United States Department of the Interior

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Memorandum

DATE: September 29, 2008
TO: Peter Morris, USAID Cognizant Technical Officer
Greg Gottlieb, USAID Agreement Officer
FROM: Barbara Bogaert
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SUBJECT: Technical Progress Report for Interagency Agreement FDAP00040006500

AGENCY: U.S. Geological Survey
PROJECT NAME: PAGER: Improvements to an Automatic System to Estimate Human Impact Following Significant Earthquakes Worldwide.
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AWARD NUMBER: FDA-P-00-04-00065-00
ACTIVITY NUMBER: 961-001
USAID Cognizant Technical Officer: Peter Morris

PAGER FY2008 End-of-year Status Report for USAID/OFDA proposal:
Prompt Assessment of Global Earthquakes for Response (PAGER):
Improvements to an Automatic System to Estimate Human Impact Following Significant Earthquakes Worldwide.

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Overview:
PAGER development continues at a rapid pace and the goals of the USAID proposal are being addressed. The proposal consists of three main improvements to the PAGER system 1) development and implementation of an intuitive "Earthquake Impact Scale" based on the likelihood of societal impact following significant earthquakes, 2) development of blackberry/PDA compatible PAGER content, and 3) development of a prototype system that distributes lists of critical infrastructure that experienced severe shaking.

This report documents progress on the three deliverables for this two-year proposal and other PAGER successes.

Earthquake Impact Scale:
PAGER currently reports the population exposed to different levels of shaking intensity and distributes maps showing the regions affected by severe shaking. PAGER's current output is useful to assess the impact of an earthquake but a succinct scale describing the overall impact (e.g. green, yellow, and red) would aid interpretation of the results. A major step towards this goal is the development of models to estimate the number of people killed, injured, and displaced by a significant earthquake. The required

components to create these models and an earthquake impact scale are 1) an assessment of user needs and capabilities, 2) improved ability to estimate ground shaking, 3) compilation of databases for model development and calibration, 4) development and testing of earthquake loss algorithms and 5) creation of an impact scale. The work completed in FY08 towards these goals include:

- A database of global building inventory and vulnerability has been compiled in cooperation with the Earthquake Engineering Research Institute (EERI). The database contains i) global building inventory distribution, ii) corresponding expert-opinion-based vulnerability functions for each building type, and iii) analytically-based vulnerability functions for building types outside of the US.

- To improve our estimates of earthquake induced ground shaking, we have completed, documented, and implemented a new approach for generating topographic-based Global Site Condition Maps. These data are publically available on the USGS Earthquake Program Web pages.

- The PAGER team has compiled an extensive global earthquake database for loss model development and calibration that combines accurate seismological parameters with reported fatality, injuries, and the occurrence of secondary effects (e.g., landslides, tsunami, and fire).

- An atlas of 5,000 ShakeMaps has been created and shared with USAID. The atlas contains maps of ground shaking for all significant earthquakes since 1973 and can be used for earthquake scenario planning and loss model development.

- We completed a comparative study quantifying the relative importance of secondary effects (including fire, landslide, tsunami, liquefaction, etc.) on overall earthquake impact as a function of region. The study guides future PAGER priorities and quantifies secondary effects for regionally-specific comments included in the current PAGER alerts.

- We held a PAGER users feedback workshop in Golden on Feb 28th, 2008 for developing an earthquake impact scale and improving other useful PAGER alert content. Attendees including USAID (OFDA), USGS, FEMA, World Bank, and NORTHCOM. Based in part on feedback, the PAGER 1-PAGE summary was re-engineered and ideas for a summary earthquake impact scale were compiled.

- Three prototype fatality estimation models have been developed and implemented in a robust operational system. The fatality estimates are now being automatically produced shortly after significant earthquakes and the results are being evaluated internally and when deemed robust the estimates will be shared with USAID.

Critical infrastructure based alerts:
We have acquired the necessary hardware and installed the software (ShakeCast) to distribute prototype infrastructure based alerts. The final steps needed to distribute infrastructure based alerts are the identification and acquisition of the necessary databases and configuration of the system. These steps were discussed during a conference call with the PAGER principal investigators (David Wald and Paul Earle), the OFDA-USGS Geoscience Advisor (Gari Mayberry) and the OFDA GIS coordinator (Nate Smith) on July 17th. Several possible databases were discussed to use for critical infrastructure based alerts. Nate Smith will look into getting the locations of US consulates and embassies and Gari Mayberry is working to obtain a database of health and safety facilities. Once obtained, the databases will be added

to an implementation of the ShakeCast system and infrastructure based alerts will be sent to a test group of users.

