# Design and Implementation of a Global Earthquake Disaster Alert System

**LI Yigang Zhang Yuan DU Xiaoxia SHANG Hong**

*National Earthquake Response Support Service*
*Email:Liyig@263.net*

**ABSTRACT:**

This paper describes the design and Implementation of a global earthquake disaster alert system (GEDAS), including the framework, the GIS database, the assessment models and the software modules. The framework of this system is introduced first, including the location of alert in the whole earthquake disaster response process and mainly components of GEDAS. The global scale data used by the system, such as VMAP0, GeoCover and Landscan, is introduced in detail. The core assessment models, including casualty alert model, tsunami alert model, are described in detail. As to the software, the whole workflow and the function of each model are introduced briefly. The sample alert report and webpage that created by GEDAS is also given in this paper.

**KEY WORDS:**

Global Earthquake Disaster, Alert Model, Software system

## 1. INTRODUCTION

Earthquake and earthquake induced disasters, such as the heavily damaged South Asia earthquake in 2005 and the 8.0 magnitude Wenchuan earthquake in 2008, caused huge economic loss and casualty. Earthquake disasters are becoming the mainly part of catastrophes recently. Although earthquake can not be predicted exactly until now, we can get the magnitude and location for a certain earthquake event quickly after it occurred based on the earthquake monitoring network. An earthquake disaster alert system can give a quick estimation of the probable impact and trigger a reasonable emergency response based on the earthquake information and local data. Quick response for a disaster event can effectively reduce casualty and economic loss. GDACS（Global Disaster Alert Coordination System）and PAGER (Prompt Assessment of Global Earthquakes for Response) are such alert systems (Martin,2004,2005;USGS,2005). GDACS gave alert assessment of earthquake, flood, cyclone and lots of local information to ECHO and UN since 2003. PAGER is specified for earthquake distaste, but gives more professional information.

CISAR (China International Search and Rescue Team), an international disaster aid team, was established in 2001 and took part in the Algeria, Iran and Pakistan earthquake rescue deployments after it was established. From the three deployments, an information support and alert software system is found to be important for quick and effective rescue. In 2005, we started to develop a Global Earthquake Disaster Alert System (GEDAS) for CISAR and the international relief affairs. GEDAS is some kind of GDACS software, such as the base data and alert model used in these systems are same. But earthquake is the only disaster event managed in GEDAS and GEDAS give more detail information about the influence area such as historical earthquake and cities around the epicenter. This paper describes the design and Implementation of GEDAS, including the Concept framework, the database, the analysis models and the software developing.

## 2. THE FRAMWORK OF GEDAS

Alert is the first step in the whole disaster information support process. A success alert needs to give casualty estimation, economic loss, disaster trend analysis and emergency response advices after the disaster event as soon as possible. Fig.1 is the picture of the whole information cycle of earthquake emergency response process. The alert must be given in one hour or shorter after the earthquake event to unfold a timely emergency response.

The GEDAS application framework includes three core parts, which are information acquiring, alert level assessment and information sending (Fig.2). Earthquake information can be got directly from monitoring stations and NEIC'S global earthquake list service (Finger). The information processing and alert assessment is the core part of GEDAS. Based on the global database and compute models, GEDAS can give a quick casualty estimation, alert level assessment and information around the epicenter. The alert information is sent to CISAR, NERSS and other related organizations by web pages, email and SMS&MMS.

