CEDIM Forensic Disaster AnalysisConcept

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1. Summary

In late 2011, CEDIM embarked on a new style of disaster research known as **Forensic Disaster Analysis (CEDIM FDA)**. In this research program, CEDIM researchers analyze disasters and their impact in near real-time[[1]](#footnote-1). This document presents the scientific background, key features, and organizational issues of CEDIM’s FDA:

* enhancing scientific quality and synergies by interdisciplinary research across different disciplines at KIT in the broader context of disaster analysis;
* publishing of science-based near-real time assessment reports prepared by CEDIM-staff and associated researcher;
* active outreach by sending out reports to different stakeholders, especially those where cooperations exist (Civil protection, development organization, insurance industry); receiving feedback about user needs from those institutions.

The **scientific challenges** of CEDIM FDA, leading to adequate science based options for disaster risk reduction, are:

* to identify and better understand major risk drivers of disasters as well as complex interactions and cascading effects in and between (1) natural hazards, (2) technical installations, facilities, and critical infrastructures, and (3) societal structures, institutions and capacities;
* to consider as far as possible the whole chain from the causes of the event to hazard and risk to the impact on society and environment;
* to develop , to apply and to validate own models and tools for rapid disaster assessment;
* to enhance the capacities required for risk prognosis including socio-economic implications of rapid and evolving disasters;
* to enhance capacities for near-real time disaster analysis;
* to draw conclusions about preparedness and precaution by identifying similarities across the events including identification of what went well and wrong (‘lessons learned’).

1. Motivation and Background
   1. Why Forensic Disaster Analysis is needed

Catastrophic natural events or disasters are defined as events with a significant impact of natural phenomena (usually referred to as hazard) on vulnerable societal assets (human life and social conditions, economy, environment) causing potential losses (risks). In general, research associated with disaster risk (DR) aims at the development of knowledge, methodologies, and technologies for disaster management leading to disaster risk reduction (DRR).

The overall objective of CEDIM as an interdisciplinary research center is to advance the scientific understanding of natural and technical risks. CEDIM is performing research on major risk drivers, coping strategies, management solutions, and prevention measures. Consequently, CEDIM’s activities are dedicated to developing tools and concepts to enhance security and resilience in a changing society and environment. To achieve this goal, CEDIM employs interdisciplinary competence and develops synergies between the involved KIT institutes and cooperates with relief organizations, emergency management institutions and the insurance industry on international and national levels.

A promising systematic approach to disaster risk research has to focus on disasters in a comprehensive, multidisciplinary and holistic way and treat disasters as ‘experiments’, which can prove or disprove our concepts, expectations, prognostic models and beliefs. Learning from disasters in this way is most efficiently done by scrutinizing disasters with the high potential of modern observational and analytical methodologies available in science, engineering, remote sensing, economics and social sciences.

* 1. The idea of Forensic Disaster Analysis

In general, *Forensic Science* or *Forensics* describe the integration of a broad spectrum of scientific disciplines and their results and methodologies to answer questions of interest to a legal system. Forensics is best known as the application of various scientific methods to identify criminal acts (or to exclude actions from being criminal acts) and to systematically analyze, to trace back and to “reconstruct” the criminal act. In our forensic analysis we transfer and apply this concept to disasters and treat disasters as the “criminal acts” that have to be reconstructed in order to find ways to prevent further disasters or to mitigate associated repercussions.

The concept of Forensic Disaster Investigations that CEDIM has adopted has been coined by the Integrated Research on Disaster Risk (IRDR) program and their Forensic Investigations of Disaster project (FORIN, 2011)[[2]](#footnote-2). The concept has been developed and motivated by the fact that losses from disasters still grow despite of decade-long efforts in research on hazards, risk management and disaster reduction. It has been defined as an "approach to studying natural disasters that aims at uncovering the root causes of disasters through in-depth investigations" and that "will help to build up an understanding of how natural hazards do – or do not – become disasters" ([www.irdrinternational.org](http://www.irdrinternational.org)). The goal of FORIN is to probe more deeply and with more rigor intensity into the complex and underlying causes of growing disaster losses than previous research has done. To obtain additional broader and more fundamental explanations for the current rise in disasters, Forensic Disaster Investigations are more penetrating investigations developed and enacted in a more explicitly designed, multidisciplinary, standard framework with a common set of fundamental questions.

