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OGC 15-095 Emergency and Disaster Management Information Framework

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Abstract

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# Introduction

The purpose of this paper is to consider how best to facilitate information handling and hence planning and decision making for emergencies and disasters, and to propose principles in this area.

The purpose of Emergency and Disaster Management is to

* Minimise loss of life
* Minimise other impacts
* Facilitate recovery

In order to achieve these aims the activities in emergency and disaster management are described as part of cycle which has 5 stages[[1]](#footnote-1)

* Prevent
* Mitigate
* Prepare
* Respond
* Recover

A key aspect of emergency and disaster management is the ability to plan for, and make timely decisions in a fluid and at times rapidly evolving situation. This requires a clear understanding of the key facts of the situation and how they are evolving – in other words it requires situational awareness.

This means that management of emergencies and disasters requires reliable data and information from diverse sources to facilitate decision making. Ideally the types data sources and data streams will be pre-defined and pre-planned, with sufficient resilience and contingencies in place to allow the effective flow of information even when telecommunication infrastructure is disrupted. However during a crisis it will often be necessary to facilitate the inclusion of data from new and unforeseen sources.

To use the data wisely often requires expert guidance. Just as judicious use of data can lead to well informed and good decision making, misunderstanding by non-experts can lead to mis-representation of the data and thus to poor decisions.

The scope of this work is to help technology providers and organizations that deal with emergencies to address the topics that such services must take into account. It presents good practices and highlight any gaps that need to be addressed. Implementation details for these services are out of scope.

# Principles

1. Abstract tools for data – use same source of data for multiple purposes
2. Ensure authoritative data sources maintain authority over their information
3. Facilitate an ecosystem of tools.
4. Facilitate access to federated data sources.
5. Facilitate new data sources through open standards for APIs and data formats.
6. Record provenance of data
7. Preserve audit trail of information used for decision making in order to improve future incident handling and to respond to legal challenge
8. Capture scenarios that can be replayed for training purposes.

# Situational Awareness

Any information framework for emergency and disaster management must facilitate the access to and the combination of information from a diverse range of sources to ensure that those managing and responding to the incident have the best possible situational awareness.

The UK government defines situational awareness as:

*The state of individual and/or collective knowledge relating to past and current events, their implications and potential future developments. [[2]](#footnote-2)*

# Common Operational Picture

In any crisis situation it is necessary for decision making to be coordinated. This in turn requires those involved in an incident to have a common understanding of the key facts. This is provided by the common operating picture.

The UK government defines the common operational picture as:

*Single display of information collected from and shared by more than one agency or organisation that contributes to a common understanding of a situation and its associated hazards and risks along with the position of resources and other overlays of information that support individual and collective decision making.[[3]](#footnote-3)*

While Wikipedia supplies the following definition from the (US) Headquarters, Department of the Army

*A common operational picture (COP) is a single identical display of relevant (operational) information (e.g. position of own troops and enemy troops, position and status of important infrastructure such as bridges, roads, etc.) shared by more than one Command. A COP facilitates collaborative planning and assists all echelons to achieve situational awareness.[[4]](#footnote-4)*

# Information Support for Decision Making

From an information perspective the process consists of :

5D/4D -> 2D -> Go/NoGo

This is illustrated in 

Figure 1: Information flow in support of decision making

To be effective the 2D common operational picture also has to be able to include other features. This is illustrated in the following diagram from the flood incident use case ():



Figure 2: Flood forecasting use case

# Information Services

One model for EDM systems is to produce a single monolithic system that aggregates all the necessary information into a single data repository that can then be queried by an equally monolithic visualisation system. This has a number of issues including

* Lack of scalability
* Lack of control for originators of data
* Single point of failure
* Expensive to build and upgrade

Instead it is proposed that a better approach is to support an ecosystem of tools for multiple functions from a common information service layer. This approach includes:

