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Search & Rescue

Emerging technologies for the Early location of Entrapped victims under Collapsed Structures & Advanced Wearables for risk assessment and First Responders Safety in SAR operations

D6.6 Report on legacy systems and their connection to the S&R related technical characteristics

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Executive Summary

This current document is produced in the scope of WP6's D6.6 "Report on legacy systems and their connection to the S&R related technical characteristics". The aim of this deliverable is to collect information, properties, and characteristics related to the Legacy Systems, as well as to find databases and retrieve Legacy Data. The collection of this information was implemented by sending questionnaires to international and global first responder organisations as well as at the end-users of the S&R. Furthermore, research regarding the existing EU Legacy Systems for crisis management has been implemented and information about CECIS, GDACS, and PAGER platforms has been collected.

As a part of data collection PAGER'S public API has been utilised to retrieve and extract historical data. The data collected concern earthquake incidents and their magnitude, the date, the consequences (tsunami), and the location where they took place.

More specifically, the first section of the current document presents general information about Legacy Systems as well as their usage in crisis management. The second part analyzes the overall approach of the procedure and develops an extensive analysis of the aforementioned EU Legacy System.

The fourth section describes the process of collection, filtering, and integration of legacy data that have been collected from the PAGER API and their interaction with other components of the platform. It describes from a technical perspective the progressive procedure of legacy data via PAGER public API, the storage in the Data Lake Ecosystem, and hereinafter the transformation to Python objects according to the object-oriented model. In conclusion, after the mapping according to the SnR data model, the rest of the components can fetch and use the data appropriately through the WebHDFS tool.

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List of Abbreviations

AEPD	Agencia Española de Protección de Datos
API	Application programming interface
CECIS	Common Emergency Communication and Information System
D	Deliverable
DSS	Decision Support System
EU	European Union
ECHO	European Community Humanitarian Aid Office
GDACS	Global Disaster Alert and Coordination System
JSON	JavaScript Object Notation
LTE	Long Term Evolution
MIC	Monitoring and Information Centre
NFPA	National Fire Protection Association
NIFRS	Northern Ireland Fire & Rescue Service
NHTSA	National Highway Traffic Safety Administration
PAGER	Prompt Assessment of Global Earthquakes for Response
S&R	Search & Rescue
SFRS	Scottish Fire and Rescue Service
SOT	Strategic Operational and Tactical
SMTP	Simple Mail Transfer Protocol

UC	Use Case
USB	Universal Serial Bus

1. Introduction

1.1 Objectives

The aim of D6.6 is to collect information, properties, and characteristics related to the Legacy Systems, as well as to find databases and retrieve Legacy Data.

A first attempt has been made concerning the collection of information and specifications about Legacy Systems through questionnaires provided by National or International organisations, end-users, and partners of the S&R project. The focus of the deliverable is to adapt legacy systems to the final platform and/or to find Legacy Systems databases to extract Legacy Data and use them in several DSS components. Regarding the Legacy data, research for the existing EU Legacy platforms for crisis management has already been carried out, from which the study focused mainly on the PAGER platform as well as on extracting data from their database.

As a next step, the "D6.9 Report on legacy systems and their connection to the S&R related technical characteristics, V2" will further include updated information as well as any additional findings from legacy systems research.

1.2 Scope of using Legacy System in the S&R project

The scope of D6.6 "Report on legacy systems and their connection to the S&R related technical characteristics", is the use of legacy data. The most essential legacy systems will be integrated with the S&R components, and through specific procedures, historical data will be extracted. To find the appropriate old systems, a necessary precondition is the analysis and presentation of the general description of the legacy systems as well as their use in crisis management.

1.3 Relationship with other Deliverables

The current deliverable is the preliminary document addressing legacy systems and their connection to the S&R. The document provides inputs to other S&R components, therefore is linked to the following deliverables:

- D3.7 Requirements to knowledge management and SA Model V2
- D4.8 Data Aggregation V2
- D4.9 Design of SOT DSS components V2
- D4.11 Development of SOT DSS components V2
- D6.3 Presentation and analysis of the designed S&R interoperability framework
- D6.4 S&R lessons learnt mechanism
- D6.5 Establishment of technical components and legacy systems taxonomy
- D7.3 Component interface specifications for interoperability within S&R
- D7.4 Adapted S&R components and services
- D7.6 Integrated S&R platform V2
- D7.12 Architecture and Design Specifications of S&R platform V2

2. Legacy Systems & Crisis Management

2.1 A General description of Legacy Systems

A legacy system is obsolete computing software or hardware that is still in use, and although novel technology or more efficient methods are now available, typically it still functions for the users' needs. These systems are often incompatible with contemporary software, no longer offer updates, or lack opportunities for extendibility. Such a system may contain procedures or terminology which are no longer relevant in the current context and may hinder or confuse understanding of the methods or technologies used.

The word legacy as a term was first used for computers in the 1970 and over the next decade, it distinguished between existing and newly released systems. Although the term may indicate that such a system is out of date, it is considered that it can continue to be used for a variety of reasons. Furthermore, the current use of legacy systems in the same cases may be affected by several reasons, for instance, economic reasons such as return on investment challenges, or a variety of other reasons other than functionality [12]. The US Government Accountability Office (GAO) identified ten of the most fundamental federal legacy systems in need of modernisation which are presenting in the following table, some of which date back to the 1970s. Many of them rely on obsolete programming languages like COBOL, have support problems, and operate with security weaknesses [13].

Table 2.1 The most critical federal Legacy Systems

Agency	Age of system	Age of oldest hardware	System criticality	Security risk
Department of Defense	14	3	Moderately High	Moderate
Department of Education	46	3	High	High
Department of Health and Human Services	50	Unknown	High	High
Department of Homeland Security	8-11	11	High	High
Department of the Interior	18	18	High	Moderate-High
Department of the Treasury	51	4	High	Moderate-low
Department of Transportation	35	7	High	Moderate-High
Office of Personnel Management	34	14	High	Moderate-low

Small Business Administration	17	10	High	Moderate-High
Social Security Administration	45	5	High	Moderate

A legacy hardware device, due to its limited memory and processing power, executes older applications and operating systems. For example, mainframe computers as massive and powerful systems, are still used by large organisations such as financial institutes, insurance companies, universities, etc. and due to the high cost of migration, many of them continue to keep such legacy infrastructure. The older individual computers use older Central Processing Units that reduce the amount of memory, USB ports, or processing systems such as Pentium II.

In general, the life expectancy of the software is longer than that of the hardware. Legacy software has been for a long time by fulfilling fundamental business needs but over time the hardware is getting more complicated and difficult to be kept maintained. Some examples of legacy software are Microsoft Windows 7 which became a legacy system in January 2020 after Microsoft stopped offering the necessary security updates. However, over 100 million machines continue to run this operating system. Moreover, as has already been mentioned COBOL is legacy programming language and is still used 55 years after its development by government organisations.

Regarding the types of legacy systems, there are several categories defined by their programming, hardware, etc. END OF LIFE (EOL) is a category of legacy systems whose useful stage is past. An EOL example would be Microsoft which dropped the support for Windows 7. Furthermore, another type of legacy system is those that can no longer be updated and extended any further. This means that a new product should be bought. There are also those which have been patched so heavily that they have become sensitive to cybersecurity. During the years, the software is becoming quite vulnerable and especially when support stops being provided [16].

Nevertheless, there are many explanations why an organisation may opt to preserve its existing legacy system. First, although these legacy systems have defects and difficulties, they are still functional. Furthermore, other crucial reasons are that companies have concerns regarding the new resources required to retrain employees on a new system or it is considered that its platform is too complex to be replaced.

