Current Status and Future Vision of TELES

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Presentation Outline

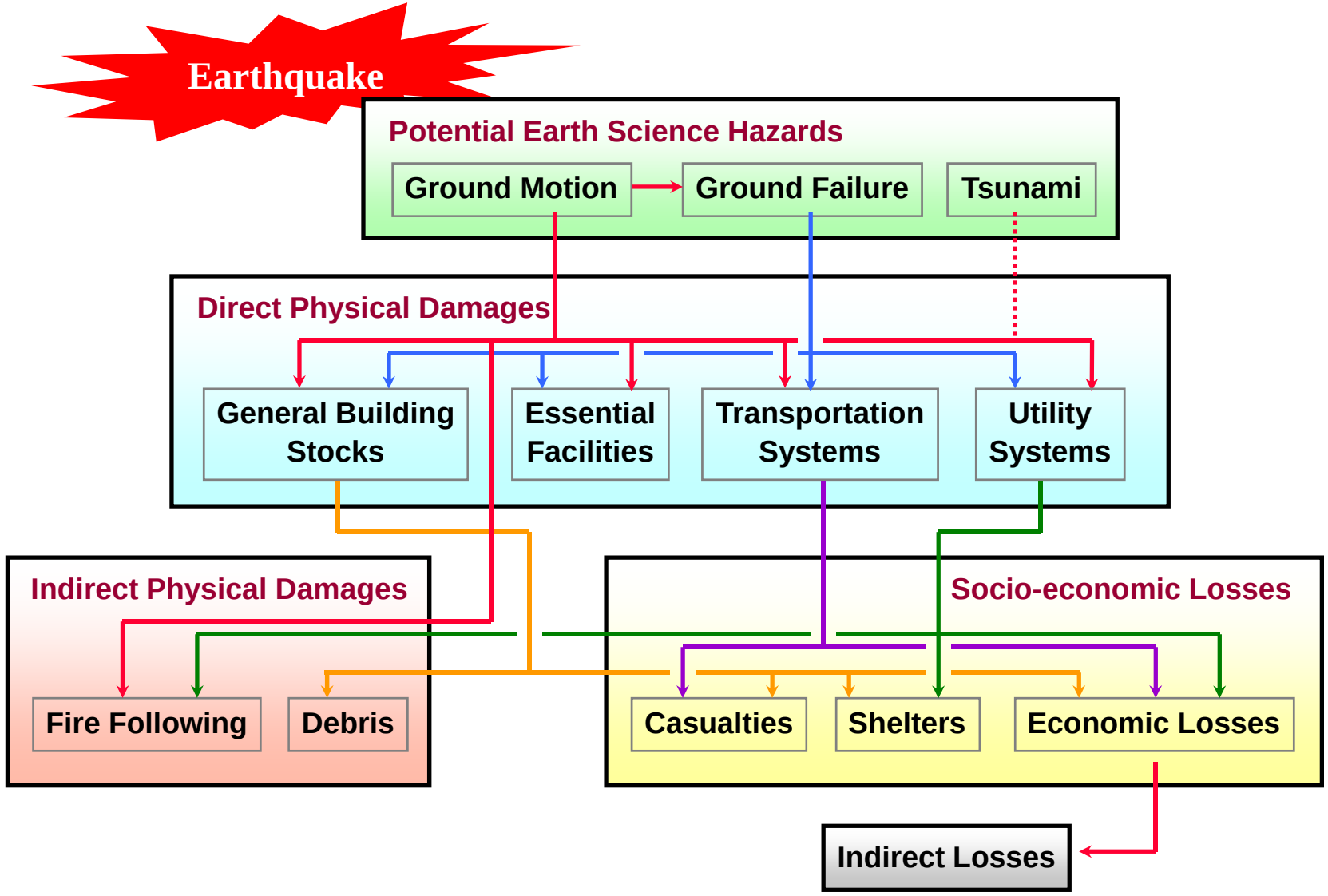
- Introduction of TELES and SDST
- Early Seismic Loss Estimation (ESLE)
- Probabilistic Seismic Risk Assessment (PSRA)
- Future Vision of TELES

Seismic Disaster Simulation Technology

- Given a set of seismic source parameters, SDST assess seismic hazards, damages and losses
- Seismic hazards
  - Ground shaking intensity
  - Ground failure probability due to soil liquefaction
  - Permanent ground deformation due to fault rupture, etc.
- Damages
  - Damage of buildings and bridges
  - Interruption and restoration of lifeline systems
  - Post-quake fires, debris, etc.
- Losses
  - Casualties
  - Resource needs for rescue, medical-care and shelter
  - Social impacts and economic losses, etc.

