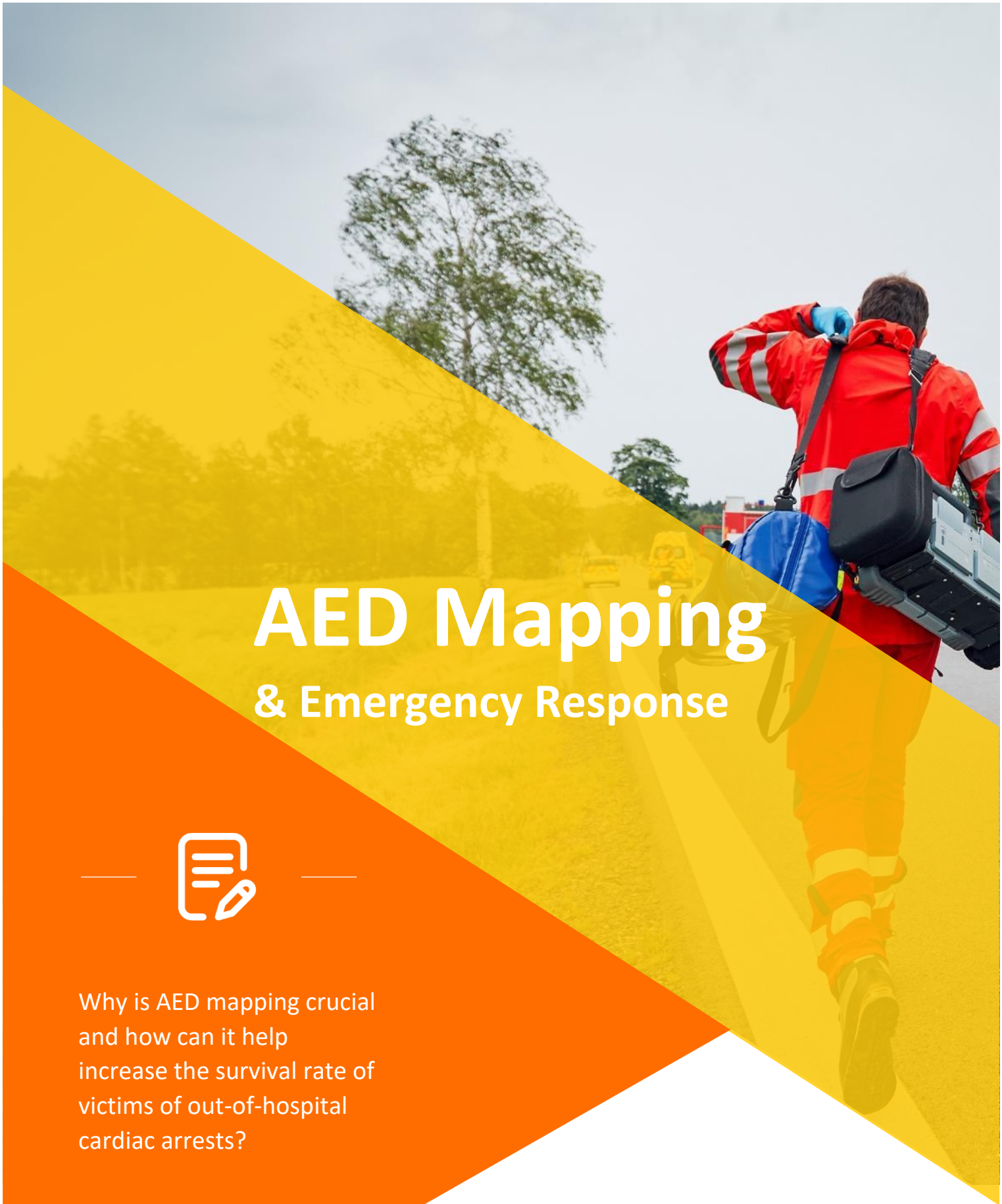

AED Mapping

& Emergency Response

Why is AED mapping crucial and how can it help increase the survival rate of victims of out-of-hospital cardiac arrests?

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EXECUTIVE SUMMARY

Sudden cardiac arrest is a leading cause of death in the EU. The chances of survival are low, and they decrease rapidly in the absence of any intervention. Early CPR and the use of an AED can increase the survival rate. The location of the AED nearest to the incident is needed to enable early use.

