D1.5 Data Management Plan (v2)

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Author (email) Institution	**Antonis Kalis (antonis.kalis@iccs.gr) Institute of Communication and Computer Systems**
Editor (email) Institution	**Antonis Kalis (antonis.kalis@iccs.gr) Institute of Communication and Computer Systems**
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[1] **R**=Document, report; **DEM**=Demonstrator, pilot, prototype; **DEC**=website, patent fillings, videos, etc.; **OTHER**=other

[2] **PU**=Public, **CO**=Confidential, only for members of the consortium (including the Commission Services), **CI**=Classified, as referred to in Commission Decision 2001/844/EC

Modifications Index

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ACRONYMS AND ABBREVIATIONS

EU	European Union
WP	Work Package
GDPR	General Data Protection Regulation
EC	European Commission
NGO	Non-governmental organization

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Executive Summary

HYPERION is a H2020 framework project funded under grant agreement 821054 which aims to introduce a research framework for assessing the risk and resilience of Cultural Heritage sites subject to natural hazards in a climate-change era.

The present deliverable reports on the project's Data Management Plan, describing the procedures for data collection, storage and processing. In principle, the data collected, generated or reused throughout the project's lifecycle were processed only for scientific reasons. All the data related activities complied with the requirements of the General Data Protection Regulation.

In parallel, HYPERION, as part of the Pilot on Open Research Data, has followed the FAIR principles thus making its data Findable, Accessible, Interoperable and Re-usable.

This deliverable provides a brief description of the data managed within the project's scope. It's worth noting that no personal data of any kind is employed for the scientific analyses of the project. Therefore, the project is fully compliant with the General Data Protection Regulation.

The project's outputs in terms of deliverables and/or any project outcomes related scientific publications will be named and indexed with appropriate keywords and will be available via the project website and in research fora.

1. Introduction

1.1 Objectives of the Deliverable

The purpose of this deliverable is to provide the Data Management Plan for HYPERION that follows the Open Research Data Pilot principles. Additionally, it explains how the project activities are complying with the Protection of Personal Data (POPD) requirements established by the EC and national regulations. The data management plan describes how data has been collected, stored, documented, shared and reused during the project.

1.2 Participation in the Open Research Data Pilot

HYPERION participates in the Pilot on Open Research Data launched by the EC along with the Horizon 2020 programme. The consortium supports open science, and the large potential benefits to the European innovation and economy stemming from allowing reusing data at a larger scale. Therefore, the majority of data produced by the project were published with open access..

Dedicated deliverables on Ethics such as “D11.1 H - Requirement No. 1” and “D11.2 POPD - Requirement No. 2” falling under the scope of WP11 are devoted to explain the procedures and criteria that will be used to identify/recruit research participants and how HYPERION activities are complying with Protection of Personal Data (POPD) requirements established by the EC and national regulations, as well as with GDPR with respect to the privacy of EU citizen.

1.3 IPR management and security

As a Research and Innovation Action (RIA), HYPERION aimed at developing close to market technological solutions. The project consortium includes partners from the private sector. Those partners obviously have Intellectual Property Rights on their technologies and data. Consequently, the consortium protected their data and had the confirmation of concerned partners before every publication of them. Moreover, as data collected through the project’s activities were of high value - measures were foreseen to prevent them from being falsified.

All data repositories used by the project complied with specific security and data protection measures. In addition, protective measures against infiltration were taken as well as physical protection of core parts of the systems and access control measures. More details on this will be provided in Section 5.

2. HYPERION Data Summary

2.1 End-users' needs

End-users' needs and expectations were gathered through different means (e.g., questionnaires, workshops, combination of previous methods).

Table 1 End-users' needs

Data Category	Data type	Description
Questionnaires	Paper or online form	Physical (paper) or online document with series of questions for the purpose of gathering information from respondents
Interviews	Notes on paper or digital	Private or public conversation with questions asked to elicit information

The purpose of the data collection/generation and its relation to the objectives of the project:

The collection of inputs from the stakeholders, combined with a deep analysis of all technical, regulatory and financial aspects were considered for the development of HYPERION integrated system.

The types and formats of data that the project generated/collected*:*

Responses to paper-based questionnaires were marked on the paper itself.

Notes from interviews were taken and saved digitally in *.doc file type or physically in paper.

The re-usability of any existing data:

No existing data was reused.

The origin of the data:

Data originated from human personal responses to several questions or where extracted as notes from conversations.

The size of the data:

Digital notes on *.doc files were of size ~2MB

Paper-based questionnaires and notes were of about 40 paper sheets.

The data utility:

All information from this process had a positive impact on the definition of the functional and non-functional requirements and the system architecture.

2.2 Pilot area surveys

Table 2 Pilot area surveys

Data Category	Data type	Description
Maps	Digital files (dwg, tiff, png, etc.)	Maps of the pilot study areas
Asset data	Paper and digital forms	Survey forms filled by Hyperion member after visiting each asset (building) designated in the area
Census data	Digital (csv, xls, pdf)	Data from the publicly available sources of the assets and population at risk in the pilot area.

The purpose of the data collection/generation and its relation to the objectives of the project:

The main objective here, was to collect data in order to have an overview of the structural characteristics of the assets belonging to Tier 3. For those building the vulnerability was quantified using some predefined parameters/information as proxies. The latter were defined based on the outcome of the surveys conducted in specific areas of the pilot cities.

The types and formats of data that the project generated/collected*:*

The data was extracted from online forms, structured in an ad-hoc manner for the purpose of the project.

The re-usability of any existing data:

Existing data from municipality or local authorities was employed to improve the survey quality and coverage.

The origin of the data:

Publicly available data repositories, such as building and population census data, municipality datasets etc. Also, data originated from human personal responses to questionnaires as well as in-person surveying of the study areas via customized asset description datasheets.

The size of the data:

- Paper format data: *.pdf files from survey form scan, about 500 KB each.
- Pictures from surveys: *.jpg from survey, about 1 MB each (depending on camera quality)
- Excel spreadsheet including all the digitalized surveys, about 500 KB per pilot city
- 100 MB of data per city

The data utility:

Assess the exposure (assets at risk) at each pilot site is a key ingredient of risk & resilience assessment. In particular, those data was used as input for assessing vulnerability and loss in the framework of HRAP resilience tool.