The concept of Forensic Disaster Analyses has been implemented and adapted by several research institutions, relief agencies, and civil protection services. Since 2013, CEDIM has an own forensic session on the European Geoscience Union (EGU) General Assembly, mirroring the large interest and importance of this style of research.

1. CEDIM near-real time Forensic Disaster Analysis

3.1 Definition and objectives

CEDIM adopts the comprehensive understanding of disasters and the general concept of FORIN while focusing on **real-time assessments** to complementing the IRDR activities. The core of CEDIM’s FDA concept is to examine disasters in an interdisciplinary way in near-real time with a focus on the complex interactions and cascading effects in and between (1) natural hazard, (2) technical installations, facilities, and critical infrastructures, and (3) societal structures, institutions and capacities. The overall aim is to assess the course and temporal evolution of a disaster, to estimate affected people and direct and indirect losses, to identify major risk drivers, to assess failure of critical infrastructure with a special focus on transportation and energy supply, and, finally, to infer implications for disaster mitigation. Based on its broad expertise, CEDIM will focus on disasters triggered by geophysical (earthquakes, volcanoes) and hydro-meteorological (floods, tropical cyclones, large-scale and convective storms) extreme events.

The tem *Forensic* is used in CEDIM’s FDA in its sense of (1) scrutinizing disasters closely by using a high potential of modern observational and analytical methodologies available in science, engineering, remote sensing, economics and social sciences and of (2) combining the methodologies and results from different disciplines in comprehensive reports. Based on the integrated broad interdisciplinary expertise and on in-house tools for conducting rapid assessments, CEDIM will compile and disseminate comprehensive and science-based rapid assessment reports during and after disasters in near-real time.

The FDA reports have a standardized format (see template) that was designed after consultations of several users. However, there is still potential for improvements, especially when serving important stakeholders such as the World Bank.

* 1. Near-real time analysis

When a disaster happens, time criticality is important as many pieces of information emerge within the first days. Therefore, CEDIM integrates the near-real time component of research as key feature of its forensic disaster analyses. During the first days of a disaster, the interaction with the many actors and stakeholder is most intensive and open, and the potential user interest (relief agencies, emergency services, insurance industry, etc.) is also at peak at this initial stage. During this critical window, in addition, media can take up reliable science-based information that can help promote mitigation and preparedness measures. Finally, the FDA reports are an important component of the outreach strategy of CEDIM and KIT. Within the Helmholtz cross-cutting program of Natural Disasters and Warning Systems (NDWS), CEDIM’s FDA reports shall be distributed among the different partners of the Helmholtz Centers.

In the days following the first critical time window, initial hypotheses (that had been posed with little information after the first day) on loss evolution and on implications can/should be tested and integrated in further reports. This can significantly speed up our understanding of natural disasters within their respective socio-economic contexts. In addition, during the course of a disaster new questions and hypotheses may arise that can be tested and discussed to enhance our understanding of disasters.

Because of the research assignment of CEDIM, each FDA case should enable to write a paper published in an ISI-referenced journal, ideally one with a two-stage publication process that enable rapid publication (e.g., Copernicus journals).

