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EUCENTRE AND SEISMIC EMERGENCY: IN SITU SUPPORT ACTIVITIES AFTER THE CENTRAL ITALY EARTHQUAKE

Chiara CASAROTTI[1], Alberto PAVESE[2], Simone PELOSO[3]

ABSTRACT

The ASA (Advanced Seismic Assessment) module is a post-earthquake technical intervention service, that the EUCENTRE Foundation developed over the years through a series of national and European pilot projects, field exercises and direct experiences after the last major seismic events that struck Italy since 2009. The system consists of a service managed at the headquarters in Pavia for the development of damage scenarios and for part of the logistic, and of a mobile unit on field for the damage assessment.
After the Central Italy earthquake, the Foundation has been involved for about eight months on several activities, including on field technical support to the Department of National Civil Protection, joint reconnaissances with internationally renowned research institutes, and dissemination activities.
The experience showed the unquestionable potentialities of the system on one hand and, on the other, suggested improvements both for the service itself and for the technical emergency management.

Keywords: Italy earthquake 2016; post-earthquake survey; Advanced Seismic Assessment module; Amatrice; damage assessment

1. INTRODUCTION

The EUCENTRE Foundation (Pavia, Italy) manages a complex technical support system for the seismic emergency that has been developed and refined over the years, starting in 2005, through pilot projects, exercise activities in real and simulated contexts, deployment following real earthquakes. The institutional involvement of the Foundation as Center of Expertise of the National Civil Protection Department is to supply technical-scientific support in the field of seismic risk on the three fundamental aspects of prevention, stand-by and response to emergency.
Since it was born, the part of the service mainly aimed at the numerical and experimental evaluation on site of complex and / or strategic structures, but also designed to support ordinary evaluation activities, has been supported by the Civil Protection Department (Dipartimento della Protezione Civile, 2008), initially as a bare operational support in terms of human resources and numerical methods. Today it has become a "capacity" according to the definition of the European Civil Protection Mechanism (Official Journal L 314 2007, Gazzetta Ufficiale dell'Unione Europea 2008), conceived as an independent service for rapid response to emergency, coded in terms of tasks, capability, main components, autonomy and preparation. The first important milestone was the STEP pilot project (DG Environment, 2007), under which the technical and technological capacity of the Mobile Unit for post-earthquake structural evaluation (Casarotti et al. 2009a) was developed. Following, within the DRHOUSE project (DG ECHO 2010, Dolce 2011, Dolce 2012), EUCENTRE was responsible for implementing the Advanced Structural Assessment (ASA) module (Casarotti & Pavese 2012), the system was integrated with a set of components designed to meet the autonomy requirements, to manage logistical and health aspects for world-wide deployment, to involve volunteer

[1]Ph.D., EUCENTRE Foundation, Pavia, Italy, chiara.casarotti@eucentre.it
[2]Professor, Università degli Studi di Pavia, Pavia, Italy, a.pavese@unipv.it
[3]Ph.D., EUCENTRE Foundation, Pavia, Italy, simone.peloso@eucentre.it

professionals, to develop operational procedures for preparation, standby, activation and management of the emergency phases for the module. The last step of this path is the ongoing MATILDA project (DG ECHO, 2014), within which the module is going to become “multi-national” by sharing the developed Italian competences, the Slovenian and Croatian organizations for emergency management.
Over the years, the service has been tested in several exercises (e.g. in Patras Dolce at al. 2013) or on occasion of the international ModEX Exercise at Tritolwerk (www.youtube.com, 2016) (Figure 1), for training of both internal staff and professional volunteers, and, above all, it has been deployed to support the technical relief activities after the last three major Italian seismic events: L'Aquila in 2009 (Casarotti et al. 2009b, Casarotti et al. 2010), Emilia in 2012 (Casarotti et al. 2012, www.eqclearinghouse.org, 2012), and the recent prolonged seismic sequence in Central Italy between August 2016 and January 2017 (www.eqclearinghouse.org, 2016b).

Figure 1. Mobile Unit for structural assessment at ModEX exercise (Tritolwerk, Austria, June 2016)

The deployment procedures and the involvement extent always depend on the different operating conditions of each particular emergency environment. In the case of the Italian events, the intervention usually lasts for the entire duration of the crisis, or until the Civil Protection Department requires, with turnover of teams, support from the central unit also from the logistical point of view, and a more flexible operating scheme, according to the evolving needs. In the case of wide-range deployment, the mission is conceived to be more intense and independent of the central unit.