* An ecosystem of tools tailored for specific purposes – thus easily maintainable.
* Tools decoupled from data sources by standards based APIs – enabling flexible access to multiple data sources.
* The authoritative data providers make their data available through standards compliant APIs thus maintaining control and authority over their information.
* Additional federated data sources can be readily added.
* Thematic curation layers – including federated access control and discovery services ensure that the best data for specific purposes can be found.
* The curation layer can be used to throttle lower priority uses ensuring the availability to high priority uses

In short by using a federated approach for the information layer the authoritative sources for each category of information maintain control and authority over their information, while permitting flexible access and use from an ecosystem of tools, which can be optimised for specific purposes. The federated approach and exploitation of semantic web technologies will also permit the inclusion of new and ad-hoc sources of information. These sources will include input from crowd sourcing and citizen sensing.



Figure 3: Emergency and Disaster Management Information Services



Figure 4: Generic Information Source

****

Figure 5: Facilitate Re-Usability by Making Output of Tools Available through the Information Service

## Curation Layer

What does this look like?

* Authentication, Authorisation and Access control (XACML, SAML)
* Metadata including QA and provenance (O-Prov)
* Predefined layers for set scenarios (Web map context)

## Security

For sensitive information we need the ability to :

* encrypt to preserve confidentiality
* access control (access only for authorised users.)

To guarantee availability there may be a need to consider resilient network infrastructure (i.e. not internet) which can interoperate with information available over the Internet

It will also be necessary to ensure that the integrity of the information has not been compromised and for pushed/broadcast information there is a need to validate the source of the data. This can be done by digitally signing the message

## Ontologies and Symbologies

It is essential that terms used are clearly understood and agreed upon. This can be done using :

* Defining an emergency and disaster management ontology
* Pre-defined and agreed symbologies

e.g. UK Civil Protection Common Map Symbology

<https://www.gov.uk/government/publications/emergency-responder-interoperability-common-map-symbols>

* Registries

e.g. WMO Codes Registry

<http://codes.wmo.int/>

## Network views vs “Real”

Some information is best visualised as a network rather than a “real” geographic view. A classic example is the London tube map. This is particularly relevant to cyber security, where dependent of the particular issue the network view may be more informative than the cartographic view.

## 3D and Beyond

Some incidents require the understanding and exploration of the 3D nature of some information – e.g. volcanic ash plumes, toxic plumes in the atmosphere. Download services based on WCS can be used to exchange information using NetCDF or HDF. However there is as yet no agreed solution as to how we best represent these. A common approach is to use horizontal 2D slices. Another approach may be to allow experts to use immersive 3D visualisation to explore the data from which the most appropriate view is extracted. Similar issues are posed by higher dimensional data that reflect temporal evolution and ensembles of model output. In some cases it may be necessary to enable the extraction of a 2D “curtain” along a trajectory.

# Alerting and Push Architectures

Many aspects of emergency scenarios require access to large amounts of information that can then be collated into a coherent picture that highlights the most important facts. This is the essence of situational awareness and the common operating picture and is best dealt with via the pull architecture described above. However another important aspect of emergency and disaster situations is ensuring that warnings and alerts reach key user groups in a timely fashion. This alert message function requires a push architecture. Push APIs should only be used to provide notification of events and should not be used to transfer data. Two design patterns for push architectures are:

1. Point-to-point messaging. This is used when the data provider indicates that an event has occurred and it is required to be processed by a single consumer
2. Publish and subscribe. This when the data provider indicates that an event has occurred and it is required to be processed by multiple consumers

The elements of a push architecture include

## Alert message

Short message issued by an authoritative source summarising the key aspects, including severity and recommended courses of action.

e.g. Common Alerting Protocol

## Broadcast Media

Particularly for messages targeted at the general public a range of media are needed to broadcast the message to the target audience. These include:

* television and radio stations
* cell broadcast
* satellite broadcast
* social media
* web

## Aggregation Point

In order to validate the alert and disseminate in a trusted manner to the broadcast media it is usually necessary to have a message aggregation and onward dissemination point.