PDA access:
The problem of access to PAGER results using the OFDA duty officer's blackberry was clarified during the July 17th conference call. We discussed several solutions that we will explore internally before implementing for OFDA.

PAGER successes
We send more PAGER alerts to USAID/OFDA than any other agency. Currently, alerts are sent to 29 USAID recipients including the OFDA duty officer. Other agencies that receive PAGER alerts include the White House, State Department, National Security Council, Thompson-Reuters, the United Nations, Mercy Corps, NorthCom, SouthCom, and the World Bank.

So far, PAGER alerts have been created for 450 events in 2008. The most notable was the May 12th, 2008 Wechuan, China Earthquake. This earthquake was the first catastrophic earthquake to occur since the Oct. 2007 public release of the PAGER system. Thirty minutes after the earthquake, exposure estimates were sent to USAID that indicated 1.2 million people were exposed to Intensity VIII or greater shaking. Exposure to this level of shaking in China, where infrastructure is known to be vulnerable, is a clear sign of a disaster. A follow up phone call was made to the USGS/OFDA liaison to verify the message was received and implications were understood. Over the next 12 hours, several refinements were made to ShakeMap's ground shaking estimates based on an increasing knowledge of the fault geometry. These refinements showed the shaking extended northeast of the epicenter for about 200 km and updated PAGER exposure estimates indicated over 5 million people were exposed to Intensity VIII or greater (see attached PAGER figures, one 30 minutes after the earthquake and the second 14 hours after the earthquake).

Planned work for FY2009
The USGS plans to continue work on the three tasks described in the two year USAID proposal. Specifically, 1) development of blackberry/PDA customized alerts, 2) development of customized infrastructure based alerts, and 3) development of an Earthquake Impact Scale. Addressing task #1, the PAGER group recently hired a web-programmer to help improve PAGER and related web pages. Task #2, implementation of infrastructure-based alerts, will rely on the USGS ShakeCast system. Computer hardware to run ShakeCast has been set up and application expertise exists within the PAGER team. We will continue to work with USAID/OFDA to obtain the desired databases. Task #3, defining and implementing the Earthquake Impact scale, involves further research and development of our fatality estimation models and coordination with USAID on the presentation of the results. The fatality estimates currently being generated by the prototype system will be evaluated and refined. Analysis will also include uncertainty evaluation as well as developing approaches to portray the uncertainty in the fatality estimates.

Selected recent PAGER related references
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Allen, T. I., K. D. Marano, et al. (2008a). "PAGER-CAT: A composite global earthquake catalogue for casualty estimation." Seism. Res. Lett. in review.

Earle, P. S., D. J. Wald, T.I. Allen, K.S. Jaiswal, K.A. Porter, and M.G. Hearne (2008). Rapid Exposure And Loss Estimates For The May 12, 2008 Mw 7.9 Wenchuan Earthquake Provided By The U.S. Geological Survey's Pager System, *Proc. 14th World Conf. Earth. Eng.*, Beijing, China.

Earle, P. S. and D. J. Wald (2007). "Helping solve a worldwide problem—rapidly estimating the impact of an earthquake: PAGER (Prompt Assessment of Global Earthquakes for Response)." U. S. Geological Survey, Fact Sheet 2007-3101: 4 pp.

Jaiswal, K. S., and D. J. Wald (2008). Creating a global building inventory for earthquake loss assessment and risk management. *U.S.G.S. Open File Report* 2008-1160, pp 109.

Jaiswal, K., and D.J. Wald (2008). Creating Global building inventory for earthquake loss estimation and risk management, *Proc. 14th World Conf. Earth. Eng.*, Beijing, China.

Marano, K. D., D. J. Wald, et al. (2008). "Global Earthquake Casualties due to Secondary Effects: A Quantitative Analysis for Improving PAGER Losses." *Natural Hazards*, submitted.

Porter, K.A., Jaiswal, K.S., Wald, D.J., Greene, M., and C. Comartin (2008). WHE-PAGER Project: A new initiative in estimation global building inventory and its seismic vulnerability, *Proc. 14th World Conf. Earth. Eng.*, Beijing, China.

