

# Distributed Information Sharing for Disaster Response and Recovery: [www.VirtualDisasterViewer.com](http://www.VirtualDisasterViewer.com)

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## ABSTRACT

*A prototype geospatially-based information sharing tool for disaster response and recovery was first announced at the Sixth International Workshop on Remote Sensing for Disaster Management, Pavia, in 2008. One year on, the Virtual Disaster Viewer ([www.virtualdisasterviewer.com](http://www.virtualdisasterviewer.com)) is gathering momentum as a unique integrated visualisation and community remote sensing and GIS tool for past and future disasters. Its first foray into the disaster realm saw VDV used by a panel of international experts to provide distributed remote damage assessment following the Wenchuan, China earthquake. VDV has since been used for pre-deployment planning and in-field support, allowing instant sharing of field information to a global audience. Used also as a repository for historical data to support resilient planning and mitigation activities, VDV is evolving to meet user needs in many areas of disaster management. This paper outlines the evolution of the system to date, and gives an insight into the future challenges and the many potential uses of this exciting online system.*

## 1. INTRODUCTION

Significant populations throughout the world are prone to the effects of natural disasters, whether from hurricane events in the Atlantic and Caribbean regions, or from earthquakes along tectonic plate boundaries. Many of these catastrophes strike in remote regions of the globe as was evident from the September 2009 South Pacific tsunami, for which, at time of writing, the full extent is still unknown, but has caused in excess of 150 fatalities in American Samoa, Samoa and Tonga. Disaster managers, research scientists, NGOs and governments rely on rapid and accurate information following natural disasters to inform their response and recovery decisions. One method that has been created to provide this information is the Virtual Disaster Viewer (VDV).

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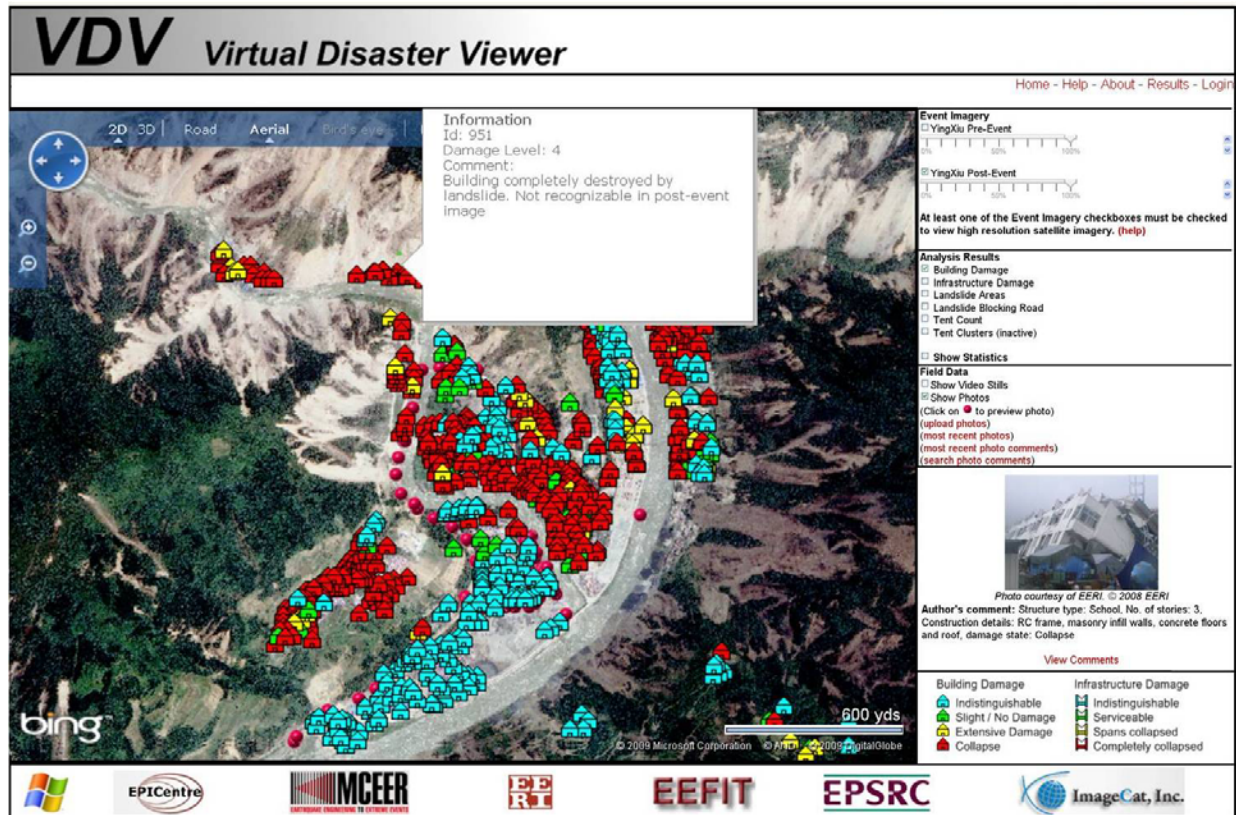