2.3 Geographic & Climate Data

Based on the requirements gathered via consultation with the users all the available geographic and other data and services (e.g. hydrological, atmospheric, meteorological) related to CC and various geo-hazards were recorded. In addition, an extensive analysis on existing EUROCORDEX climate simulation results was made to identify relevant "episodic" periods. The analysis involved results previously obtained by various Regional Climate Models (RCMs) in resolutions of 0.11 and 0.44 degrees driven by the ERA-Interim input, as well as for one or a few scenarios carefully selected to span the spread of expected uncertainties.

Table 3 Geographic & Climate Data

Data Category	Data type	Description
Episodic Periods	Dataset	Datasets collection for identification of episodic periods.

The purpose of the data collection/generation and its relation to the objectives of the project:

The identification of episodic periods throughout the datasets collected played a major role in the project's lifecycle and outcomes.

The types and formats of data that the project generated/collected*:*

Datasets collected from EUROCORDEX contain:

Regional Climate Models are mathematical climate prediction models that can be employed to describe the evolution of the climate over the extended area of interest.

The outcome of the analysis generated the episodic periods datasets which contain spatially correlated fields of intensities on a daily or 10-min discretization time scale that convey the weather intensities over a time (episodic period) of interest, typically associated with the exceedance of given thresholds of intensities of interest (e.g., high/low temperatures, extreme wind events etc.).

All data were encoded in csv and netCDF formats

The re-usability of any existing data:

Climate data from existing sources, such as IPCC and EUROCORDEX, and existing climate models, such as the Eulerian Mesoscale models HARMONIE and MEMO, CFD models MIMO and PALM-LES and coupled model MEMICO.

The origin of the data:

Data collected from EUROCORDEX can be found in https://www.euro-cordex.net/

The size of the data:

Collected data from EUROCORDEX were of size ~10 GB

Collected data of Regional Climate Models were of size ~100 GB

The generated data containing the episodic periods were of size ~100 MB

The data utility:

Datasets collected combined with the Regional Climate Models determined the episodic periods. The episodic periods were used as inputs to the Multi-Hazard Models module, and eventually HRAP.

2.4 Micro-climate stations and Smart Tags

A smart and distributed sensor network based on small, autonomous, unattended, reliable and long-life wireless tags was developed.

Table 4 Micro-climate stations and Smart Tags

Data Category	Data type	Description
Smart Tags data	Numerical values & Sensor Metadata/ JSON	Datasets derived from Smart Tags on the distributed sensor network
Micro-climate stations data	Numerical values & Sensor Metadata/ JSON	Datasets derived from sensors placed in specific locations of the sites

The purpose of the data collection/generation and its relation to the objectives of the project:

The collected data provided direct input to the Dynamic Data Assimilation of meteorological and climate data task where data aggregated from the sensor network and delivered through the monitoring system. When engaged with the simulated data, they were analyzed and fused (including aggregation, synchronization, calibration and assimilation) through a fully interoperable data management platform. The data were used by the deterioration functions, the hygrothermal simulator and the HRAP platform.

The types and formats of data that the project generated/collected*:*

Smart Tags data: JSON data objects containing time series of measurements.

Micro-climate stations data: JSON data objects containing time series of measurements.

The re-usability of any existing data:

No data were reused from existing sources.

The origin of the data:

The data originate from on-site deployed sensors and monitoring systems.

The size of the data:

The Smart Tags datasets are of size ~ 10MB per sensor per month.

The Micro-climate stations datasets are of size ~ 10MB per sensor per month.

The data utility:

The data generated by the smart tags were incorporated in the monitoring and mapping tasks and tools.

2.5 Atmospheric Models

Table 5 Atmospheric models

Data Category	Data type	Description
Improved 3D model	Mathematical model	Dynamic Data Assimilation of meteorological and climate data from sensors.
Time-series	Datasets	
impact indicators	Datasets	

The purpose of the data collection/generation and its relation to the objectives of the project:

Topological data, CC scenarios and digital georeferenced maps, in scales ranging from 100km down to <1km including long-term hydrological time-series for each site or a concise set of statistics of historical hydrology data that were collected, led to the compilation of very high resolution (better than 1 km) time-dependent land use and land cover maps, including historical data and future land use scenarios. Further to this, maps of thermophysical, biophysical and artificial-surface parameters were compiled, in cases that such thematic layers could not be easily derived from the Land Use maps. A 3d model development was also used in a very-high spatial resolution simulation together with an optimized allocation of temporal study periods for each selected case study.

The types and formats of data that the project generated/collected:

The time-series and statistics of atmospheric and climatic impact indicators include the following parameters: ambient temperature, precipitation, relative humidity, radiation, atmosphere and the soil, as well as their relevant statistics on medium- and long-term extreme values.

The impact indicators included parameters as defined in the WMO/ETCCDI specification of Descriptive Indices of Climate Extremes.

The re-usability of any existing data:

No data external to the project were reused.

The origin of the data:

All related data came from previous internal project sources.

The size of the data:

The Time-series datasets are of size ~10 GB.

The Micro-climate stations datasets are of size ~100 GB.

The data utility:

A qualitative and quantitative assessment on the relevance of primary and secondary impact indicators derived from climate calculations and RT in-situ measurements that were used in the process of providing RT hazard assessments for the DSS, as well as HT and structural vulnerability assessment.

The time-series indicators were used as input in the hydrothermal and structural modelling tools.

The impact indicators were used to dynamically update an independent mapping of atmospheric stressors in the smallest scale that were explicitly simulated by the modelling cascade.

2.6 Building materials and d-HAM properties

Table 6 Building materials and d-HAM properties

Data Category	Data type	Description
d-HAM properties	Dataset, Lab. measurements	Descriptions, images, numerical values
Building materials	Dataset, Field survey, Lab. measurements,	Descriptions, maps, images, numerical values

The purpose of the data collection/generation and its relation to the objectives of the project:

The data were collected so as to classify and characterize the building materials and their deterioration patterns/mechanisms, and to define the dynamic HAM properties of the materials.

The types and formats of data that the project generated/collected*:*

The Building materials outcomes data were collected on .doc, .jpg, .tiff and .xls files.

The d-HAM properties outcomes data were collected on .doc and .xls files.

The re-usability of any existing data:

No data external to project were reused.

The origin of the data:

The building materials and the d-HAM properties were extracted by in-situ inspections and laboratory measurements.

