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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

D4.9 Design of SOT DSS components, V2

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Executive Summary

The current deliverable reports the second version of the Design of SOT DSS. More particularly, it presents the Data sources and the inputs that SOT DSS needs for each Service with a more technically detailed presentation to be demonstrated in the D4.11 "Development of SOT DSS components, V2". Moreover, a detailed description of the extensions for each Service which contribute to more realistic management of resources in a real crisis situation, and more accurate decisions during the disaster responses are presented.

Moreover, this document shows the roadmap of the data to the SOT DSS that provides an overall representation of the data flow to the SOT DSS.

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List of Abbreviations

Abbreviation	Explanation
API	Application Programming Interface
CIS	Computer Interactive System
DSS	Decision Support System
D	Deliverable
EMS	Emergency Medical Services
EU	European Union
JSON	JavaScript Object Notation
KT	Konnektable
S&R	Search and Rescue
SOT	Strategic Operational and Tactical
UC	Use Case
UTA	UTilités Additives

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1 Introduction

The previous version, D4.3 "Design of SOT DSS components" had as a scope the implementation of an effective SOT Decision Support System in order to support users on decision-making procedures through designed models of linear programming. In the current version, the extensions of SOT DSS are presented. These extensions have been implemented in order for the SOT DSS to accomplish the optimal allocation for each Service. To achieve this the models have been improved and new variables have been added as presented in the following chapters in order to succeed more realistic results.

1.1 Relationship with other Documents

The current deliverable is the second version of the document addressing the design of the SOT DSS components. The document provides inputs to other S&R components, therefore is linked to the following deliverables:

- D3.1 Requirements to knowledge management and SA Model
- D3.7 Requirements to knowledge management and SA Model, V2
- D4.1 Data aggregation
- D4.2 Situational Analysis & Impact Assessment
- D4.3 Design of SOT DSS components
- D4.4 Design of PHYSIO DSS component
- D4.5 Development of SOT DSS component
- D4.8 Data aggregation, V2
- D4.10 Design of PHYSIO DSS component, V2
- D4.11 Development of SOT DSS component, V2
- D4.12 Development of PHYSIO DSS component, V2
- D6.6 Report on legacy systems and their connection to the S&R related technical characteristics
- D6.9 Report on legacy systems and their connection to the S&R related technical characteristics, V2
- D7.2 Architecture and Design Specifications of S&R platform
- D7.3 Component interface specifications for interoperability within S&R
- D7.4 Adapted S&R components and services
- D8.2 S&R Use Case 1: Victims trapped under rubble (Italy) - Pilot plan
- D8.8 S&R Use Case 7: Chemical substances spill (Spain) - Pilot plan

2 SOT DSS Services

2.1 Service 1 – Allocation of available EMS units to incidents, depending on estimated needs

2.1.1 Data Sources

Service 1 concerns the optimal allocation of resources to incidents by employing optimization techniques. The specific service is determined by:

- the supply of EMS units (fleet size) from the EMS station,
- the demand resources of the incident,
- and the location of the incident and EMS station.

All this information is obtained by the COncORDE platform [1].

The following table shows the JSON format of the parameters feeding Service 1. [2]

Service 1	Allocation of EMS units from EMS Stations to Incidents

	{"EMSStationList":[
	{
	"id": int
	"location": [float, float], # lat, lon
	"fleet_size": int
	},
	{
	...
	},
	...],
	"IncidentList": [
	{
	"id": int,
	"location": [float, float], # lat, lon
	"demand": int
	},
	{
	...
	},
	...]
	}
	
	Google API
	Distance Matrix response -> {

	"destination_addresses": [ ],
	"origin_addresses": [ ],
	"rows": [
	{
	"elements": [
	{
	"distance": {
	"text": string,
	"value":int
	},
	"duration": {
	"text":string,
	"value":int
	},
	"duration_in_traffic": {
	"text":string,
	"value":int
	},
	"status":"OK"
	},
	{
	…
	}

Table 2-1: JSON format of the parameters feeding the Service 1

2.1.2 Extensions of Service 1

Compared to the first version of the current deliverable (D4.3 "Design of the SOT DSS components"), an essential extension for the Service 1 is the use of the Google API instead of haversine distance for the calculation of the cost function between the EMS station and the incident. This modification provides a more realistic approach to the results of Service 1 because it is able to compute the time that a vehicle takes from one point to another taking into account the real-time traffic of the roads. To achieve this, the driving mode of the Google API is used which gives the time of a vehicle to go from one point to another.