2.2 Legacy systems in Crisis Management

Emergency incidents are caused by natural factors or by human intent or a combination of both. Natural disasters include earthquakes, wildfires, storms, volcanic eruptions, floods, etc. Disasters caused by humans include local conflict, war, terrorist attacks, chemical spills, and explosions, or accidents related to airplanes, trains, cars, and vessels. China witnessed SARS (Severe Acute Respiratory Syndromes, 2003), the Songhua River Benzene Incident (2006), avian flu (2006), icy rain and snow in the southern provinces (January 2008), the Lhasa riots (March 2008), the Great Sichuan earthquake (May 2008), hand-foot-and-mouth disease (March 2009), swine flu (April 2009), and the Urumqi riot (July 2009) [15]. Thus, the Chinese government has established specific procedures to limit the intensity of the consequences and prevent further harmful situations. This type of management system is based on the

concept of the legacy system similar to those in developed states, such as the Federal Emergency Management Agency (USA-FEMA), Disaster Preparedness Division (Cabinet Office of Japan), Directorate of Protection and Defence Security (France), etc. [15]. So, it is certain that the conflict between the natural system and the technical systems designed by human beings, the methodologies and procedures based on the legacy system could be able to manage all the urgent events.

Crisis Management is a challenge. Hazards change, and climate change is well-known examples. After several studies conducted by organisations into current natural disasters, there has been a realisation that emergency services could be better to overcome existing obstacles to collaboration and extend current systems in order to respond effectively to an incident. There is also an inclination towards the integration of emergency services, either by integrating within a single service to cover a larger geographical area or by integrating different services to improve joint operational capacity. In both approaches, first responders confront significant challenges.

Keeping up with the new challenges such as the establishment of settlements in new areas or societal evolution affect people's ability to manage crises and interact to generate new challenges for Crisis Management. As societies become more complex, both the increasing scope and unpredictability of potential crises, and the rapid dynamics of the incidents to be managed demand crisis management of an ever-higher level of complexity.

There are several examples of legacy technologies that involve effective emergency and natural disaster management. The agencies for emergency incidents consist of fire departments, rescue groups, emergency medical services (EMS), and general groups known as emergency first responders (EFR). The EFR's ability to communicate and seamlessly share serious information directly affects its ability to save lives.

Technologies responsible for communication such as legacy radio systems, commercial networks (2G/3G), and broadband (LTE/WiFi) are largely used by public safety organisations [14]. LTE emerged as a widespread wireless communication technology that has the potential to transform the capabilities of public safety technologies. Land Mobile Radio System (LMRS) is also a legacy technology used for critical voice communications with limited use for data applications. It's a wireless communication system for terrestrial users covered with portables and mobiles, such as two-way digital radios or walkie-talkies (Figure 1).

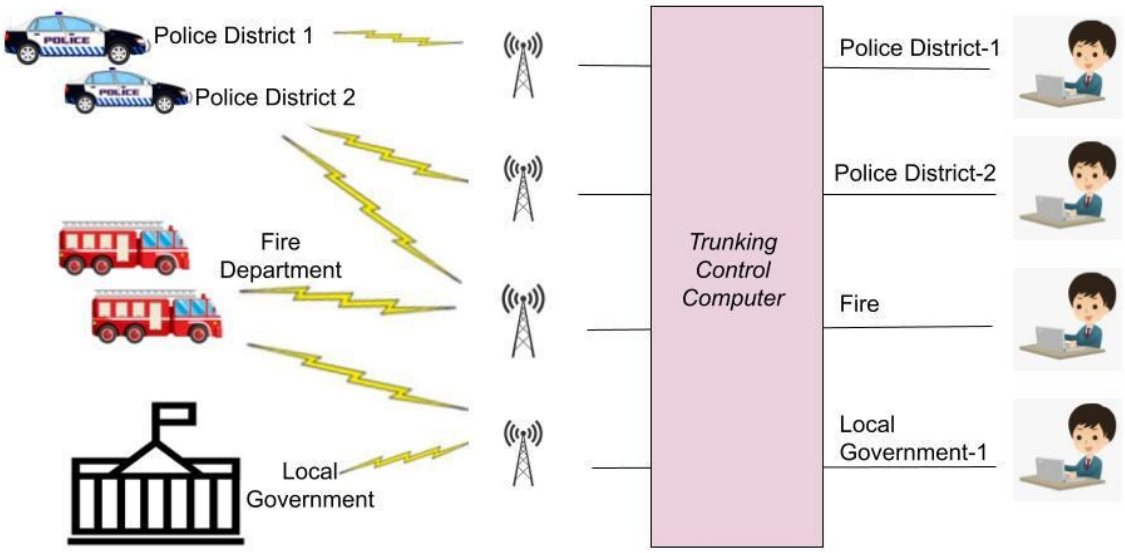

Figure 2.1 An example for an LMRS network

It is well known that the complexity of an emergency often requires adequate resources. Nevertheless, several legacy systems can deal with a crisis, let alone a natural disaster along of course, with new technologies. Therefore, it can be concluded that Legacy Systems can reinforce the goal of the S&R.

2.3 Legacy systems disadvantages

Legacy systems, during the last two decades, are one of the most widely used business applications implemented in the organisation. The legacy applications were constructed based on technologies such as mainframes, SAP, etc., which provide fundamental services to an organisation. Lately, due to the noticeable advances in technology, it is necessary to replace legacy systems with new ones for the development of business applications. However, there will be some operational perils that may cause damages to the entire system, if it is not managed suitably. Therefore, these systems find it difficult to upgrade with modern technology.

Legacy systems are hardware and/or software systems currently performing useful tasks of reengineering or upgrading for various reasons. Most essential are:

- The age of the system
- Its specifications
- Needs of the system e.g., greater functionality
- Improved processing
- Enhanced form
- Effortless conservation

Legacy information systems are the pillar of the information flow within an organisation and the vehicle to manage business information easily. A lot software/hardware systems live significantly longer than their developers had expected. Companies spend a large amount of money on these and to get a return on that investment, the software must be functioning for several years. The lifetime of the systems is very variable, but many large systems remain in use for more than ten years. There are several situations where companies and organisations still rely on such systems that are more than 20 years

old. The legacy information systems are currently posing ample and essential issues to a host organisation [1]. In particular:

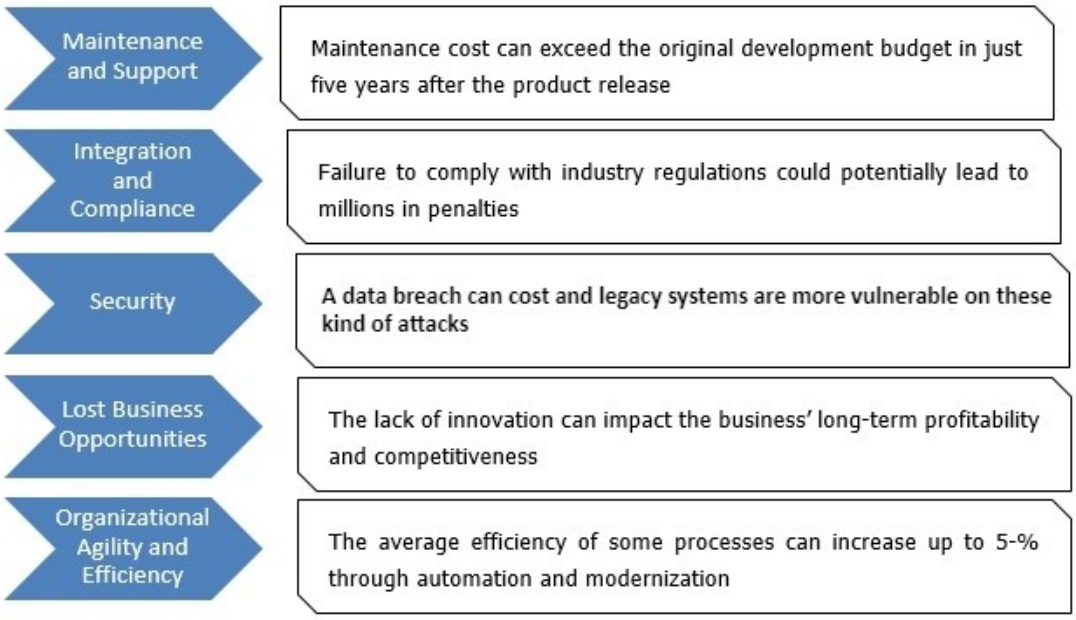

Figure 2.2 Consequences of Using Legacy Software

Indeed, organisations are continuously developed, altering business focus to remain competitive. Fundamental changes in business practice inevitably require major changes to the supporting information systems. However, legacy systems are characterised as being very weak concerning change and small modifications or enhancements can lead to unexpected system failures. So, based on the above negative consequences of using a legacy system, there is a need to have an efficient plan to restructure the system into a contemporary one.