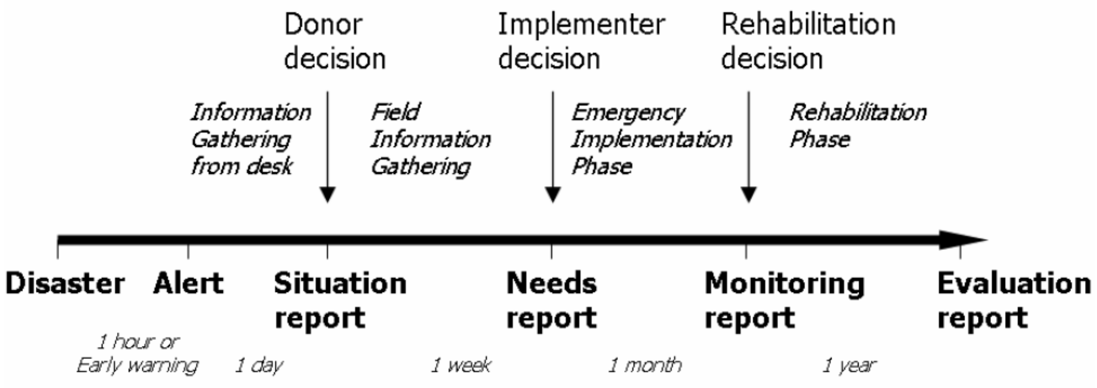



Fig.1 Information cycle of earthquake emergency response process (IPSC, 2005)

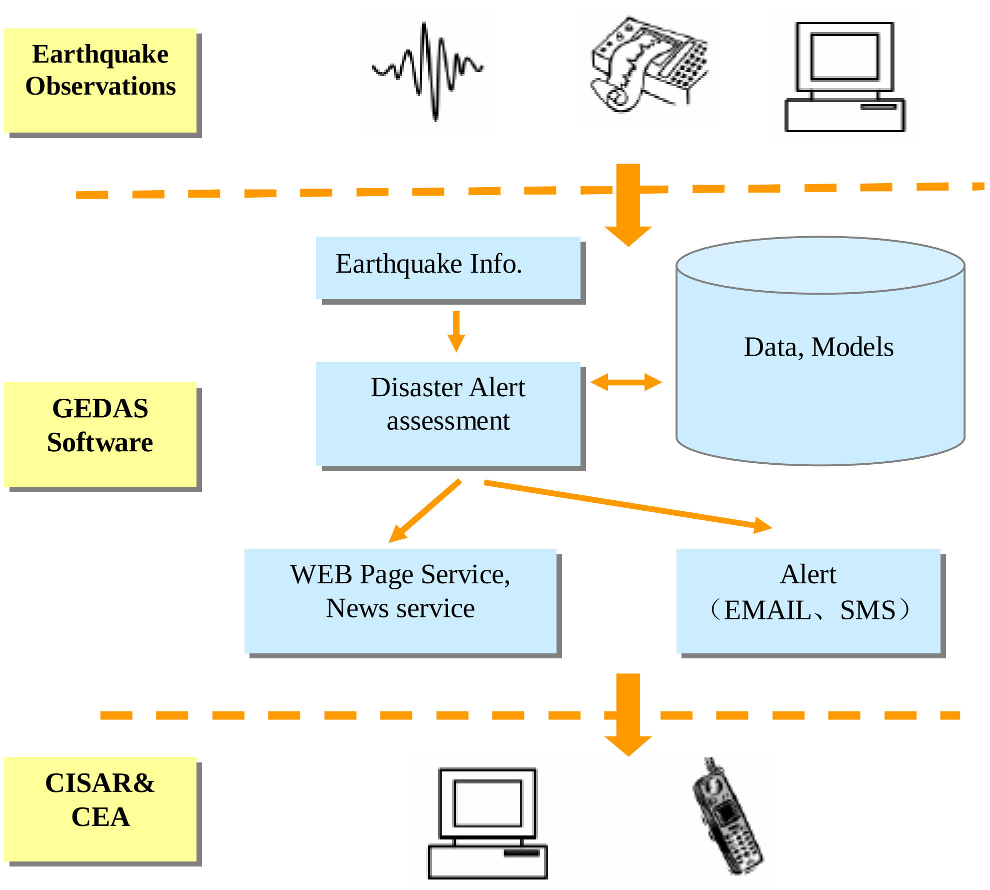



Fig.2 Application framework of the global earthquake disaster alert system (GEDAS)

Database, models and software are the mainly components of GEDAS software. A global database was established during 2006 to 2007 and most of the data can be found on internet for freely non-commercial use. We use the same population data that used by GDACS and PAGER and the version is landscan 2001. The basic map making data we used are VMAP0 and Geocover 2000 and other GIS-based vector and grid data such as GOTOP30, SRTM and historical earthquake. The alert assessment models we used in GEDAS are developed upon Chinese seismologist's research and We have a casualty assessment model and a tsunami assessment model so far. These models are empirical and use experience decision flow to give the alert result with the input parameters of magnitude, depth and population. The software was developed on the ArcGIS developing platform, it has a user interface for system setup and can minimize to the system bar and monitoring the earthquake information, assess the alert level and send the alert message automatically.