Some emergency services use AED mapping to locate the closest AED to a cardiac arrest incident so that people onsite can start the rescue operation until emergency services arrive. This document highlights why AED mapping is crucial and how it can help increase the survival rate of victims of out-of-hospital cardiac arrests. It explains the challenges behind the implementation, the maintenance of such a tool and demonstrates good practices.

Acronyms	
AED	Automated External Defibrillator
AHA	American Heart Association
BLSD	Basic Life Support and Defibrillation
CA	Cardiac Arrest
CC	Chest Compression
CPR	Cardio Pulmonary Resuscitation
EDC	Emergency Dispatch Center
EMS	Emergency Medical Service
ERC	European Resuscitation Council
PSAP	Public Safety Answering Point
VF	Ventricular Fibrillation

AED Mapping: An easily and publicly accessible digital map or registry providing information on the location of AEDs nearest to a point of interest taking into account the avaialbility of the device at specific times.

The document is a revision of the EENA document on AED mapping, first published on 4 May 2018. This version has been enriched with more recent information and updates.

Survival rates decrease 10% a minute without CPR & AED use

1 | Introduction

Cardiac arrest is the sudden cessation of the spontaneous heart activity leading to failure of blood, and therefore oxygen, transport to all organs and tissues. The predominant underlying cause in adult population is the ischemic coronary artery disease. The partial or total obstruction of the coronary arteries leads to an increased susceptibility of the ischemic areas predisposing to the development of ventricular fibrillation (1). The development of the electrical disorder (uncoordinated heart activity) causes the cessation of the mechanical pump function.

An immediate restoration of an artificial circulation through particularly uninterrupted chest compression (CC) (2) is mandatory **as survival dramatically decreases by approximately 10% for every minute elapsed in the absence of any intervention** (3,4). Chest compression alone, however, does not convert VF into a pulsatile rhythm as only an electrical defibrillation can interrupt the malignant arrhythmia.

Early chest compression and early defibrillation have proven to be highly effective in favoring the restoration of cardiac and, in turn, of neurological functions (5). **Successful rates rose up to 65% when lay people could begin the initial Cardio Pulmonary Resuscitation (CPR) maneuvers together with an early defibrillation by an Automatic External Defibrillator** (AED) (6,7). These results prompted the diffusion of these devices in many public locations to allow anyone to defibrillate even before the arrival of the ambulance or of the experienced emergency teams (8,9).

So far **the overall proportion of cardiac arrest victims treated by lay people with both interventions (early CC and early defibrillation) is less than 5%**, being the greatest proportion of interventions still performed by emergency crews (3, 6-8, 10, 11). Recently, however, The Resuscitation Outcomes Consortium investigators showed a much higher proportion of cardiac arrest victims defibrillated by lay people (18.8% of the shockable rhythms), leading, in turn, to a proportion of 66.5% of discharged alive patients vs 43% of the group defibrillated by the EMS personnel (12).

The AED diffusion is now favoured by large information campaigns which prompted the acquisition of thousands of AEDs by either individuals, authorities, companies or associations (10-15). **However, an AED unknown to the local Emergency Dispatch Center is a useless resource as the dispatcher cannot activate it even in case of a cardiac arrest in a vicinity of a nearby AED** (14). Indeed, there is evidence that AEDs are still infrequently used and that many of them are unknown to the local EMS (16,17).

All representative members of EENA and of the European countries pinpointed the necessity to provide an AED mapping to the Emergency Dispatch Centers.

2 | What is an AED & how can it increase survival from cardiac arrest?

An AED is a small portable device (approximately 20 x 20 x 7 cm) that can automatically analyse the underlying rhythm in a victim of suspected cardiac arrest and determine if it is needed to give a high energy electric shock to the heart of the victim. This shock is called defibrillation and the AED can automatically determine if defibrillation is required and deliver it to the victim's heart. This feature relieves the lay rescuer from choosing whether or not to defibrillate, as they have the unique task of guaranteeing the safety of the scene by preventing anyone from touching the patient while the defibrillator is operating.