Example Architectures:

* IPAWS Architecture

<https://www.fema.gov/media-library/assets/documents/105491>

## Security

Maintaining appropriate assurance of confidentiality, integrity, availability and authenticity is essential for all information for emergency and disaster management. It is particularly important to ensure that mechanisms are in place to allow the verification of the integrity and authenticity of alerts. Therefore all alerts should be signed.

## Examples of Existing Alerting Services

* IPAWS

<https://www.fema.gov/integrated-public-alert-warning-system>

* Volcanic Ash Advisory Centre (VAAC)

<http://www.metoffice.gov.uk/aviation/vaac/>

* Space Weather

<http://www.swpc.noaa.gov/>

<http://www.metoffice.gov.uk/publicsector/emergencies/space-weather>

* National Sever Weather Warning Service

<http://www.metoffice.gov.uk/public/weather/warnings/#?tab=map>

* Pacific Tsunami Warning Centre

<http://ptwc.weather.gov/>

* Flood Warning Service

<https://fwd.environment-agency.gov.uk/app/olr/home>

* IAEA - Convention on Early Notification of a Nuclear Accident

<http://www-ns.iaea.org/conventions/emergency.asp>

* NOAA Storm Prediction Center

<http://www.spc.noaa.gov/products/wwa/>

# Standards Landscape

* OGC
* OASIS
* NIEM
* INSPIRE
* WMO
* W3C

## Related OGC Domain Working Groups

* EDM
* LEAPS
* Defence and Intelligence
* Met Ocean

## Relevant OASIS Standards

* EDXL
	+ CAP
	+ HAVE
	+ DE
	+ SitRep
	+ RM
	+ TEP
* SAML
* XACML

##

## INSPIRE and OGC Service Standards

INSPIRE[[5]](#footnote-5) is a European Union (EU) directive that came into force on 15 May 2007 and will be implemented in various stages, with full implementation required by 2019. The INSPIRE directive aims to create an EU spatial data infrastructure. This will enable the sharing of environmental spatial information among public sector organisations and better facilitate public access to spatial information across Europe.

INSPIRE is based on a number of common principles:

* Data should be collected only once and kept where it can be maintained most effectively.
* It should be possible to combine seamless spatial information from different sources across Europe and share it with many users and applications.
* It should be possible for information collected at one level/scale to be shared with all levels/scales; detailed for thorough investigations, general for strategic purposes.
* Geographic information needed for good governance at all levels should be readily and transparently available.
* Easy to find what geographic information is available, how it can be used to meet a particular need, and under which conditions it can be acquired and used.

To achieve its aims the INSPIRE directive mandates that datasets within scope of the directive are made available via view, download and discovery services. While not legally mandated the technical guidelines [[6]](#footnote-6)for implementing these services map these services directly to a number of OGC web service standards



## Other Standards

* OAuth
* Prov-O

# Scenarios and Use Cases

There are a number of common scenarios and use cases for emergency and disaster management. These include:

* Search and Rescue
* Flooding
* Earthquake
* Oil Spill
* Volcanic Ash
* Toxic Plume

## Search and Rescue

The information required for this scenario includes:

* Weather (current and forecast, at surface and above )
	+ Significant weather
	+ Wind speed and direction (mean and gust)
	+ Precipitation
	+ Pressure
* Shipping location
* Aviation location
* Sea state
* Tide
* Marine Charts

## Flooding

Flooding encompasses a number of scenarios

* Fluvial
* Surface water
* Ground water
* Coastal
	+ Storm surge
	+ Wave over topping of defences

The information required for this scenario includes:

* Weather (current and forecast)
	+ Precipitation
	+ Wind speed and direction (mean and gust)
	+ Significant weather
* Ground water level (current and forecast)
* River level (current and forecast)
* Tides
* Surge forecast
* Sea state
* Vulnerable infrastructure
* Vulnerable individuals
* Map
* Satellite imagery

## Earthquake

The information required for this scenario includes:

* Weather (current and forecast)
	+ Precipitation
	+ Wind speed and direction (mean and gust)
	+ Significant weather
* Map
* Satellite imagery

## Oil Spill

The OGP / IPIECA Oil Spill Response Common Operating Picture (COP) report[[7]](#footnote-7) provides a full discussion of this use case. This paper includes a discussion of the main information layers and data sets required.

