severely impacted.
VentilatorRecoveryDelay	Delay to full recovery for those patients on ventilator
WorkforPercent	Percentage of 15-64 in the workforce
EconomicValuePerYear	Estimated value to the economy of one working person for one year
CostPerUnitVaccine	Cost per unit for vaccines
CostPerUnitAntiViral	Cost per unit for antivirals
CostPerUnitVentilator	Cost per unit for ventilators

Table 4: PANDEM-CAP parameters for simulation run (2/2)

(4) PANDEM-CAP Dashboard

An interactive web-based dashboard will allow user interaction with PANDEM-CAP, whereby a number of policy interventions can be selected, and the model run for different member states. The dashboard provides options for simulation and analysis of results, and an initial screenshot of the appearance is shown in Figure 8. This dashboard will be available for use via a web url, which will be specified in the final project documentation.

Figure 8: PANDEM-CAP Dashboard (early version)

OUTPUTS

The operational output from this solution will be an integrated modular resource planning system, which can be adapted and configured for any member state, depending on their specific requirements. It will have a library of components that can support pandemic planning, and can be assembled using modular software engineering design methods. Examples of modules would include: transmission modelling using a meta-population approach; dynamic models of key resources such as anti-virals, vaccines, ventilators, ICU beds, and health system personnel availability; real-time links to health information system resources, including data on current hospital bed utilisations, vaccine availability and levels of anti-virals across the member state; and optimisation algorithms to provide temporal planning data on where best to allocate member state resources as effective countermeasures to an emerging pandemic scenario. Several of these modules - for example the transmission modeling component - would also be fully aligned with demonstration strand 2.5, which aims to forecast the course of a pandemic in different MS.

IMPACT

As an integrated planning approach, the impact of this system will be to provide MS of a realistic assessment of their preparedness for a pandemic event. The system will also allow for the quantification of resources required across a MS, and provide guidance as to the optimal ways to allocate these resources in order to minimise morbidity and mortality rates.

DEMO CONCEPT 1.4 RISK COMMUNICATIONS PRINCIPLES IN PRACTICE

BACKGROUND/JUSTIFICATION

As shown in the comprehensive literature review (deliverable D3.3), international principles and guidance on risk communications for epidemics appear to be known among Member State authorities and academics. However, the review also shows that the principles are not implemented consistently either before or during public health emergencies, including pandemics.

GAP IDENTIFIED

Gaps results mainly from lack of preparedness and can range from a failure to acknowledge uncertainties, to delivering conflicting messaging, to failing to listen to key audience and public feedback or adapt messaging to these audiences. This in turn can lead to lack of trust between members of the public, health workers, governments officials and political leaders, and ultimately to a failure of pandemic communications to deliver the desired impact.

SOLUTION CONCEPT

Risk communications encompasses four main capacities:

1. Transparency and early announcement
2. Coordination
3. Listening and two-way communications
4. Effective channels and engaging stakeholders.

Together, these capacities help to build trust in responders and in turn contribute to public resilience. To be effective, risk communications capacities need to be part of planning.

Here we want to focus on two of the most crucial areas, which are general planning and adherence to principles, and listening and two-way communications capacity. We propose in this area to work in tandem with the training work stream to build confidence and capability in this area:

1. **Making a stronger case for using and adhering to risk communications principles, during a pandemic, as well as before a pandemic strikes.**

According to our expert interviewees, one of the key barriers to using risk communications properly during a pandemic is the lack of investment in preparedness for pandemic communications. The solution to this starts in “peacetime”, by establishing key audience

groups (health workers, likely at risk population sub-groups) and systematically testing their reactions to different information approaches. This should help to amass a country-relevant dataset on the probable reactions of the most important audiences to pandemic communications before a pandemic emerges.

2. **Practical guidance and tools on how to prepare for and enact the "listening" function of risk communications during a pandemic.**

One of the weakest areas of risk communications in practice is the principle that communication should be multi-directional, meaning that public health authorities should listen to their intended communications audiences, take into consideration their perceptions and adapt their strategies and messaging accordingly. The challenge with this approach appeared to be related to the fact that, although many guidelines on risk communications do exist (WHO 2008, ECDC 2017), there are few formal tools available to help countries to do the listening and adaptation part of this work.

We propose:

1. A research project to draw from the body of existing risk communications literature and form an investment case reflecting both government priorities and population responses. This would be backed up by a consolidated literature review on the benefits of listening and risk communications as part of response. This exercise would further allow countries to establish baselines and pre-test more tailored approaches to delivering communications strategies for and messages to specific audiences. A key component of this would be to identify opinion leaders for example those with an active presence on social media and agree on key messages that might be used in a pandemic. Networks of organisations such as patient advocacy groups can also be harnessed to get key messages out to those most at risk.
2. A specific set of guidelines and tools – linked with the audience groups mechanisms research described above - that would help communicators to perform the listening and feedback strategies, activities and messages. Online, offline and social input would be combined to compile a comprehensive dataset. However, this alone would be insufficient without well-researched and tested guidelines to ensure it would be a practical approach and would enable listening and feedback into the communications process.
3. Data and research from these two areas would also feed into the training module (D3.1).

The literature review and landscape analysis showed little if any evidence of listening and feedback being applied in the delivery of communications strategies. Therefore there is considerable scope for improvement. We would hope to see these guidelines and tools used regularly and consistently across a range of communications activities conducted by public health authorities.

The importance of listening in the practice of risk communications is widely accepted, and this was an area in which interviewees from MS requested more research and tools during our phase I investigation. We therefore anticipate that at MS level the proposed project would be highly applicable and appropriate, as well as appreciated by government officials. However, we also recognise that the extent to which the project will be successful is likely to depend on the political commitment to use feedback from listening to drive communications. This, in turn, would depend on successful risk communications training for managers and others who may decide the approaches communicators are allowed to take, as described as part of D3.1.

Transparent legal and ethical standards would need to be applied to data collected via the various aspects of listening as part of this project.

OUTPUTS

1. Guidance and a practical tools on segmenting and using audience groups and listening surveys to both test and adapt messages before a public health emergency and to build up a specific investment case.
2. Guidelines and a listening, monitoring and feedback tool to enable communicators to gather responses in real time and adapt their strategies and messaging effectively in response.

IMPACT

Communicators at MS level actively engage their communities, and build resilience and trust through consistent and relevant messaging, based on the principles of risk communications. This facilitates more effective communications during a pandemic, contributing to reduce the spread of disease by laying the foundation for messages to be well received and acted upon.

Today, information flows more freely than ever between governments and citizens, so helping to improve cohesion between public health authorities around Europe is an important step to help counter the negative effects of competing messages.

Improved sharing of communications messages between EU institutions and countries would raise higher awareness of potential disputes over message generation and delivery, and how to avert, explain or justify them. At the EU level, this would ultimately contribute to stronger, more effective communications during a pandemic with to a more confident, informed set of communicators at country level.

DEMO CONCEPT 1.5 SOCIAL AND BEHAVIOURAL SCIENCE FOR COMMUNICATIONS

GAP IDENTIFIED

Public health messages delivered by national or local health authorities during a pandemic are often intended to generate a particular behavioural response from their target audience. However, current evidence indicates that communications interventions in outbreak situations often have limited success doing this. Our literature review revealed poor design, weak causal pathways and inadequate evaluation, as well as very limited use of theories and evidence from behavioural science, social science and anthropology in communications interventions. Equally, we saw little evidence of the huge catalogue of research and knowledge generated by decades of highly targeted commercial marketing and advertising being applied to public health messages, including in emergency situations.

SOLUTION CONCEPT

Different academic specialisms related to communications can be technical and difficult to apply, and communicators at MS level may not have the time to investigate them in their day-to-day work, let alone amid the pressure of a pandemic or outbreak. Additionally, there is sometimes reluctance among public health professionals and communicators to adopt the methods used by commercial marketing and advertising experts. Mapping out and digesting these relevant fields, and then translating them into frameworks to help communicators design specific interventions whose results could then be written up, shared, and examined, would help to provide ready-made solutions.

The required research would include:

- Researching and mapping out models, frameworks and evidence relevant to pandemic communications interventions from these currently neglected areas, including expertise from sociologists, anthropologists, crisis communications specialists, marketers, advertisers and others whose work involves understanding how to change people’s behaviour.