Data were provided by:

1. Tier 1 building survey: petrographic description and state of damage
2. Petrographic description (macro- and microscopic description)
3. Physical characterisation
    a. Bulk density and porosity (types of analysis: Mercury Intrusion Porosimetry, micro-Computed Tomography, Hydric Tests)
    b. Physical and mechanical properties (ultrasound tests and uniaxial compressive tests)
4. d-HAM properties measurements
    a. Hydric behaviour/capillarity
    b. Relative Humidity (RH) condensation
    c. Specific heat capacity
    d. Thermal conductivity
    e. Water vapour thermal diffusion resistance factor
    f. Hygroscopic sorption properties
5. surface topography (3D profilometry)

When surface patinas were present, specific analyses were performed (e.g. by XRD, FT-IR, ER-FTIR, μ-Raman, IR-thermography, XPS, Dual VNIR-SWIR).

The size of the data:

The building materials properties data are of size ~2Tb.

The d-HAM properties data are of size ~50Gb.

The data utility:

These data were used to evaluate the effect of micro-climate conditions on deterioration of the different building materials and quantify the linearity of surface recession rate.

2.7 Damage and dose-response functions

Table 7 Damage and dose-response functions

Data Category	Data type	Description
Prediction of decay	Dataset, lab measurements, on-site measurements	Numerical data, images
Validation of Lab tests	Dataset, on-site measurements	Numerical data, images
Dose-response functions	Mathematical model	Numerical data

The purpose of the data collection/generation and its relation to the objectives of the project:

The purpose of data collection was to refine damage and dose-response functions considering the different petrographic and textural features of the building materials, and measuring variations in the surface topography of samples exposed to on-site and lab environmental conditions. Dose-response functions were validated against long-term recession rate measurements on tombstones from historical war cemeteries.

The types and formats of data that the project generated/collected*:*

The outcome of these data categories were collected on .xls, .tiff, .jpg, .doc, files.

The re-usability of any existing data:

No data external to project were reused.

The origin of the data:

The prediction of decay was achieved by in-situ inspections and lab measurements, building a database of materials surface features including topography and patinas (3D profilometry IR-thermography, XPS, Dual VNIR-SWIR), and performing aging tests (freeze-thaw cycles and salt crystallization cycles).

The size of the data:

The prediction of decay dataset is of size ~2Tb.

The validation of lab tests dataset is of size ~50Gb.

Dose-response functions dataset is of size ~1Gb.

The data utility:

The data generated and collected provided a better prediction of decay and, integrated in d-HAM models, allowed reliable estimates of CH vulnerability considering validated downscaling climate simulations.

2.8 Materials' physical-mechanical properties

Table 8 Materials' physical-mechanical properties

Data Category	Data type	Description
Physical-mechanical properties	Dataset, lab. measurements	Numerical data, images, descriptions
Deterioration estimation rules.	Dataset, lab. measurements	Descriptions, images

The purpose of the data collection/generation and its relation to the objectives of the project:

This section describes the physical-mechanical properties of the building materials, and develops simplified models/rules for the estimation of their deterioration due to the decay imposed by climate over time. This led to a more precise prediction of the possible structural risks (from detachment of parts to collapse) of the cultural asset in a changing climate characterized by an enhancement of extreme events.

The types and formats of data that the project generated/collected*:*

The data format of these data categories were of .doc, .tiff, .xls, files.

The re-usability of any existing data:

No data external to project were reused.

The origin of the data:

The definition of the physical properties and behaviour during stressed climate conditions were simulated by aging test cycles in the lab (water, sunlight, and thermal cycles).

The size of the data:

The physical-mechanical properties data is of size ~20GB.

The deterioration due to decay data is of size ~10GB.

The data utility:

The innovative climate/time dependent mechanical properties of materials were accessed by the SG simulator's structural analysis tool and by the HRAP model.

2.9 Materials' decay

Table 9 Materials' decay

Data Category	Data type	Description
Materials' decay	On-site measurements	Numerical data, images

The purpose of the data collection/generation and its relation to the objectives of the project:

Determining the effect of extreme events in order to evaluate the vulnerability under climate change scenarios predicting increasing frequency and intensity of such events.

The types and formats of data that the project generated/collected*:*

The field tests outcomes were of .xls, .tiff, file type.

The re-usability of any existing data:

No data external to project were reused.

The origin of the data:

On-site surveys after extreme events (e.g. m-Raman spectroscopy, Dual VNIR-SWIR, IR-Thermocamera), and analyses of deterioration patterns on assets which have been exposed to documented extreme events in the recent past.

The size of the data:

The field tests outcomes data were of size ~1TB.

The data utility:

Data were collected to study the expected significant effect of floods, coastal storms and strong wind events on deterioration mechanisms related to salt transport and deposition, in combination with extreme tidal range events and sea-level rise.

2.10 Hygrothermal simulator

Integration of all in-situ and lab measured d-HAM properties of building materials with the proposed HT simulator.

Table 10 Hygrothermal simulator

Data Category	Data type	Description
HT Simulator data	Datasets	Tabular data with minimal metadata. Textual data. Documentation and scripts. Image data

The purpose of the data collection/generation and its relation to the objectives of the project:

The HT simulator integrated all in-situ and lab measured d-HAM properties of building materials and involved a detailed database of building material and their HT properties, as have been identified, collected and characterized. The transient measured data validated the model of the simulator.

The types and formats of data that the project generated/collected*:*

The simulator generated the predictive results of HT performance of building components and constructions in CH sites, in the form of .csv; .rtf and .pdf; .txt and .tiff

The re-usability of any existing data:

No data external to project were reused.

The origin of the data:

Previously reported data were integrated and analyzed.

The size of the data:

The size of the simulation outcomes were of size ~1TB.

The data utility:

The simulator will be open-access through a webpage to host the databases allowing a realistic prediction of HT performance of building components and constructions in CH sites.

2.11 Multi-Hazard Model

Table 11 Multi-Hazard Model

Data Category	Data type	Description
Natural & human induced disasters	Database	
Hazard model	Dataset	Model results

The purpose of the data collection/generation and its relation to the objectives of the project:

A database was set containing information layers depicting present hazards and their associated potential to cause harm and a model for a broad spectrum of natural and man-made hazards were developed

The types and formats of data that the project generated/collected:

The natural & human induced disasters database contains data in formats .tiff and NetCDF.

The hazard model outcomes are in NetCDF format.

The re-usability of any existing data:

No data external to project were reused.

The origin of the data:

Previously reported data were integrated and analyzed.