The DSS calls the Google API by giving a list of the latitude and the longitude of the EMS stations and the incidents in JSON format. The API provides the destination matrix that contains the durations from each start point to every final destination in JSON format. By using this information, the SOT DSS allocates the EMS units to incidents even more precisely. [3]

Figure 2-1: Example of Google API Output

The figure above is a dummy example in order to show the output of the Google API.

2.2 Service 2 - Allocation of patients to transport vehicles and first receivers (hospitals), based on given order of evacuation and triage results for present injuries

2.2.1 Data sources

Service 2 concerns the Allocation of patients to transport vehicles and first receivers (hospitals) by employing optimization techniques. The specific service receives data from two different sources.

First of all, the physiological score of patients (Triage score), the order of evacuation, and the location of the patient in the incident are obtained from the Triage application.

The Triage application is part of the COncORDE platform that provides easy and detailed software for the Triage process of deciding which patients should be treated first based on how sick or seriously injured they are. In the same direction is the PHYSIO DSS which returns different triage scores in a completely deterministic way or returns the average of the distribution of the expected time to death. These values could be considered as input for Service 2. However, despite the fact that in the current implementation the PHYSIO DSS and the SOT DSS are completely disconnected, this aspect may be a good challenge in the future. [1]

Furthermore, additional detailed information about the hospital such as basic contact details, the location of the hospital, the number of beds by specialties, and the expertise are received by the **COncORDE** platform.

The following table shows the JSON format of the parameters that feed Service 2. [2]

Service 2	**Allocation of Patients to hospitals**
	{"PatientList": [{ "id": int, "physiological_score": float, "evacuation_order": int, "is_child": 0 or 1, "location": [float, float] # lat, lon }, { ... }, ...],

	"EMSUnitList": [
	{
	"id": int,
	"location": [float, float] # lat, lon
	},
	{
	...
	},
	...],
	"UseUTA": bool
	
	"FirstReceiverList": [
	{
	"id": int,
	"beds": int,
	"location": [float, float], #lat, lon
	"name": string
	}, {
	...
	},
	...],
	"UseUTA": bool
	
	Google API
	Distance Matrix response -> {
	"destination_addresses": [ ],
	"origin_addresses": [ ],
	"rows": [
	{
	"elements": [
	{
	"distance": {
	"text": string,
	"value":int
	},

	"duration": {
	"text":string,
	"value":int
	},
	"duration_in_traffic": {
	"text":string,
	"value":int
	},
	"status":"OK"
	},
	{
	…
	}

Table 2-2: JSON format of the parameters feeding the Service 2

2.2.2 Extensions of Service 2

Service 2 has been extended with the allocation of the loaded EMS units to Hospitals (First Receivers). This is achieved by solving the Transportation problem as detailed described in D4.3 "Design of SOT DSS components" by modeling the EMS units as Suppliers (with supply = 1) and Hospitals as Demanders. For this Service, the actors of the COncORDE who are responsible for the transportation of the patients to hospitals are the first retrievers.

Furthermore, to define the cost function for this extension, the Google API has been used in order to provide the time the EMS unit takes from where it is to the hospital. [3] The output of the extension of Service 2 is the recommendation of the optimal allocation of the EMS units to hospitals based on the aforementioned characteristics. In case the hospitals are more than EMS units then the SOT DSS corresponds the remaining hospitals to a dummy node to avoid any errors.

2.3 Service 3 - Allocation of tasks to available actors on the field, given demand pre-defined by the field commander

2.3.1 Data sources

Service 3 concerns the allocation of tasks to available actors in the field by employing optimization techniques. The specific Service receives inputs such as the role of the actors, their location, the number of demanded actors, and the demanded role of the task from the **COncORDE** platform. The roles that will be used by DSS are every first responder such as firefighters, medics, etc. More specifically, as the D7.3 "Component interface specifications for interoperability within S&R" describes, there are:

- **EMS Rescuer:** The first responders (Police, Firefighters, etc.)
- **EMS Runner:** The first responders, medics (Doctors, Nurses, etc.) who are rescuing the victims on the emergency scene.
- **EMS Retriever:** The EMS units (ambulances with skilled staff), which will transfer the patients to the hospitals.