- Building on these and where needed and develop them into a practical tool, allowing communicators to design their usual messages and materials, with a more evidence-based and informed approach based on the above cross-sectoral input. Some general approaches to this to exist (WHO 2012), but would benefit from additional work focused on improving pandemic preparedness.
- Developing a more scientific approach to evaluation and measurement, which would then be shared as part of an ongoing concerted effort to better document and share evidence in this sector.

The standard of good performance here would be that MS communicators used the guidelines and were able to evaluate and record their interventions specifically after they had been conducted, thus adding to the evidence base for them and for wider use in pandemic communications.

A vast amount of information has been gathered and analysed from years of experience delivering commercial and non-commercial messages to consumers. Little of this is currently making its way to public health communicators working to improve preparedness and response in the event of a pandemic. Learning lessons from this experience would help to ensure better and more targeted messages are delivered by the public health community.

OUTPUTS

Additional high quality, evidence-based practical guidelines building on work already done by ECDC and WHO to help in the design of communications interventions by incorporating expertise from other specialisms. These new guidelines would be focused in particular on the need for a clear, two-way communications in the preparedness phase. The guidelines would be intended to generate a more specific, diverse and actionable evidence base for communications interventions ahead of and during a pandemic.

IMPACT

- More strategically and transparently designed communications interventions, engaging the community, will lead to faster, more predictable behaviour change, contributing to more effective outbreak control in the event of a public health emergency including a pandemic.
- An accumulation of higher quality evidence and analysis of lessons learnt will help to improve the strategies and tactics used to deliver communications messages in different contexts.

5.2 DEMONSTRATION STRAND 2: SITUATIONAL AWARENESS & DECISION SUPPORT

Despite advances in technology and tools to increase situational awareness in the areas of surveillance, the PANDEM Project has identified a number of gaps and importantly new opportunities to leverage, test and implement new and innovative approaches. The concepts proposed under Strand 2 seek to enhance significantly the situational awareness and decision support capabilities within the EU to:

- Gather, process and analyse data at the community level thereby giving vital lead time in event detection and the capacity to measure and track the societal and economic impacts of pandemics in future.
- Enhance EU and Member State capacity to analyse and visualise data by developing visual analytic tools that can be targeted at experts, decision makers, front line workers and civil society.
- Carry out sophisticated predictive/prognostic modelling to examine likely scenarios in the development of a high impact epidemic/pandemic including morbidity, mortality, extent and rate spread as well as the impact of countermeasures.
- Get ahead of the next pathogen jump by supporting the development and integration of the next generation of laboratory services and diagnostics.

The proposed demonstrator concepts under this Strand include:

- Visual Analytics
- Participatory Surveillance
- Predictive Modelling tool
- Laboratory Services and Diagnostics

DEMO CONCEPT 2.1 VISUAL ANALYTICS DRIVING DECISION MAKING

BACKGROUND/JUSTIFICATION

Recent years have seen a huge deluge in data that can be used for pandemic risk and emergency management. However, to date this data remains underutilized due to a lack of advanced methods for understanding and analysing it. Visual analytics, a novel discipline leveraging various disciplines such as human cognition, information visualization, and data analytics, can prove useful in this regard.

GAP INDENTIFIED

Traditional visualizations used in the public health domain mainly include simple graph-based or map-based visualizations. With the data deluge taking place, the use of such

simple visualization techniques is proving ineffective as they essentially lack the ability to deal with enormous data. Understanding massive amounts of disparate, dynamic data from heterogeneous sources calls for advanced visualization techniques that may incorporate automated methods of data analysis as well as human perception. In addition, there is a lack of a common visualization and data presentation tool, or a (pandemic) dashboard, at EU level that could be used by all Member States during a high impact epidemic or pandemic.

SOLUTION CONCEPT

We suggest the development of a common visual analytics based tool at EU level. The tool would provide a dashboard like interactive interface to all the Member States for understanding the data flows during a high impact endemic or pandemic. Essentially the tool would leverage information visualization with principles and techniques from varied disciplines such as human perception and cognition, spatio-temporal data analytics, data management, and human computer interaction.

The underlying component of the proposed visual analytics tool would be an efficient data management layer that would be effectively able to integrate data from various disparate, heterogeneous sources. An integrated representation of various data sources as well as the ability to clean and harmonize the increasingly available big data would form the basis of the data management layer. A data analytics approach, making use of the state-of-the-art machine learning and data mining techniques would correspond to the next step in the building of the visual analytics based tool. Finding meaning in the increasingly enormous volumes of data is practically impossible now without resorting to automated data analytic methods.

The third and perhaps the most significant component of the visual analytics tool would be the incorporation of human perception and cognition knowledge. This would further entail drawing from fields of sociology, neurosciences, psychology and design. The incorporation of such knowledge is beneficial as it would help develop user-centred models and tools.

As efforts will be made to make the proposed tool available across a variety of platforms and on different devices, the lessons and research from the field of human computer interaction will also be incorporated. An effective user interface that would effectively minimize the barriers between human cognition and computers can be developed only by considering and understanding the interaction styles and cognitive models of humans.

OUTPUTS

The output from this project is an IT system that would provide MS with a common situational awareness and decision-making tool based on visual analytics, i.e., a dashboard based system based on human perception, information visualization, and advanced data analytics. Such a system would reduce the cognitive load of the decision-makers enabling better decisions, improved public health, and effective pandemic management.

IMPACT

A visual analytics based tool would allow for a better understanding of the available complex data and would aid the decision-making process. Specifically, a common visual analytics based tool that could be used by all Member States and that would incorporate data from all sectors would be highly impactful. Better visualizations derived by considering human perception and data analytics technique, can go a long way in improved decision-making. By making the right information available at the right time and in the right format they can lead to improved communications and response.

DEMO CONCEPT 2.2 PARTICIPATORY SURVEILLANCE

BACKGROUND/JUSTIFICATION

Traditional surveillance in the EU has developed an increased collaboration between Member States, through the support of ECDC and the WHO. This surveillance will always be the backbone of data-gathering during a pandemic. However, additional complementary data from non-traditional sources will be also required to give policy-makers a relevant mapping of the problem, so as to provide enhanced decision support.

GAP IDENTIFIED

Traditional surveillance gives information only on a limited part of the impact caused by a pandemic, mainly from the health care sector since that is from where data is recorded and reported. This information needs to be complemented with information on the impact the pandemic causes also in other sectors of society. These sectors are for instance workplaces and schools. With this information, policy makers on different levels will be better guided to make informed decisions on policies on what countermeasures to implement.

SOLUTION CONCEPT

A number of initiatives have been made to address the need for acquiring information on the impact of pandemics in a broader perspective, that is, how sectors other than the health care sectors are affected. Some of these initiatives are routinely used by countries to complement traditional surveillance, and are often referred to as population based surveillance or non-traditional surveillance. The key point with this surveillance is that data on the whole spectrum of illness in a society is collected, not only data reporting by health care sector such as general practitioners and hospitals.

We propose that a general tool for population-based surveillance is developed, for use by the Member States. Such an information system would use various data sources as input; for instance activities on social media, school and workplace absenteeism, over the counter (OTC)-sales of anti-pyretics, and media attention. The tool should be designed in a modular way so that new sources easily could be added, for instance web searches and sensor-based streaming data. As mentioned, several implementations to such systems exist but Member States would benefit from being provided with a ready-to-use tool and not having to reinvent the wheel.

There are several relevant research questions: Firstly regarding the technological development, how to best develop modular, efficient and scalable IT solutions? Secondly, the legal aspects around the use of new data sources is important and difficult. Thirdly, the epidemiological and statistical interpretation of collected information, what does e.g., a ten percent school absenteeism correspond to in terms of disease prevalence in the general population? What are the levels of cross protection in difference age cohorts? Do such relationships vary between diseases and countries and also the different phases of a pandemic?

OUTPUTS

The output from this project is a validated and field tested IT system, where this system for population based surveillance is regarded as an integrated part of a standard architecture for diseases surveillance, visualization, pandemic forecasting and resource mapping.