2. ACTIVITIES WITHIN THE CONTEXT OF THE CENTRAL ITALY EARTHQUAKE

The system consists of a service managed at the headquarters of Pavia with regard to the territorial management system for damage scenarios and the support to field activities, and a mobile unit deployed on site for the evaluation of the damaged structures.
The EUCENTRE Foundation, as a research centre in seismic engineering, centre of knowledge of the Italian Civil Protection Department (CPD) and, in collaboration with the ReLUIS Consortium (Network of University Laboratories of Seismic Engineering), conducted several activities of different nature following the seismic event occurring in central Italy on August 24th August 2016 (Figure 2), as described in the following sections.
In compliance with the CPD's procedures, EUCENTRE activated i. the territorial management platform group for the production of real-time damage scenarios in different contexts, ii. the Structural Assessment Intervention Module, and iii. the developers of DESIGNA system (Distributed Environment to Support Individual and General Need Accommodation), to accomplish the needs of temporary housing management. In addition, training to groups in charge of surveying precast structures has been provided.
Within the nine months of intense field activity, the Foundation teams conducted more than 700 inspections (Figure 5) in the four regions struck by the earthquake. Most of the surveys were carried out on monumental buildings, school structures, public buildings and manufacturing facilities.

Different inspection forms have been delivered, i.e. Churches, Historical Buildings forms (D.M. 2006), Aedes (ordinary buildings) forms (D.M. 2014) and GL-Aedes (precast structures) forms (D.M. 2015).
Since the end of August 2016 to May 2017, 652 man-days were deployed: in what follows, an overview of the activities carried out by EUCENTRE in the context of the seismic emergency of the Centre of Italy in 2016 and 2017.

Figure 2. Activities within the context of the Central Italy earthquake

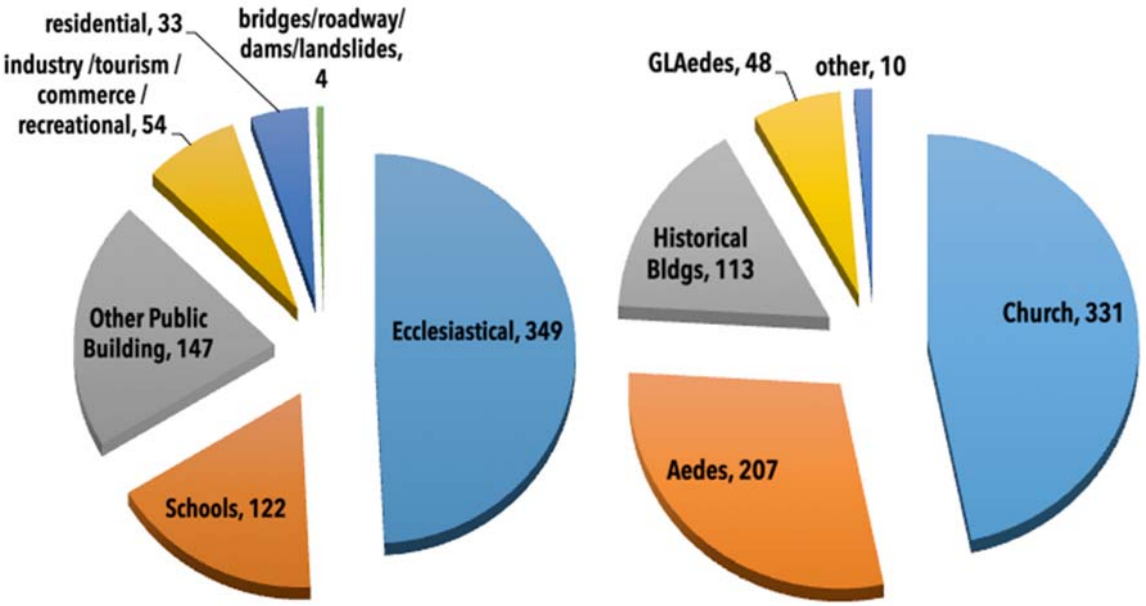

Figure 3. Surveyed building typologies (left) and delivered inspection form types (right)