The aim of the defibrillation is to interrupt ventricular fibrillation, which is the most dangerous cardiac arrhythmia. Although the ultimate goal is the return of a spontaneous cardiac activity, the shock alone rarely converts VF into a viable perfusing rhythm unless the time interval between the collapse and the defibrillation is very short (no more than 30 -60 seconds). **In most events of cardiac arrest, it is the combination of both early external chest compression and early defibrillation that increases survival.** Accordingly, the Emergency Dispatch Centres (EDC) must have a clear overview on the AED location to favour their early arrival to the scene.

It is important to look for an AED in every instance of suspected CA and not only after having ascertained a real CA, as any delay may compromise the restoration of the cardiac (and ultimately neurological) function.

An issue that EENA is pursuing is the goal that anyone should be allowed to take an AED and to apply the paddles on the chest: the AED vocal prompts and the dispatchers' instructions are sufficient to allow a correct use of the device. EENA has published a document on "*AED Legislation*", describinf the legislation, rules and recommendations regardin AED use in 22 countries (21).

In addition to delivering defibrillation, **more recent AED models have locations and connectivity capabilities**. Wi-Fi and mobile network data connectivity allow the device to communicate data such as its status, battery capacity, call emergency services or transmit cardiac arrest data to medical professionals. Some AEDs also have location capabilities enabling the device to precisely estimate its location. Connectivity and location capabilities can provide real-time data to an AED registry or map and help overcome the challenge of maintaining an up-to-date registry. For example, if a device is out of order or has been recently used, it could transmit its status to the registry and be excluded from nearby AED searches.

> *The combination of both early CPR and early defibrillation can significantly increase survival.*

3 | Ownership & Maintenance

Anyone can buy an AED. There is a wide availability of Automated Defibrillators on the market and all possess the requirements of delivering energy of 150J for truncated exponential waveform and 120J for rectilinear by-phasic waveform. There are, conversely, differences concerning the peak current, the average current, the duration of the first and second phase as each company developed its own software and algorithm (18).

AEDs can be deployed by the owners or others who receive the good from the owners (custodians). **It is important to emphasise that the maintenance belongs to the custodian, who has the task of guaranteeing that the device is fully operating**. Device manufacturers should specify the maintenance procedures and plan, including visual inspection, checking the expiry date of electrodes, battery checks, replacing batteries or electrodes when needed and that all necessary secondary supplies are available, for example, razors, gloves, scissors, rescue masks, etc. Future development could favour private companies with whom an agreement of maintenance service on behalf of the local authorities could be activated.

4 | Use of an AED and legislation

Automatic External Defibrillators are designed to be used by anyone without needing any prior training. When a bystander turns on the AED, the device gives clear instructions on how to apply the two adhesive jelly pads to the chest of the unconscious victim. The device checks the heart rhythm and determines if a shock is needed.

The vocal prompts of the device ensure its correct use, which is also usually guided by the dispatchers who will instruct the users on their proper deployment. The European Resuscitation Council Guidelines (22) suggest training as many citizens as possible, including school children.

European countries have different ways of handling AEDs use (20). National legislations vary from the absence of restrictions to strict regulations establishing that only those who successfully accomplished a Basic Life Support and Defibrilation (BLSD) course can use an AED. EENA advocates that the use of AEDs should be allowed in the legislation and authorities should strive to train people in CPR and defibrillation.

European countries have different ways of handling public AEDs...

5 | Why an AED mapping?

The most important information the owner should know is the necessity to provide the data of the purchased AED to the local dispatch centre such as to feed the database of AEDs. This database should be continuously updated and the emergency service should be aware of the precise location of the device and of its accessibility. **The mapping system thus works by providing to the dispatchers (and/or to the local Emergency Service) the exact location of the Automated External Defibrillator spread on the territory and by concurrently highlighting additional paramount information such as their accessibility, the daily availability, the battery and paddle conditions**. In addition, the software handling the AED mapping should also allow the recruitment of the volunteers who could perform not only the first resuscitation maneuvers (chest compression and/or artificial ventilation) but could also use an AED.

AED mapping can then expectedly promote an increased survival rate from cardiac arrest thanks to the activation of the closest and accessible AED by the operators of the Emergency Dispatch Centers who could quickly indicate to the callers their location and by concurrently providing the CPR with the pre-arrival instructions (telephone guided CPR).