Numerous methods have been proposed to transform these legacy systems, which are categorised into redevelopment, wrapping, and migration. Consequently, to convert these legacy systems, there is a need to evaluate and analyse the existing legacy software systems. Thus, to understand the functionality of the current legacy technologies to handle the business needs for a specific field, it is required to automate the legacy analysis process in order to the time and cost efforts of the organisation.

Another essential feature of legacy systems is a close binding of the applications to the data [2]. While this condition may have been caused by the file-based data management technology in use at the time of their development, many systems in use today retain this relationship simply because of the large volumes of corporate data that are still maintained within file-based systems.

According to Bianchi, Caivano [2], there are two main classes of data within a legacy system: primary and residual. Primary data is any that is needed to perform the application's business function. It exists in two forms: conceptual, the data that is used to describe the concepts of the application domain, and structure that is needed to organise and support the program's data structure. Residual data is not required for the business but is the result of the implementation and execution details of the system's functions. Categories of residual data are control, regulating behavior, and redundant (either structurally, semantically, or computationally), which may be introduced during the original design but is more often a consequence of routine maintenance. Today, many current business legacy systems consist of several different programs which share common data. These systems have been implemented using flat or structured files, rather than a database management system. Data is often duplicated because the same information may be represented in different ways in different files. The figure below describes the situation:

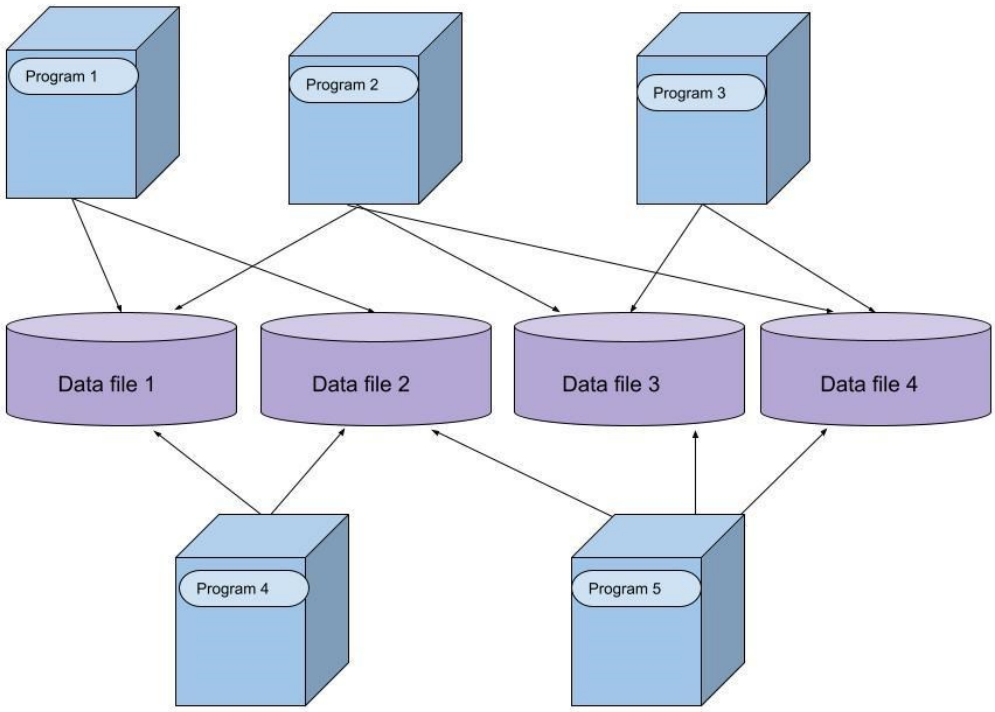

Figure 2.3 Structure of data in a Legacy System

Legacy systems are fundamental for organisations. Their influence, though, is to some extent harmful. Generally, it is not advisable to use legacy systems as these are no longer supported by their respective retailers. Essentially, they no longer accept serious patches, especially for cybersecurity. If they get attacked, retrieving data or even the simple turn of restarting them could be impossible.

3. Research on Legacy systems used in Crisis Management

3.1 Approach

The current deliverable aims to collect and evaluate the characteristics, properties, global objectives, needs, and legacy crisis management system status. For this reason, two different questionnaires were created and sent to several national and international organisations and End-Users of the S&R project. These information forms contained specific questions aimed at obtaining information and features about the organisations' legacy systems.

More specifically, the first questions referred to general information such as the name of the legacy system, a short analysis of this, and the name of its organisation. The next questions focused mainly on legacy systems characteristics if it is hardware or software, the age of the system, and the age of the oldest hardware. Subsequently, using a scale from 1 (low) to 5 (high) questions regarding the security risk, the system criticality, the importance of systems modernisation, the importance of legacy data recovery and re-engineering, the importance of system redesign, and the importance of system re-code to create a general view regarding the state of the legacy system.

The next session of the questionnaire was about the database of the legacy system. One of the most fundamental questions was regarding the accessibility of the database. Open access in a legacy system database could be linked in the S&R project and historical data extracted.

Another key piece of information is data. So, the questions concerned the type of data stored (medical record, earthquake casualties, etc.), the language in which it is stored, its format (CSV, XML, JSON, etc.), and the place where the data is stored (Excel, database, etc.). In the last part of the questionnaire, participants had to answer whether access to its database should be provided and how it could be achieved by highlighting an email address or other means of communication. In the following subchapters, the participants of the questionnaires are analyzed as well as their results are presented.

3.2 International Organisations

Based on the scope of this current deliverable, a first questionnaire[1] was sent to several First Responders organisations, and information about their Legacy Systems was to be collected. From the following ten countries, we selected specific organisations to respond to the questions. More specifically:

- **Australia**: Tasmania Police, Northern Territory Police, South Australia Police, VS Emergency Service, CFA, Department of Community Safety, Department of Fire and Emergency Services, Fire & Rescue NSW, QFE Services, State Fire Commission, Ambulance Victoria Group, Australian Capital Territory, SA Ambulance Service,
- **Canada**: Canadian Centre for Justice Statistics, Ambulance New Brunswick group, Ambulance New Brunswick group, BC Ambulance Service, EHS, Health PEI, Ministry of Health, Health and Community Services
- **Finland**: Finnish Rescue Services
- **France:** Police Association

[1] https://forms.gle/FyPxKqLSm7LB36fC6

- **Germany**: European Public Service Union, Arbeiter-Samariter-Bund, Falck Assistance team, German Red Cross.
- **Netherlands**: Ambulancezorg Nederland
- **New Zealand**: St John New Zealand, New Zealand Police
- **Sweden**: Falck
- **United Kingdom**: SFRS, NIFRS
- **United States:** NHTSA, NFPA

Unfortunately, there was no positive answer to continue with this approach, thus the research was focused mainly on internal data from partners/End-Users and from the EU Legacy platforms which are still in use. For that reason, the questionnaires were also sent to the UCs' leaders of the S&R project. More specifically SUMMA 112 and EPAYPS, answered the questions and shared information about their legacy systems.