The size of the data:

The natural & human induced disasters database is of size ~1TB

The hazard model outcomes is of size ~10 GB

The data utility:

All related data were used to develop an advanced and reliable model for a broad spectrum of natural and man-made hazards, and provided the involved stakeholders, scientists and users with useful information for their specific needs in handling natural and human induced disasters.

2.12 Vulnerability modules

Table 12 Vulnerability modules

Data Category	Data type	Description
Integration software toolkit	numerical values, diagrams, interface software	Tier 1 monitoring interface.
Detailed structure model	Structural response (numerical values)	Tier 1-2 structures model
Hazard simulator	Prognostic results (numerical values)	Vulnerability assessment. MHVM.

The purpose of the data collection/generation and its relation to the objectives of the project:

A software toolkit for approximate Bayesian computation and model updating to integrate sensor output with SG detailed Model of Tier 1 structures to incorporate monitoring data and allow rapid updating of the model properties.

A highly detailed component-by-component Model was developed for Tier 1-2 structures in the SG simulator, together with corresponding fast-running simplified surrogate Model.

The types and formats of data that the project generated/collected:

The software toolkit is an .exe file and generated data in format xslx.

The structural response outcomes are in JSON or xml format.

The prognostic results are in JSON or xml format.

The re-usability of any existing data:

The software toolkit reused data from various sensing devices, hazard intensity data and local climate data (previously mentioned and described).

The origin of the data:

Previously reported data were used. The origin of most data is from the project analyses themselves, while some data on climate and asset typologies/configurations come from local surveys or publicly available databases.

The size of the data:

The size of the toolkit and the outcomes is of maximum 2GB.

The size of the structural response outcomes is of several MB depending on the modeled structure.

The prognostic results are of size of several GB depending on the simulation ran.

The data utility:

The software toolkit orchestrates the multitude of structural analyses under different hazard scenarios to assess the vulnerability of high-importance (geo)structures, post-process the results and incorporate them into the HRAP environment in order to be available to the DSS of HYPERION. It also produced adaptive (near-real-time) assessment of the health state of (geo)structures. The SG simulator results encoded in software libraries, termed MHVM, enabled a seamless integration of hazard simulators and vulnerability results into the HRAP model of the CH system.

2.13 System Risk Assessment Module

Table 13 System Risk Assessment Module

Data Category	Data type	Description
Holistic risk assessment framework	Dataset (Model results)	Results from the assessment of risk & resilience, including physical and socioeconomic impacts in each pilot-study area

The purpose of the data collection/generation and its relation to the objectives of the project:

The failure of CH and non-CH assets can propagate to affect other interconnected assets or networks. The applied modelling and simulation tools estimates the state of

CH (or its assets) depending on its previous state and/or the states of its interconnected assets. The state of an interconnected asset is thus a result of the nature of the hazard pressure affecting the originating asset, the characteristics of the asset under consideration (risk mitigation, means of immediate response, safety equipment) and the type of interconnection between the assets. The results from millions of hazard/vulnerability/impact realizations were collected and stored to form the database that supports what-if scenarios, as well as running near-real-time trans-event assessments.

The types and formats of data that the project generated/collected*:*

The generated data of the holistic risk assessment framework are digital netcdf, csv, and xml files.

The re-usability of any existing data:

No data external to project were reused.

The origin of the data:

Previously reported data were integrated and analyzed.

The size of the data:

The generated data of the holistic risk assessment framework are of size: 2-10 GB per each pilot study.

The data utility:

The holistic risk assessment framework pertains to how risk and impacts are propagated. The resulting data form the basis for all impact/risk/resilience assessment studies of the pilot areas.

2.14 Socioeconomic Resilience Engine

Table 14 Socioeconomic Resilience Engine

Data Category	Data type	Description
Socioeconomic model	JSON, CSV, png	Mathematical model
Resilience framework	Text, binary	Software

The purpose of the data collection/generation and its relation to the objectives of the project:

A socioeconomic model of users (residents and visitors), local economy (production and consumption of goods, services), small businesses, and local governance was generated.

The types and formats of data that the project generated/collected:

Directed surveys, expert opinion elicitation, end user input and literature data were collected to provide the necessary information for model building.

Existing resilience frameworks were also assessed in order to propose the format and potential components dealing with the basic parameters of CH-based resilience (anticipation, capacity building, absorption, coping, restoration and adaptation).

Sensor data and observer reports were also integrated to provide a best-available rapid report of CH core status at the system level.

The re-usability of any existing data:

Existing resilience frameworks found in literature were reused.

The origin of the data:

Apart from the existing resilience frameworks that were employed after literature review, all other data were generated by project activities, based on expert opinion, partner and user input, including local surveys

The size of the data:

The generated data from the Socioeconomic, Community and Organizational Resilience engines are of size ~10MB per pilot.

The data utility:

The model offers a hierarchical model of the function and of the CH core community. The overall output was a resilience framework that allows CH sites' operators and managers, cultural authorities, policy makers, etc. to assess the complete resilience of an entire CH area, its assets and users.

The overall framework is encoded on top of the structure/infrastructure resilience software, completing the integrated HRAP engine that supports the simulations and forms the basis for the development of the enterprise-level HRAP tool.

2.15 Impact Assessment & Mitigation Tool

Table 15 Impact Assessment & Mitigation Tool

Data Category	Data type	Description
Damage/Loss impact	Dataset	Loss calculation after applying consequence model to damage levels estimated in another module
Damage/Loss impact	Mathematical model	Impact of mitigation strategies on loss estimation

The purpose of the data collection/generation and its relation to the objectives of the project:

The impact estimation is among the final products of the platform; it quantifies the consequences of given perils on CH and non-CH assets in terms of direct losses, downtime, and casualties. Here we assess the effects of some scenarios considering or not the influence of a series of mitigation strategies (financial or physical); information coming from the Social Vulnerability and the Business Continuity modules were integrated.

The types and formats of data that the project generated/collected*:*

Table summarizing the different outputs from the simulations in csv or xml format.

The re-usability of any existing data:

Literature review and existing data about damage and its link with loss were considered as reference.

The origin of the data:

Data coming from Socioeconomic Resilience Engine Module, Business Continuity Module and System Risk Assessment Module were used. Some data came from surveys and expert opinion, but most were generated from the analyses run.

The size of the data:

Total of 1 GB of data.

The data utility: The products of this module were encoded in the structure/infrastructure resilience software, completing the integrated HRAP engine.