The following table shows the JSON format with the parameters feeding Service 3. [2]

Service 3	Allocation of tasks to Actors

	{"ActorList":[
	{
	"id": int,
	"role": string,
	"location": [float, float] # lat, lon
	},
	{
	...
	},
	...],
	"TaskList": [
	{
	"id": int,
	"role": string,
	"demand": int,
	"location": [float, float] # lat, lon
	},
	{
	...
	},
	...],
	"UseUTA": bool
	}

Table 2-3: JSON format of the parameters feeding the Service 3

2.3.2 Extensions of Service 3

Regarding Service 3, a change compared to the first version, which is described in D4.3, is in the task formula that calculates the cost matrix. The new formula is:

$$cost_{i,j} = \left(1 + \varphi^2(r_i, r_j)\right) \cdot s_i \cdot \sqrt{td_{ij}}$$

where td is the time distance between the actor and the task, $\varphi(r_i, r_j)$ is the role distance function that is defined as:

$\varphi(r_i, r_j)$=shortest path length between r_i and r_j, and r_i, r_j are the roles of the actors.

Furthermore, the change in distance function/API with the use of Google API in Patient Allocation applies to this module too. In this Service, the Google API is used to provide the time it takes for an actor to arrive at the incident site. [3]

Moreover, the main concern for *TaskAllocation* is the role tree definition. In the first version of SOT DSS, the role tree definition was hardly-typed in *TaskAllocation* class with the _get_role_tree() function. In the current version of SOT DSS, the information about the actors is received through the COncORDE API in order to define the role tree.

2.4 Service 4 - Estimation of expected casualties and demanded resources (EMS units), given historical data on emergency incident recordings

2.4.1 Data sources

The current service concerns the estimation of casualties during the incident. Regarding this specific Service, a solution for the earthquake incidents has been already proposed in the previous version of this deliverable D4.3 "Design of SOT DSS Components". In this case, the Advanced National Seismic System (ANSS) Comprehensive Earthquake Catalog (ComCat) is used. ComCat encloses earthquake source parameters (e.g., hypocenters, magnitudes, phase picks, and amplitudes) and other products (e.g., moment tensor solutions, macroseismic information, tectonic summaries, maps) created by contributing seismic networks. This seismic system provides earthquake detailed information through the PAGER platform by exporting the onePAGER product. The onePAGER is a thorough summary of an earthquake incident providing information such as the estimation of casualties, estimates of economic losses and population exposed to the earthquake shaking, map with the population exposure, structures, etc. [4] The following table shows in JSON format the parameters in order a request to PAGER API to be made and finally, its response on service 4 to be retrieved (more details about the technical part of requests to PAGER are given in D6.6 "Report on legacy systems and their connection to the S&R related technical characteristics").

Service 4	Estimation of Casualty

	* Depends on the event type.
	Earthquake:
	{
	"event_type": "EQ",
	"lat": float,
	"lon": float,
	"stime": float,
	"etime": float
	}

Table 2-4: JSON format of the parameters feeding the Service 4

2.4.2 Extensions of Service 4

The actual extension of Service 4 is on the response from the PAGER API. PAGER provides to the system a PDF, the onePAGER, with the information on the incident's casualties estimation. This onePAGER product, which is a summary document of the earthquake, is extracted into JSON format in order for its outcome to be used on the SnR platform. The earthquake data which are provided, are historical

data from legacy systems (PAGER) from D6.6 "Report on legacy systems and their connection to the S&R related technical characteristics" and PAGER is EU compatible as described in D6.2 "Data Communication Interoperability Framework".

Last but not least, KT predefined this data, in order to get used in the earthquake Use Cases which have as an incident an earthquake, especially in UC1, UC5, and UC7 where SOT DSS service 4 was requested to be used. Other than that, PAGER generates real-time data, meaning that SOT DSS service 4 could also provide real-time casualties estimation.