Also **by knowing the location of mobile AEDs** such as those assigned to police cars, fire fighters, taxi drivers, Coast Guard boats, and any other vehicle, **the likelihood of early arrival of a defibrillator to the scene may be further increased** (19).

6 | How can AED mapping be implemented?

Pre-requisite is the definition of the items to be requested to the AED owner/users to create a database. The dataset could be constituted as described in the appendix. These forms should be transmitted or made available in a website and downloaded by anyone who has an AED (owner or custodian). The information filled and returned to the dispatch center would feed the database. Then the data have to appear on a screen map where the AED icons will be highlighted indicating their precise location and accessibiity.

Caveats & pre-requisites to consider for mapping AEDs…

7 | Implementation Caveats & Pre-requisite

There are some caveats and pre-requisites that need to be considered when looking to the implementation of an AED Mapping. Some of them result more from a technical perspective, some of them are more operationally driven

Technical caveats

Integration with the EDC software: The software has to be structured so as not to interfere with the software used to receive the emergency calls and to activate the emergency means.

Information highlighted: It has to provide information regarding the AED location in the shortest time possible.

The software deployed for AED mapping has to provide information about the status of the AEDs and of the batteries and paddles.

Organisation, information and communication caveats

Protocol and operative instructions: EDCs must have a detailed protocol whereby each operator can decide when and how to guide the caller as quickly as possible. The protocol must carefully describe the suggested ways to provide the AED location information (the path, distance and time to reach the AED) to the person who can get the device and should also consider ways to provide links to navigation apps. The EDC staff must precisely indicate the AED location, as seconds are crucial to ensure its arrival to the patient as quickly as possible.

Awareness: Public authorities, population, political institutions, associations, sport societies and any other AED owners/users have to be aware and informed about the importance of providing the AED related information to the dispatch centers. Indeed each one can be active part of an emergency process and can help to save a life. The major concerns are related to medical and legal issues which, so far, seem to be the major limitation hampering the availability of the information to the dispatch centers. As some owners could not keep in mind the expiration of the batteries and paddles, the software should automatically warn of the expiration date. Services should be set up to provide assistance for the replacement of the expiring materials.

Label and visibility: Although the AEDs are commonly identified by a green label with the text "AED" (according to the languages), it is important to share a common decision of the kind of label (i.e. the term "AED" should always be written and the acronyms in the own language should also appear to facilitate the comprehension to the non-English speaking people).

Gold standard or minimum acceptable criteria: To facilitate the wide spread diffusion of the AEDs and their recognition, EENA proposes to achieve a minimum standard based on the presence of a system within the EDCs able to indicate to the callers the closest and accessible AED.

Data acquisition and analysis: The organisation responsible for an AED registry should provide a facility for AED owners to provide device data to the registry. The AED registry can provide data for subsequent analysis for collecting insights on how to improve its use, including assessments of AED positioning in comparison to past

AED Map updates is one of the biggest challenges currently

locations of OHCAs and in an attempt to identify geographical areas that require an increase of AED availability.

Keeping AED registries up to date: Keeping the data up to date is one of the biggest challenges in AED mapping. Relevant authorities should define clear procedures for registry updates, including descriptions of how AED owners should update the AED registry. The increasing availability of AEDs with connectivity capabilities that can remotely update an AED registry about their status without human intervention will reduce the current difficulties in keeping information up to date.

When manual updates are needed, authorities should consider evaluating practices already successfully implemented in some countries. These practices differ in their approach and three approaches have been identified so far:

1. campaigns to have the registry updated by the public, who can win a prize for their contributions
2. frequent reminders to owners/people responsible for validating/updating the information previously provided to the registry
3. regular inspections to make sure that the information provided in the registry is accurate

The procedures can extend to define the conditions for deleting data from the registry, after a certain number of failed update notifications or after a certain time with no updates.

Need to develop a citizen responder programme: Citizen responders show excellent potential to increase the use of AEDs in out-of-hospital cardiac arrests. The European Resuscitation Council Guidelines (22) suggest setting up citizen responder programmes. Citizen responders provide an effective way to increase CPR and AED use and help resolve an operational issue during the emergency call.