IMPACT

The impact of having developed a ready-to-use tool IT platform for surveillance, visualization, pandemic forecasting and resource mapping, in the different Member States is significant. Besides the obvious advantages in terms of increased situational awareness

by having information on disease burden in different sectors of society, a common tool would enable better communication within and between the different countries since they would share the same information. In summary development of a tool for population based surveillance would give the Member States better quality data. Enhanced data quality allows for higher quality in risk assessment, prognoses, and resource mapping and pandemic policy making in general.

DEMO CONCEPT 2.3 PREDICTIVE MODELLING TOOL

BACKGROUND/JUSTIFICATION

The dynamics of an epidemic or pandemic are complex. The speed and intensity of the disease spread is affected by many factors, such as virulence of the infectious agent, susceptibility in the population, social mixing, and public health interventions. Mathematical modelling has been used as a technique to forecast the spread of disease since 1766 when Daniel Bernoulli calculated the effect of inoculating against smallpox. Since then epidemic models of various kinds have been become a common tool to predict the spread of disease in populations with and without countermeasures.

GAP IDENTIFIED

Forecasting the development of an evolving epidemic or pandemic is challenging. Data from the early stages of an epidemic is often sparse and many times biased. However, during an ongoing epidemic, information on the potential impact is demanded by the public, media and decision makers. The influenza A(H1N1) pandemic in 2009 and the recent Ebola epidemic in West Africa demonstrated how difficult it is to forecast the spread and how often epidemic data is misinterpreted. There is a need for standardized tools that can forecast the course of an epidemic or pandemic. Since the development of such software is time consuming, there is insufficient time to do this during an evolving epidemic. If the tool is already available in peacetime, policy makers can make good use of it for preparedness planning, training and communication. Such a tool would need to be updated and used regularly to ensure it would be useful in a crisis situation. Forecasts are never better than the data they are based on. New methods to tackle initial uncertainty surrounding epidemiological parameters are therefore needed. Not only the quality of data, but also the coverage is important. Therefore data sources on disease burden at all levels of society is needed as input into the modelling tool.

SOLUTION CONCEPT

There are many epidemic models currently available, mainly developed in academic settings. These small scale software projects seldom survive more than a couple of years when the researcher stops updating them. The many homemade modelling tools, hard to understand for persons who are not computer scientists, make it difficult to communicate and compare models and results between research groups, organizations and countries. If Member States were provided with a modelling tool, which could be adapted to the specific needs of each user, communication about the potential development of an ongoing epidemic would become much easier.

We suggest that a flexible modelling tool able to forecast the course of a pandemic is developed, for application by the different Member States. Such a modelling tool would ideally be flexible enough to incorporate various types of data. In some countries reported cases may be the sole available surveillance data, while other countries have more diverse data sources, e.g. immunity levels in the population, risk group distribution, number of children absent from school every day. The tool should be designed in a modular way so that new data sources and potential interventions could be easily added. The tool would also link to the PANDEM-CAP resource modelling tool.

OUTPUTS

The output from this project is a modelling tool; a software application for forecasting the course of an epidemic or pandemic in a population with visualization of possible outcomes depending on available interventions.

IMPACT

The availability of a ready-to-use modelling IT-tool in the Member States would be significant. A common modelling tool would help policy makers making informed decisions, and would enable better communication and understanding of the complex dynamics at play during a pandemic.

DEMO CONCEPT 2.4 DIAGNOSTICS AND LABORATORY SERVICES

BACKGROUND/JUSTIFICATION

Enhanced laboratory services and diagnostics with fast tracked development of solutions to improve diagnosis, containment and surveillance of emerging diseases are essential to reduce the impact of the next pandemic.

PANDEM has identified important research and innovation needs to improve diagnostic capacities for pandemic-prone pathogens, improve the way in which laboratory data is collected, analysed, and communicated, improve coordination between laboratory services and other sectors and build capacity for pandemic management.

SOLUTION CONCEPT

The solutions developed and proposed by PANDEM Phase II will integrate:

- Specific proprietary developments and
- Complementary developments and tools from ongoing projects in health (DG SANTE) and security domains (DG HOME): e.g. H2020 REACHING OUT; H2020 eNOTICE, H2020 ENCIRCLE, H2020 PANTHUB, EMERGE Health Programme.

The solution will address identified gaps and needs by:

- Enhancing ontology and decision support
- Optimizing the functional networking of laboratories and scaling up of diagnostic capacity in time of crisis
- Ensuring optimal transportation, tracking and tracing (traceability) of the samples and related data
- Using new diagnostic tools for rapid detection of emerging diseases at point-of-care
- Integrating NGS analyses in the routine surveillance and response
- Improving biosafety/biosecurity
- Developing training tools to enhance laboratory capabilities
- Developing tools to enhance communications between laboratory staff, crisis managers, caregivers and decision makers.

Ontology and decision support

While reference laboratories from EU Member States and laboratories deployed for surveillance outside the EU are directly connected to sample providers, the data produced are very heterogeneous, as a result of different technologies, methods, reagents and format. Accordingly, and to improve the communication between stakeholders (i.e. laboratory staff, caregivers and decision makers), there is a clear need to homogenize data

sharing, integration and visualization in a common framework accessible and understandable by the whole chain of responders and crisis managers. Therefore, a glossary for all terms in use has to be issued. Common ontologies, vocabularies and semantics are therefore necessary to speed up the response to cross-border threats to health and security, to improve the decision making process, help identify disease events, conduct risk assessments and optimize response strategies.

OUTPUTS

1. Decision support and ontology will be developed based on current development initiated in other H2020 projects, and adapted to the PANDEM specificities implemented.
2. Link with other projects: A connection will be made with the European Space Agency project IAP/ARTES20 B-LiFE where these aspects have specifically been developed for the deployment of a mobile capacity and with REACHING OUT where they will be further developed.

Optimizing the functional networking of laboratories and scaling up of diagnostic capacity in time of crisis

Over-stretched public health facilities can easily occur in some MS in the EU. There is a need for flexible, interactive and cooperative response enabling scalability and modularity of the response according to the crisis severity (scale and speed of development). This should integrate the whole analytical capacity represented by on-site capacities deployed inside and outside the EU, and reference laboratories inside and outside the EU. Strengthening the functionality of this network is a top priority to optimize cross-border responses, hence enabling the best use of limited resources and facilitating timely allocations to cope with surge-capacity requirement

OUTPUTS

1. Exploitation of a PORTAL-solution enabling better sharing of protocols, guidelines and standards and strive to harmonization regarding request forms, diagnostic processes, development and validation of new tests, sample inactivation, and Biosafety issues (i.e., laboratory and equipment decontamination, residual hazard assessment).
2. Implementation of EQA and international quality assessments of shared protocols, methods and technologies. This would accelerate the development and validation of new diagnostic assays, in accordance with international accreditation requirements.

3. Secure real-time/online exchange tools and platform for sharing data.
4. Link with other projects: a connection will be made with the REACHING OUT, eNOTICE and EMERGE solutions and integrate them in PANDEM whenever possible and appropriate.

Ensure an optimal transportation, tracking and tracing (traceability) of the samples and related data

A rapid transportation of precious and delicate samples shortly after their collection on site is a well-identified issue. There is a need to have quick, safe, reliable and affordable transportation to reference laboratories and to work on a high priority basis. This is especially important when precious samples have been collected on purpose in very distant and remote locations and may carry potentially dangerous pathogens of BLS3 or BSL4 Levels, and particularly RNA viruses with a short viability. About the preservation of chain of custody, there is currently a lack of simple, reliable and affordable system for identifying, tracking and tracing samples throughout the site of collection to the laboratory and post-analytical transmission to stakeholders; this is a major well identified gap which hampers a secure and reliable handling and sharing of sensitive and crucial information.