Porter, K. A., M. Greene, et al. (2008). WHE-PAGER project: A new initiative in estimating global building inventory and its seismic vulnerability, *Proc. 14th World Conf. Earth. Eng.*, Beijing, China.

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Wald, D. J., P. S. Earle, et al. (2008). Development of the U.S. Geological Survey's Prompt Assessment of Global Earthquakes for Response (PAGER) System. 31st General Assembly of the European Seismological Commission ESC 2008. Hersonissos, Crete, Greece.

Wald, D.J, P.S. Earle, K. Porter, K. Jaiswal, and T.I. Allen (2008). Development of the U.S. Geological Survey's Prompt Assessment of Global Earthquakes for Response (PAGER) System, *Proc. 14th World Conf. Earth. Eng.*, Beijing, China.

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GSN USAID FROM THE AMERICAN PEOPLE

M 7.5, EASTERN SICHUAN, CHINA

Origin Time: Mon 2008-05-12 06:28:00 UTC
Location: 31.08°N 103.27°E Depth: 10 km

PAGER
Version 1
Created: 30 mins, 54 secs after earthquake

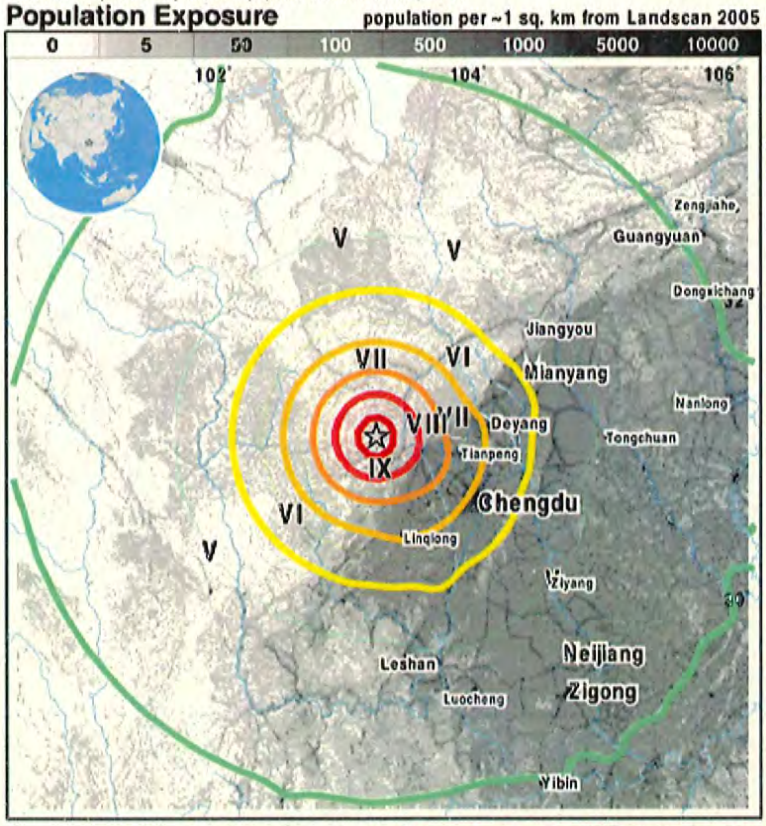
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		--*	--*	8,827k*	42,892k	10,123k	3,567k	1,072k	86k	21k
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landscan 2005



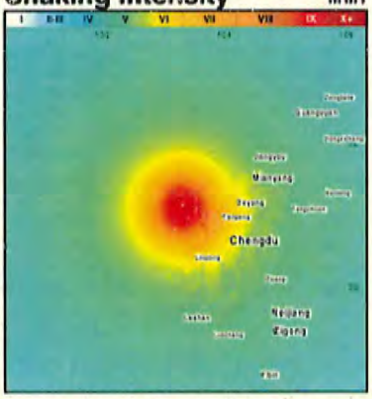
Selected City Exposure

MMI	City	Population
VII	Tianpeng	60k
VII	Linqiong	55k
VI	Chengdu	3,950k
VI	Deyang	152k
V	Jiangyou	127k
V	Mianyang	264k
V	Ziyang	87k
V	Neijiang	546k
V	Zigong	689k
V	Nanchong	7,150k
IV	Yibin	242k

bold cities appear on map (k = x1000)

Shaking Intensity

MMI



Users should consider the preliminary nature of this information and check for updates as additional data becomes available. Population exposure estimates are NOT a direct estimate of earthquake damage; comparable shaking will result in significantly lower losses in regions with well built structures than in regions with vulnerable structures.