The European Resuscitation Council Guidelines suggest CPR as a top priority in OHCA, followed by the use of AED. Emergency services staff have reported that it is not always possible to use an AED, even if one is nearby. The priority of the call-taker is to provide verbal CPR guidance during the emergency call. It is only sometimes possible to inform bystander about the nearest AED without interrupting the CPR guidance. Notifying the volunteers in the vicinity of the incident is the most effective way to maintain CPR guidance while a citizen responder fetches an AED.

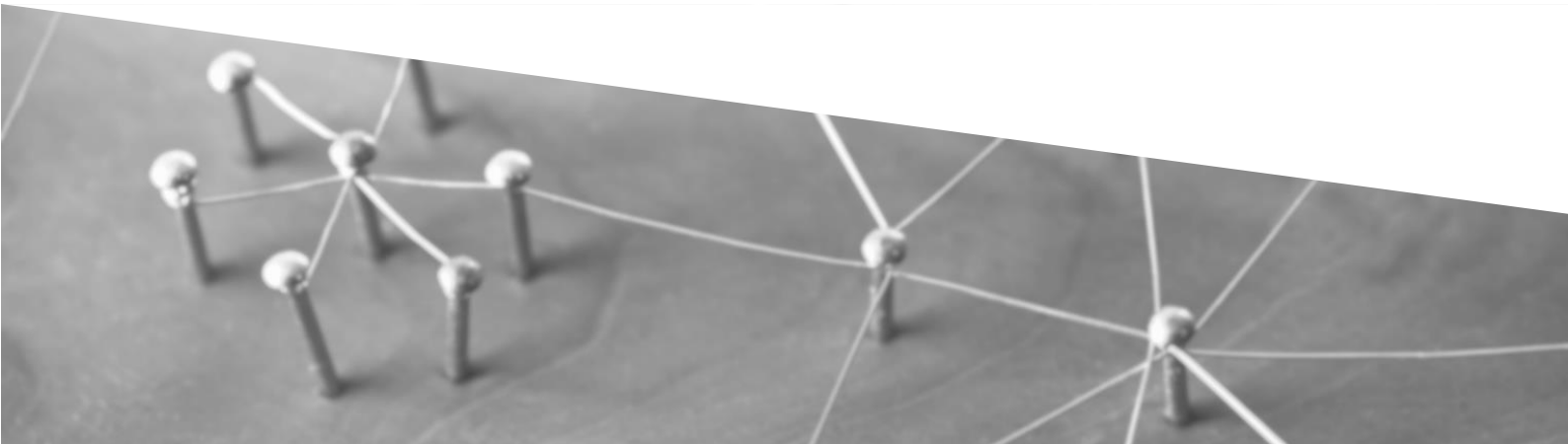
EENA has published the document "*Citizen response to cardiac arrest*" (23) with information about these programmes.

At least 14 countries in Europe have AED maps

8 | Examples of AED maps in Europe

The table below provides a non-exhaustive list of the online AED registries and maps in Europe. To view a demonstration of some examples of good practice in the implementation of the AED maps, please view the webinar "*Findings of the 'Galileo for AEDs' project*" and the presentation on "*Best practices in AED mapping*". Other countries that may have smartphone apps that provide similar information are not listed in the table.

Country	URL
Austria	*https://definetzwerk.at*
Belgium	*https://www.monrythmecardiaque.be/defibrilator.php*
Croatia	*https://www.hzhm.hr/en/aed-device-network-in-roc*
Czechia	*https://www.zachrankaapp.cz/cs/aed*
Denmark	*https://hjertestarter.dk/find-hjertestartere/find-hjertestartere*
Finland	*https://defi.fi/?lang=en*
Germany	*http://definetz.online/defikataster-hp*
Greece	*https://kidssavelives.gr/aed/*
Ireland	*http://cfr.ie/maps/*
Luxembourg	*https://www.reagis.lu/#!/reperage*
Netherlands	*https://hartslagnu.nl*
Norway	*https://www.113.no/hjertestarterregisteret*
Sweden	*https://www.hjartstartarregistret.se/*
United Kingdom	*https://www.thecircuit.uk*



9 | Recommendations

Many of the recommendations listed below are outcomes of the *EENA Members Workshop 2017*, which contained a session about AED Mapping. These initial recommendations have been extended by EENA's activities in AED mapping since 2017.