OUPUTS

1. A combination of tools enabling recording and storage of the useful information on all collected samples in a single LIMS (Laboratory Information and Management System), i.e. location (geolocation whenever possible), patient epidemiological, personal and medical data, sample identification in the laboratory, sample result, operator of the analysis and recipients of the results).
2. Exploitation of automatic and wireless transmission from the analyser to the LIMS and an adequate storage of all the information throughout the chain of custody, using integrated geolocation, Bluetooth, WiFi and internet/ cloud tools, and technological developments in computational science.
3. Exploitation of sample data and tracking and tracing to produce real-time of near real-time epidemiological mapping giving crisis managers and international institutions (DG ECHO, ECDC, WHO) a much quicker and better situational awareness.
4. Documentation and assessment of the most common transportation means currently used when bringing samples inside the EU (e.g. World Courier, FEDEX, DHL) or to share infectious samples inside the EU, address the costs and shortfalls and propose optimized solutions.

5. Link with other projects: These issues will be developed in connection with REACHING OUT, ESA/B-LiFE and H2020 GIFT. Attention will be paid to the EU eHealth system (e.g. One Health/ my care net) to link the lab to patient meta-data (complete patient medical file, pictures, video and positioning data (GIS).

Use of new diagnostic tools for rapid detection of emerging diseases at point-of-care

Improved diagnostic technologies taken in a broad sense are critical better identify, assess and monitor risks related to contagious diseases. They encompass point of care testing (POCT) and the rapid diagnostic testing (RDT) which are different but overlapping concepts. POCT/ RDT are insufficiently developed and are very much needed for Zika, Ebola and Yellow Fever. These methods are mandatory as first line surveillance and as situational awareness in case of rapidly expanding outbreak (risk assessment and risk communication) when they are performed both near the site of sample collection and/or near the patient's bed in hospital facilities. Two complementary types of assays should be developed: (i) assays for first line of detection and identification of pathogens with a syndromic diagnostic approach (multiplex assays), (ii) assays to monitor vital patient parameters as part of laboratory-guided care. They are particularly useful for the surveillance of side effects of new treatments and for monitoring the patient condition during the treatment (e.g., hydro-electrolytic disturbances, metabolic acidosis and/or impaired kidney and liver function). This is particularly beneficial when patients cannot be transported in appropriate medical facilities and are treated on site, or if these facilities are overwhelmed by the number of patients, prompting medical cares in field hospitals.

OUTPUTS

1. Existing technology will be used based on isothermal amplification of genetic material and on protein detection flow. Key characteristics should be considered: usable at collection- and bed-site, fast (low turnaround time; ~15 minutes), low cost, and easy handling by a non-expert operator. Development will focus on a lateral flow device technology with a multiplex format in order to address common symptoms (fever, diarrhoea, coughing) in a "syndromic approach". The study will pay attention to a simple, user friendly assay customized for an operational use and targeting a short list of prioritized viral agents. To be safely used at patient bedside and in laboratories as rapid screening, attention will be paid to biosafety issues, especially when used on-site by first responders (use with PPE or negative pressure glovebox).
2. Connect the use of PCOT/RDT by first line responders (general practitioners and caregivers) to a web service linking them with the laboratory network and health

authorities. POCT results will be automatically transferred at the suitable format, analysed, exploited and integrated in the LIMS of laboratories and/or database of public health institutes (connection to eHealth, Electronic Medical Record (EMR) and Electronic Patient File (EPF)), improving the interaction of caregivers with all relevant stakeholders (e.g. EPIS from ECDC, HealthMap).

3. Link with other projects: these issues will be developed in close connection with H2020 ENCIRCLE and with ESA/B-LiFE.

Integrate NGS analyses in the routine surveillance and response

Next-Generation Sequencing (NGS) is a promising technology enabling the simultaneous multi-genotypic characterization of a pathogen using whole genome comparison and is clearly the best tool for deep characterization on a below species level. When culture of a specific agent is impossible, sequencing specific sequences might be used as a tool for screening.

The use of molecular typing information for epidemiological studies and public health investigations of infectious disease is therefore rapidly shifting to NGS to replace DNA restriction/MLVA (multiple-locus variable-number tandem repeat analysis) typing techniques and classical single gene sequencing techniques. In many countries, whole-genome-sequence (WGS) based typing is in the trial implementation phase for use as the routine first-line or second-line typing method for national surveillance of a number of bacterial and viral diseases. ECDC is working with Member States to support capacity for NGS in routine surveillance and response.

However, the available evidence supporting the public health utility of WGS-based typing derives mostly from retrospective studies that did not measure the impact of the intervention on population health. Similarly, there have been no cost-effectiveness studies to evaluate the system-wide implementation of the technology for public health. Currently, a number of organisations, collaborative projects and laboratory consortia are actively working to overcome technical hurdles, develop bioinformatics solutions and pilot studies of WGS-based typing for public health protection in Europe, USA and globally. NGS appears already as a very useful tool for surveying the evolution of pathogens of interest in their environment and in patient samples in terms of resistance, virulence, genetic shift or drift and is a powerful tool to study vector-host-pathogens interactions.

Due to its capacity to identify a pathogen without any prior knowledge on the causative agent, NGS appears as a key method for rapid identification of new/emerging pathogens, hence as a tool to be used for characterizing a pandemic agent and provide a quick understanding the of change in resistance and virulence pattern which is critical for

adequate clinical care and for elaborating adapted health measures (new drug, new vaccine).

OUTPUTS

This solution will be developed in connection with REACHING OUT, ESA/B-LiFE and EMERGE as well with partners of the UNSGM networks for whom the use of NGS has become the essential tool. There are a number of challenges which require a close cooperation with public health and academic laboratories.

Several technical and bioinformatics constraints hamper a wide use of this methodological breakthrough and restrict its use to few highly experienced laboratories. Several challenges need to be addressed with other laboratories using the same method for reliably applying NGS to outbreak investigation:

- Pre-analytical steps (i.e., sample collection and handling) need to be improved and standardized;
- Need for validated and standardized approach for the data analysis using optimal bioinformatics tools and sequencing platform as inter-laboratory reproducibility is needed;
- Need to create a repository of the useful genotypic information accessible to reference and deployable laboratories: relevant strains and reference genome are needed;
- In some scenarios, there is an interest to use NGS on-site as close as possible of the outbreak; the huge amount of data require however to improve the analytical workflow, to develop/improve tools to use and share this large amount of information (SatCom resources dedicated to information transfer - IT tools to store/transfer/manage/secure the data)
- Proficiency testing and quality check of results by a group of experts is mandatory
- Data storage - archive of useful sequences- and security for large scale investigations need also to be addressed.

Improve biosafety/biosecurity

Handling pathogenic samples represent a major risk for exposed non-expert first responders involved in sample collection and sample transportation, as well as for the laboratory staff involved in sample reception and analysis outside certified BSL3 or BSL4 facilities. Efficient biosafety measures are therefore needed to minimize exposure to - and avoid the spreading of - these potentially highly pathogenic agents. Several gaps and needs arise directly from this situation.

There is a need to train stakeholders (first line responders, transporters, laboratory personnel) to biosafety measures in order to prevent unintended spreading of the pathogens: how to pack, manipulate, transport samples properly, how to inactivate efficiently a biological sample. This includes clear guidance and training for donning and doffing personal protective equipment.

Likewise, there is a need to have efficient and validated decontamination protocols that can be used safely, without being harmful neither for the patient nor for electronic components of the analytical equipment, and can be proposed as standards across the EU. Moreover, there is a need to control the efficiency of routine decontamination process hence to monitor residual hazard after decontamination. In that respect, a striking gap is the availability of real-time non-contact technologies enabling caregivers and laboratory staff to immediately assess the residual biological hazard in the vicinity of the patient and in the laboratory environment. Validation and quality controlled procedures are currently lacking.

There is also a need for caregivers and laboratory staff to be better trained to biosecurity issues, i.e. to prevent intentional misuse of the samples - protect the samples against theft) - but also to protect personal medical data and data transmitted, especially when caregivers and lab staff operate outside a heavily controlled hospital setting.

OUTPUTS

1. Procedures for infection control in health care settings. Existing decontamination protocols will be reviewed with the aim to define consensus protocols across the EU. Existing rapid, easy and standardized methods/protocol for decontamination will be identified. For identified gaps, solutions will be recommended to the Commission
2. Testing of new technologies enabling real-time non-contact “residual hazard assessment” based on short range LIDAR. These will be assessed through inter-laboratorial testing.
3. Link with other projects: These issues will be developed in connection with PANTHUB, REACHING OUT, ESA/B-LiFE, EMERGE and eNOTICE.