## 3. THE GEDAS DATABASE

### *3.1 The Fundamental Geographic Data*

Vector Map Level 0 (VMap0) is an updated and improved version of the National Imagery and Mapping Agency's (NIMA) Digital Chart of the World (DCW). VMap0 database provides worldwide coverage of vector-based geospatial data which can be viewed at 1:1,000,000 scale. It consists of geographic, attribute, and textual data. VMap0 includes major road and rail networks, hydrologic drainage systems, utility networks (cross-country pipelines and communication lines), major airports, elevation contours, coastlines, international boundaries and populated places. VMap0 is divided into four parts.VMAP0 are transformed from VPF format to ArcGIS Geodatabase and used as the background for loss estimation and map making in GEDAS.

The Landsat GeoCover dataset is a collection of high resolution satellite imagery provided in a standardized, orthorectified format, covering the entire land surface of the world (except Antarctica). The GeoCover 2000 mosaics are segmented into tiles of approximately 250,000 square kilometers. Each tile covers five degrees of latitude in a UTM zone, which is 6 degrees of longitude. In GEDAS, the MrSid format GeoCover data are managed by using an index vector layer and used as background for loss estimation and also for map making and 3D visualization.

### *3.2 The Population Data*

Oak Ridge National Laboratory(ORNL)'s Global Population Project, part of a larger global database effort called LandScan (Fig.5), collects best available census counts (usually at province level) for each country, calculates a probability coefficient for each cell, and applies the coefficients to the census counts which are employed as control totals for appropriate areas (usually provinces).The probability coefficient is based on slope, proximity to roads, land cover, nighttime lights, and an urban density factor. GIS is essential for conflation of diverse input variables, computation of probability coefficients, and allocation of population to cells, and reconciliation of cell totals with aggregate (usually province) control totals. Remote sensing is an essential source of two input variables-land cover and nighttime lights-and one ancillary database-high-resolution panchromatic imagery-used in verification and validation (V&V) of the population model and resulting LandScan database. Until now, Lanscan is the best population database for disaster estimation. In GEDAS, Landscan is a core database and used as base input for casualty and economic loss estimation.

### *3.3 Other data and map sample*

Other data, Such as SRTM DEM data, GDP data, historical earthquake data, GeoName data, are also parts of the GEDAS database, used mainly for map making and disaster influence estimation. Fig.3 is a sample map that made by GEDAS automatically about 30 minutes after the earthquake occurred.

## 4. ALERT ASSESSMENT MODELS

When a strong earthquake occurred, what the Chinese government, CISAR or other international humanitarian organization want to know is the scale of the disaster and the rough number of casualties at the first beginning. When we start developing GEDAS in 2006, we hope to use numerical models that developed by Chinese seismologists to give a prediction of casualties and economic loss. Because the lack of attenuation models and the predication models are only based on earthquake disasters occurred in China, we found that it is difficult to apply the numerical models globally. In 2007, we began to develop an empirical model to give a casualty level assessment based on earthquake magnitude, depth and population around the epicenter. A similar tsunami alert assessment model was also developed in case that the earthquake occurred in sea area.