* 1. Specific targets, questions, and methods of CEDIM FDA

In its near-real time analysis of a particular disaster, CEDIM FDA targets specifically at:

* assessing losses in a structured and strategic way
* monitoring the course of disasters and identifying options for loss, recovery, loss reduction, etc., and
* identifying interactions of disaster-determining phenomena and socio-economic context of loss
* …

The specific questions to be addressed in the forensic analyses and the reports are:

* What are critical factors that control loss of life, critical infrastructure, and economy in large-scale disasters? Which factors are relevant for aggravating adverse effects?
* What are the most important hazard-related factors (intensity, duration, spatial extent, cascading effects, multi-hazard) that trigger disasters?
* Which are the critical interactions between hazard – socio-economic systems – technological systems?
* Which supply chains are interrupted and what are the consequences?
* Where warnings issued appropriately? How did the people / society reacted? Pros and cons in the decision making process?
* Can we predict pattern of losses and socio-economic implications for future extreme events from simple parameters: hazard parameters, historic evidence, socio-economic conditions?
* How is the event related to the climatological / risk context including consideration of heavy tail / Black Swan (Taleb 2010)?
* …

For issuing rapid assessment statements, CEDIM will use a wide set of information and methods that were already developed and in place, for example

* data bases of historic disasters and extreme events (CATDAT; Wettergefahren-Frühwarnung)
* loss and damage modelling
* information provided by crowd sourcing
* Google Map utilization
* …

It is part of the research in CEDIM to explore and study how these and other existing methods can be used, adapted and improved for near-real time.

* 1. Collaborations

CEDIM has long-term strategic research cooperations with various national and international scientific institutions and disaster management organizations. In connection with the FDA activities, of particular interest and strategic importance are the following:

* World Bank and its program of Post Disaster User Needs Assessment (PDNA), where members of CEDIM are already contributing.
* IRDR via the International Centre of Excellence on Critical Infrastructures and Strategic Planning as a network with the University of Stuttgart, United Nations University *Environment and Human Security* and University Potsdam,
* Willis Research Network, a network of Excellence of researcher from various disciplines, where CEDIM is the only member in continental Europe.
* …

In the future, the partnership with the World Bank shall be further deepened within the framework of the PDNA program and the program Global Facility for Disaster Reduction and Recovery (GFDRR).

* 1. Near-real time CEDIM FDA Task Force: Organization

CEDIM FDA Task Force mode requires a lean and effective organizational structure summarized in the next sections.

* + 1. CEDIM Coordinators

The CEDIM Coordinators (= CEDIM Sprecher) have the overall responsibility for CEDIM FDA and for the statement reports to be produced. They decide in consultation with the Event/Topic Coordinators whether CEDIM should get active and start a FDA Task Force or not.

* + 1. Event Coordinators

The Event Coordinator is the reference person who is responsible for coordinating and guiding the activities during a CEDIM FDA:

* In case of a major disaster, the Event Coordinator decides in consultation with the CEDIM Coordinators whether CEDIM gets active or not.
* He/she decides on the main topics addressed in the report(s) such as disaster losses, economy / supply chains, transportation interruption, crowd sourcing / web 2.0, knowledge management / case based reasoning.
* During the active phase of a CEDIM FDA Task Force, the Event Coordinator has the responsibility to coordinate the rapid assessment process and to lead writing of the reports. He/she informs the relevant CEDIM FDA team and the Head Office about the structure (planned outline, central questions) and deadlines for the next planned reports.
* During the course of a disaster, the leading role for the near-real time assessments and for compiling and writing the reports may shift from one Event Coordinator to another when it is obvious that new aspects of the disaster that refer to another Event Coordinators’ field of expertise become more prominent. The change in the responsibility for guiding the FDA Task Force and for compiling the reports is decided together with the CEDIM Coordinators and must be communicated to the team.
  + 1. CEDIM Team

The CEDIM Team is formed by the CEDIM scientists at KIT, the Event Coordinator(s) and the CEDIM Coordinators. Additional CEDIM members may be part of the CEDIM Team as well as additional researchers at KIT or other institutions who are interested to support and to contribute to CEDIM’s FDA Task Force activities on a voluntary basis. When a CEDIM FDA Task Force starts, the CEDIM Team become active and form the **CEDIM FDA Task Force**.