Emergency Services

AED location:

- Provide data to public authorities on locations with relatively high incidences of cardiac arrests (based on figures they have and/or thanks to mathematical models that can be used to optimise the placement of AEDs)

Caller location:

- Make sure to have the most accurate caller location as possible (so that the closest accessible AED can be located and used)

Use of AED:

- Develop protocols on when and how emergency call-takers should provide the location of the nearest AED to citizens/callers, while maintaining the provision of CPR guidance verbally
- Build a community of volunteers (citizen/community responders) able to reach very quickly the scene of incident and knowing how to perform CPR and how to use an AED.

AED map:

- Integration of AED mapping in the GIS/CAD or Access to cloud based AED map
- Make the AED map is publicly available
- Develop a programme on how to feed data to the AED map and how to keep the data up to date

Public authorities

Legislation:

- Make sure that anyone is allowed to use AEDs

AED provision:

- Make AED provision mandatory in public locations, both in highly populated as well as in remote isolated areas
- Clarify who pays what (e.g. battery when AED has been used)

AED location:

- Define guidelines on how to optimize AED placement, based on emergency services data related to cardiac arrests locations and/or based on mathematical models
- Create and maintain a public database where AED owners and emergency services can share the location of AEDs
- Make provision of AED location information into a public database mandatory for AED owners

AED maintenance:

- Make sure AED owners keep emergency services informed on availability of their AEDs and their good functioning
- Future development of AED maintenance could involve private companies who could be responsible of a free-of-charge service on behalf of Authorities and/or of the owners

Use of AED:

- Promote the ability for anyone to learn CPR and experience the use of an AED

AED Mapping Companies / Apps

Sourcing:

- Provide reliable AED mapping, accurate AED location, and accurate routing to the nearest AED
- Allow emergency services to provide data to the map

Supervision:

- Provide a mapping (location, AED working) that is always up to date (reliability)
- Make the map dynamic so that emergency services can update the map when AED has been used or an AED is missing

AED Owners

AED location:

- Make the location of their AEDs public (online database accessible by emergency services at least)

AED availability:

- Make sure their AEDs are always operational and current
- Keep the AED registry informed on when their AEDs are available
- Keep the AED registry informed on the good functioning of their AED

AED Manufacturers

AED maintenance:

- Define clear guidelines for the maintenance of AEDs
- Location:
- All new AEDs to be able to geo-locate themselves and share their location with online databases accessible by emergency services

Supervision:

- AEDs to provide status of the machine (operational, need of maintenance... etc)

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Appendix: AED registration form

Form from: Database of the Emergency Dispatch Center (SORES, Sala Operativa Regionale Emergenza Sani- taria, Friuli Venezia Giulia, ITALY) by the Regional AED Working Group

Type of information	Explanatory notes
Authority	
Owner	State name or denomination of the AED owner
Maintainance responsibility	Write the name and phone number of the person(s) committed to the AED control/maintenance
Municipality	Write the municipality where the AED is located
Address of location	Write the complete Address (Street, Square, civic number, zip code) of the building where the AED is located
Location	Write the precise place where the AED is located (floor, room, corridor, etc.)
Geographic coordinates (optional)	Indicate the geographical coordinates (i.e. Latitude, Longitude - Lat 45.91, Long. 13.72)
Availability	Indicate time and days of the week when the AED can be activated
Fixed location or mobile	Specify whether the AED remains permanently in the location above described or whether is temporarily placed in a mobile vehicle at certain situations (i.e. during racing or other events)
Phone	Write the phone number(s) required to activate the AED
AED	
AED name and model	Write the name, model, and Company of the AED
Reference number	Write the reference/serial number of the AED
Date of battery expiration	Write the date of battery expiration
Date of expiration of adult paddle	Write the date of adult paddle expiration
Date of expiration of pediatric paddle	Write the date of pediatric paddle expiration
Date of expiration of spare paddles	Write date of expiration of any (adult, pediatric) spare paddles
Number of subject authorized to the AED use (if established by national, regional or local law/policy)	Write the number of subjects authorized to the AED use (if established by law/policy)
Trainer Authority	Write the name of the Trainer Authority that performed the BLSD course