Figure 1. Browser Interface of VDV

VDV is the brainchild of an international consortium of earthquake experts and engineers from the US and UK. Its early development was in the months following the May 2008 Wenchuan, China earthquake, as a response to restrictions in access to the disaster site due to geopolitical considerations and the isolated location of the impacted area. As with any catastrophic event, there was a very real need to gather situational intelligence from the affected area for the coordination of response and recovery efforts. To facilitate this in future events, VDV was created to offer remote damage assessment from high spatial resolution pre and post-event satellite imagery stored in the system. As a community remote sensing tool, it was designed to divide the study area into a series of small grid squares for individual analysis by a panel of expert volunteers from the remote sensing and earthquake engineering communities, therefore providing a picture of the disaster area gained from an amalgamation of expert opinions. Previous *crowd-sourcing* applications have divided large processing tasks, with possibly the most famous being the search for the aviator, Steve Fossett<sup>i</sup>, and with the OpenStreetMap project<sup>ii</sup>.

Seed-funding for VDV has been attained from the UK's Engineering and Physical Sciences Research Council (EPSRC), and core members of the project team have included UK-based Earthquake Engineering Field Investigation Team (EEFIT), Earthquake and People Interaction Centre (EPICentre), the US-based Earthquake Engineering Research Institute (EERI)

and Multidisciplinary Center for Earthquake Engineering Research (MCEER), with ImageCat R&D being lead developer throughout. Funding has been sought on a per-disaster basis from research councils, which has allowed an organic evolution of the system: Initially developed for damage assessment, the evolution of VDV has been needs-driven, and functionality has been extended to include tools allowing the rapid uploading of geo-referenced data captured by field deployment teams, and also facilitating the incorporation of geo-referenced video footage.

This paper presents an outline of the key functionalities currently available in VDV. A discussion of the system in its present guise is detailed in section 3 offering an insight into potential ways in which it could be developed beyond its prototype phase in the future.

## 2. THE VDV SYSTEM

### 2.1 System architecture

The VDV system, developed by ImageCat R&D, consists of a centralized data repository that is accessed and manipulated by users through a browser-based mapping interface. On the server side, VDV is currently implemented using a WAMP (Windows/Apache/MySQL/PHP) software stack, and utilises the University of Minnesota's MapServer software for rendering satellite imagery custom to the disaster event. In the browser, the user interface is built around a Microsoft Bing Map component, with custom Javascript code for controlling interaction with the map and asynchronous communication between the server and browser.

### 2.2. Functionality: Damage Assessment

The origins of VDV are as a tool for providing remote damage assessment of a disaster through the expert interpretation of a high spatial resolution pre and post-event optical satellite image of Ying Xiu, a city affected by the Wenchuan earthquake. The study area was split into grids which were assigned to a network of volunteer experts to provide damage interpretations for several urban features tailored to their expertise: buildings, infrastructure, extent of landslides, presence of aid tents and temporary shelters. Volunteers were required to systematically analyse the geographic area within their assigned grid square to classify each feature according to pre-defined damage classes. A panel of 84 volunteers were gathered, and assigned 144 different grids, of which 73 were completed. Collation and in-depth analysis of the China damage results is due to be completed in a future phase of the project, however basic statistical results for building and infrastructure damage are shown in Tables 1 and 2 respectively.