* + 1. CEDIM Head Office

The CEDIM Head Office is formed by the CEDIM General Manager. The CEDIM Head Office in general serves as facilitator for CEDIM FDA and disseminates the reports to the identified stakeholder and coordinates the outreach with KIT SEK.

* + 1. Organizational chart of CEDIM FDA

tba.

1. CEDIM FDA Task Force: operational procedures

Disasters unfold at different velocities. In most cases of high-impact weather or hydrological events, the triggering mechanisms can be predicted, while in case of geological events, short-range prediction may be possible (tsunamis, volcanic eruptions) or not at all (earthquakes). These different patterns carry along different requirements for the FDA activities in terms of initializing an FDA, and for the information that is available for the first report.

* For earthquakes, an FDA is initialized immediately after the event according to certain criteria (see next section).
* For floods / atmospheric events, the possibility to predict an upcoming event enables to send out a **pre-alert**. Upon receiving this pre-alert, the FDA Task Force team members should get active and prepare aspects that may become relevant (socio-economic environment of the possible disaster, important industry, infrastructure…). Due to the uncertainty inherent in weather forecasts, pre-alerts are for internal communication only.
  1. Alert and activation criteria
     1. Alert process

The alert process has to ensure that (1) it is noticed that a major event is either upcoming or already happened (earthquake) and that (2) the Event Coordinators and CEDIM Coordinators are informed about the event. Options to contemporary inform all CEDIM scientists are alerts via Mail and SMS.

A clear information chain and responsibility for initializing an alert is important (see chapter 3). Given the general situation of CEDIM with scientists located at different places, travelling activities, vacancies, limited personnel resources, a reliable and robust 7/24 structure is not envisaged.

* + 1. Activation criteria

The decision about an FDA Task Force is generally based on expert opinion (Event Coordinator, CEDIM Coordinators) and on criteria that refer to the impact of an event.

Following criteria have been developed (see Fig. 1): A CEDIM FDA Task Force will be invoked based on early damage levels (as known from information available in the first hours):

* if the event is expected to have many fatalities and to be a “catastrophic” event; this scheme applies especially for earthquakes;
* if there are fatalities and major losses, and if there are interesting effects or aspects to study;
* if the event is in Germany or neighbouring countries where the public interest is high, or if the event is of other strategic interest to CEDIM.



*Fig. 1: Activation criteria CEDIM FDA Task Force exemplary for earthquakes.*

* 1. Issuing CEDIM FDA Reports
     1. Coordination

For the near-real time research activities and the reports, a template has been developed that should serve as guideline (cf. chapter 5). The first statement report is of highest priority and most important because there will be only limited information available and the public interest is usually very high. For the first report, the designated Events coordinator will take responsibility, which, however, can be taken over by someone else who addresses the corresponding topics of further reports.

* + 1. Numbers and issue date of FDA reports and public relation

The number of reports per disaster and the dates for releasing the reports are not strictly defined, yet the “near-teal time” approach and the existing “window of opportunity” require that the first report should be released as early as possible, i.e. within one or two days after the disaster. A possible second report, with an increasing level of scientific work and assessments, should be released one or two weeks later.

The reports are published on the webpage of CEDIM and via ResearchGate. They are also forwarded to the press departments of KIT, the information platform (Earth System Knowledge Platform, ESKP) and the CEDIM network (E-Mail list) by the CEDIM General Manager. In the reports, Ms. Monika Landgraf (KIT) from KIT-SEK is listed as contact persons for media activities. Further press activities are coordinated via the KIT press department.