3 Roadmap of data

In this section, the data flow and how the data inserted to/exited from SOT DSS are described. First of all, the whole process starts when a S&R component makes a request from the SOT DSS via COncORDE. The SOT DSS is triggered and receives data from the COncORDE platform. Each Service receives different data. Additionally, Services 1 and 2 receive data from google API regarding the duration from one point to another and send back the results about the EMS allocation to incidents, Patient allocation to EMS units, and EMS allocation to hospitals in order to be shown to the end-users. More details about this process are presented in subchapters 2.2.2 and 2.1.2. Service 3 receives the information through the COncORDE API about the roles of the actors and sends back the allocation of actors to tasks. Furthermore, Service 4 receives data from PAGER through API about the earthquakes. More details of the process are described in subchapter 2.4.2. The whole data flow is shown in the Figure below.

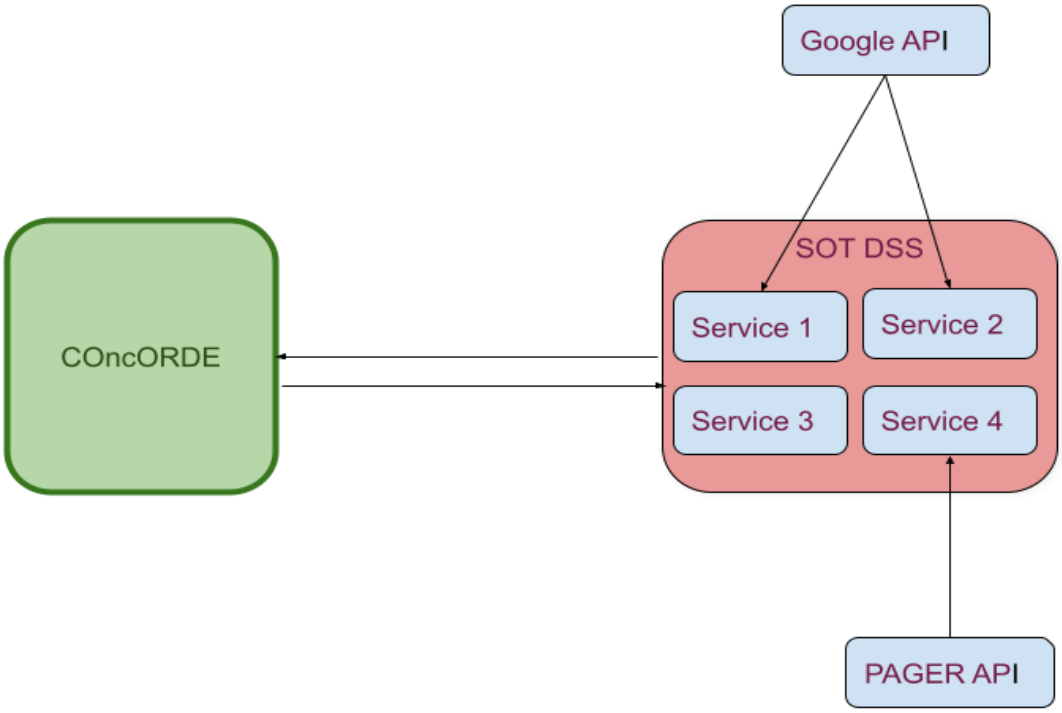

Figure 3-1: Data flow

3.1 Service 1 - Allocation of EMS UNITS to Incidents Data Flow

The figure below demonstrates the data flow for the first service of SOT DSS.