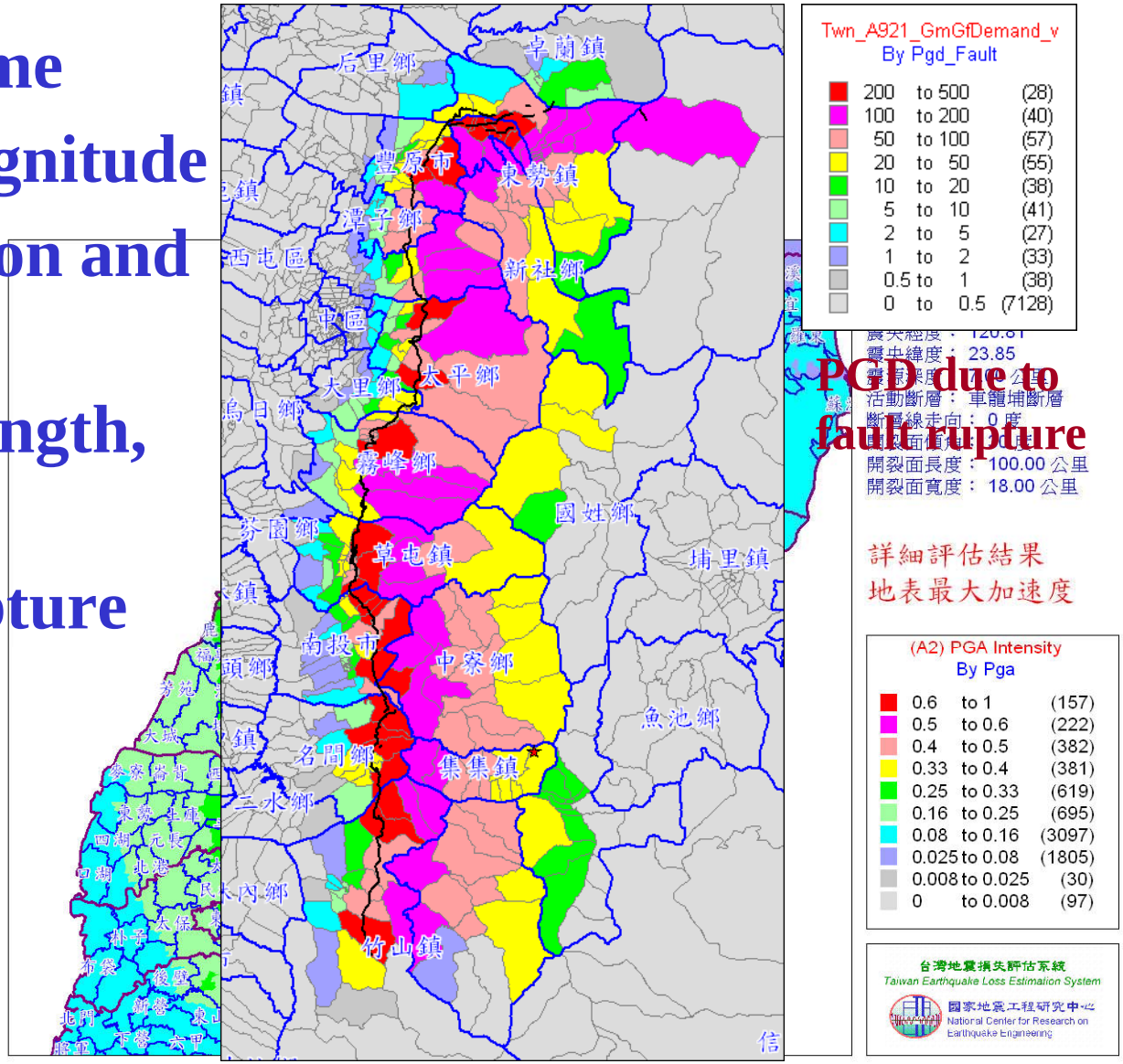
Analysis Framework of TELES

Database, Analysis Models and Application Software

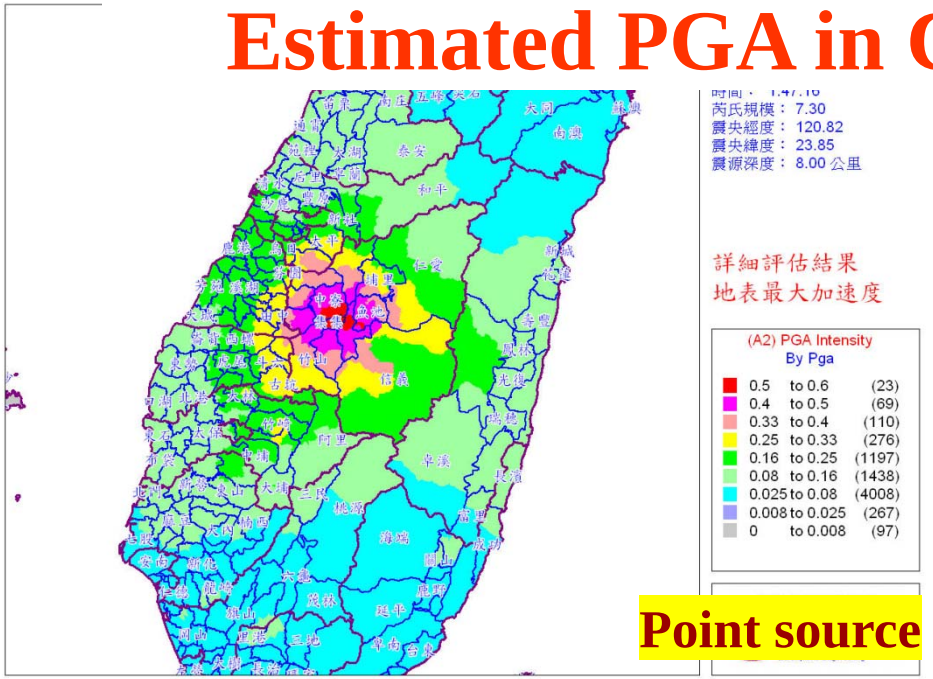


Specify Seismic Source Parameters

