Appendix 1: ELE software tools

The computation of losses of any type that result from the shaking effects of an earthquake basically requires software which is able to process available information on ground motion characteristics, inventory and building fragility. Nowadays, a large number of ELE software exists that make use of the different approaches as described before. Since the herein described loss computations are related to the mezo- and macrolevel, the combined use of loss computation software with Geographic Information Systems (GIS) has become common practice. Some of the existing ELE software are integrated in a GIS, while others are disconnected. An overview of available ELE software tools and their main characteristics is given in Molina *et al.* (2010)[132] and Haldar *et al.* (2013). A complemented list of ELE software tools is provided in **Table A1**.

[132] Paper P3: Molina, S., Lang, D.H., and Lindholm, C.D. (2010). SELENA – An open-source tool for seismic risk and loss assessment using a logic tree computation procedure, *Computers & Geosciences* **36** (2010): 257–269.

Table A1. Overview of available ELE software tools and their main characteristics (partly taken from Molina *et al.*, 2010; Haldar *et al.*, 2013; Crowley *et al.,* 2010).

Tool (Institution) (Reference)	Approach	Type of analysis	Methodology	Output						Open source	Proprietary software required	Integrated GIS interface	Regional constrictions
				damage to buildings	damage to infra-structures	economic loss	human losses (casualties)	shelter estimates	business disruption				
EQRM (Geoscience Australia)	A	D, P	CSM (ATC 40, 1996)	✓	–	✓	–	–	–	yes[133]	MATLAB, Python[134]	flexible	Australia
SELENA (NORSAR) (Molina *et al.,* 2009; 2010)	A	D, (P)[135], R	CSM, MADRS, I-DCM (both FEMA 440), inelastic spectrum	✓	–	✓	✓	(✓)[136]	–	yes[137]	MATLAB	flexible or *RISe* (Lang *et al.,* 2009a)	flexible
ELER[138] (Kamer *et al.*, 2009; Hancilar *et al.,* 2010)	E, A	D, P	CSM, MADRS, DCM, Reduction Factor Method (Fajfar, 2000)	✓	✓	✓	✓	–	–	no	MATLAB[139], MapInfo	yes (MapInfo)	customized to Euro-Med region but principally flexible
QUAKELOSS (WAPMERR) (Wyss 2005) now: QLARM (Trendafiloski *et al.,* 2009)	E (intensity, (PGA/PGV))	D, R	DPM (EMS–98)	✓	–	✓		–	–	"open" but user login and password required	no	yes (WebGIS, internet browser)	constricted to those regions where data is available
CEDIM Risk Estimation Tool (CREST) (Tyagunov *et al.,* 2006)	E (intensity)	D, (P)	DPM (EMS–98)	✓	–	✓	✓	–	–	no	ESRI ArcGIS	yes (ESRI ArcGIS)	flexible
CAPRA (World Bank) http://ecapra.org → *CRISIS 2007* (seismic hazard module) (M. Ordaz, A. Aguilar and J. Arboleda; UNAM) → *ERN-Vulnerabilidad* (vulnerability module)	A (intensity, PGA, Sa), Peak and spectral parameters (a, v, d)	P, (D)	method by Miranda (1999) → but flexible in terms of using other methods, e.g. CSM (handled by *ERN-Vulnerabilidad)*	(✓)[140]	–	✓	✓	–	–	no	no	yes (CAPRA-GIS)	flexible

[133] distributed via www.sourceforge.net
[134] EQRM originally consisted of MATLAB, which is a commercial and proprietary software. Then, the use of an object-oriented language was favored and the latest releases have been coded in Python
[135] (P) – instead of a probabilistic risk analysis, a probabilistic ground motion shaking map (shakemap) is used to provide the ground motion input for a deterministic analysis
[136] available from version 5.1
[137] distributed via www.sourceforge.net
[138] ELER is an updated version of KOERILoss (Erdik and Aydinoğlu, 2002), which is not further developed anymore
[139] compiled executable using MATLAB code and toolboxes, thus not necessary to have a MATLAB version in order to run the software and conduct the analysis
[140] CAPRA's outputs are: (1) loss exceedance curves (LEC), (2) probable maximum loss (PML), (3) aggregated average annual loss (AAAL), and (4) average annual loss (AAL)