3.3 S&R End-Users

Based on the non-response of the international organisations to the specific questionnaires, a second questionnaire[2] was sent to End-Users of the S&R project and the following answers were received.

- **SUMMA 112**

Table 3.1 SUMMA's responses from the questionnaire

Legacy System Name	TECHNOLOGY PLATFORM FOR THE MEDICAL EMERGENCY SERVICE OF MADRID SUMMA 112
Legacy System Analysis	Registered at the AEPD as "Comprehensive treatment of emergencies and medical transport
Hardware or Software?	Software
Age of System	It has been in use since August 2007
Age of oldest hardware	It has been in use since August 2007
Security Risk	5 (scale 1(low) to 5 (high))
System Criticality	5 (scale 1(low) to 5 (high))
The importance of systems modernisation	4 (scale 1(low) to 5 (high))
What kind of data is stored in your legacy systems?	Includes telephone systems, call recording systems, medical records, and affiliation data of calling patients.

[2] https://forms.gle/PVfvpKEYWGUCKYQh6

From which database the data are retrieved?	-
Importance of legacy data recovery and re-engineering	5 (scale 1(low) to 5 (high))
Importance of system redesign	5 (scale 1(low) to 5 (high))
Importance of system re-code	5 (scale 1(low) to 5 (high))

- **EPAYPS**

Table 3.2 EPAYPS' responses from the questionnaire

Legacy System Name	Analog VHF terminals
Legacy System Analysis	-
Hardware or Software?	Hardware
Age of System	The system is 30 years old
Age of oldest hardware	5 years
Security Risk	5 (scale 1(low) to 5 (high))
System Criticality	4 (scale 1(low) to 5 (high))
The importance of systems modernisation	5 (scale 1(low) to 5 (high))
Importance of legacy data recovery and re-engineering	1 (scale 1(low) to 5 (high))
Importance of system re-design	5 (scale 1(low) to 5 (high))
Importance of system re-code	1 (scale 1(low) to 5 (high))
Is your Database open access?	No

The above information provides some specific information and features from the Legacy System of some S&R End-Users. However, there is the necessary prerequisite to have open access to these features, in order to adapt their data into the SnR operation. That means, there is the need of a communication interface from them, in order to retrieve data to the Data Lake Ecosystem and as next step, spread this information to the rest of the components who need it.

As the next procedure, it was the research of the existing EU Legacy Platforms as far as their legacy attitude which are analyzed in the next section.

3.4 Existing EU Legacy Systems of Civil Protection

3.4.1 Common Emergency Communication and Information System (CECIS)

The major role of the Community Mechanism for Civil Protection is to help the collaboration in civil protection assistance interventions in the event of major crises which may require urgent response actions. CECIS is a web-based alert and notification application that provides an integrated platform to send and receive not only alerts and notifications but also details of assistance required in order to aid and to view the growth of the continuing emergency as they happen in an online logbook [3].

The tool is proposed to provide better protection, mainly of people but also of the environment and property, including cultural heritage, in the event of foremost crises, i. e. natural, technological, or ecological accidents happening inside or outside the Community, including accidental marine pollution. The platform, in order to attain its goal of emergency management, CECIS fundamentally offers a communication service for email like message exchange. Detailed functionality is offered for corresponding requests with offers, and for managing resources.

The end-users of the Common Emergency Communication and Information System (CECIS) is the Monitoring and Information Centre (MIC) already established within the Civil Protection and Environmental Accidents Unit of the Directorate-General for Environment at the EC (ENV/A/5) and the adequate authorities that the Member States will designate based on Article 3(e) of the Council Decision of 23 October 2001 establishing a Community mechanism to facilitate reinforced co-operation in civil protection assistance interventions[3]. Both, through the CECIS they will be able to exchange information reliably.

From the technical side, the solution is based on permanent accesses of the capable specialists and communication points to TESTA II, a data communication network service operated by the European Commission, through the corresponding national networks. Based on a survey which was conducted among the Member States, a central database accessible through a common web browser was decided as the best solution for the communication system. The basic functions are:

- Communication: includes not only notifications and alerts for an emergency situation, with warning messages but also a follow-up of requests for assistance in case of a crisis.
- Data content: includes the database of messages exchanged. Moreover includes databases of National Contact Point. competent authorities, assessment, coordination, intervention experts, and medical resources

The figure below demonstrates the relation between the different components [11].

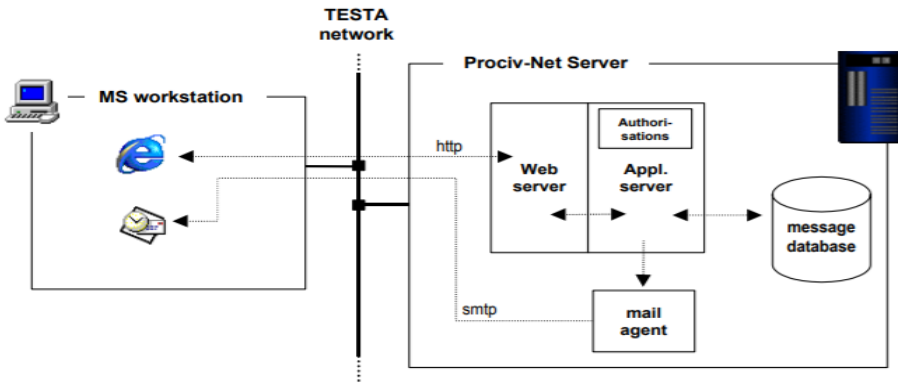

Figure 3.1 Schematic summary of the CECIS mechanisms

Intending to send messages, there are categories in which users are clustered. The use of categories is to make the choice of receivers of messages simpler. In CECIS the messages can only be sent to users that are defined in the system, and can only be received from known users. Though a user's data possibly will contain (SMTP) e-mail addresses, these are used along with CECIS-based message exchange only. So far there is no possibility to contain stable email addresses in the list of recipients, and all messages that can be referred to in CECIS have by definition been produced in CECIS.

A user will receive a message informing about an incident. For a certain user to receive a warning about a certain event, the user must be organised to receive notifications about it. This is being presented in the notification matrix and handled by the users with the "MIC administrator" and "Member state administrator" profiles. The notification matrix is centralised and system-wide. As it seems in the following picture, in the last version of CECIS, the matrix in the system includes the types of notification per type of profile and per country.

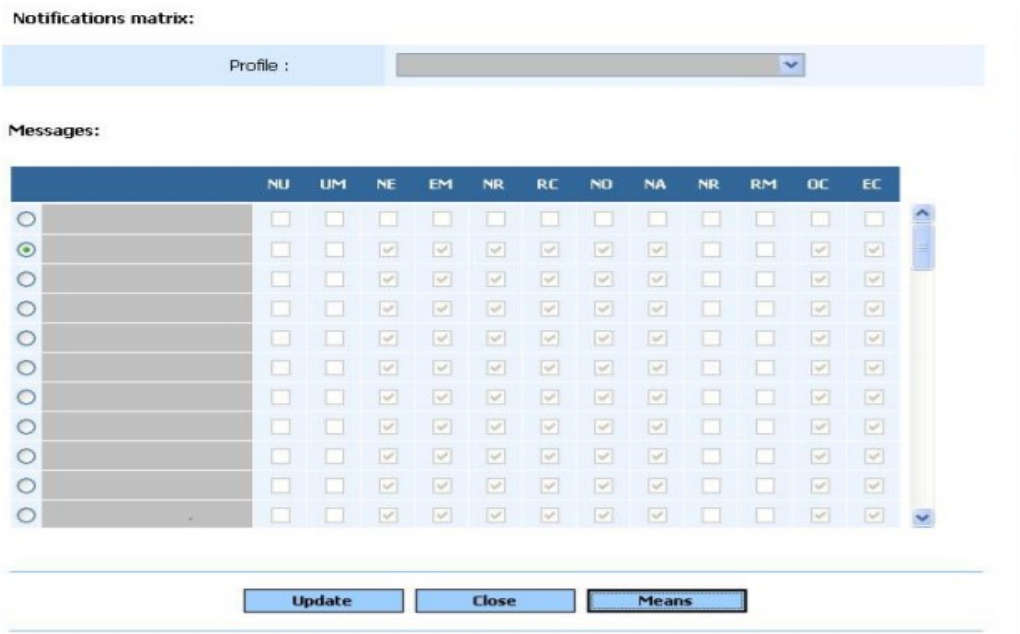

Figure 3.2 Notification matrix

From a technical approach, the platform is resilient ensuring integrity of the data and high availability. Systems architecture at the server side plays the main role for the high availability, if only the application

server part has to be enabled for load balancing, as all servers will be deployed in a redundant setup. Clustering at the database level is transparent to the application server.