5.3 DEMONSTRATION STRAND 3: WORKFORCE CAPACITY, TRAINING AND NETWORKING

Pandemic management depends on adequate core capacities to prepare and respond to infectious disease threats in every country. In order to respond effectively to a pandemic, a knowledgeable skilled, effective and networked workforce with the right skill mix is essential.

Many countries would benefit from systematically and dynamically quantifying their own workforce shortages and assess the core competencies required to perform essential epidemic/pandemic response functions. In addition, innovation is required to develop teaching practices, methods, platforms and networks that can ensure the capacity to respond to current and future health security threats.

It has long been recognised that the best way to prevent the global spread of diseases is to detect and contain them while they are still local. This implies the presence of a local well trained public health workforce. A challenge identified in the PANDEM project is the difficulty in ensuring training reaches down to the local level.

Increasingly e-learning, in conjunction with other blended methodologies, is seen as a way to increase access to good learning resources at all levels of the workforce and reduce inequities in availability of life-long learning materials. This reduces travel costs and allows upskilling at a time best suited to the individual learner. In addition, user-oriented e-learning platforms offer the possibility to connect learners virtually, across organisational and geographical boundaries.

Unfortunately, experience has shown us that not all outbreaks will be detected and controlled while they are still local and we need to better prepare for large-scale epidemics and pandemics. The challenge then becomes one of integrating the response across sectors and wider geographical areas. Inter-sectoral and transnational simulation exercises can help to enhance the interoperability of preparedness plans of the different sectors such as civil protection, transport etc. can stimulate national training. Multi-country simulation exercises which would promote cross-border collaboration could prove to be a good investment and would support Article 4 of the EU Decision 1082/2013 on serious cross-border threats to health.

To these ends the PANDEM Consortium has identified a number of innovative concepts with specific objectives that will be included in a Roadmap for a PHASE II project:

- **Workforce Capacity and Capability Mapping:** to develop the processes and tools evaluate and monitor the pandemic preparedness and response workforce distribution, capacities, capabilities and skill mix in Member States
- **Training, E-learning :** to develop a multi-disciplinary and cross sectoral approaches to training and e-learning including online and immersive e-learning platforms
- **Game Base Learning and Serious Gaming**: to develop, test an validate a game based learning tool for pandemic preparedness which will be aimed both at pandemic responders, decision makers, the media and civil society
- **Cross-sectoral Networking and Simulation Exercises for Pandemic Readiness:** to enhance the networks that drive pandemic readiness and response by developing a multi-disciplinary, cross-sectoral and transnational simulation exercise platform.

DEMO CONCEPT 3.1 WORKFORCE CAPACITY AND CAPABILITY MAPPING

BACKGROUND/JUSTIFICATION

One of the initial challenges is to identify workforce gaps and the diversity and balance of disciplines required to counter infectious disease threats. Many health systems would benefit from systematically and dynamically quantifying and monitoring their own workforce shortages and assess the core competencies required to perform essential epidemic/pandemic response functions. Enumeration studies of this work force in Europe are hampered by the different systems and nomenclature used in the different Member States. PANDEM therefore proposes:

SOLUTION CONCEPT

Development of a systematic approach and innovative IT tools to evaluate the pandemic preparedness and response workforce capacity of Member States focusing on the diversity and balance of disciplines required to counter infectious disease threats. This tool developed would feed into and link closely with the Resource Modelling Tool PANDEM-CAP described in Demo Strand 1.

OUTPUTS

1. A review of methodologies already in use to measure workforce capacity to combat infectious disease threats.
2. Development of a template registry of disciplines working in pandemic preparedness and response, including the development of short videos outlining their role in a pandemic or high impact epidemic.

3. Building on work already performed by ECDC, develop and agree a list of core competencies for professionals working in pandemic preparedness and response.
4. Development of a Pandemic Workforce Assessment Tool to inventory the public workforce capacity both in quantitative (FTE's) and qualitative (competency) terms.
5. Carry out country assessments of pandemic workforce: Four country pilots to validate and refine the assessment tool will be undertaken.
6. Link with other Projects: The WHO Regional Office for Europe have also identified this as an important priority for the region focusing on the total public health workforce – not just those involved in combatting infectious disease threats. However, it will be important in Phase II of the PANDEM project to actively collaborate with this initiative.

IMPACT

- Better understanding of what constitutes a public health workforce
- Better workforce planning
- Scope to learn from countries with the best practice of workforce planning

DEMO CONCEPT 3.2 TRAINING and eLEARNING

BACKGROUND/JUSTIFICATION

Training and capacity development needs to be established across sectors prior to the emergence of a pandemic to enable effective collaboration between all relevant sectors. Multidisciplinary collaboration in training and exercises is seen as key to ensuring a synergistic approach to tackling emerging infectious disease threats in Europe.

GAP IDENTIFIED

The PANDEM consortium **identified a gap** in the development and availability of online and e-learning resources for training of health, security and civil protection professionals including first responders. Linking these to continuing professional development requirements in the Member States would encourage early adoption. Certification could be provided through international organisations such as EUPHA. The use of MOOCS (massive online open courses) is particularly suited for continuing education because they enable interaction, including quiz taking and online discussions with fellow course takers.

Specifically, the PANDEM consortium examined the requirements for training in a number of areas including:

- Risk communications
- Public health law
- Laboratory services

The PANDEM Consortium is aware that developments are planned and underway in risk communications training in WHO and networking in public health law by the Health Security Committee (HSC). Any developments proposed by PANDEM will seek to coordinate with and build on these developments and avoid any duplication of effort.

One of the key challenges when helping communicators to enact the principles of risk communications is to create an environment in which political leaders and government officials are also committed to following these principles in the event of a public health emergency. There is a tendency for leaders and officials to over-reassure members of the public rather than following the principles of establishing trust and acknowledging uncertainties. More effective and/or immersive training of national spokespeople is needed, including training and exercising political leaders and decision-makers in risk communications principles and techniques to ensure these are more widely understood. Real-time and table-top gaming exercises can help by simulating a response, as well as the problems that can arise if these principles are not followed.

It was difficult to identify or measure the input of public health lawyers to national pandemic plans. Previous research by the PHLawFlu project (2007-2010) concluded that "there is a dearth of expertise and training in public health law across Europe. Most pandemic planning in Europe is undertaken by public health practitioners with no input from persons with expertise in law". PANDEM researchers found no evidence that this situation has changed.

In Europe (unlike in the US) there are few public health lawyers outside academia, and few training courses in public health law. Those which do exist tend to be very general, often forming just a small part of a broader course on health law and focussed upon lawyers likely to become involved in cases of litigation or prosecution for breach of laws.

National pandemic governance (plans, policy, legislation) should be informed and developed with input from public health lawyers and/or health policy makers with training in public health law. This is important to ensure that governance is compliant with national and international legislation and that it respects human rights.

These experts should have a thorough understanding of both legal and ethical issues from a national perspective. They would also understand how national measures might coordinate

with measures of neighbouring countries, and how all these governance measures would fit into regional and international contexts.

OUTPUTS

1. **Development of an online e-learning platform** which would provide an immersive learning environment with state of the art resources for the transnational and cross-sectoral training of health, security and civil protection professionals on pandemic preparedness and response.
    a. The beneficiaries of such an approach would include, pandemic planners & coordinators, communicators, public health lawyers, Logistics and resource managers (e.g. hospital managers), laboratory personnel, security services, first responders, NGOs and civil society.
    b. Methods could include simulation-based learning and "war gaming," as well as borrowing techniques such as obligatory standard checklists from industries such as aviation. These solutions will use validated instructional design, engaging highly interactive presentations, tailored to individual needs and localized to language and culture of the learning site. Webinars will be developed to assist in building national capacity on pandemic preparedness.
2. **The PANDEM-CAP resource modelling tool will be incorporated into a training tool** for use by Member States at national level to examine the implications of resource requirements for pandemic response.
3. **Development of virtual and augmented reality based knowledge transfer modules** for innovative teaching of new laboratory methods. Training on biosecurity and biosafety including use of personal protective equipment, management of stress and hazards, and accident avoidance and management can be delivered using virtual and augmented reality modules.
4. **Training modules built around simulation exercises** will also demonstrate the impact of effective risk communications in parallel to other measures and types of modelling (e.g. cases, resource capacity) to ensure it would be taken seriously.
5. **Landscape analysis and user surveys** will be conducted in order to understand the specific audiences who need this training and would be willing to undertake it, and to identify the best methods by which to convince them of the value of training approaches. The challenge will be to deliver this training in a way that all stakeholders would feel it is applicable and relevant to their work, as well as being as important as other parts of preparedness and response.