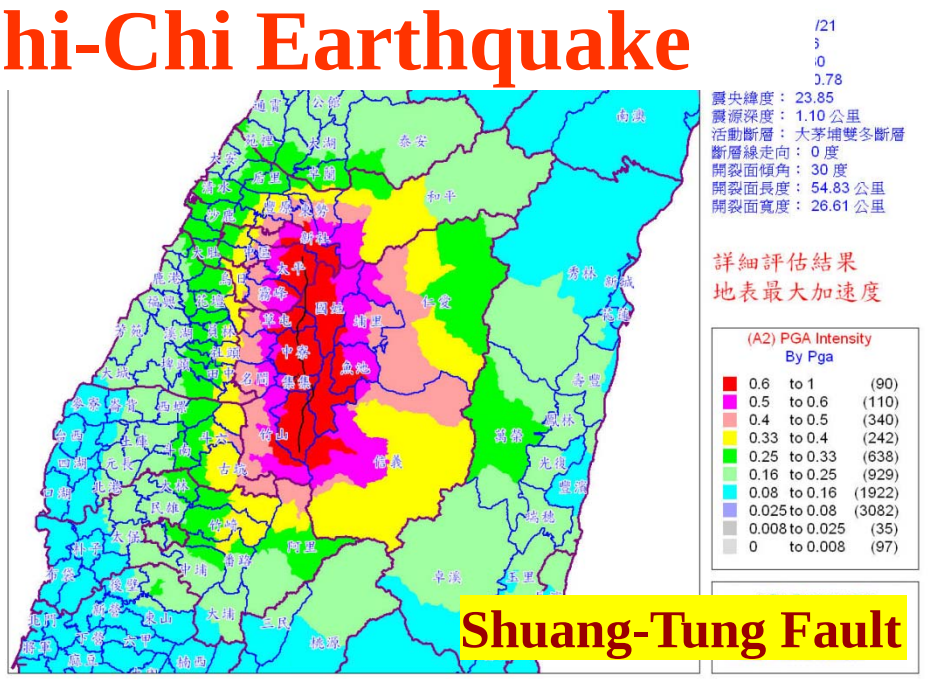
- Event date & time
- Earthquake magnitude
- Epicenter location and focal depth
- Fault rupture length, width
- Dip angle of rupture plane