Furthermore, the design of the platform focuses on flexibility. It's possible to extend the application in the future, without requiring replacing or renovating the general system [3]. The software of the application follows the 3-tier model, with separate presentation, application and data layers. Any of the three tiers or layers can be upgraded or replaced independently as requirements or technology change. Furthermore, regarding the accessibility the "Monitoring and Information Centre" should be able to access the platform remotely, for instance through a Virtual Private Network (VPN) over the internet.

3.4.2 Global Disaster Alert and Coordination System (GDACS)

GDACS was established in 2004 by the JRC as a system to monitor unexpected on-set disasters in near real-time to support the emergency processes of the European Community Humanitarian Aid Office (ECHO). The platform combines information management systems intending to alert in case of major sudden-onset disasters and to facilitate the coordination of international response during the disaster. There is a restriction and only through registration disaster managers in donor countries, response organisations, and disaster-prone countries can enter GDACS.

Furthermore, GDACS will be accessible to the research community that evaluates disaster impact and response activities in order to enhance international disaster management concepts. Disaster-prone countries should be the primary stakeholders of GDACS [6]. As a result, dedicated focal points are established and trained in these countries to ensure that in case of major disasters, the relevant information is reliably and timely provided to the international community according to defined GDACS standards and methodology.

The platform offers global multi-hazard disaster monitoring and alerting for earthquakes, tsunamis, floods, volcanoes, and tropical cyclones. About GDACS alerts, the platform provides automated early warning and estimates the impact on natural disasters. There are four types of alerts:

- **Green** alerts indicate moderate events where the need for international assistance is not likely;
- **White** alerts indicate a minor event, where the need for international assistance is very unlikely;
- **Orange** alerts indicate potential local disasters, where international assistance might be required;
- **Red** alerts indicate potentially severe disasters, where international assistance is expected to be required.

By using algorithms and data available at the time alerts and notifications are produced. The alerts are based on the calculated risk, which the given event poses to the potentially affected population. The following risk indicators are taken into consideration [6]:

1. The severity of the disaster, such as wind strength, earthquake intensity
2. The exposure to this hazard in terms of the population and infrastructure potentially affected by it; and
3. The vulnerability of the potentially affected country or countries, which is estimated based on several socio-economic variables.

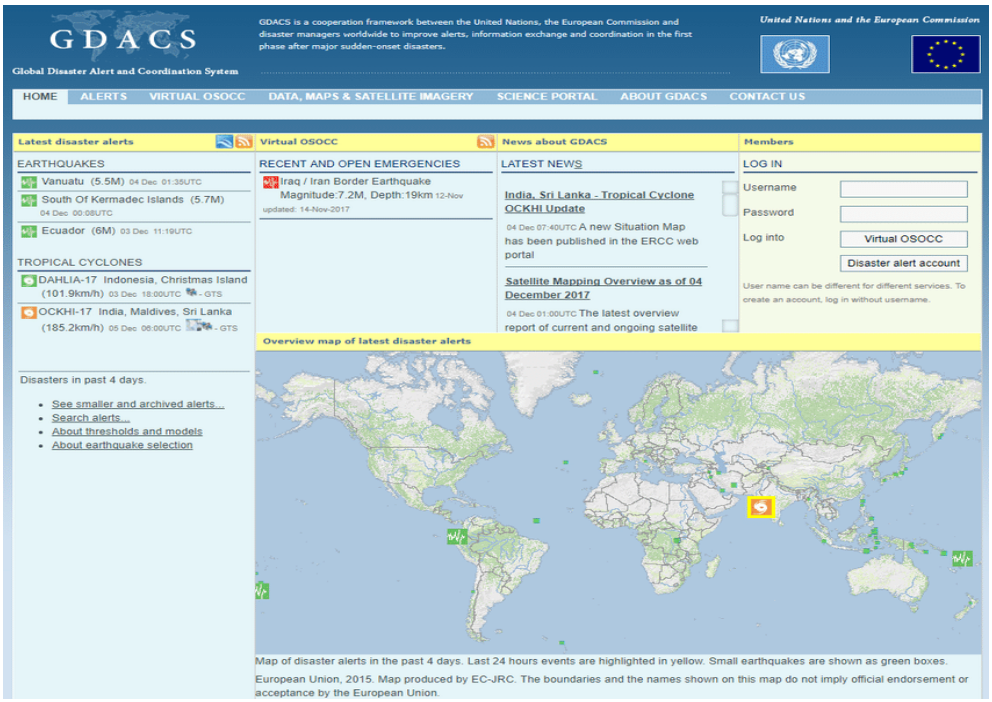

Figure 3.3 An overview of the GDACS website

Consequently, depending on where they take place if the events have the same intensity can result in different alert levels. For instance, a shallow 6.5 RS earthquake under an uninhabited desert would activate a Green, or even White, alert. Nevertheless, an earthquake touching 7.0 RS in a densely occupied area would probably trigger a Red alert in a susceptible country and an Orange alert in a developed, strong country.

GDACS gathers natural data by monitoring data feeds of related organisations and scraping useful information automatically. Authorised organisations can directly transmit data to GDACS through a push interface while custom data entry is also potential for particular users.

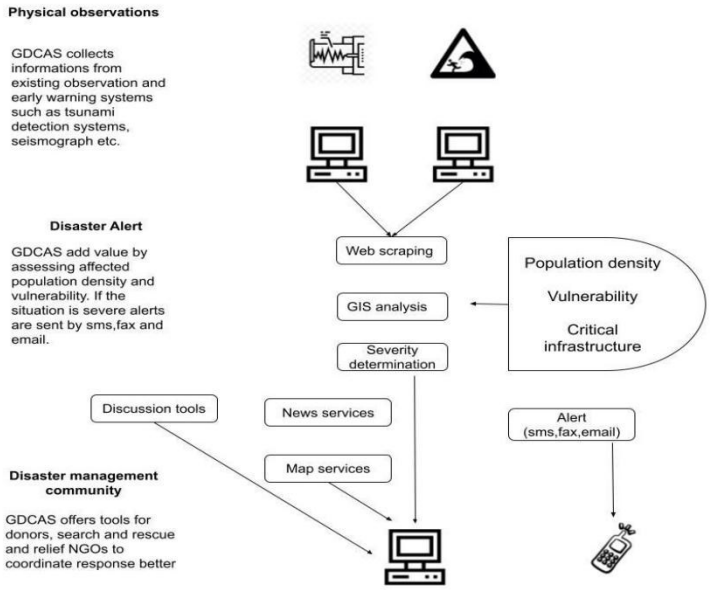

Figure 3.4 Principle of GDACS system

As for the access to the database[10], Registered and non-registered users can subscribe to GDACS alerts through its RSS feed by providing the URL[3] to RSS readers, or by clicking on the RSS icon on the GDACS Website, as illustrated above. The RSS feed contains geographical information (GeoRSS) for eventual use in geographic software. A KML file with the latest alerts and polygons of interest, such as the track of tropical cyclones, for use in Google Earth, is also available. To obtain the file, click on the KML icon on the GDACS Website, as also shown in the image above.