6. **Training in Public Health Law**: Certified training tools or modules focussed on law and regulatory approaches to public health emergencies. This would include training for lawyers, which would give a grounding in public health issues as well as law. It would also be beneficial to provide training in public health law for non-legally trained public health practitioners and policy makers. In both cases, the central role of ethics and human rights should be taught. The aim is to create a professional cadre of public health lawyers at a recognised standard across the continent, as well as ensuring that policy makers understand the fundamentals of public health law for major public health emergencies. Training modules could be taught in a number of academic institutions across Europe, following an agreed syllabus and level to ensure consistency and a recognised high standard. Collaboration and networking between institutions would be actively encouraged to share ideas and examples of best practice, as well as enabling greater understanding of other legal systems and contexts. Developments will include:
   - Teaching materials for public health professionals and government authorities responsible for preparedness and response
   - Teaching materials for lawyers;
   - EU certified training module to an agreed international standard. Linking with recognised accrediting international bodies such as EUPHA, ECMID etc.
   - Support the development of training tools for the Network of public health lawyers from all Member States under the HSC.
7. **Communications Training:** an effective risk communications training programme for communicators and non-communicators involved in pandemic response and preparedness.
8. **Laboratory Training:** in new techniques as well a biosafety and biosecurity

IMPACT

Differences exist across Member States in relation to the availability workforce capacity to respond to pandemic threats. While some of this is undoubtedly related to financial resources, it is also in part related to traditional methods of organizing our workforce. New specialties such as informatics or public health anthropology can transform how we manage surveillance or utilise the optimal communications techniques. It is essential to ensure that all Member States can harness advancing technologies and learn from each other the most efficient and effective ways of developing the public health workforce. The work force capacity and capability mapping is a necessary first step on this journey.

- Training for preparedness using E-learning modules will ensure the availability of shared understanding of approaches required both at a sub-national and national level to adequately prepare for serious outbreaks and pandemics.
- An effective risk communications training programme for communication specialists and crisis managers involved in pandemic response and preparedness will enhance the skills of those tasked with delivering messages. Having a more embedded commitment to strategic risk communications would help to build and maintain trust and transparency and enable effective behaviours to be adopted at the recommendation of the relevant public health authorities.
- Training tools and Modules in public health law will lead to stronger national governance, i.e. greater compliance with national and international legal instruments, understanding of both legal and public health issues, recognition of ethical issues; increased governance coherence across Member States; increased collaboration between representatives of Member States and recognition at EU level of the role of law and public health lawyers in creating strong national pandemic governance.

Links between PANDEM Phase II with existing projects supporting proposed future developments

Both ECDC and the WHO Regional Office for Europe play a major role in training for pandemic preparation and response. Training usually is undertaken using face-to-face workshops. There is a high and often unmet demand for places in ECDC summer schools and both WHO and ECDC courses.

Other organisations involved in training include: Associations of Schools of Public Health in the EU Region (ASPHER), Centre for Health Sciences Training, Research and Development (CHESTRAD), Global Health Action (GHA), Institute for International Medical Education (IIME), Training Programs in Epidemiology and Public Health Interventions Network (TEPHINET), World Federation for Medical Education (WFME), European Union Institute for Security Studies (EUISS). ▫The European Programme for Intervention Epidemiology Training (EPIET) and the European Public Health Microbiology Training Programme (EUPHEM) are two year training fellowship programmes co-ordinated through ECDC and highly valued as demonstrated by the high number of applicants for each place.

The Global Health Network was established to create a subject specific online community of researchers who can build collaborations, develop documents, share resources and

exchange information. Its Global Health Training Centre provides links to online training resources across many relevant areas in laboratory sciences, disease surveillance and infectious diseases among others. The Global Health Network has recently announced the launch of a new seven-module eLearning course which has been adapted from the WHO training manual and resources on: 'Ethics in epidemics, emergencies and disasters: Research, surveillance and patient care'. The course offers comprehensive training exploring the wide range of ethical issues faced by health professionals and policy makers working in the context of epidemics/pandemics and disaster situations, focusing primarily on the key areas of research, surveillance and patient care.

INFORM is a collaboration of the Inter-Agency Standing Committee (IASC) Reference Group on Risk, Early Warning and Preparedness and the European Commission. The Index for Risk Management – INFORM – is a way to understand and measure the risk of humanitarian crises and disasters. INFORM is an open-source methodology for quantitatively assessing crisis and disaster risk. The results of INFORM can support decisions about crisis and disaster prevention, preparedness and response, as well as strategies that build resilience. For example, INFORM can be used to: help develop priorities for risk management, preparedness and building resilience; support decisions about resource allocation; and to monitor risk trends over time. INFORM can be used at global, regional or national level. INFORM is designed to be an open-source, easy-to-use risk assessment for crises and disasters that can be used and adapted by anyone.

PREPARE (Platform for European Preparedness Against (Re-)emerging Epidemics) is establishing a European clinical research framework for harmonised large-scale clinical research studies on infectious diseases, prepared to rapidly respond to any severe ID outbreak, providing real-time evidence for clinical management of patients and for informing public health responses. It does incorporate a training element (virtual learning centre) on its website (www.prepare-europe.eu) including powerpoints from conferences and publications. PREPARE is funded by the European Commission's FP7 Programme under grant number 602525. PREPARE has formally commenced its activities on 1 February 2014. PREPARE has its roots in the International Severe Acute Respiratory Infection Consortium (ISARIC), and builds on established clinical research networks (GRACE, TRACE, COMBACTE, CAPNETZ, PENTA and SERGAS) and pre-clinical FP7 funded research networks (EMPERIE, ANTIGONE, PREDEMICS, RAPP-ID).

COMPARE (December 2014 –November 2019 No 643476) is a large EU project with the intention to speed up the detection of and response to disease outbreaks like Zika among humans and animals worldwide through the use of new genome technology. They include

dissemination and training to ensure that relevant stakeholders of COMPARE are adequately informed about COMPARE's progress and results and have access to the training they need in order to apply the harmonized workflows, analytical tools and data resources developed and implemented by COMPARE in their pathogen detection and outbreak response activities.

PHEME (2014-2017) and ASSET (2014-2018) are ongoing Seventh Framework Programme projects examining respectively the detection of rumours on social media and scientific and societal challenges raised by pandemics

ACRIMAS (Aftermath Crisis Management systems-of-systems Demonstration Phase I) (no. 261669) developed a roadmap for a Demonstration Phase II project in crisis management which focused on large-scale man-made and natural incidents that would require a coordinated response. Though this project focused on natural disasters, terrorist attacks, and industrial accidents, the systems-of-systems approach is relevant to pandemic preparedness and response.

PULSE, the Platform for European Medical Support during Major Emergencies, (no 607799) focuses on preparedness in both a biological attack and a major stadium "crush," and how cross border support would be coordinated. This project seeks to develop a standardized response to such events across Europe.

eNOTICE network of military and civilian CBRN training centres across the EU. PANDEM and eNOTICE shares similar stakeholders (caregivers, first responders, technology providers and crisis managers).

REACHING OUT intends also to develop a set of training tools for improved crisis management through simulation exercises including an Ebola crisis demonstration. The phase II project will ensure any relevant ongoing outputs will be built on.

DEMO CONCEPT 3.3 GAME BASED LEARNING/SERIOUS GAMING FOR PANDEMIC READINESS

BACKGROUND/JUSTIFICATION

Game-based learning (GBL) refers to different learning methodologies based on the use of games as part of educational strategy in training processes. "Serious Games" are digital games, virtual environments and mixed reality/media that provide offer a unique approach and structure to complement traditional teaching strategies and which can:

- Allow multiple participants or units to train individually or simultaneously on a task or train on several tasks in an interrelated manner
- Energise training and act as ice-breakers between players
- Stimulate innovative and creative/divergent thinking/behaviour
- Act as learning triggers and drive discussion between players
- Allow players to look at the implications/consequences of their decisions

"Serious Gaming" represents an effective and innovative learning methodology and, in recent years, there has been an increasing interest in the beneficial aspects of using games as learning tools.