2.16 Drone-based and satellite data

An efficient and comprehensive monitoring system of historic areas including multiscale monitoring ranging from satellite to ground inspection was developed combining forces of ground, drone based and satellite sensors. The data provided by the aforementioned sensors are listed below.

Table 16 Drone-based and satellite data

Data Category	Data type	Description
Satellite images	Raster dataset	SAR Sentinel 1A and 1B images (open access data) Multispectral very high resolution (World View, QuickBird) images (not publicly available)
Multispectral (RGB) images	Raster dataset	Ground and/or aerial images acquired using a drone
Hyperspectral images	Raster dataset	Ground and/or aerial images acquired using a drone

Data Category	Data type	Description
Thermal images	Raster dataset	Ground and/or aerial images acquired using a drone

The purpose of the data collection/generation and its relation to the objectives of the project:

Satellite imagery were collected and processed in order to:

- Identify hazards with slow or gradual onset (e.g. subsidence)
- Define the risk factors that have the potential to cause harm (e.g. increase of the impervious surfaces around the historic area)
- Provide warnings for disasters with acute onsets (e.g. cyclones, storms)
- Assess their impact in the area after the event (e.g. ground deformation after earthquakes, flood monitoring) in the broader area of the cultural heritage assets.

Multi-copters equipped with multispectral camera provided data for monitoring not easily accessible surfaces and enable the 3D monitoring of the historic area. Multi/hyperspectral and thermal sensors monitored the surfaces of selected structures.

Images generated by passive (multispectral, hyperspectral and thermal cameras) and active sensors (SAR), were optimally processed and analyzed using time series analysis, photogrammetric analysis, SAR differential interferometry, and advanced ML, such as deep CNN methods.

The types and formats of data that the project generated/collected*:*

The satellite images were collected in the following formats: Sentinel product (.safe, .zip), JPEG2000 (.jp2), GeoTIFF (.tif).

The multispectral data were generated in JPEG2000 (.jp2) or GeoTIFF (.tif) format.

The hyperspectral data were generated in ENVI data product (.hdr), PCIDSK (.pix) or TIFF (.tif) format.

The thermal data were generated in TIFF (.tif) format.

The re-usability of any existing data:

Sentinel 1 and 2 are publicly available. Due to their high volume, they are kept outside the HRAP system, however they can be reused from sources inside and outside of the project. The very high-resolution satellite data hold copyrights that have to be respected. All other data were project generated and available for reuse from sources inside and outside the project.

The origin of the data:

SAR satellite imagery were collected from Copernicus EO services while very high-resolution multispectral satellite images were purchased and are subject to public

access restrictions. All ground and/or aerial data were generated within the project's lifecycle.

The size of the data:

The size of the satellite imagery was about 10Tb (depending on the time span of the time series).

The size of the multispectral camera data is 1Tb per acquisition

The size of the hyperspectral camera data is 500Gb per acquisition

The size of the thermal camera data is 100Mb per acquisition

The data utility:

The collection of ground, drone-based and satellite data generated regularly updated reference data to support the risk hotspot identification and to establish a monitoring benchmark on which methods to predict hazard event outcomes can be developed.

2.17 HRAP Platform

The design and development of HRAP included authoring tools to design the CH interdependences logic in terms of functional flow block-diagrams, a clearly defined plug-in mechanism where new algorithms/analyses could be added anywhere along the analysis workflow enabling scientists to create new end-to-end analyses or to enhance existing analyses, modelling various hazards impacts on CH, developing risk reduction strategies and implementing adaptation strategies to minimize their impact on societies.

Table 17 HRAP Platform

Data Category	Data type	Description
HRAP validation results	Dataset	Scenario results to validate HRAP and assess its capability to simulate community resilience

The purpose of the data collection/generation and its relation to the objectives of the project:

The overall outcome of the HRAP platform was to design the CH interdependences logic for end-to-end analyses resulting in risk reduction strategies and implementing adaptation strategies. HRAP was validated by running some typical scenarios whose expected outputs could be inferred from simple mathematical models or historical data, where available.

The types and formats of data that the project generated/collected:

The HRAP generated risk and resilience assessments per asset, or collection of independent or interdependent assets. The outputs are encoded in csv, xml, and netCDF files.

The re-usability of any existing data:

Available historical data were employed to act as a benchmark for the HRAP tests

The origin of the data:

Publicly available data were employed as benchmark

The size of the data:

The outputs of HRAP are of size 100MB per scenario tested

The data utility:

Data used from previously mentioned sources helped in testing and validating the platform.

2.18 Business Continuity Models

HYPERION introduces a consistent adaptation framework, supported by the HRAP platform, allowing for the definition, authoring, examination and consistent comparison of a large number of different scenarios that will allow CH to be able to better cope with CC, such as on demand planning as mitigation strategy, structural/organizational changes.

A systematic procedure to align different adaptation measures with the needs of the regional stakeholders to assure the optimal use of the systems (tools) was developed. Therefore, general conditions of the Member States, regional and local authorities, CH operators are matched with the policy targets and optimal adaptation measures.

Table 18 Business Continuity Models

Data Category	Data type	Description
Business continuity model outputs	Digital files (csv, xml)	Model outputs from business continuity simulations for each pilot area
Business continuity historical data	Digital files (csv, xml)	Historical data from past disruptions in the pilot area

The purpose of the data collection/generation and its relation to the objectives of the project:

Data that were collected were used in the development of the consistent adaptation framework and the systematic procedure to align different adaptation measures with the needs of the regional stakeholders.

The types and formats of data that the project generated/collected:

Numerous scenarios of business interruption events were simulated and stored for assessing post-event functionality of the pilot areas. Data from historical disruption events were gathered and digitized to be compared with the model outputs for reasons of validation.

The re-usability of any existing data:

Any existing data from past events were collected and stored

The origin of the data:

Outputs from business continuity model simulations under different disruption scenarios. Data from municipality, chamber of commerce, Eurostat and other publicly available sources.

The size of the data:

The total size of the files is ~50MB

The data utility:

Data were used for the analysis of a range of different methodologies to identify sector best practices that will maximise Business Continuity (BC) while minimising service disruptions to CH under different hazards pressures.

2.19 Communities' Engagement ICT Tool

The Communities' Engagement ICT tool was based on PLUGGY's Social Platform and Curatorial Tool and mostly employed crowdsourcing techniques to collect data at the pilots from local residents.