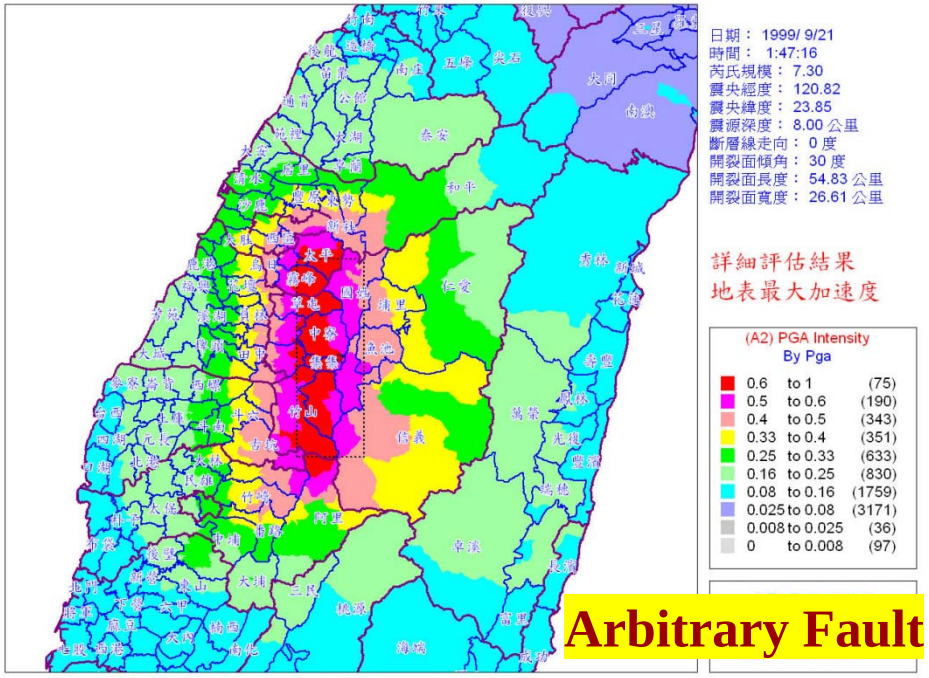
Estimated PGA in Chi-Chi Earthquake