Studies have shown the effectiveness of these training methodologies in promoting the acquisition of knowledge and skills for adults, in a number of areas. Relevant game-based learning methods have been used in the field of education and training in the health sector.

GAP IDENTIFIED

Through the process of PANDEM's work and across all of the core areas assessed, a number of specific gaps have been identified:

- There are existing knowledge gaps amongst multiple stakeholders (e.g. public health and clinical personnel, first responders, lab personnel, security services, communicators etc) involved in pandemic event management which is exacerbated by the reality of dealing when dealing with rapidly developing and changing events with multiple points of coordination
- A lack of knowledge, recognition and understanding of the roles and responsibilities of other actors and responders
- A lack of in-service training tools that allow front line users to experience and train on standard operational procedures, response decision making and timing, scale and distribution of countermeasures available.

SOLUTION CONCEPT

Playing Serious Games on pandemic threat management and response can engage and excite players/users due to competitive element, authenticity, entertainment value and feedback mechanisms. This leads to constructive situational and experiential learning. It is argued that the impact and outcomes of serious gaming include “softer” emotional, motivational, and attitudinal outcomes as well as “harder” cognitive acquisition including declarative, procedural and strategic knowledge construction. Ericsons’s theory of deliberate practice argues than players of games are not naturally good at playing a serious game, but with intentional repetitive training and feedback a player will become an expert. By drawing largely on innovative gaming technologies, Serious Games would provide an interactive, real-life learning experience.

It is vital that any game-based learning solutions are designed with specific educational learning outcomes and needs, and are co-created together with the end-users. In particular, the roles of users’ motivation (e.g., achievement, immersion, social motivation, intrinsic vs extrinsic), technology acceptance and learning preferences (e.g., deep vs surface vs. strategic, emotions) need to be taken into account. Furthermore, the learning design needs to recognise that not all health professionals learn in a similar, linear manner. Adaptive approaches, non-linear problem-solving routes and variations may provide a more realistic, bespoke and transformative environment.

Consequently, the co-creation process involving a multiple disciplinary team composed of subject matter experts, training facilitators, experienced health practitioners, game designers, instructional designers, developers etc.

The approach of the project is to devise a toolbox of game-based learning solutions, where each one will have its own lifecycle. The process is highly interactive, starting with the exploration of the needs to be addressed, using a variety of different tools and methods, adopting principles of design thinking and living labs:

- Analysis and empathy (Shadowing for on-site observation; Collecting habits of energy consumption; Identification of implicit needs of comfort and well-being; Monitoring energy management practices; Cultural Diagram)
- Positioning and filter ideas (Analysis models consumption profiles; Identification and selection of problems and opportunities; Identification of the potential application of technology; Management needs of cultural change)
- Generating ideas (De-multiplication of creative approaches to the problems identified; Brainstorming on issues and opportunities)

- Prototyping and testing (Selection and implementation of prototypes; Simulacrum of prototypes in the field; Application of real prototypes in the field; Interactive gauging of the impact on application of prototypes).

As each solution matures in the prototyping and testing phase, the project will design and conduct extensive evaluation with large groups of end-users, across national European borders, which will contribute to the delivery of the final solution.

OUTPUTS

The output of the project would be a toolbox/portal of game-based learning solutions to rapidly build capacity and transfer competence (knowledge, skills and attitude) amongst stakeholders. Solutions would be both digital and non-digital, packaged as multi-lingual learning resources to be integrated into existing learning management systems (LMS) or as standalone. The project would have a strong emphasis on sustainability, thus the aim is to establish a business model to exploit the results supported by appropriate communication and marketing material to engage with the market.

The solution would provide various users/players with a gaming experience which is interesting and stimulating while at the same time transferring knowledge to the user on various aspects of pandemic planning, preparedness and response.

The tool/portal would allow players to choose different scenarios and to choose the role that they will play in the response. In doing this, users from other sectors can choose to experience the role, tasks and experiences of others users/responders. This will allow for greater understanding of the role of other responders and other sectors in pandemic response. In addition, the game portal would allow users to experience the implications and consequences of decisions on the developing disease scenario.

IMPACT

- The use of game based learning will foster rapid competence development thus enabling the building of capacity and improve the response capability to pandemics as the knowledge from the field can be more easily transferred across the teams
- A better understanding of the role, responsibilities and stresses upon other responders and sectors during a response
- Increased decision making and consequence management skills in users across many sectors.

DEMO CONCEPT 3.4 CROSS SECTORAL NETWORKING AND SIMULATION EXERCISES

BACKGROUND/JUSTIFICATION

To improve preparedness for response to existing and emerging pandemic threats, the community of pandemic management needs to be:

- **Proactive -** by developing credible threat analysis, effective planning and resource allocation, and innovation on countermeasures (products, processes, services, tools, technologies)

AND

- **Reactive -** by delivering rapid detection, risk assessment, prediction scenarios, risk communications and the deployment of the appropriate countermeasures and skilled workforce for containment/mitigation of the event.

All of the above can only be achieved by:

- **Using science-based and collaborative approaches**
- **Building trust, capacity and capability** of multiple stakeholders and sectors
  - **Users** (direct beneficiaries – practitioners, technology operators, customers) of technological solutions;
  - **Technology suppliers** - academic researchers, RTOs, SMEs, large industry;
  - **Regulators and policy-makers**, i.e., members of European, intergovernmental and/or governmental regulatory agencies that ensure compliance with laws, regulations, established rules
  - **Civil society/the general public** as an ultimate user/beneficiaries of the products, technologies, services and processes.
- **Joint simulation exercises** that **test system effectiveness and integration** by practicing for high impact epidemics and pandemics at all levels - local, national, regional, European and international
- **Building networks and partnerships** that deliver efficient and effective innovation, preparedness and response to stimulate:
  - **Active dialogue between all the stakeholders** to ensure that innovation is based on practical users' needs and that solutions correspond to the actual requirements of the practitioners.
  - **Communication and information sharing** between existing successfully functioning communities and platforms, connecting
  - **Joint activities**, expert meetings on pandemic risk scenarios, inter-sectoral meetings on specific threats.

- **Joint simulation exercises, serious gaming and demonstrations.**
- **Liaising with existing scientific, training and policy networks and projects**. Existing initiatives include: DG HOME CoU, ERCC and JRC Disaster Risk Management Knowledge Centre (DRMKC), DG ECHO EU Disaster Management Training Network (EU DM-TraiNet), DG DEVCO CBRN Center of Excellence; H2020 project eNOTICE – European network of military and civilian CBRN training centres, H2020 project ENCIRCLE – CBRN cluster of industry and technology suppliers, EMERGE - DG SANTE Health Programme initiative, H2020 project Reaching Out – a project on crisis management demonstrations outside the EU.

GAP IDENTIFIED

While many functional networks for pandemic preparedness and response exist within the EU, PANDEM has identified gaps in cross sectoral readiness and networking that can at least be partially addressed though multi-disciplinary, multi-sectoral and multinational joint simulation exercises that would bring players together with the specific objectives of:

- Stimulating broader collaboration and networking for pandemic readiness
- Testing existing preparedness plans and processes
- Testing inter-sectoral coordination, integration and effectiveness
- Identifying weaknesses and gaps
- Providing training, learning and knowledge sharing opportunities at all levels.

SOLUTION CONCEPT

Development of a multidisciplinary collaboration platform for transnational, inter-sectoral simulation exercises to forge relationships which will:

- enable more effective responses during a high-impact epidemic/pandemic.
- enhance, test and improve the interoperability of preparedness plans of the different sectors
- assess the effectiveness of control measures at borders.

These exercises will:

- Simulate different evolving scenarios during operations using near-casting techniques and will enable the simultaneous training of decision makers, crisis managers as well as use for training of local responders.
- Incorporate the latest 3D realistic visualisation techniques integrating the latest advances in Virtual and augmented reality techniques.