This information was automatically generated and has not been reviewed by a seismologist.

USGS
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GSN USAID FROM THE AMERICAN PEOPLE

M 7.9, EASTERN SICHUAN, CHINA

Origin Time: Mon 2008-05-12 06:28:00 UTC
Location: 31.10°N 103.28°E Depth: 10 km

PAGER
Version 6
Created: 14 hrs, 56 mins after earthquake

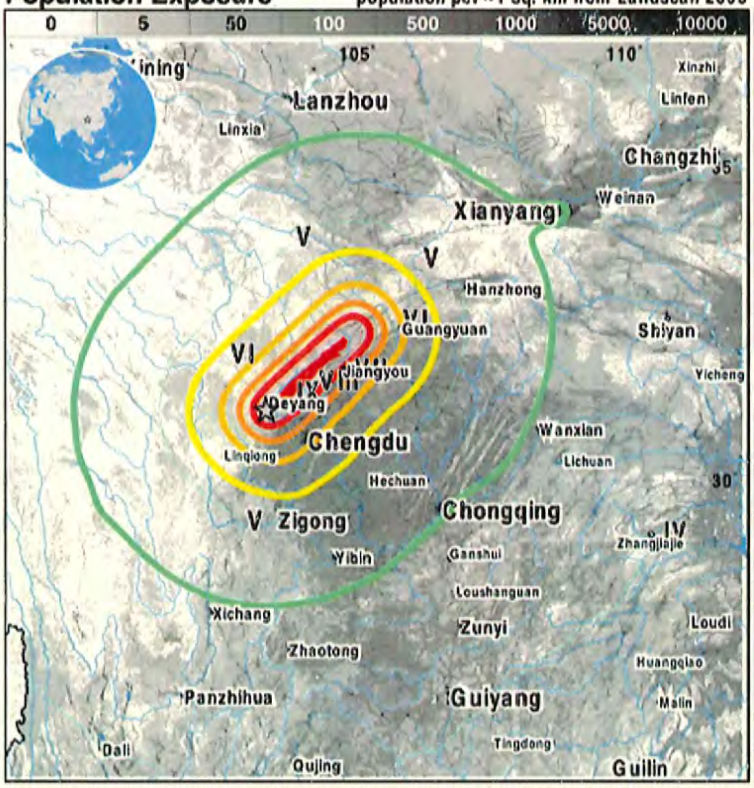
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		--*	--*	181,513k*	89,747k	15,409k	12,351k	3,962k	668k	606k
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landscan 2005



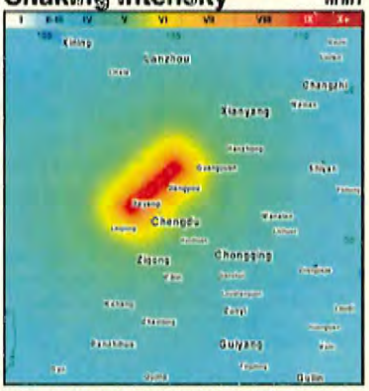
Selected City Exposure

MMI	City	Population
VIII	Jiangyou	127k
VIII	Tianpeng	60k
VII	Deyang	152k
VII	Lingjiong	55k
VII	Mianyang	264k
VII	Chengdu	3,950k
VII	Guangyuan	213k
V	Nanchong	7,150k
V	Chongqing	3,967k
IV	Lanzhou	3,200k
IV	Shiyan	3,460k

bold cities appear on map (k = x1000)

Shaking Intensity

MMI



Overall, structures in this region are vulnerable to earthquake shaking, though some resistant structures exist. A magnitude 6.4 earthquake struck the Sichuan, China region on August 23, 1976 (UTC), with estimated population exposures of 1,500 at intensity IX or greater and 5,700 at intensity VIII, resulting in 41 deaths. Additionally, a magnitude 7.3 struck this region in 1933 killing 6,800 people. Recent earthquakes in this area have also triggered landslide hazards that have contributed to losses. Users should consider the preliminary nature of this information and check for updates as additional data becomes available.

This information was automatically generated and has not been reviewed by a seismologist.