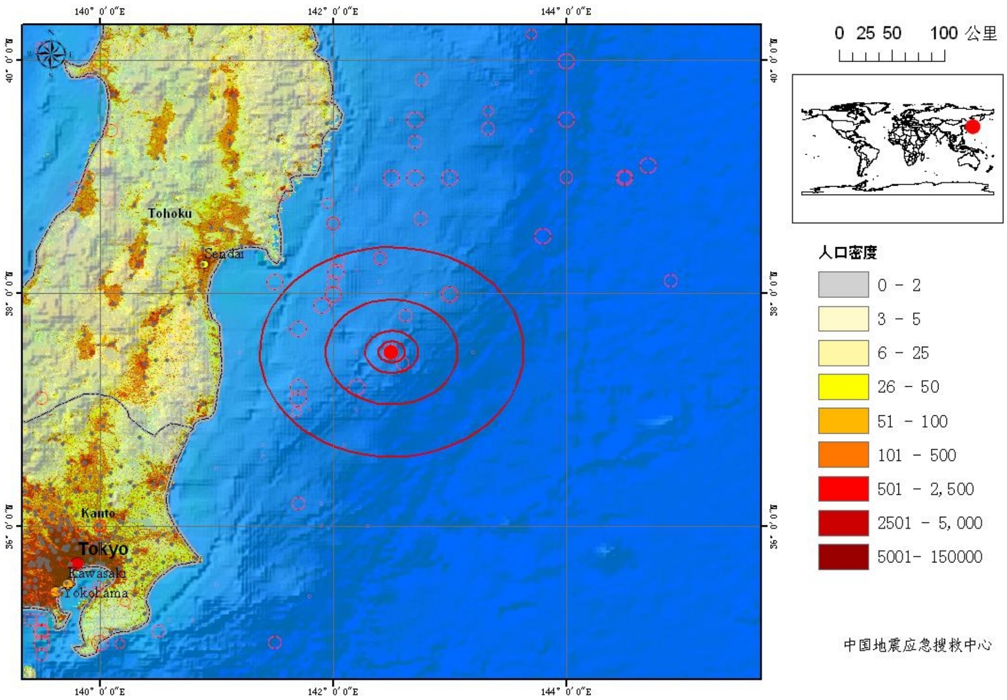



Fig.3 a sample alert map that made by GEDAS automatically

### *4.1 Casualty assessment model*

Our alert assessment model in GEDAS is based on casualty estimation. The estimation model we used was developed upon GDACS's alert assessment model and our own experience. It is a empirical analysis flow model which includes magnitude, source depth and population around the epicenter as input parameters. It is difficult to decide the population within how large area should be considered as the input parameters. Based on a few case tests, we decide to use population within 100 kilometer as the input parameters. As the analysis flow showed in fig.4, the disaster scale or the alert was divided into four levels: A.Blue Alert, No casualties will be caused by the earthquake; B.Green Alert, Some casualties will caused by the earthquake; C.Orange Alert, Lots of people will die because of the earthquake; D.Red Alert, The earthquake will caused a catastrophe.

### *4.2 Tsunami assessment model*

The scale description of tsunami alert model is similar to the disaster alert model, but the input parameters are magnitude and sea water depth. We develop this model based on some rough study which shows that the tsunami caused by earthquake has a strong relationship with the two parameters we used. Some research also shows that tsunami occurred in certain sea area, but because we have no statistic data so far, we use a simple model to assess if a tsunami will happen. The four tsunami alert levels are as following: A.Blue alert, tsunami will not happen; B.Green alert, the probability of a tsunami is very low; C.Orange alert, a tsunami will probably happen, but will not cause destroy; D.Red alert, a ruinous tsunami will probably happen.(fig.5)