- Utilise the outputs of other tools/solutions proposed for Phase II such as
  - Resources modelling and allocation
  - Visual Analytics
  - Predictive (prognostic) modelling
  - Serious Gaming.

OUTPUTS

- Exercises which can be adapted and used at international, national and sub-national levels will enable different sectors to collaborate and learn from each sectors crisis response methodologies.
- A multi-sectoral on-line simulation exercise platform with multiple scenarios and levels that would allow one or many users, sectors or countries to participate, share knowledge, learn and network.

IMPACT

- A better common understanding between users, sectors and countries of the challenges and requirements of effective pandemic preparedness and response
- More effective response to high impact epidemics and pandemics across the EU.

6. CONCLUSIONS AND NEXT STEPS

The PANDEM project had a wide remit to identify gaps and solutions across three major areas critical to effective preparedness and response to high impact epidemics and pandemics affecting the EU and its' Member States.

The PANDEM partners worked closely with a broad range of experts to identify 13 innovative solutions/concepts to be proposed as part of three major demonstration strands. The impact of the solutions/concepts proposed above would be to further coordinate, integrate and leverage the capacity of EU institutions, stakeholders and service providers so that EU citizens can benefit from state of the art preparedness, planning, response, containment and mitigation measures that reduce the impact on their lives, health, socio-economic development and security.

The next step will be to define a roadmap and implementation plan for a Phase I Demonstration project (D6.2).

ANNEX I: SUMMARY OF DEMONSTRATION STRANDS AND CONCEPTS

Demo Strand	Concept	Outputs	Impact
Demonstration Strand 1 **Governance, Planning and Communications**	1.1 Model legal framework for pandemic response	✓ **Capacity building in public health law** ✓ **Mapping and Comparative evaluation** of national legislation ✓ **A Model act** to provide guidance to MS	✓ Ensure measures that are coherent, coordinated and transparent ✓ Greater clarity of response within and across MS ✓ Provide legal authority and safeguards to both public health authorities and citizens
	1.2 Trust in governmental and public health institutions	✓ **Multilevel research and analysis** of the changing pattern of trust within and across societies in Europe; ✓ Development of a **"Public Health Trust Metric and Monitoring Tool"**	✓ Enable more informed decision making at policy level. ✓ Greater public trust and cooperation making public health response more effective and ethically acceptable. ✓ Less risk of public panic which can undermine measures to respond to a pandemic.
	1.3 Resource planning – Resource Modelling Tool and Simulator	✓ **An integrated modular resource planning system** - which can be adapted and configured for any member state, depending on their specific requirements.	✓ An integrated approach to planning approach that provides MS with a realistic assessment of preparedness/readiness ✓ Support quantification of resources required across an MS and provide guidance on optimal ways to allocate these resources
	1.4 Risk communications principles in practice	✓ **Guidance and practical tools** - for segmenting and using audience groups and listening surveys to both test and adapt messages before a public health emergency ✓ **Guidelines and a "Listening, Monitoring and Feedback Tool"** - to enable communicators to gather responses in real time and adapt their strategies and messaging effectively in response.	✓ Communicators at MS level actively engage their communities, and build resilience and trust through consistent and relevant messaging, based on the principles of risk communications. ✓ More effective communications during a pandemic, contributing to reduce the spread of disease by laying the foundation for messages to be well received and acted upon.
	1.5 Social and behavioural science for communications	✓ **High quality, evidence-based practical guidelines** to help in the design of communications interventions by ○ Incorporating expertise from other specialities. ○ Focused on a clear, two-way communications in the preparedness phase	✓ Generate more specific, diverse and actionable evidence base for pre and intra-pandemic communications interventions ✓ The accumulation of better evidence and analysis of lessons learnt will help to improve the strategies and tactics used to deliver communications messages in different contexts. ✓ Better designed communications interventions will lead to faster, more predictable behaviour change in communities

Demo Strand	Concept	Outputs	Impact
Demonstration Strand 2 **Situational Awareness and Decision support**	2.1 Visual Analytics to Drive Decision Making	✓ An IT system that would provide MS with a **Common Situational Awareness and Decision-making Tool** based on visual analytics, i.e., a dashboard based system based on human perception, information visualization, and advanced data analytics.	✓ Reduce the cognitive load of the decision-makers enabling better decisions, improved public health, and effective pandemic management. ✓ A better understanding of the available complex data aiding the decision-making process. ✓ Improved decision-making by making the right information available at the right time and in the right format that leads to more effective response.
	2.2 Participatory Surveillance	✓ **A validated and field tested IT tool/system** that can utilize data from multiple non-traditional sources to support detection, risk and impact assessment with capability to be integrated as part of a common tool for surveillance, visualization, pandemic forecasting and resource mapping.	✓ Increased situational awareness by having information on disease spread and burden in different sectors of society ✓ Better communication within and between the different countries based on a common understanding of societal impact ✓ Higher quality risk assessment, prognoses, and resource allocation.
	2.3 Predictive Modelling Tool	✓ **A Predictive Modelling Tool** for forecasting the course of infectious disease in a population with visualization of possible outcomes depending on available interventions.	✓ Enable better communication and understanding of the complex dynamics at play during a pandemic. ✓ Assist policy makers in making informed decisions,
	2.4 Diagnostics and Laboratory Services	✓ **Laboratory Decision Support Ontology** ✓ **A PORTAL-solution** enabling better sharing of protocols, guidelines and standards ✓ **Secure real-time/online exchange tools and platform f**or sharing data in a in a Laboratory Information and Management System (LIMS) ✓ **Connect the use of PCOT/RDT by first line responders** to a web service linking them with the lab network and health authorities. ✓ **Integrate NGS analyses** in the routine surveillance and response:	✓ Homogenized data sharing, integration and visualization in a common framework accessible and understandable by the whole chain of responders and crisis managers ✓ Integrated testing, analytical and communication capacity across EU laboratories ensuring the best use of limited resources ✓ Integrated POCT and NGS with existing surveillance and decision making systems improving situational awareness

Demo Strand	Concept	Outputs	Impact
Demonstration Strand 3 **Workforce Capacity, Training and Networking**	3.1 Workforce Capacity and Capability Mapping	✓ **A template registry of disciplines and core competencies** for pandemic management ✓ **A Pandemic Workforce Assessment Tool** to inventory and monitor the public workforce capacity and capability. ✓ **Country assessments of pandemic workforce** in 4 country pilots to validate the Tool	✓ Better understanding of what constitutes a public health workforce ✓ Better workforce planning ✓ Scope to learn from countries with the best practice of workforce planning
	3.2 Training and eLearning	✓ **An online e-learning platform** providing an immersive learning environment for cross-sectoral training for pandemic management ✓ **Training tool for PANDEM-CAP resource modelling** tool for MS ✓ Development of **virtual/augmented reality knowledge transfer modules** for planners, communicators, laboratory staff , front line responders ✓ **Training in Public Health Law** for public health and government authorities.	✓ Shared understanding of approaches required at all levels and in all sectors to adequately prepare for serious outbreaks and pandemics. ✓ Enhance skills for those all those tasked with planning, communicating and responding to a pandemic ✓ Training tools and Modules in public health law will lead to stronger national governance
	3.3 Game-Based Learning and Serious Gaming for Pandemic Readiness	✓ **Gamed-Based Learning Tools/Portal** which would provide various users with a stumulating experience while at the same time transferring knowledge on various aspects of preparedness and response.	✓ A better understanding of the role, responsibilities and stresses upon other responders and sectors in response ✓ Increased decision making and consequence management skills in users across many sectors
	3.4 Cross Sectoral Simulation Exercises and Networking	✓ **Simulation Exercises** which can be adapted and used at international and national levels. ✓ **A multi-sectoral On-line Simulation Exercise Platform** with multiple scenarios and levels that allows many users/sectors or countries to participate, share knowledge, learn and network	✓ Enable different sectors and MS to o Gain a common understanding of the challenges and requirements of pandemic management o Enhance, test and improve the interoperability of preparedness methodologies and plans o Assess the effectiveness of border control measures o More effective response to high impact epidemics and pandemics across the EU