2.1 In field activity

Since August 24th, internal emergency activation procedures have been triggered for the management and coordination of activities. To this end, an EUCENTRE liaison officer was sent at the CPD coordination Centre (namely Di.Coma.C.) in Rieti, available to be directly addressed in the preparation of the intervention strategies in which the Foundation was involved and to facilitate an organic plan with respect to other units within the CPD emergency management. The same person was the reference for the EUCENTRE teams on the field and the interface with the ReLUIS responsibles.
In the phase preceding the seismic sequence at the end of October 2016, the Foundation focused essentially on schools, public buildings and churches, for a total of 193 inspections. Then, from November 2016 to May 2017, 516 inspections of different nature were carried out: ordinary surveys on different use buildings (schools, public, commerce, etc.), precast structures surveys, additional check on previously inspected buildings, technical support teams, reconnaissance of landslides, bridges, dams, monumental buildings usability assessment. The activities were carried out mainly in the Marche, and to a lesser extent in Lazio and Abruzzo (Figure 4), on structures of different nature and type of construction, and for heterogeneous use (Table 1).
The proportions of the outcomes were quite different depending on the type of inspected building (Figure 5), ranging from “A” (fully usable), “B” (usable after quick measures), “C” (partly usable), “D” (to be surveyed again), to “E” (totally unusable). Outcome “F” indicates unusability due to external risk, regardless the state of the building itself.