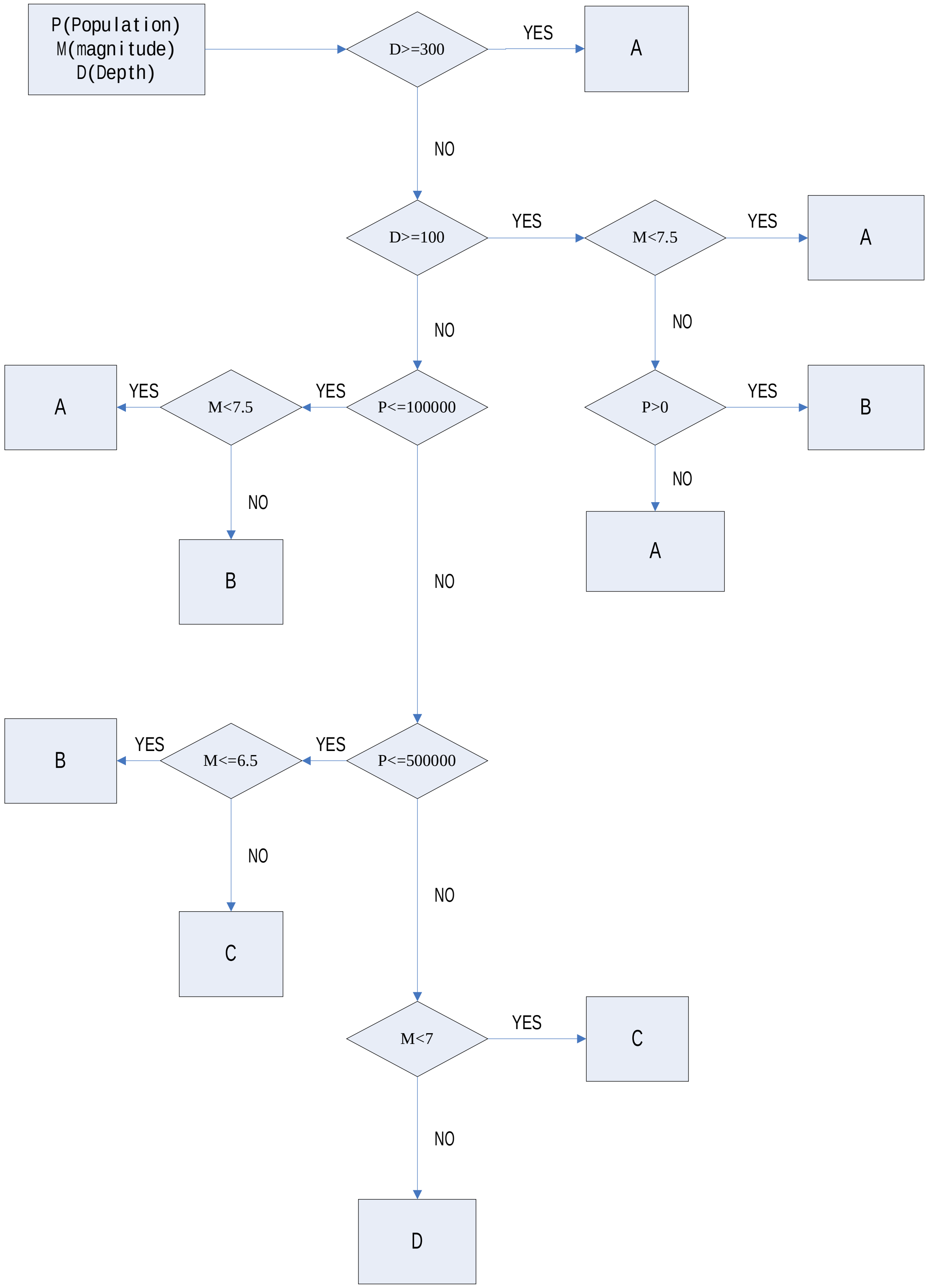



Fig.4 the empirical casualty assessment model used by GEDAS

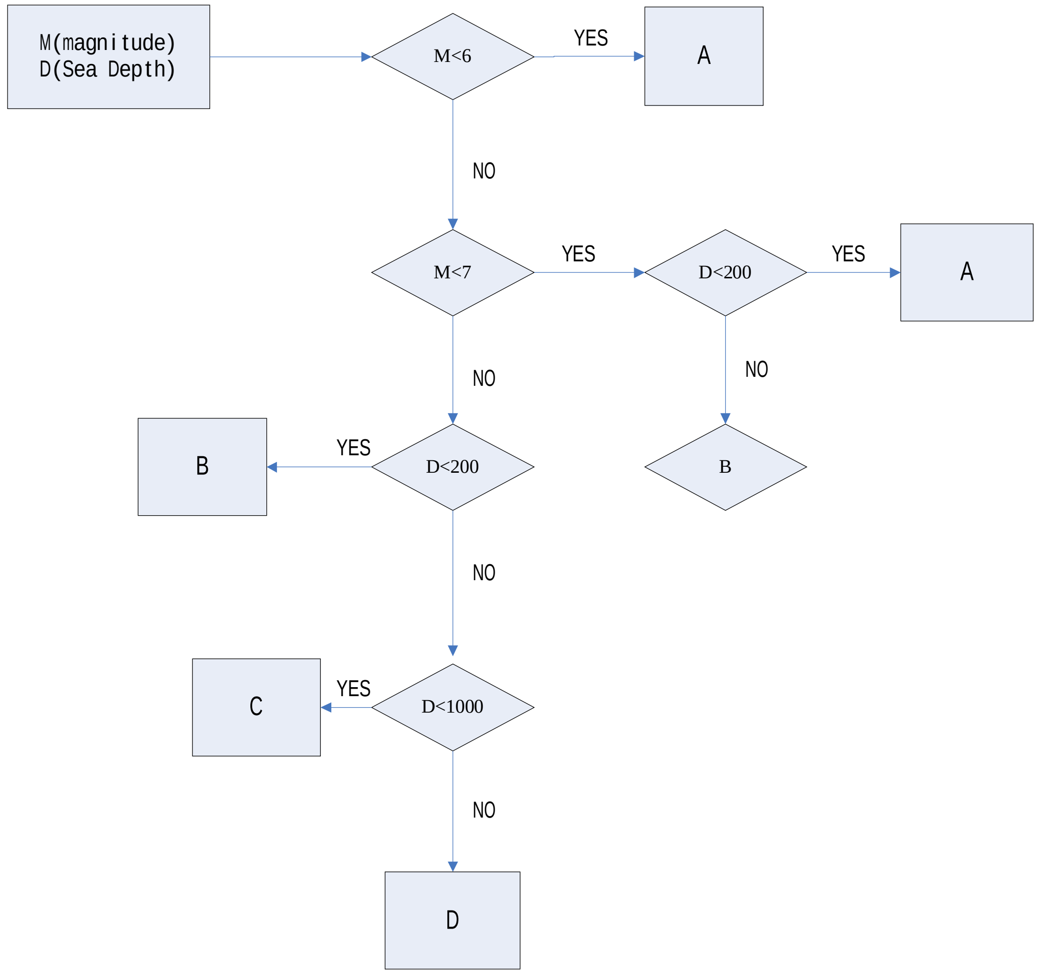



Fig.5 the empirical tsunami assessment model used by GEDAS

## 5. THE GDEAS SOFTWARE

The GEDAS software is developed on ArcGIS 9.x. Fig.6 is the sketch of the modules and the workflow. The software modules includes parameters input module, alert assessment model, map making and alert report creating model, alert releasing module.