1. CEDIM FDA reports: templates and questions to be addressed

In the CEDIM FDA reports, the available information on the disaster (hazard, loss and damage, relief, relation to the overall context, infrastructure, societal data, specific assets among others) is combined and summarized. The information provided by the reports should be compiled based on a series of questions to generate, present and disseminate knowledge on:

* affected people,
* loss and damage,
* societal aspects,
* failure of critical infrastructure (transportation, networks, energy supply);
* temporal- and spatial scales including evolution of the disaster,
* risk drivers and implications for disaster risk mitigation,
* …
  1. Common scientific practice as general rule for the reports

In general, the reports are science-based reports. They should be written in a clear, understandable language and – although rapid and although there is only little information available – not in a sensational press style. This means:

* The reports should use proper citation and should reference the sources of information that is combined in the reports. The same holds for referring to studies on past events in the same region or to comparable events in other regions.
* The reports should contain no speculations, no prognoses on the further course of the disaster and no expressions of opinions.
* The reports may employ analogies and comparisons to other disasters, and from a certain phase on they may contain evaluative statements, if the information base of the statement, the criteria for evaluation and the line of reasoning is clearly indicated (transparency and plausibility of statements).

In general, the language of the reports is English. In case of a disaster in Germany, the language may be German.

* 1. Structure of the reports (tba)

Topics to be addressed are:

1. Hazard information
2. Disaster Profile
3. Loss and Damage Analysis
4. Evolution of Disaster
5. Framework for loss and future risk reduction
6. Recommendation

|  |  |
| --- | --- |
| **A** | **Basic preparation for analysis and report** |
|  | Monitor available real-time information sources and develop information according to loss and damage template (see the list of available real-time information sources as of June 2011) |
|  |  |
| **B** | **Questions to be addressed in the reports** |
| **1** | **Hazard Information** |
| 1.1 | Where? (locational information) |
| 1.2 | How big? (information on magnitude and intensity) |
| 1.3 | How often? (historical catalogues) |
| 1.4 | Confidence/uncertainty in above 3 questions |
| 1.5 | Associated effects (e.g., aftershocks) |
| 1.6 | Secondary hazards (observed or potential for) |
| **2** | **Disaster Profile** |
| 2.1 | Background |
| 2.2 | Demographic, economic, social and cultural characteristics |
| 2.3 | Geographical setting of the affected area |
| 2.4 | Significance of the affected area to the nation or region |
| 2.5 | Local and international response/relief |
| 2.6 | Governance/management style (political system, corruption, etc.) |
| 2.7 | social and policy context |
| 2.8 | At-risk groups (social vulnerability and inequality) |
| 2.9 | National disaster management structure and relevant legislation |
| 2.10 | National land use management system and relevant legislation |
| 2.11 | Historical context |
| 2.12 | Previous risk assessment studies (if available) |
| 2.13 | Previous historical events in region with indicative information |
| **3** | **Loss and Damage Analysis** (Quantitative estimates – wherever possible) |
| 3.1 | People |
| 3.2 | Fatalities/casualties |
| 3.3 | Health and healthcare impacts |
| 3.4 | Homeless (short-term); displacement (long-term) |
| 3.5 | Infrastructure |
| 3.6 | Damage to buildings and building aggregates (including debris volume) |
| 3.7 | Damage to critical facilities (schools, hospitals, ports, harbors, etc.) |
| 3.8 | Interruption to transportation, water supply, energy supply and telecommunication systems |
| 3.9 | Environment |
| 3.10 | damage to environmental protected areas |
| 3.11 | Damage to fluvial environment |
| 3.12 | Damage to ground water |
| 3.13 | Agricultural areas |
| 3.14 | Economy |
| 3.15 | Direct losses (e.g., Capital Losses) |
| 3.16 | Indirect losses (e.g., interruption of supply chains, store of production, unemployment, etc.) |
| 3.17 | Loss of economic power (e.g., long term loss of economic production GDP) |
| 3.18 | Loss of commercial and industrial earning power (e.g., loss of tax revenues) |
| 3.19 | Intangible losses |
| 3.20 | Implications for public security |
| 3.21 | Political implications/impact on institutions |
| 3.22 | Psychological implications |
| 3.23 | Loss of cultural values |
| **4** | **Evolution of Disaster** |
| 4.1 | Development of fatality numbers |
| 4.2 | Shelter needs and issues |
| 4.3 | Tents and temporary housing (Availability) |
| 4.4 | Weather impacts |
| 4.5 | Frequency of aftershocks |
| 4.6 | Aggravating social factors |
| 4.7 | Implications on intermediate and long-term housing (i.e., resettlement and reconstruction) |
| 4.8 | Historical/regional case studies and analysis |
| 4.9 | Health and healthcare impact |
| 4.10 | Vulnerable populations (age, gender, poor, social status, minorities) |
| 4.11 | Health care parameters (availability/affordability of healthcare programs, good governance) |
| 4.12 | Aggravating environmental parameters (weather, nutrition, transportation, water and sanitation, residential crowding, contamination risk) |
| 4.13 | Epidemiological parameters (mortality, baseline health status, potential for disease outbreak, chronic diseases, mental health status) |
| 4.14 | Infrastructure restoration times and socio-economic impacts |
| 4.15 | Transportation |
| 4.16 | Water |
| 4.17 | Energy |
| 4.18 | Recovery conditions and times |
| 4.19 | Disaster evolution diagrams |
| 4.20 | Cascading effects and “black Swan problems” (Taleb 2010) |