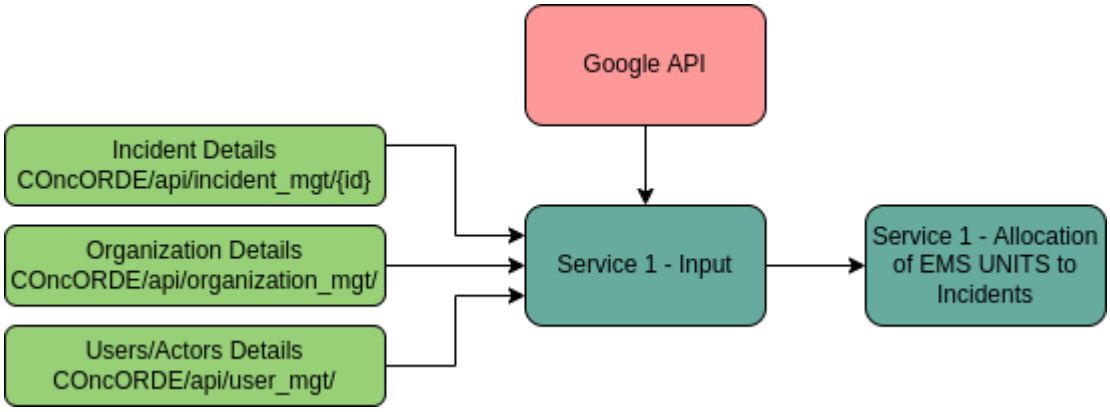

Figure 3-2: Data flow for the Service 1

3.2 Service 2 - Allocation of Patients to First Receivers (Hospitals)

The figure below demonstrates the data flow for the second service of SOT DSS.

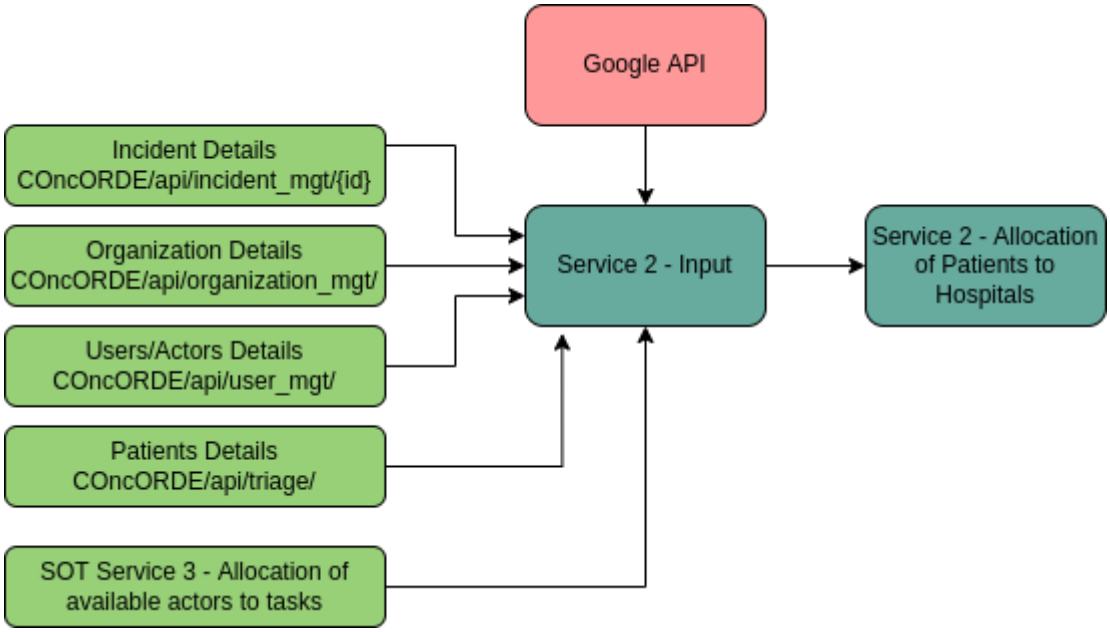

Figure 3-3: Data flow for Service 2

Service 2 receives additional input from the Triage for the patients on the field, as long as the SOT Service 3 for the available actors on the field. Moreover, the available hospitals, with bed capacity, are provided in the Incident details from the COncORDE API.

3.3 Service 3 - Allocation of available actors to tasks

The figure below demonstrates the data flow for the third service of SOT DSS.