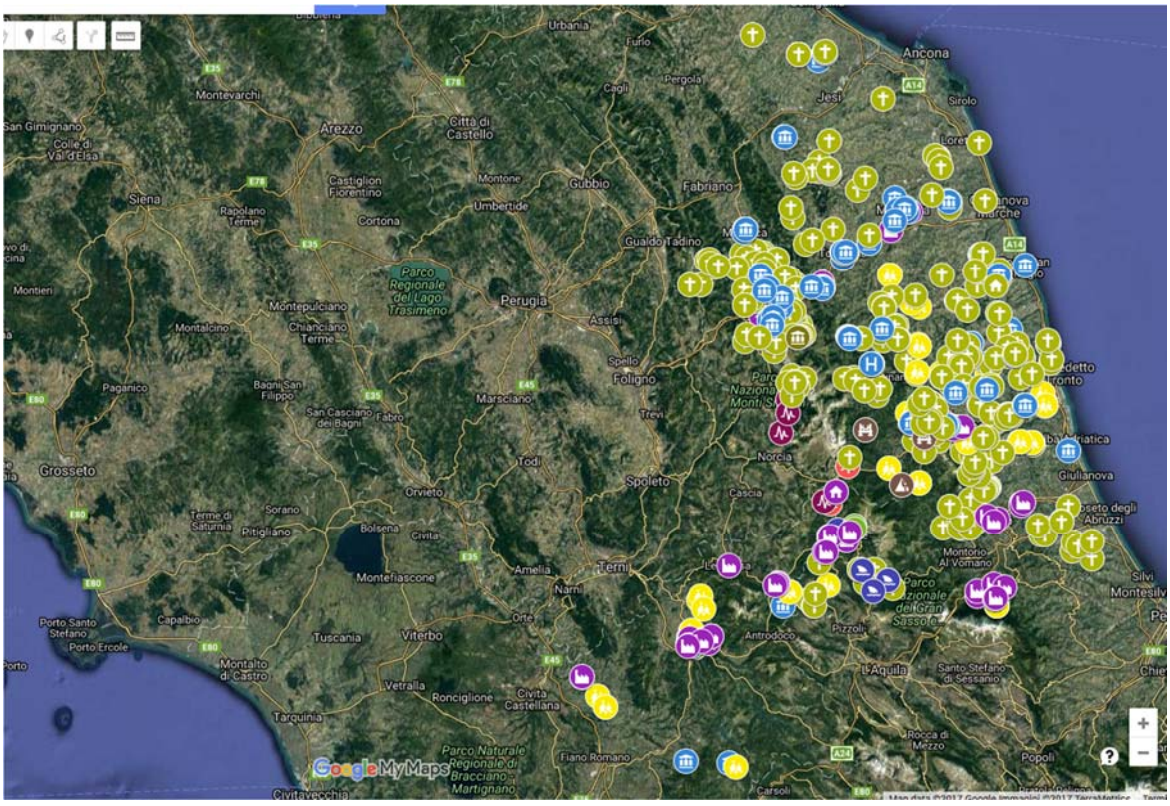

Figure 4. Map of surveys

Table 1 Use of inspected structures and type of survey form

	Ordinary Aedes	Church	Historical buildings	Precast buildings	other	total
other public buildings	63	2	65	16	1	147
commerce	3					3
ecclesiastical		329	20			349
landslide/dam/geo/bridge			1		3	4
manufacturing	6			19		25
housing	7		26			33
tourism	15		1	2		18
recreational	5			3		8
schools	113			8	1	122
total	**212**	**331**	**113**	**48**	**5**	**709**

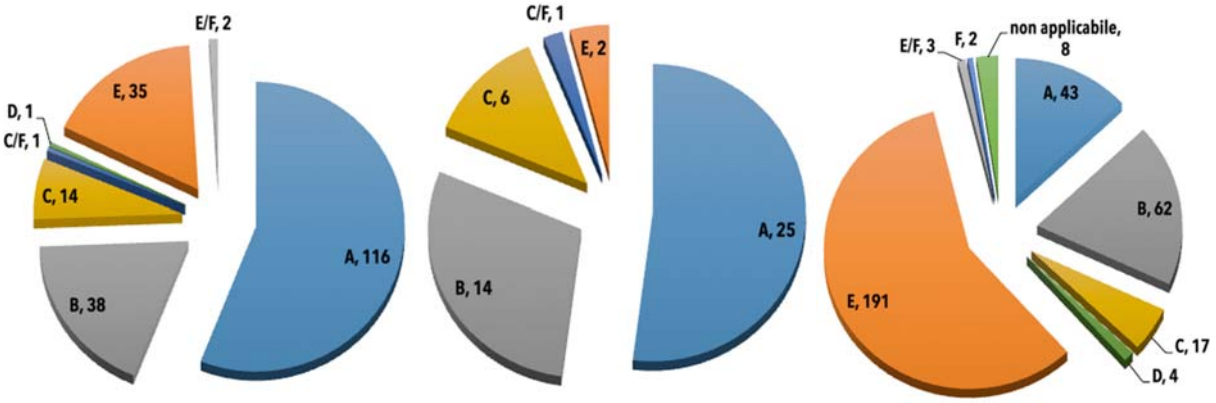

Figure 5. Usability outcomes: ordinary buildings (left), precast structures (centre) and churches (right)

Monumental building surveys on the affected areas were conducted under the joint coordination of the Department of Civil Protection and the Ministry of Cultural Heritage and Tourism, in collaboration with the ReLUIS Consortium.

In the first cycle of surveys (before October 26th 2016), a joint EUCENTRE-University of Pavia team was available each week. A total of 93 churches and 1 palace were inspected in the provinces of Ascoli Piceno, Macerata, Fermo, L'Aquila and Teramo. In the second cycle of inspections (from January 2017 to March 2017), the Foundation guaranteed a weekly presence of at least 2 teams. Surveys were conducted on 238 churches and 112 palaces, filling church forms and historical building forms. For the latter, only the damage was surveyed, without any appraisal of usability. As shown in Figure 5 (right), 61% of the churches for which a result was issued were no longer usable.

From November 2016 to January 2017, a team specialized on precast structures was also operating, which mainly assessed manufacturing, receptive or commercial structures, for a total of 48 precast structures. As seen in Figure 5 (centre), 52% of the inspected structures were fully usable. Most of Aedes forms (82%) were related to ordinary surveys on school or public buildings (Table 1). Their outcomes were mainly of full usability (68% of schools and 52% of assessed public buildings), while only 9% and 13% respectively were completely unusable (Figure 6).