Table 19 Communities' engagement ICT tool

Data Category	Data type	Description
Images	Jpeg	Images provided by users
Video	Mp4	Video provided by users
Text	JSON	Stories composed by the users
Metadata	JSON	Time and space annotation for the data collected

The purpose of the data collection/generation and its relation to the objectives of the project:

Data were collected in a way to enable citizens to create stories about the deterioration of CH sites, geo-locate the sites and also provide specific information.

The data support the business continuity models as well as the HRAP platform and the validation of the outputs from the models.

The types and formats of data that the project generated/collected*:*

Hyperion generated (collected) crowdsourced data from an extension to PLUGGY's curatorial tool in the form of stories, images, video or text. More specifically the dataset was composed of geotagged and timestamped images, video and text from the pilot areas.

The re-usability of any existing data:

No data were reused from existing sources.

The origin of the data:

The data came from stakeholders and project partners using their smart phones and tablets during demonstrations.

The size of the data:

The size of the crowdsourced data is of size GBs. The data include all the images, video, stories and metadata.

The data utility:

The stories that were collected were presented in an innovative way to users, in order for them to experience the story and better understand the changes imposed by climate change and extreme events. The data were also used in the HRAP platform by scientists and end users for the validation of the outputs from the models.

3. FAIR data

Making research data findable, accessible, interoperable and reusable (FAIR), aims to ease knowledge discovery and innovation as well as to allow data and knowledge integration and reuse.

To this end, HYPERION has ensured to:

i) make the outcomes of the research and innovations of the project openly accessible and findable whenever possible, and

ii) disseminate and communicate the findings of the research available not only through public deliverables as defined but also, with other means as promoted or collaborative events.

The following sections provide the key considerations towards following the FAIR data policies that underpin the usage of HYPERION's data.

3.1 Making data findable, including provisions for metadata

The project strongly focuses on making sure that generated data are identifiable and easily discoverable. Consequently, it has used established standards for the generated data whenever possible.

An overview the data types that were handled within the context of the project is described in detail in section 2 of the present deliverable. Most of the data include a unique ID and a timestamp allowing for proper indexing and handling when stored.

Datasets created have followed a unique naming convention that contains: *Date, Dataset Name, Project Acronym and Version Number*. A Digital Object Identifier (DOI), a persistent identifier used to uniquely identify objects, can be created to be used a solid reference to the dataset for future use. Related keywords have been added to the metadata to enhance dataset search ability. Search keywords and clear version numbers have also been provided so as to optimize possibilities for re-use.

Data related to the end users such as pseudonym, email, country, password, GDPR-oriented consent, and farmer's identifier, have been kept internally and not published and shared externally.

Regarding documents/deliverables, clear and harmonized naming conventions have been used. All project deliverables have been named following the following nomenclature.

Project name	"HYPERION"
Space, dash, Space	" - "
Next 3-4 digits following a pattern	"DX.X" + with X.X representing deliverable number according to Description of Action (DoA).
Space	" "

Deliverable title as in DoA	E.g. “Data Management Plan”
Space	“ “
Deliverable version following a pattern (if needed)	"VX.X" with X.X representing revision number of the deliverable.

Example:

“HYPERION D1.1 Project Toolbox v1.0”, means the version 1.0 of D1.1 deliverable, entitled Project Toolbox. Deliverables that have been defined in the DoA as Public were published in the project’s website (https://www.hyperion-project.eu/) after being reviewed and approved by the EC, so that anyone may access them. Apart from the title and their short description, they include search keywords in their title page. Regarding the deliverables that are confidential and their content is restricted, the executive summary of the deliverable has been placed in the project website after the EC acceptance.

3.2 Making data openly accessible

The end users’ pseudonymous personal data have been stored in dedicated databases, hosted by relevant partners and accessible only to certain authorized users. Any data that has been shared externally to the consortium has been registered in the Registry of Research Data Repositories[3]. Specific scripts have been developed and published for accessing project’s data and offering basic statistics depending on it.

Open datasets have also been uploaded to open access repositories like Zenodo[4]. Links to the open shared datasets are available in the HYPERION Web site.

Access to data has been enabled through the use of Open APIs and interoperable formats. All legal and other restrictions have been clearly outlined in the metadata.

All project deliverables are available to authorized consortium members the project through the internal project management tool and document repository, Redmine.

The public project deliverables and the executive summaries of deliverables which are marked as non-public published in the project website and are available through ResearchGate[5].

Moreover, HYPERION has followed the Open Access practice[6] of providing online access to its scientific research articles.

[3] https://www.re3data.org/

[4] https://zenodo.org

[5] https://www.researchgate.net/

[6] https://ec.europa.eu/research/openscience/index.cfm?pg=openaccess

3.3 Making data interoperable

Interoperability aspects have been considered, aiming to enable the maximization of the value of the data provided by the project through the utilization of common systems for transmitting and/or exchanging information. All project developed tools have been based on open-source software to facilitate their adoption, expansion, and possible modifications. Interoperability of data has been enabled through the use of standardized data. Database datasets were exposed in a text format following well-known and established standards (e.g., CSV, JSON or XML).

Any script developed aiming to externally offer data, make use mainly of the HYPERION's APIs that is open and thoroughly documented to enable and encourage re-use from every third-party application without forcing any dependencies.

All security mechanisms rely on information security industry standard format and representations (e.g., for malicious traffic signatures or incident reporting), to allow for interoperability with associated mechanisms and tools widely available in the field. For example, for cybersecurity related data, such formats may include the MISP open standards[7], as well as the Snort rules format[8].

3.4 Increase data re-use (through clarifying licenses)

Appropriate licensing schemes were applied to project's data. By default, the open access data are available to the public for reuse for scientific purposes and are licensed under the provisions stipulated in the Grant Agreement.

Data shared externally were offered under Creative Commons License Attribution-Non-Commercial CC BY-NC[9], Open Data Commons[10] and ODbL[11]. The source code of the scripts developed for data sharing, were licensed under Apache v.2 license[12] and are available on a public repository along with detailed documentation of usage.

Appropriate licensing project generated data allow for re-usability by third-party applications. The infrastructure facilitates resources utilization in a standardized way as previously mentioned.