3.4.3 Prompt Assessment of Global Earthquakes for Response (PAGER)

PAGER (**P**rompt **A**ssessment of **G**lobal **E**arthquakes for **R**esponse) is a platform that generates information about the impact of major earthquakes around the world, updating emergency responders, government and aid agencies, and the media of the scope of the potential disaster [7]. The platform evaluates earthquake impacts by comparing the exposed population and fatality losses based on past earthquakes in each country or region of the world.

Earthquake alerts will also be produced based on the estimated range of fatalities and economic losses. To enhance the accuracy of the evaluation of an incident, the USGS creates the PAGER to deliver essential information including comments describing the main types of susceptible buildings in the region, exposure and deaths from previous adjacent earthquakes, and a summary of locally detailed information regarding the possibility for secondary hazards, such as earthquake-induced landslides, tsunami, and liquefaction. USGS has been producing for a long time timely and accurate earthquake location and magnitude determinations.

3.4.3.1 PAGER Processing

As it has already been mentioned, PAGER usage to estimate the population and cities exposed to shaking is straightforward. Though, the generation of the individual components and the operations of

[3] http://www.gdacs.org/xml/rss.xml

a vigorous real-time system is complex. The main process starts with the nearby real-time earthquake parameters of hypocentre and magnitude calculated by the NEIC and contributing to ANSS local seismic networks. With these parameters, maps of ground shaking are produced by the USGS ShakeMap system. The shaking maps are combined with population and geographical databases to produce estimates of the number of people exposed to different levels of shaking and the shaking intensities at selected cities. These maps are used by federal, state, and local organisations, both public and private, for post-earthquake response and recovery, public and scientific information, as well as for preparedness exercises and disaster planning [7].

In conclusion, the system produces estimates of the ranges of possible fatalities and economic losses based on country-specific loss models that account for alterations in construction practices and building vulnerabilities around the globe. Furthermore, the PAGER estimates the potential for earthquake-induced landslides, and, if available, damage and fatality reports from previous nearby historic earthquakes for comparison purposes.

Regarding the report of the PAGER (Figure 3.5), these are generated for all earthquakes magnitude 5.5 and greater globally and down to magnitudes of about 3.5 to 4.5 within the contiguous United States, Alaska, and Hawaii. Alerts are generally distributed within 15 minutes after an earthquake in the United States and within 25 minutes for earthquakes outside the United States.

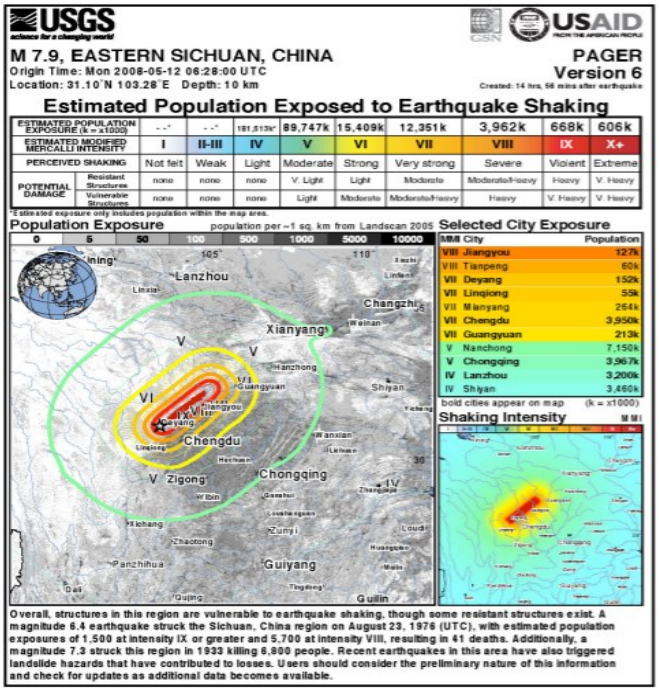

Figure 3.5 An example of a PAGER report [7]

After a significant earthquake, the PAGER delivers results within 30 minutes, shortly after the determination of its location and magnitude. Nevertheless, additional information on the extent of shaking will be uncertain in the minutes and hours following an earthquake and enhance as additional sensor data are attained and merged into models of the earthquake's source.

3.4.3.2 Email Alerts

E-mail alerts from PAGER are disseminated in "short" and "long" text formats. The short format is appropriate for reading on a cell phone or mobile device and includes information such as the earthquake location, depth, region name, and number of people exposed to the four highest intensity levels. The long format email besides that it covers the same information also includes the regionally-specific comment, intensity estimates at selected towns, the onePAGER report as an attached Portable Document Format (PDF) file.

An intensity and magnitude threshold is specified by Recipients of PAGER email alerts. Only when his or her intensity or magnitude threshold is exceeded the user receives an alert. Such an ability has the advantage of reducing the amount of alerts users receive because large earthquakes in abandoned regions will not activate emails. Even with intensity-based alerts, some deadly events will be missed [7]. Even moderate shaking experienced over an extensive area will rarely ruin a few extremely weak buildings. This situation hardly results in a large-scale disaster that requires external support.

3.4.3.3 Reasons for selecting PAGER

Development of the USGS PAGER system began in 2005 after the 2004 Great Sumatra tsunami earthquake. In 2007, PAGER started to expose results for all significant global earthquakes, providing both estimated intensities as well as estimates of populations exposed to each shaking level. Finally, in 2010, the PAGER system began publicly releasing impact-based alerts following significant earthquakes around the globe based on estimates of ranges of likely casualties and economic losses shortly after the introduction of an Earthquake Alert Scale [18].

Based on the above, and the description of the official term that a legacy system is an old method, technology, computer system, or application program, "of, relating to, or being a previous or outdated computer system," yet still in use and remain vital for the organisations [17], PAGER can be definitely considered as Legacy System. Another significant factor is that PAGER, although it is offering real time notification services, the platform also offers a plethora of historical earthquake data which can be easily extracted through its public API and use them in several components within the S&R project as legacy data.

PAGER had also been tested in COncORDE FT7. In the S&R project, where the new version of COncORDE is used, PAGER notifications are feeding the rest of the components with data (distributed in the chapter below), such as SOT DSS service. In order to feed the system with accurate data, a comparison has been made with other casualties' data coming from existing databases, provided by NTUA for the needs of T4.1 "Specification of the S&R Governance model**"**, inside the Data Lake Ecosystem via its aggregation mechanism. This new adaptation could not be implemented, as it was in the old version of COncORDE, where PAGER was used in its original form, meaning producing a PDF to the final system. For this reason, the PDF was extracted into a JSON format, in order to be compared and used to the requested S&R components. The output of these data are shown in "Table 34. Examples of Service 4 in JSON format" of "D7.3 Component Interface specifications for interoperability within S&R". It is crucial to mention that this process has been made for the SnR needs, since the accuracy of data plays a define role in the emergency scenes.

There are also other S&R components that may use PAGER's notifications via request to the Data Lake Ecosystem or the SOT DSS service (e.g., PHYSIO DSS, SA model, etc.). These components will request this data, in order to empower the knowledge, they produce, following the above philosophy.

This how the selection of PAGER enhances the final platform and through the comparison of these data with the existing ones (historical data), more accurate situation awareness is being produced, with the aim to serve and empower the decision making in the field.