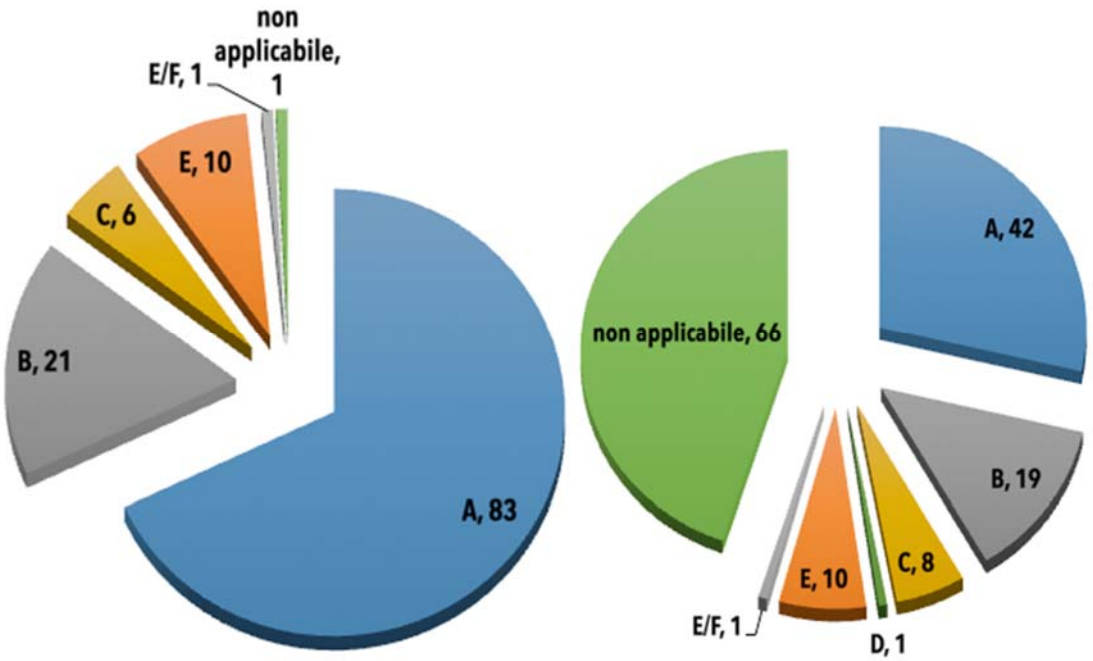

Figure 6. Usability outcomes on schools (left) and other public buildings (right)

2.3 Other technical and scientific activities

To complete the overall picture of the role played by EUCENTRE in the recent seismic emergency, a number of activities carried out by the Foundation on a voluntary basis are described. Among these, the most important were the technical-scientific reconnaissances, in collaboration with internationally renowned research institutes. From September 5th to 8th 2016, EUCENTRE participated in the first post-event geotechnical reconnaissance within the team of GEER (Geotechnical Extreme Events Reconnaissance) in the provinces of Rieti, Ascoli Piceno, L'Aquila and Perugia. The related activities are reported in the synthetic technical reports published shortly after the event (Lanzo et al. 2016a) and in a more detailed report (Lanzo et al. 2016b) with additional studies.

From September 12th to 16th 2016, EUCENTRE joined EERI (Earthquake Engineering Research Institute) and ReLUIS consortium for a technical reconnaissance visit to Central Italy, as part of the Learning from Earthquakes (LFE) program, to study August 24th earthquake impact on the affected areas. At the end of the mission, the team shared the experience in a web-based reconnaissance seminar, available on the specific Clearinghouse website (ww.eqclearinghouse.org, 2016a). A further mission was conducted from May 8th to 12th 2017, to assess the effects of important seismic swarm occurred between October 2016 and January 2017.

From October 18th to 21st 2016, EUCENTRE joined the AFPS (Association Française du Génie Parasismique) team in the post-event reconnaissance conducted in the provinces of Rieti, Ascoli Piceno and L'Aquila on the dams of Scandarello, Poggio Cancelli, Rio Fucino and Sitter Pedicate. The results of the mission were included in the section "Dams" and "Retaining walls, rockfall barriers and road embankments" of the GEER report (Lanzo et al. 2016c), and in the section on dams of the AFPS report (Balgiu et al. 2017).

EUCENTRE finally joined the experts in seismic geotechnics, geology, seismology and geomatics of the GEER Italia-United States team, which conducted the main phase of landslide surveys with LIDAR and UAVs from November 30th to December 5th 2016. Such activities are reported in a synthetic summary (Lanzo et al. 2017a) and in a detailed technical report (Lanzo et al. 2017b).