Other than the conditions imposed by this license, no other restrictions for re-usage by third parties are envisaged. No embargo period is foreseen. Data is intended to remain reusable for a period of at least 2 years after its publication while also being offered to repositories and portals such as Zenodo for long-term sustainability. Moreover, the data generated from HYPERION will be also made available for re-

[7] https://www.misp-project.org/

[8] https://www.snort.org/rules_explanation

[9] https://creativecommons.org/licenses/by-nc/4.0/legalcode

[10] https://www.opendatacommons.org/

[11] http://opendatacommons.org/licenses/odbl/

[12] https://www.apache.org/licenses/LICENSE-2.0

usability either through the relevant APIs for at least 2 years after the end of the project.

4. Allocation of resources

No resources have been specifically allocated for making project's data FAIR, and no extra-costs were involved. As equipment and the relevant maintenance costs are concerned, these have been covered by the consortium.

Regarding personnel costs, making data FAIR did not demand any extra calculable time of effort and thus, any personnel hours dedicated to this have been counted within the Person Month dedications to the respective tasks.

The Consortium has taken advantage of the fact that costs associated with open access to research data could be claimed as eligible costs of any Horizon 2020 grant.

Moreover, it should be noted that 3 person months have been allocated to Task 1.4: "Knowledge and Information Management" which concerns mostly data related matters.

More information regarding the resources for internal data and for data shared with external entities are provided in the next sections 4.1 and 4.2 respectively.

4.1 Resources for internal data

The internal data exchanged within the consortium are related to deliverables, internal reports, minutes of meetings and teleconferences, agendas, templates, presentations, administrative documents and files of any kind in general. The project has made use of Redmine, a free and open source, web-based project management and issue tracking collaborative tool in order to facilitate information exchange, storage, ordering and retrieval as needed in the project. Redmine was used as the common document repository of the project and is already configured and runs under the responsibility of ICCS, the project coordinator. All consortium members are actively using this interactive knowledge-sharing platform for information exchange, discussions, news and calendar. This collaborative tool and relevant storage structure are consortium confidential with restricted access.

Since Redmine is free of cost, the only resources consumed concern only the setting and deployment of the collaborative platform. In addition, resources relevant to administrative and maintenance issues with respect to Redmine are covered by the project coordinator, ICCS, who also has the rights for managing users, groups and assigning roles and permissions. To this end, ICCS has already provided credentials to all partners, upon their request for an account, in order for them to be able to login and use it. Further to this, for the needs of continuously upgrading the collaborative tool and back-up its database in order to address unforeseen events (hard disks failures, web attacks, etc.) resources have already been allocated by the consortium.

4.2 Resources for data to be shared with external entities

Any need of personnel hours' allocation for data stewardship is already part of the allocated person months per Work Package, as Work Package leaders are the main responsible for such activities, with the support of all other partners involved in the certain Work Package and in particular with the overall guidance and support of the project's consortium that has budgeted for dissemination costs. HYPERION followed

the Open Access practice[13] of providing online access to scientific information that is free of charge to the end-user and reusable.

This covered both peer-reviewed scientific research articles (published in scholarly journals) and research data (data underlying publications, curated data and/or raw data).

In the cases where publication in a scientific journal was selected as a means of dissemination of the project activities, one of the two channels of open access was chosen (evaluated per case), i.e., either:

- Self-archiving / 'green' open access – the author, or a representative, archives (deposits) the published article or the final peer-reviewed manuscript in an online (either institutional, or centralized such as Zenodo) repository before, at the same time as, or after publication.
- Open access publishing / 'gold' open access - an article is immediately published in open access mode. In this model, the payment of publication costs is shifted away from subscribing readers. The most common business model is based on one-off payments by authors/partners.

HYPERION has also used free-of-charge, open data repository services, such as Zenodo. Through such repositories, metadata and digital object identifiers are assigned to the project's datasets in order for them to be located via search after the end of the project. The datasets in Zenodo are preserved in line with the European Commission Data Deposit Policy. The data is maintained indefinitely (minimum 5 years) ensuring no costs for archiving.

[13] https://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/open-access-data-management/open-access_en.htm

5. Data security

All data were collected, stored, secured, transmitted, preserved and destroyed in accordance with state-of-the-art security measures and in full compliance with relevant EU legislation, following the requirements of the Protection of Personal Data (POPD) defined by the EC and national regulations. A precise presentation of the POPD requirements in the context of HYPERION is included on deliverable "D11.2 POPD - Requirement No. 2". In summary, this data has been stored on paper and/or electronic files secured by state-of-the-art physical and digital protection measures:

- archives containing paper directories were locked
- digital information was stored on servers
- hard disks and cloud repositories were accessible only to approved staff (within the applicable DIONE partners) via user and password schema identification

Data were acquired in conformity of security best practices through protected connections and dedicated state-of-the-art IT infrastructures (LANs, protected servers, firewall).

To guarantee security and reliability of the communication, the most advanced web standards were implemented:

- HTTPS transport level security was applied.
- Authentication and authorization were required both for user interactions with the system and for machine-to-machine transactions.
- Access and interactions were controlled and audited.

All the documents, deliverables and reports generated in the context of the project are deposited in Redmine. The online access to https://redmine.iccs.gr/ is protected using a TERENA (https://www.terena.org) digital certificate. The server hosting the Redmine installation is located in ICCS premises in Athens, Greece in a safe rack in ICCS's server space. Server databases were backed up on a regular basis. The server is designed with numerous redundancies, network and disk wise, in order to ensure its continuous operation and network access.

6. Ethical aspects

The project's consortium adheres to ethical rules and complies with European legislation on data protection (Regulation (EU) 2016/679 General Data Protection Regulation[14]), the national legislation applicable in countries where the research was carried out, together with recommendations and codes of conduct relevant to research activities.

No specific ethical issues have been identified, related to the activities of the project that are not already addressed in the Grant Agreement. Ethical procedures have been specified within the project, throughout the two dedicated ethics deliverables (and disseminated between consortium members). These procedures have been followed during project activities. The activities related to the user requirements elicitation and the implementation and assessment of the pilot demonstrations were designed and implemented taking into consideration the dignity of the participants as well as other fundamental rights and freedoms (freedom, non- discrimination, etc.) and core values have been respected (proportionality, minimization, confidentiality) and conformed with The General Data Protection Regulation (EU) 2016/679 ("GDPR"). As national and EU laws and recommendations on privacy and data protection issues play an important role, the design of activities within the project involved all partners' engagement in designing, deploying and testing of HYPERION's solutions, which might raise concerns on data sharing and protection issues. The project assessed the execution of the different ethical requirements in accordance with applicable national and European legislation. Ethical standards and guidelines have been rigorously applied, irrespective of the country in which the research was carried out. Obtaining, if needed, the required national authorization and adherence was the responsibility of the partners in each of the EU states.