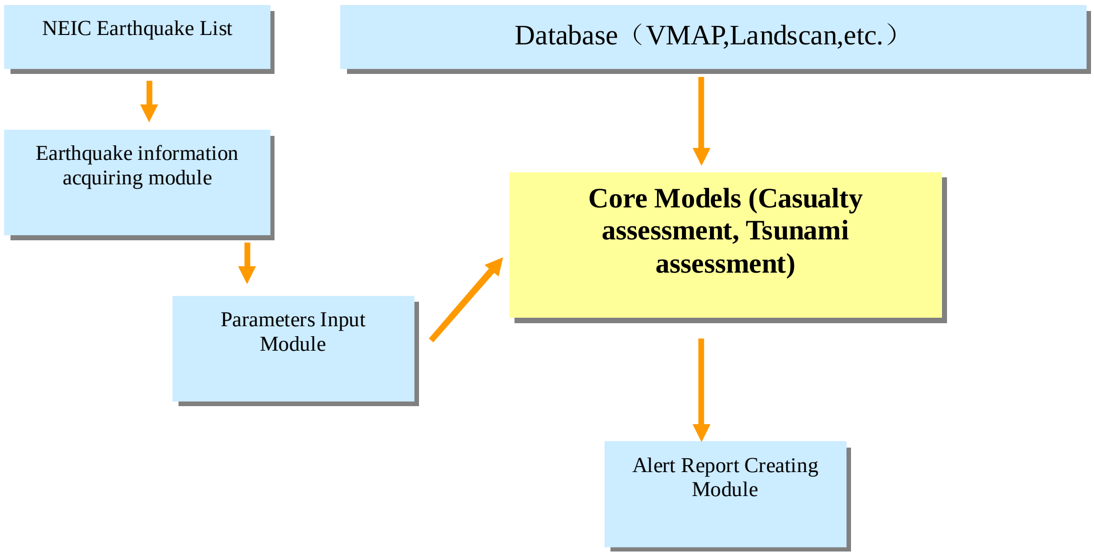
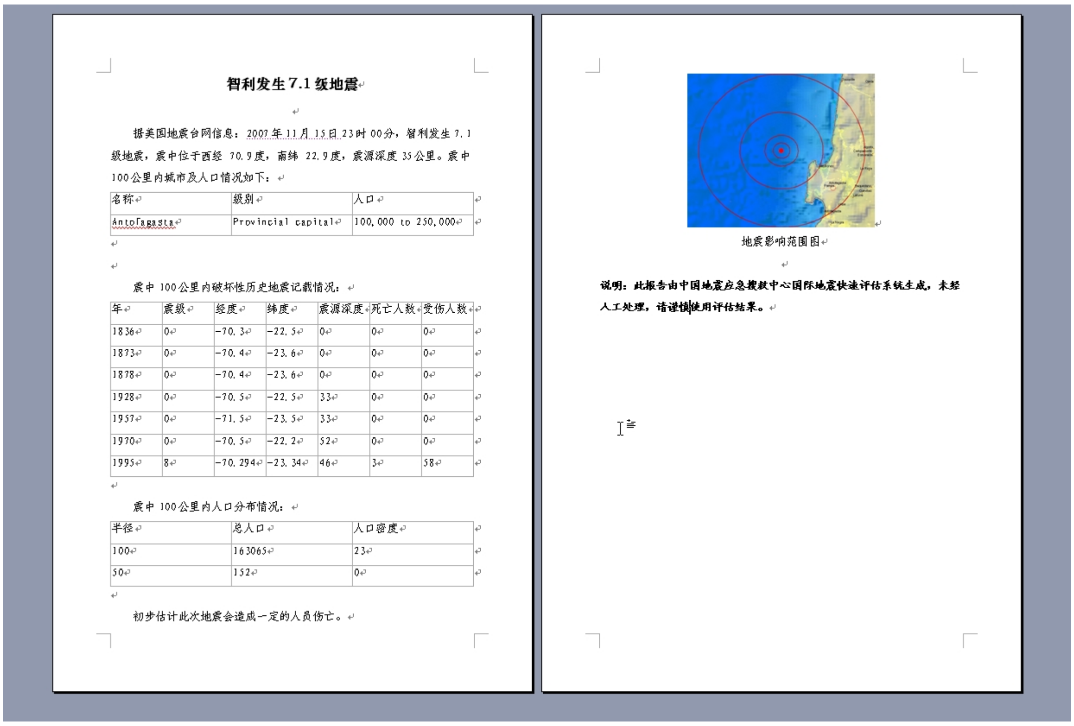



Fig.6 Modules of the global earthquake disaster alert software

The earthquake information can be got automated or by hand from the NEIC website. The core assessment models will compute the earthquake affected field first and get the population within 100 kilometers by using the zonal analysis function supplied by ArcGIS. As to the tsunami assessment model, the sea depth is acquired from the ETOPO2 data. The alert report and SMS&MMS message are created by GEDAS automatically in a routine format. The report also has information about settlements, historical earthquake and population statics which are got by spatial analysis. A website is still in construction but it can already supply alert information of earthquakes occurred globally whose magnitude is larger than 6.