## Volcanic Ash

The information required for this scenario includes:

* Weather (current and forecast, at surface and above)
	+ Precipitation
	+ Wind speed and direction (mean and gust)
	+ Significant weather
* Ash source
* Ash Plume observations
* Ash Plume source
* Satellite imagery
* Map

## Toxic Plume

The information required for this scenario includes:

* Weather (current and forecast, at surface and above)
	+ Precipitation
	+ Wind speed and direction (mean and gust)
	+ Significant weather
* Source
* Plume observations
* Plume source
* Satellite imagery
* Map

# Existing Systems

* GDACS

<http://www.gdacs.org/>

* Hazard Manager

<http://www.metoffice.gov.uk/publicsector/hazardmanager>

* ResilienceDirect
* (WMO)
* Google Public Alerts

<https://google.org/publicalerts>

* IPAWS

<https://www.fema.gov/integrated-public-alert-warning-system>

* C2-Sense

<http://c2-sense.eu/>

* MeteoAlarm

<http://www.meteoalarm.eu/>

* Oskari

<http://www.oskari.org/>

* RSOE EDIS

<http://hisz.rsoe.hu/alertmap/index2.php>

* CleanSeaNet

<http://www.emsa.europa.eu/operations/cleanseanet.html>

* Copernicus

<http://www.copernicus.eu/main/emergency-management>

* EFAS

<https://www.efas.eu/>

# Misc.

AsonMaps

<https://code.google.com/p/asonmaps/>

# Telecommunication Infrastructure

Detailed discussion of the telecommunication infrastructures required to support data exchange in emergencies is out of scope of this paper. However it is necessary to consider a number of possible options to ensure resilient and performant data exchange in a crisis when normal methods are unavailable or significantly degraded. In particular the availability of the Internet should not be assumed. In a number of scenarios either the physical connectivity may be disrupted or the available bandwidth severely restricted. The latter may be due to malicious attack or more simply due to overwhelming public demand causing denial of service. As a result contingencies need to be in place to use alternative resilient infrastructure, and the data architecture needs to take these into account.

Annex <insert Annex number>: Revision history

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Date | Release | Author | Paragraph modified | Description |
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|  |  |  |  |  |

1. Variations on this exist, sometimes combining the prevent and mitigate phase, others focusing on the latter 3 phases such as in the UK government’s concept of operations.

<https://www.gov.uk/government/publications/the-central-government-s-concept-of-operations>

<http://www.gdrc.org/uem/disasters/1-dm_cycle.html>

<http://www.who.int/water_sanitation_health/hygiene/emergencies/emergencies2002/en/> [↑](#footnote-ref-1)
2. <https://www.gov.uk/government/publications/emergency-responder-interoperability-lexicon> [↑](#footnote-ref-2)
3. <https://www.gov.uk/government/publications/emergency-responder-interoperability-lexicon> [↑](#footnote-ref-3)
4. <http://en.wikipedia.org/wiki/Common_operational_picture> [↑](#footnote-ref-4)
5. <http://inspire.ec.europa.eu/index.cfm/pageid/48> [↑](#footnote-ref-5)
6. <http://inspire.ec.europa.eu/index.cfm/pageid/5> [↑](#footnote-ref-6)
7. <http://www.opengeospatial.org/projects/initiatives/ogpoilspill> [↑](#footnote-ref-7)