The project adheres to the commitment of holding any data in secure conditions, and has made every effort to safeguard against accidental or unlawful destruction, loss, alteration, unauthorized disclosure of, or access to, personal data.

Additionally:

- The Consortium has established a secure storage and transfer system/channel
- Research and other data were stored in a secure and accessible form
- The Consortium specified procedures for keeping data accessible in terms of migration (conversion of data files from older formats to newer ones) and refreshing (transfer of data from one storage tool to another), whenever needed
- The Consortium defined procedures for backup and recovery of data
- Access rights and access conditions were defined taking into consideration the task allocation and the category/type of data

[14] https://ec.europa.eu/info/law/law-topic/data-protection_en

- When defining roles and permissions, special attention was paid to the possibility to track any interaction that entails access, modification and deletion of personal data

Each partner was responsible for informing their own staff involved in the project about the need to comply with the legal principles and provisions with regard to data processing. The Consortium considered all necessary and appropriate measures to mitigate risks, which include:

- The handing over of any data
- The collection of data and its secure storage and transfer
- The confidentiality declaration to be signed by staff

6.1 Informed consent

No Consent forms were used, as we did not use personal data. Any discussions with stakeholders were conducted anonymously, without storing any information, and they were only used to inform the design of HRAP.

7. Conclusions

The primary goal of the present deliverable is to demonstrate the Data Management Plan for HYPERION.

It provides a general overview of the kind of data that were produced, reused, collected and processed within the project's context.

Issues such as data types generated and their purpose and relation to the project objectives, as well as how the consortium has made sure that it complies with FAIR data principles were discussed. Moreover, data security and generic ethical issues were also mentioned, along the same guidelines.

The Data Management Plan emphasizes also on the appropriate collection – and publication of data and metadata, storing all the necessary information for the optimal use and reuse of those datasets in compliance with all regulations.

8. ANNEX - Public Deliverables

Deliverable number	Deliverable title	WP	Responsible	Nature	Dissemination	Date
D1.3	Data Management Plan (v1)	WP1	ICCS	ORDP: Open Research Data Pilot	Public	M12
D1.4	Societal impact report	WP1	ICCS	Report	Public	M48
D1.5	Data Management Plan (v2)	WP1	ICCS	ORDP: Open Research Data Pilot	Public	M48
D2.1	End-user needs and practices report	WP2	RG	Report	Public	M4
D2.2	Definition of System Requirements, Use Cases and KPIs specification	WP2	ICCS	Report	Public	M10
D2.4	Geographic data and services inventory	WP2	AUTH	Report	Public	M14
D3.1	Report on available climate data and scenario selection	WP3	FMI	Report	Public	M10
D3.2	High-resolution surface parameter maps	WP3	AUTH	Other	Public	M12
D3.3	Report on the dynamical downscaling of climate & atmospheric impacts	WP3	FMI	Report	Public	M24
D3.5	Report on Dynamic Data Assimilation methodology	WP3	AUTH	Report	Public	M28
D3.6	Report on site-specific risk parameters and stressor indicators	WP3	AUTH	Report	Public	M28
D4.1	Classification of building materials, physical-mechanical	WP4	IUAV	Report	Public	M24

	characterization and determination of decay forms and products					
D4.2	Assessment of hygrothermal and textural features controlling building materials decay, and required as input in the hydrothermal simulations	WP4	UNIPD	Report	Public	M24
D4.3	Analysis of microclimatic time series and assessment of systematic deviation from local time series required as input in the hygrothermal simulations	WP4	UNIPD	Report	Public	M27
D4.4	Deterioration of the building materials under extreme events required in the CH vulnerability assessment	WP4	UNIPD	Report	Public	M24
D4.5	Material specific dose response functions and validation required in the CH vulnerability assessment	WP4	UNIPD	Report	Public	M27
D5.1	Advanced and Reliable Models for Natural and Man-Made Hazards	WP5	AUTH	Demonstrator	Public	M24
D5.3	MHVM for CH and non-CH elements	WP5	UGR	Other	Public	M24
D5.4	HRAP software and documentation	WP5	NTUA	Other	Public	M32
D5.5	HYPERION resilience framework	WP5	RG	Report	Public	M32
D6.1	Conceptual framework for remote sensing-based CH monitoring	WP6	NTUA	Report	Public	M10
D6.3	Methodology for routine CH monitoring with multi-type remote sensing	WP6	NTUA	Report	Public	M24
D6.4	Novel methodologies for damage detection and assessment along the CH assets and the surrounding disaster affected area	WP6	NTUA	Other	Public	M24

D6.5	Dynamic link to hazard and resilience assessment	WP6	UGR	Report	Public	M30
D7.3	BC Models and Adaptation Strategies assessment report	WP7	RG	Report	Public	M30
D7.4	Standard Response Procedures Document	WP7	RG	Report	Public	M30
D7.7	Communities' Engagement ICT Tool	WP7	ICCS	Other	Public	M32
D8.6	Reports on pilot testing	WP8	CyRIC	Report	Public	M48
D8.7	Trials assessment and recommendations	WP8	RG	Report	Public	M48
D9.1	Corporate identity and general templates for dissemination material	WP9	IEMC	Other	Public	M3
D9.2	Project Website	WP9	IEMC	Websites, patents filling, etc.	Public	M5
D9.3	Dissemination and Communication Plan (v1)	WP9	IEMC	Other	Public	M6
D9.4	Information Packs for referenced networked communication amplifiers (v1)	WP9	IEMC	Other	Public	M12
D9.5	Annual Magazine issued (v1)	WP9	NTUA	Other	Public	M12
D9.6	Report on Standards and Liaison Activities with relevant organisations	WP9	RG	Report	Public	M48
D9.7	Dissemination and Communication Plan (v2)	WP9	IEMC	Other	Public	M48
D9.8	Information Packs for referenced networked communication amplifiers (v2)	WP9	IEMC	Other	Public	M48
D9.9	Annual Magazine issued (v2)	WP9	NTUA	Other	Public	M48
D10.2	Market Analysis	WP10	RG	Report	Public	M48
D10.3	Workshop Documentation	WP10	IEMC	Report	Public	M48

D10.4	HYPERION Roadmap and Project Handbook	WP10	ICCS	Report	Public	M48