**Figure 2. Grid-based allocation of expert analysis**

**Table 1. Percentage of identified buildings according to damage classes**

Indistinguishable	Slight/No Damage	Extensive Damage	Collapse
35.1%	8.9%	8.3%	47.7%

**Table 2. Percentage of identified infrastructure according to damage classification**

Indistinguishable	Serviceable	Spans Collapsed	Completely Collapsed
23.3%	23.3%	43.3%	10%

### 2.3 Functionality: Field Team Support

VDV was used during response to the L'Aquila, Italy Earthquake in March 2009. In preparation for deployment, EEFIT team members used the system to view the newly captured post-event Quickbird satellite imagery and prioritise their field mission to focus on the most affected cities. The funding gathered for response to this event was used to extend the functionality of the system to include a batch upload of geo-referenced photographs, providing the field teams the ability to instantaneously share their newly gathered data to the live VDV site. The site also included the functionality to allow field teams and independent experts from around the globe to comment on the photographs on the site, encouraging discourse and engagement about the event, in a message board-style format.

### 2.4 Functionality: Historical Data Repository

One of the strengths of the VDV system is the ability to customise the site based on an unfolding event. This can be achieved without altering the previous data from past events. To date, VDV has been customised for the China and Italy Earthquakes, and is also being used as an historic archive storing field data captured in the aftermath of the 1999 Izmit, Turkey earthquake, and the 2004 Hurricane Charley in Florida. Additional components have made this sharing of archive information possible: One of the newest features of VDV, GPS-enabled streaming flash video, uses the Flowplayer video player component. This component allows the VDV system to synchronize playback of a streaming video clip with an associated set of GPS points overlaid on the satellite imagery. Examples of this can be seen in the archive of Hurricane Charley data, which includes data captured in the days following the hurricane by an NSF/MCEER/TTU team using the VIEWS reconnaissance system<sup>iii</sup>. This information is currently publically available through VDV, and is currently being utilised in an ongoing NSF-funded recovery project on Charlotte County, FL.



### VIRTUAL DISASTER VIEWER (VDV)

Understanding disasters through shared knowledge

**BACKGROUND**

- VDV created after 2008 Wenchuan, China Earthquake
- Incorporates Microsoft BING functionality with pre & post event high-resolution satellite imagery
- Includes geo-referenced field images & video
- Ability to include event specific GIS layers
- Beta version customized for:
  - 2009 L'Aquila Earthquake (Italy)
  - 2008 Wenchuan Earthquake
  - 2004 Hurricane Charley (USA)
  - 1999 Izmit Earthquake (Turkey)

### DISTRIBUTED REMOTE DAMAGE ASSESSMENT

- Disaster area divided into grid cells
- Cells assigned to community of volunteer experts for analysis of damage classes
- Nearly 100 volunteers from 3 continents
- Analysis of results is ongoing

### HISTORICAL DATA LIBRARY

Field video from Hurricane Charley

- Storage of event-specific data
- Allows public dissemination of scientific results & data
- Stores maps, field images, video & comments

### FIELD TEAM SUPPORT

Field photo from L'Aquila earthquake

- VDV used to prioritize field deployments
- Ability to rapidly upload geo-referenced photos from the field
- VDV incorporates all field-collected data
- Comments facility allows specialists to share their expert knowledge

Figure 3. The evolution of VDV

### 3. DISCUSSION

The building damage scale used in VDV was based on EMS-98 building damage scale<sup>iv</sup> that was extended to include both engineering and remote sensing observations, with classes ranging from *Indistinguishable* to *Collapse* (Table 1). Early results from the damage assessment reveal a large percentage of studied features that were classified as *Indistinguishable* in the imagery. The classification scheme used required the volunteer experts to classify buildings or bridges as indistinguishable if they have changed in the interim time periods between pre and post-event images. A supervised analysis of buildings in this class suggests that many appeared to have been moved as a result of regular urban morphology rather than damaged or destroyed in the catastrophe. As a result, an additional class may be used for future damage assessment applications to avoid analyst confusion.