4. Data retrieval from Legacy systems

4.1 Legacy systems' scope in SnR Operations

The main purpose of this current task is the integration of an amount of specific and important legacy systems in the S&R database, but apart from this the most important is the historical or other useful data to be extracted and used for a proper and efficient system functionality.

As it has already been analyzed in the previous chapters, legacy systems can be either hardware or software. So, if the legacy system is hardware a necessary requirement is the functionality of the system in order to eliminate problems related to its connectivity with the existing S&R components. For example, if there is a router or a desktop (hardware) its usage in the project is highly important as its network could be offered to the other components of the project e.g., to contribute to the communication among first responders. In the case of software, this is necessary and important for its data or the services it offers. For instance, an automated system for notification for earthquakes (software) is able to contribute to the project by offering historical data and using them in several components within the project for further processing and extraction of domain knowledge.

4.2 Approach to data migration

4.2.1 Identification/classification of data

In many organisations, older outdated Enterprise Resource Planning applications in many cases depend on technology which is over 20 years old. Processing errors, and lost data are some of the most prevalent issues due to the fact that the older the software, the greater the risk of data loss. A thorough data migration plan is the first step in a data migration project where it is needed to select, prepare, extract, change and transfer data of the right quality and form. The next six steps describe the process for a successful data migration:

1. **Identify the data, format, location, and sensitivity**

   Most important is the understanding of what data is going to be moved. Especially if this type of data is currently in and in what format it should be in port-migration. Throughout this procedure, potential risks may be met that you'll need to plan or understand that certain security actions must be taken during this process.

2. **Determine technical, time, and financial requirements**

   The procedure takes time and every aspect of the source data needs to be understood. The process of data migration from legacy systems can be long-lasting and may need assistance from finance, IT, developers, and engineers to work out budgeting and technical aspects of the project respectively;

3. **Backup all your data**

   All data and important files in the event of a system crash or if a hard drive failure occurs should be saved;

4. **Execute the data migration plan**

It should be ensured that the correct system permissions are applied, and successful data migration is allowed. Another important factor is the data to be cleaned to protect the target system and then to transform it into the proper format for transfer

5. **Test the system after each phase of your migration**

   It must be checked if the system migration works successfully. Test for minimal downtown, data integrity, make sure that no data is lost and check that the application is fully functional post-migration;

6. **Follow-up with any maintenance of your data migration plan**

   Regular check-ups on your data migration plan should be performed to ensure that it is all in working order.

4.2.2 Migration Feasibility Assessment

In this section, we focus on two parts. One is the legacy system decomposition, and the other one is the legacy source code collaboration pattern and role analysis. The system decomposition focuses on how to decompose the legacy system into parts, thus facilitating the next stage of applying a divide-and-conquer approach to implement the legacy system re-architecturing and incremental migration.

The migration process model consists of two parts:

1. Reverse Engineering

   Assessment of the cost-benefit of the migration project; Estimation of the risk factors: resources, migration plan, human, technology, inner and outer environments, disaster event prediction, etc.; Reproduced with permission of the copyright owner. Further reproduction is prohibited without permission. Estimation of possible migration strategy failures: migration requirements, environment integration, migration process, legacy knowledge mining.

2. Forward engineering

   Comprehensive object-oriented modeling and architecture reorganising step are performed to establish the object-oriented design, which is based on the recovered artifacts from the former reverse engineering.

4.3 Data retrieval through PAGER API

4.3.1 Scope

The scope of data retrieval through PAGER's API is to extract historical data from past earthquake events with their consequences in order to process and analyze them and set alerts and notifications for the SnR platform regarding earthquake use cases. However, PAGER can be used for real-time notifications too, if an incident really happens. The functionality that may provide can assist in the decision-making of the SnR Platform components.

4.3.2 Steps to retrieve data

To fetch the historical data from USGS's database a public API has been provided by the organisation which includes historical data of previous events. Data can be fetched by sending a HTTP GET request. To achieve that a set of actions should be followed. These actions include the cleansing of data, the data transformation and data loading. The final step is the data encapsulation.

- **Data extraction and data cleansing**

  Data extraction is the process of retrieving the data from the source database into a logical model of the source application[4]. This is usually done by writing SQL queries on the source database tables or using a migration tool that allows you to specify what data needs to be extracted. The database model is represented in a relational database schema that formats the json data to python objects to be processed easily by the backend mechanism. In the case of SnR platform, the ORM tool, that Flask micro framework provides, will be used to query the data provided in object-oriented methodology.

- **Data transformation**

  Data transformation is the process of transforming the data in the logical models of the source applications into logical models of the target applications. The main operations used in the transformation process are mapping, filtering, separating and combining. [5]

  Mapping is the process of matching the data fields of the legacy model to the python model fields. Data filtering is the process of selecting only the columns which are required, joining the data from different tables and performing aggregate operations and calculation of new fields based on the extracted data.[6] Separation and combination of data include the collection of the required data for the platform needs and the combination of those data as a logical python model.

- **Data loading**

  Data loading is the process of moving the information in the logical model of the target application into the physical database tables. This is usually achieved by writing SQL insert or update scripts[7]. In this point data loading will be achieved by using the ORM tool. By completing

[4] Velimeneti, Sushma, "Data Migration from Legacy Systems to Modern Database" (2016).

[5] Ibid

[6] Ibid

[7] Ibid

the object-oriented transition of the data, it becomes easier to process the required data. Some simple query-scripts in python can fetch and adapt properly the data to SnR codebase avoiding this way the disparity between the legacy model and the mechanism functionality that might occur in the case that data are inhomogeneous.

- **Methodology of Data Migration**

  In order to proceed with the data migration, a methodology has been followed that evaluated the data which needed to be migrated to the SnR platform. The first step is to depict the scoping of data migration.

  - Which is the time period that the data need to cover?
  - Does the database include duplicate data that need to be normalised?

  After that a requirement gathering has been followed in order to distinguish the data that needed for the SnR platform and to analyze how the data is structured and the interaction with other components on SnR platform.

  Next step after the data evaluation is the data cleansing. In this stage all the redundant data have been removed and only the appropriate data for the SnR platform have been kept.

  Before proceeding to the data migration, the final step is data collection. This procedure includes the following steps:

  - ➢ Investigation of the required data needed to be migrated.
  - ➢ Legacy data retrieval from Data Lake Ecosystem
    - Creation of the appropriate objects with the necessary attributes for data mapping to the SnR platform.
  - ➢ Legacy data filtering via S&R Data Model
  - ➢ Filtered legacy data retrieval via WebHDFS to rest of the required components

4.3.3 Data Migration Phase

Data migration is the final phase of this procedure. PAGER public API provides the option of date selection regarding a determined time period for the historical data retrievement. The API can be called with a GET http request from different clients. The sample below covers the time period between **01-01-1989** and **01-03-1989**:

https://earthquake.usgs.gov/fdsnws/event/1/query?format=geojson&starttime=1989-01-01&endtime=1989-03-01