At the beginning of December 2016, the Department of Civil Protection, on behalf of the Italian Government, requested the ReLUIS Consortium to carry out with major urgency an evaluation activity on the possibility of restoration / adaptation of schools classified unusable, with the aim of supporting decisions for the re-activation of interrupted school services. The joint teams of the University of Pavia-EUCENTRE evaluated four schools in Force, Falerone, Montalto in Marche and Acquasanta Terme.

3. FINAL REMARKS

As happened for the major seismic events that have hit Italy over the last decade, also after the Amatrice earthquake, the EUCENTRE Foundation has been operating for the emergency technical support to the national Civil Protection department and with a number of additional technical and scientific activities.
In the nine months following the first event of the long-lasting sequence, according to the needs and requests, the several activities (performed both from Pavia and on site) included production of damage scenarios, numerical-experimental activities, diagnostics and assessment on structures and infrastructures, damage reconnaissance.
The field experience of EUCENTRE and of the colleagues involved in the emergency has once again highlighted the unquestionable potential of the system and, on the other hand, a series of lesson learnt to improve both the system and generally speaking the emergency technical management.
Regarding field operations, one of the most urgent needs emerged was the updating of the damage survey tools to the modern technology currently available to most national technicians.
On this issue, the future is considered to be the complete computerization through web app of all the current survey forms. The important advantage of the web app is that it can be used on different operating systems (Android, macOS, windows mobile, etc.), still maintaining the independence from connectivity conditions through local save.
Computerization of data collection tools, alongside an appropriate management system, would bring enormous advantages in an emergency situation, such as: i. the possibility of technicians remote registration, ii. registered survey assignments, iii. data exchange (contact inspections, addresses, etc.) on cloud platform, iv. automatic implementation of basic completeness checks (“error”), v. automatic implementation of logic controls ("alert"), vi. real-time delivery of survey forms, vii. automatic data storage; viii automatic production of the survey results statistics and the their mapping on the territory.
In this way, the times of bureaucracy and territorial dispersion of technicians would be reduced and number of inspection increased, resources dedicated to manual data storage could be re-targeted, the possibility of random error associated with manual input and of errors due to incomplete data sheets would be would be prevented. The technical inspector will be assisted in his own evaluation with the logical inconsistency tool.
In a time when a lot of official paperwork with public administration is electronically processed, the management of privacy, security and secure login are issues to be considered but largely manageable with the current technology. It is believed that the ability to set up such a system as a preparedness activity has now reached sufficiently maturity.
It should also be noted that such system, as in many cases of public administration bureaucracy, would not be incompatible with the persistence of the paper method for those technicians (in our opinion, progressively reducing) comfortable with the present system, and in general for those who need support when delivering the evaluation forms: the paper-related burden would be significantly reduced in favour of increased efficiency in global management.
Another problem emerged during the last emergency was that of the apparently insufficient number of technicians able to compile survey forms. As the training protocol on the subject today is well defined in terms of duration and content, a good solution could be to prepare standard recorded course modules and teach them through the e-learning system, reducing training costs at source. In this way, a significantly larger number of professionals could be trained. Moreover, virtual support service at regional or university level can be as well implemented to assist them, considering that anyway we are not talking of teaching inexperienced personnel, but of upgrading professional technicians, i.e. engineers and architects. If a few years ago this kind of approach would be unaffordable for several reasons, it is believed that the time has come, both because the courses have been greatly improved and because technology today offers widely tested and efficient tools.
Notwithstanding the great work done by the many actors involved in the occurrence of these dramatic events, it is deemed that today there is a wide space for improvement of the system through tools, which can be handled affordably within preparedness activities, both involving the different possible stakeholders and exploiting the full potential of technological advances.
As far as the European scale is concerned, as mentioned, the ASA module has been implemented within the UCPM (Union Civil Protection Mechanism) perspective as a capacity to support

international emergencies: in the case of wide-range deployment, the mission is conceived to be more intense and independent of the central unit. Concerning the platform for damage scenarios, it would be very useful to have it implemented in the Emergency Response Coordination Centre (EERC), in order to visually appraise the situation at large scale to organize focused intervention on the most critical areas, better coordinating response capacities. The platform could be integrated within existing tools developed within DG-ECHO projects on the multi-hazard monitoring, in order to provide a powerful tool for the risk assessment, eventually together with the creation of a pool of technical experts able to support the ERCC with regard to situation assessments in crisis situations.

4. ACKNOWLEDGEMENTS

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