The volunteers who completed their allocated grids were surveyed to gather opinions of their experience of VDV as a damage assessment tool. Of the 14 respondents, most felt it was

not demanding to participate in the analysis, and 79% were impressed with the interface and overall concept of the system, with only 1 negative response. Several users provided comments for how VDV could be extended, and specific feedback was received from a number of international and local organisations who have used the system. UNOSAT, whose remote sensing technical team trialled the system, saw potential for the future use of the damage assessment in their online maps, as a way of harnessing the community aspect of remote sensing. The British Geological Survey (BGS), who were keen to share their archive data from the 1999 Izmit, Turkey Earthquake in VDV, viewed the system as a potentially very powerful tool. They see potential in the system for the establishment and promotion of best practise for data collection, and the potential for public dissemination of data from archive events has already beginning to be realised. VDV has also been chosen as a flagship project for the Community Remote Sensing plenary session in the 2010 IGARS Symposium.

The future development potential of VDV is considerable, and several priorities have been identified as some of the possible areas for improvement. Current research is focusing on the inclusion of an Expert Judgement Model, which would apply a quantified score for each volunteer, depending on their experience, expertise and the nature of the catastrophe event. Incorporating this innovation would allow the weighting of results and the identification of *super-users* who can be used to randomly validate the analysis that has taken place. To date, the results from the expert analysis have not been verified, and this is one of the immediate priorities for the next phase of funding. Additional funding is currently being sought for such enhancements, and is planned on an ad-hoc, per-disaster basis.

### **What VDV can do for you**

There is potential for VDV to be used as a field support tool for future EEFIT missions, building on the experiences of the L'Aquila earthquake, and the system is open to be used to support multiple and simultaneous field teams who are willing to share their data with the wider scientific community. At time of writing, VDV is on standby to support teams of earthquake engineers who may deploy following the recent Padang, Sumatra earthquake and the Samoan Islands tsunami events. Opportunities exist to extend the reach of the system and bring together the disaster community using this web-portal: VDV can provide a repository and community discussion forum for new data and the plethora of underutilised archive data collected after previous disaster events currently stored on CDs and hard drives in many scientific offices. VDV can disseminate your information and facilitate a new understanding of disasters through shared knowledge.

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#### 4. SUMMARY

VDV, as a first stage prototype, has had a solid start to its career as a disaster management tool. Further enhancements should be made in the next phases of development to improve the information provided by the system. VDV needs greater publicity for future usage, not only as a rapid field response tool, but also for use as a data sharing mechanism and historic repository of information. It has strong potential scope within disaster management arenas beyond traditional remote sensing and earthquake engineering fields, both to synthesise and integrate data from social scientists, planners and architects, and also to leverage the power of professional social network tools to generate partnerships for the future advancement of VDV as a community remote sensing tool.

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#### REFERENCES

<sup>i</sup> <http://www.stevfossett.com/>

<sup>ii</sup> <http://www.openstreetmap.org/>

<sup>iii</sup> Adams, B.J., Womble, J.A., Mio, M.Z., Turner, J.B., Mehta, K.C., Ghosh, S. (2004) Collection Of Satellite-Referenced Building Damage Information In The Aftermath Of Hurricane Charley. *MCEER/NHRAIC Response Report*. <http://mceer.buffalo.edu/research/Reconnaissance/Charley8-13-04/04-SP04.pdf>

<sup>iv</sup> Grünthal, G. (Ed.) (1998) *European Macroseismic Scale 1998 (EMS-98)*. European Seismological Commission, subcommission on Engineering Seismology, working Group Macroseismic Scales. Conseil de l'Europe, Cahiers du Centre Européen de Géodynamique et de Séismologie, Vol. 15, Luxembourg. <http://www.gfz-potsdam.de/portal/-?§part=binary-content&id=1883158&status=300>

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