Additional:

|  |  |
| --- | --- |
| **5** | **Framework for loss and future risk reduction (FORIN Questions)** |
| 5.1 | What were understood to be the immediate, proximate causes of the disaster or the triggering natural event(s)? |
| 5.2 | Could it be forecasted or predicted? |
| 5.3 | Would early warning have helped? |
| 5.4 | Was scientific knowledge available? Implemented? Not implemented? |
| 5.5 | Effectiveness of current DRR arrangements |
| 5.6 | Disaster response capacity |
| 5.7 | Risk perception before event |
| 5.8 | Post-event societal climate (crime, looting, social coherence, solidarity, etc.) |
| 5.9 | Obstacles to disaster risk reduction (e.g., institutional vulnerability) |
| **6** | **Recommendations** |
|  | Prioritizing support and relief |
|  | Capacity building |
|  | Science needs |

1. Infrastructure for collaboration

For the CEDIM FDA task forces, an effective and lean IT-infrastructure for communication and writing is necessary. The work for CEDIM FDA is done decentralized in the institutes, where the necessary tools and software are available.

Unless no other tools are available, we will use the following:

* communication during a CEDIM FDA Task Force via the German Research Network DFN[[3]](#footnote-3) (video conference; conference calls)
* MS SharePoint
  + Internal access (with KIT ID): <https://team.kit.edu/sites/cedim>
  + External access (other mail address):   
    <https://team-extern.kit.edu/sites/cedim>; externals need to be registered by the general manager
  + Important: Usage of MS Office 2010 and higher is necessary (.docx is mandatory; doc is not synchronized); don’t use the online editing tool as it may destroy the layout of the template.
  + The SharePoint has a version archive, so don’t be frightened to irretrievably delete anything ☺
* In addition, the FDA mailing list can be used; but make sure that everyone is on the list.
* All technical systems may fail in case of a disaster in/near Karlsruhe ☺

1. References

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FORIN (2011): Forensic Investigations of Disasters, The FORIN Project, FORIN report No.1, IRDR Integrated Research on Disaster Risk, http://www.irdrinternational.org/wp-content/uploads/2011/06/FORIN\_final%20draft.pdf

Taleb, N. N. (2010): The Black Swan, Second Edition, Penguin.

1. In the FDA program, CEDIM adopts the concept of Forensic Disaster Investigations (FORIN) coined by IRDR while incorporating a real-time component to impact assessment, complementing the IRDR activities. [↑](#footnote-ref-1)
2. The Project Group Forensic Investigations of Disaster (FORIN) has been established in 2010 within the Integrated Research on Disaster Risk (IRDR). IRDR is a 10 year research program launched by the International Council for Science (ICSU), the International Social Science Council (ISSC) and the UN International Strategy for Disaster Reduction (UN-ISDR). [↑](#footnote-ref-2)
3. <https://www.vc.dfn.de> [↑](#footnote-ref-3)