Tool (Institution) (Reference)	Approach	Type of analysis	Methodology	Output						Open source	Proprietary software required	Integrated GIS interface	Regional constrictions
				damage to buildings	damage to infra-structures	economic loss	human losses (casualties)	shelter estimates	business disruption				
RiskScape (GNS Science) (Reese *et al.,* 2007)	E (MM intensity)	D, (P in planning)	DPM	✓	✓	✓	✓	–	✓	no	no	yes	originally New Zealand but principally flexible
LNECLOSS (LNEC Lisbon) (Campos Costa *et al.,* 2006; 2010)	E (intensity), A (peak and spectral parameters)	D	4 different empirical methods, CSM	✓	–	✓	✓	–	–	upon request	ArcView, MATLAB	yes (ArcGIS)	originally Portuguese mainland but principally flexible
MAEviz (Mid-America Earthquake Center) (Spencer *et al.,* 2008)	A	D, P	"CSM type"	✓	✓	✓	✓	✓	✓	yes (web)	no	yes (Open GIS)	flexible
EPEDAT (Early Post-Earthquake Damage Assessment Tool) (Eguchi *et al.,* 1997)	A	D		✓	✓	✓	✓	–	✓	no	MapInfo	yes (MapInfo)	California oriented
HAZUS–MH (FEMA, 2003)	A	D, P	CSM (ATC 40, 1996)	✓	✓	✓	✓	✓	✓	no	relational database management systems (RDBMS) and Knowledge-based expert system (KBES) embedded within GIS system	yes (ArcGIS, MapInfo)	United States
MDLA (MATLAB Damage and Loss Analysis) (Mitrani-Reiser, 2007; Haselton *et al.,* 2008; Muto *et al.,* 2008)	E (intensity), structural response measures (peak transient IDR, peak floor acceleration)	D, P		✓	–	✓	✓	–	✓	yes	MATLAB	no	flexible

Tool (Institution) (Reference)	Approach	Type of analysis	Methodology	Output						Open source	Proprietary software required	Integrated GIS interface	Regional constrictions
				damage to buildings	damage to infra-structures	economic loss	human losses (casualties)	shelter estimates	business disruption				
NHEMATIS [141] (Natural Hazards Electronic Map and Assessment Tools Information System) (Webb, 1999)	E (intensity), A (spectral parameters)	D		✓	✓	–	✓	–	–	no	no	yes (Open GIS)	flexible
PACT (Performance Assessment Calculation Tool) (ATC–58, 2009; Naeim *et al,*. 2007)	intensity-, scenario-, and time-based	D, P	Various analysis methods implemented (e.g., nonlinear time history analysis, linear analysis, etc)	✓	–	✓	✓	–	✓	yes	no	no [142]	Initially for U.S., but flexible
SIGE-DPC (Sabetta *et al.,* 1998)	E (intensity)	D		✓	–	–	✓	✓	–	no	no	*n.a.*	Italy, Istanbul
RADIUS (IDNDR, 1999)	E	D	DPM	✓	✓	–	✓	–	–	no	provides risk-mapping functionality using GIS	yes	Africa, Latin America, Europe, Asia
HAZ-Taiwan (Yeh *et al.,* 2006)	A	D	CSM	✓	✓	✓	✓	✓	✓	no	C++ , FORTRAN, MapInfo	yes (MapInfo)	Taiwan
ESCENARIS (Giovinazzi, 2005; Mouroux and Le Brun, 2006; Roca *et al.,* 2006)	E	D	DPM	✓	–	✓	✓	–	–	no	yes	yes	Catalonia, Eastern Pyrenees
RISK.iitb (Sinha *et al.,* 2008)	E	D	DPM	✓	–	✓	✓	–	–	no	yes	yes (ESRI ArcGIS)	India
SEISMOCARE (Anagnostopoulos *et al.,* 2008)	A	D	CSM	✓	–	✓	✓	✓	–	yes	relational database management systems (RDBMS) and geographical information system (GIS)	yes (MapInfo Professional)	Chania (Crete), Greece

[141] The respective NHEMATIS website cannot anymore be accessed.
[142] PACT is customized for the analysis of individual buildings.

Tool (Institution) (Reference)	Approach	Type of analysis	Methodology	Output						Open source	Proprietary software required	Integrated GIS interface	Regional constrictions
				damage to buildings	damage to infra-structures	economic loss	human losses (casualties)	shelter estimates	business disruption				
IVARA (Haldar *et al.,* 2010)	E (intensity)	D	DPM	✓	–	✓	✓	✓	–	yes	no	no	flexible
SeisVARA (Haldar *et al.*, 2013[143])	A, E (intensity)	D	DPM, CSM, inelastic spectrum	✓	–	✓	✓	✓	–	yes	no	no	flexible
OpenQuake (GEM) (Crowley *et al.*, 2011; 2012)	A	P, eP, D[144]	*pending* [145]	*to be defined*						yes	no	yes	flexible

[143] Haldar, P., Singh, Y., Lang, D.H., and Paul, D.K. (2013). Comparison of seismic risk assessment based on macroseismic intensity and spectrum approaches using 'SeisVARA', *Soil Dynamics and Earthquake Engineering* (2013), http://dx.doi.org/10.1016/j.soildyn.2013.01.016..

[144] Different hazard analysis types are implemented in OpenQuake: P – classical probabilistic seismic hazard analysis (PSHA), eP – event-based PSHA, D – deterministic SHA

[145] In OpenQuake's current version (V0.4) only discrete vulnerability functions are implemented, the implementation of other types of vulnerability and fragility functions are planned. The methodologies as well as potential outputs are therefore dependent on the implemented options of OpenQuake's final version.