智利发生 7.1 级地震

据美国地震台网信息：2007 年 11 月 15 日 23 时 00 分，智利发生 7.1 级地震，震中位于西经 70.9 度，南纬 22.9 度，震源深度 35 公里。震中 100 公里内城市及人口情况如下：

| 名称 | 级别 | 人口 |
|---|---|---|
| Antofagasta | Provincial capital | 100,000 to 250,000 |

震中 100 公里内破坏性历史地震记载情况：

| 年 | 震级 | 经度 | 纬度 | 震源深度 | 死亡人数 | 受伤人数 |
|---|---|---|---|---|---|---|
| 1836 | 0 | -70.3 | -22.5 | 0 | 0 | 0 |
| 1873 | 0 | -70.4 | -23.6 | 0 | 0 | 0 |
| 1878 | 0 | -70.4 | -23.6 | 0 | 0 | 0 |
| 1928 | 0 | -70.5 | -22.5 | 33 | 0 | 0 |
| 1957 | 0 | -71.5 | -23.5 | 33 | 0 | 0 |
| 1970 | 0 | -70.5 | -22.2 | 52 | 0 | 0 |
| 1995 | 8 | -70.294 | -23.34 | 46 | 3 | 58 |

震中 100 公里内人口分布情况：

| 半径 | 总人口 | 人口密度 |
|---|---|---|
| 100 | 163065 | 23 |
| 50 | 152 | 0 |

初步估计此次地震会造成一定的人员伤亡。

地震影响范围图

说明：此报告由中国地震应急搜救中心国际地震快速评估系统生成，未经人工处理，请谨慎使用评估结果。

Fig.7 A sample alert report that created by GEDAS automatically

GEDAS
GLOBALEARTHQUAKEDISASTERALERTSYSTEM
国际地震灾害预警系统
GUO JI DI ZHEN ZAI HAI YU JING XI TONG

首 页 | 地震事件中心 | 手动记录 | 帮 助 | 关 于

欢迎访问本站点， 当前位置：NEDAS >> 地震事件中心， 页面最新读取时间：07月29日 16时19分。

地震事件总览
近期地震事件分布
事件分类查看
按年度顺序查看
2008年度
按震级分类查看
震级M 6+
震级M 7+

近期的所有地震事件

1 2

| 震级 | 发布日期 | 地震编号 | 发震区域 | 震源深度 | |
|---|---|---|---|---|---|
| 6.1 | 2008-7-29 5:40:53 | us2008vabe | Solomon Islands | 52.8 | 选择 |
| 6.1 | 2008-7-29 5:37:37 | at00728105 | Solomon Islands | 41 | 选择 |
| 6.3 | 2008-7-24 9:43:18 | at00686379 | Kuril Islands | 48 | 选择 |
| 6.8 | 2008-7-23 23:26:20 | us2008uva4 | eastern Honshu, Japan | 111.7 | 选择 |
| 6.1 | 2008-7-21 19:30:31 | us2008utaj | off the east coast of Honshu, Japan | 33.7 | 选择 |
| 6.4 | 2008-7-20 6:39:53 | us2008urb9 | Fiji region | 396 | 选择 |
| 6.3 | 2008-7-19 19:01:22 | us2008ura4 | Santa Cruz Islands region | 43.1 | 选择 |
| 6.7 | 2008-7-19 17:27:05 | us2008uraw | Santa Cruz Islands region | 39.9 | 选择 |
| 7 | 2008-7-19 10:39:30 | us2008urah | off the east coast of Honshu, Japan | 27 | 选择 |
| 6.1 | 2008-7-13 22:58:32 | us2008ukay | Taiwan region | 10 | 选择 |

1 2

NERSS,技术部

Fig.8 The alert Website which is still in countruuction

## 6. CONCLUSION

This paper described the design and software implementation of a global earthquake disaster alert system, including the framework, GIS database, assessment models and software modules. This software system already supply information and decision support in CISAR's international rescue work. and national emergency response. It can also supply information to the international relief community in the future.

The GEDAS software is still in developing, and the assessment model is still rough now. Because the lack of more scientific attenuation model as shakemap and predication model thinking about the building's vulnerability, we can't give more exact information such as the heavily damaged county which is very useful for search and rescue, this is a big problem especially in Wenchuan earthquake. More works, such as the detail assessment models and alert release module are still need to be accomplished.

## REFENERENCE

IPSC. Global disaster alert system[M]. JRC, 2005

Martin Jacobson. Asgard system design[M]. IPSC, 2004

Martin Jacobson. Asgard system description[M]. IPSC, 2005

USGS, PAGER-Prompt Assessment of Global Earthquakes for Response, http://pubs.usgs.gov/fs/2005/3026/, 2005, 3