The API call returns the results of the events in json format:

```
{
  "type": "FeatureCollection",
  "metadata": {
    "generated": 1629963506000,
    "url": "https://earthquake.usgs.gov/fdsnws/event/1/query?format=geojson&starttime=1989-01-01&endtime=1989-03-01",
    "title": "USGS Earthquakes",
    "status": 200,
    "api": "1.12.1",
    "count": 7711
  },
  "features": [
    {
      "type": "Feature",
      "properties": {
        "mag": 2.34,
        "place": "5 km NNW of Kea'au, Hawaii",
        "time": 604713388740,
        "updated": 1585692099610,
        "tz": null,
        "url": "https://earthquake.usgs.gov/earthquakes/eventpage/hv337388",
        "detail": "https://earthquake.usgs.gov/fdsnws/event/1/query?eventid=hv337388&format=geojson",
        "felt": null,
        "cdi": null,
        "mmi": null,
        "alert": null,
        "status": "reviewed",
        "tsunami": 0,
        "sig": 84,
        "net": "hv",
        "code": "337388",
        "ids": ",hv337388,",
        "sources": ",hv,",
        "types": ",origin,phase-data,",
        "nst": 14,
        "dmin": null,
        "rms": 0.29,
        "gap": 230,
        "magType": "ml",
        "type": "quarry blast",
        "title": "M 2.3 Quarry Blast - 5 km NNW of Kea'au, Hawaii"
      },
      "geometry": {
        "type": "Point",
        "coordinates": [
          -155.0513333,
          19.6736667,
          -0.052
        ]
      },
      "id": "hv337388"
    },
    {
      "type": "Feature",
      "properties": {
        "mag": null,
        "place": "42 km NNE of Taunggyi, Myanmar",
        "time": 604713360690,
        "updated": 1415321019090,
        "tz": null,
        "url": "https://earthquake.usgs.gov/earthquakes/eventpage/usp0003sf1",
        "detail": "https://earthquake.usgs.gov/fdsnws/event/1/query?eventid=usp0003sf1&format=geojson",
        "felt": null,
        "cdi": null,
        "mmi": null,
        "alert": null,
        "status": "reviewed",
        "tsunami": 0,
        "sig": 0,
        "net": "us",
        "code": "p0003sf1",
        "ids": ",usp0003sf1,",
        "sources": ",us,",
        "types": ",origin,phase-data,",
        "nst": null,
        "dmin": null,
        "rms": 0.5,
        "gap": null,
        "magType": null,
        "type": "earthquake",
        "title": "M ? - 42 km NNE of Taunggyi, Myanmar"
      },
      "geometry": {
        "type": "Point",
        "coordinates": [
          97.166,
          21.158,
          10
        ]
      },
```


Figure 4.3 An example of a PAGER report [7]

The json contains multiple variables regarding the incident location, magnitude, the tsunami effect etc. After the data modelling, the required notifications will be stored in HDFS directories (according to the data mapping) and will be sent to the rest of the components.

Data encapsulation

Since the data cleansing and the data mapping has been formatted the next step is the integration to an object-oriented python model. This way the data can be queried and processed from the SnR platform and they can interact with other components in order to trigger alerts and notifications according to each use case. The first step is to develop the encapsulation layer that serves as an interface and provides access from the legacy database to the python code and converts raw data to python objects.

This interface is developed in python and exposes an API that can be called from each component. It contains structured data models in an object-oriented way. It is the middleware between the legacy database and the SnR platform.

4.4 Common Taxonomy & Data Classification

Data retrieved by PAGER API can be classified according to the earthquake events data. Those data include the type, the estimation of casualties etc. Data from PAGER API can be sorted and consist of a knowledge base for the platform for alerts and notifications. The taxonomy is aligned with existing centrally operated systems and databases across national, European, and International Organisations as follows:

Table 4.1 Data taxonomy and its interaction with other components

Data	Operational definition	Interaction with Components
place	The location where an earthquake took place.	SOT DSS
type	Type of the event (earthquake, quarry blast, explosion)	SOT DSS
time	The time the incident took place.	SOT DSS
alert	Indicates if an alert has been triggered as a result.	SOT DSS
casualties	Estimation of casualties in the aftermath of an earthquake according to the magnitude of the event.	SOT DSS

Therefore, it can be observed that several of the data are common and can be used by components such as the Decision Support System of the SnR in order to enhance DSS service 4 Estimation of

casualties. The input of the PAGER platform, as it has already been presented in the previous chapter, and without any filtering by the data model, have common data with other components so are aligned with the final platform. However, in future work, this data must be filtered with the SnR data model provided by THALIT and compliant with the EU framework, as T6.2 "*S&R Data Communication Interoperability framework*" indicates. This approach is necessary for the usage of the legacy data by all the components.

Moving forward with the previous instance and in order to demonstrate the usage of legacy data by the SOT DSS component, the following table illustrates the result response from SOT DSS service 4:

Table 4.2 Output from the SOT DSS Service 4

Estimation of Casualties
"Estimation of casualties": [["There is a 7% chance for 1-10 human casualties."], ["There is a 26% chance for 10-100 human casualties."]

Apart from the estimation of casualties, PAGER's output includes additional information such as estimates of economic losses and population exposed to the earthquake shaking, map with the population exposure, structures, historical earthquakes, and selected city exposure, which could be used by several components within the S&R project.

Legacy data through their common taxonomy can be correlated within the Platform's components with historical and real-time data enhancing in that way the estimation of the earthquake or explosion consequences and mitigate them by acting faster than in any other case.

Last but not least, this chapter demonstrated the common taxonomy that was used for the SOT DSS needs. In future work, the taxonomy could be enhanced taking into account other components of the SnR platform that will request PAGER legacy data.

5. Conclusion

In this deliverable Legacy Systems information, as well as their relationship with crisis management were presented. Moreover, specific information and specifications about Legacy Systems from the End-Users were depicted. Regarding the existing EU Legacy platform characteristics also peculiarities of the Systems were analyzed.

In the field of software maintenance, legacy software systems are continuously evolved to meet the constantly changing requirements. The demand for change may come from various resources, such as correcting errors, providing new functions, or porting to new platforms. PAGER's historical database can assist in the role of Search and Rescue as an emergency platform and to the respective Use Cases that those data can be used for. In the next deliverable, D6.9, the report will include the extension of the legacy data database and their further migration to SnR platform as well as any further development and updated information of legacy systems.

ANNEX I References

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ANNEX II

- Questionnaire No1

SnR_WP6_T6.6 – Legacy systems Questionnaire

Legacy crisis management system status

* Required

Email *

Your email

Consent Form

Organisation *

Your answer

Legacy System Name

Your answer

Legacy System Analysis

Your answer

Hardware or Software?

- ◯ Hardware
- ◯ Software

Age of System

Your answer

Age of oldest hardware

Your answer

Security Risk

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

System Criticality

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

The importance of systems modernization

	1	2	3	4	5	
Low	○	○	○	○	○	High

What kind of data stored in your legacy systems?

Your answer

From which database the data are retrieved?

Your answer

Importance of legacy data recovery and re-engineering

	1	2	3	4	5	
Low	○	○	○	○	○	High

Importance of system re-design

	1	2	3	4	5	
Low	○	○	○	○	○	High

Importance of system re-code

	1	2	3	4	5	
Low	○	○	○	○	○	High

A copy of your responses will be emailed to the address you provided.

Submit

Never submit passwords through Google Forms.

- Questionnaire No2

SnR_WP6_T6.6 – Legacy systems Questionnaire

Legacy crisis management system status

* Required

1. Email *

Consent Form

2. Organisation *

3. Legacy System Name *

4. Legacy System Analysis *

5. Hardware or Software?

Mark only one oval.

- ◯ Hardware
- ◯ Software

6. Age of System *

_____

7. Age of oldest hardware *

_____

8. Security Risk *

Mark only one oval.

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

9. System Criticality *

Mark only one oval.

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

10. The importance of systems modernization *

Mark only one oval.

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

11. Importance of legacy data recovery and re-engineering *

Mark only one oval.

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

12. Importance of system re-design *

Mark only one oval.

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

13. Importance of system re-code

Mark only one oval.

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

14. Is your Database open access? *

If your answer is no, thank you for your participation.

Mark only one oval.

- ◯ Yes *Skip to question 15*
- ◯ No

Data section

15. What kind of data is stored in your legacy systems? *

e.g Medical records

16. What is the source where the data are stored? *

e.g Excel, Database etc.

17. What is the data format? *

e.g Csv, XML , JSON

18. What is the language of your data? *

19. How the data can be extracted*? *

e.g. csv/XML , API

20. Is it possible to provide your open access database, and how this can be achieved? *

e.g Yes/No , email/other