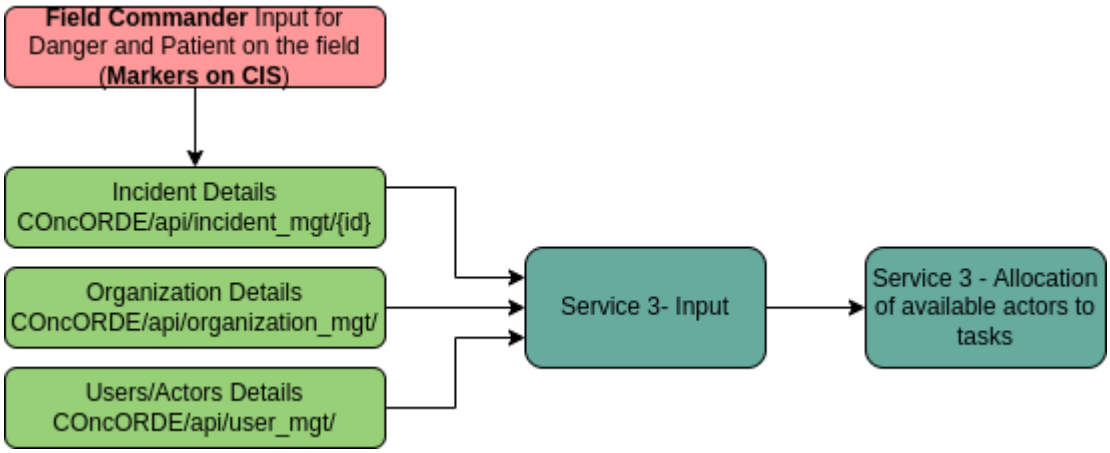

Figure 3-4: Data flow for Service 3

3.4 Service 4 - Expected Casualties

The figure below demonstrates the data flow for the fourth service of SOT DSS.

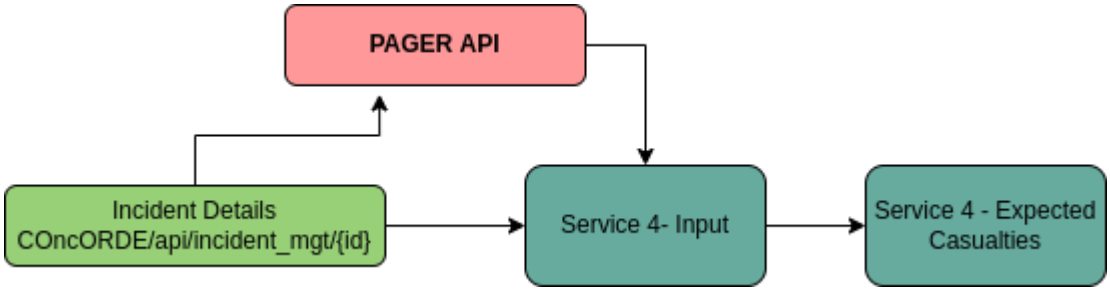

Figure 3-5: Data flow for Service 4

In Use Cases that are going to take place in Greece (UC2, UC4), Service 4 will also use input from existing databases with historical data (provided by NTUA for T4.1 needs).

The whole process of all the four services will be described in more detail in D4.11 "Development of SOT DSS components V2" where the technical aspect will be presented (Technical analysis, backend and frontend instances for each Service).

4 Conclusions

In addition to D4.3, further information for the design of the SOT DSS was presented in the current report. Especially, details for the extensions based on the functionality and the reliability of the models of the SOT DSS were demonstrated in this document. More precisely, the Data sources and the inputs for each Service that the SOT DSS needs were presented.

Furthermore, a detailed description of the extensions of the models and input data was presented along with the relative technical implementation and with the front-end and back-end examples described in the D4.11 "Development of SOT DSS component, V2". Finally, the roadmap of the data to the SOT DSS provides a general picture of the data process.

Annex I: References

[1] KT, "KT's Technical Documentation CONCORDE v0.2," [Online]. Available: https://alfresco.epu.ntua.gr/share/page/site/search-rescue/document-details?nodeRef=workspace://SpacesStore/bf0c1995-674c-4102-89be-e2f05b8a78d0.

[2] "SnR Gitlab," [Online]. Available: https://gitlab.com/konnektable-devops/horizon-2020/s-r-central-repo-group/sot_dss.

[3] "Introduction | Google Docs API | Google Developers," [Online]. Available: https://developers.google.com/docs/api/how-tos/overview.

[4] "onePAGER Information," [Online]. Available: https://earthquake.usgs.gov/data/pager/onepager.php.