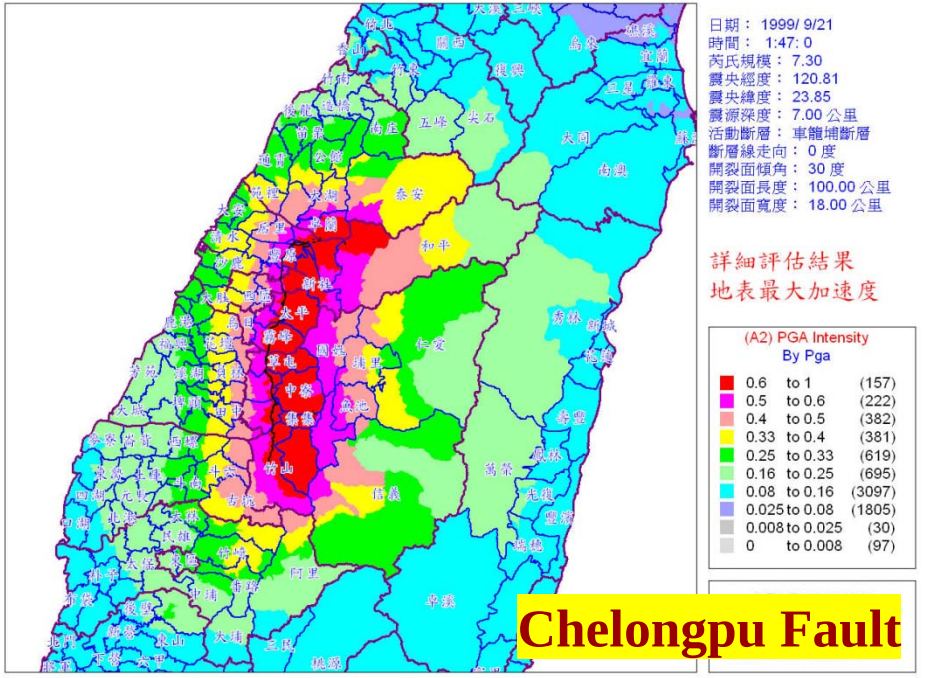
Point source



Shuang-Tung Fault

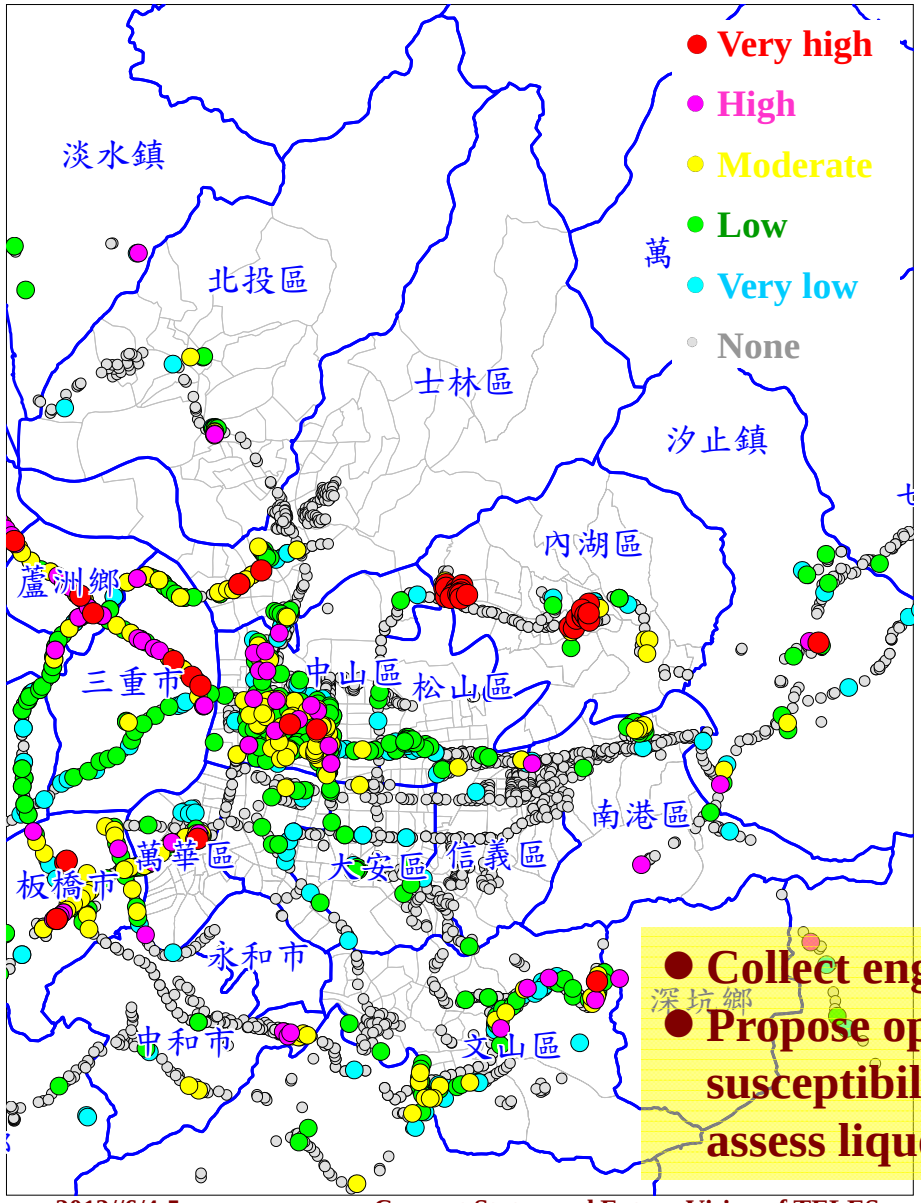


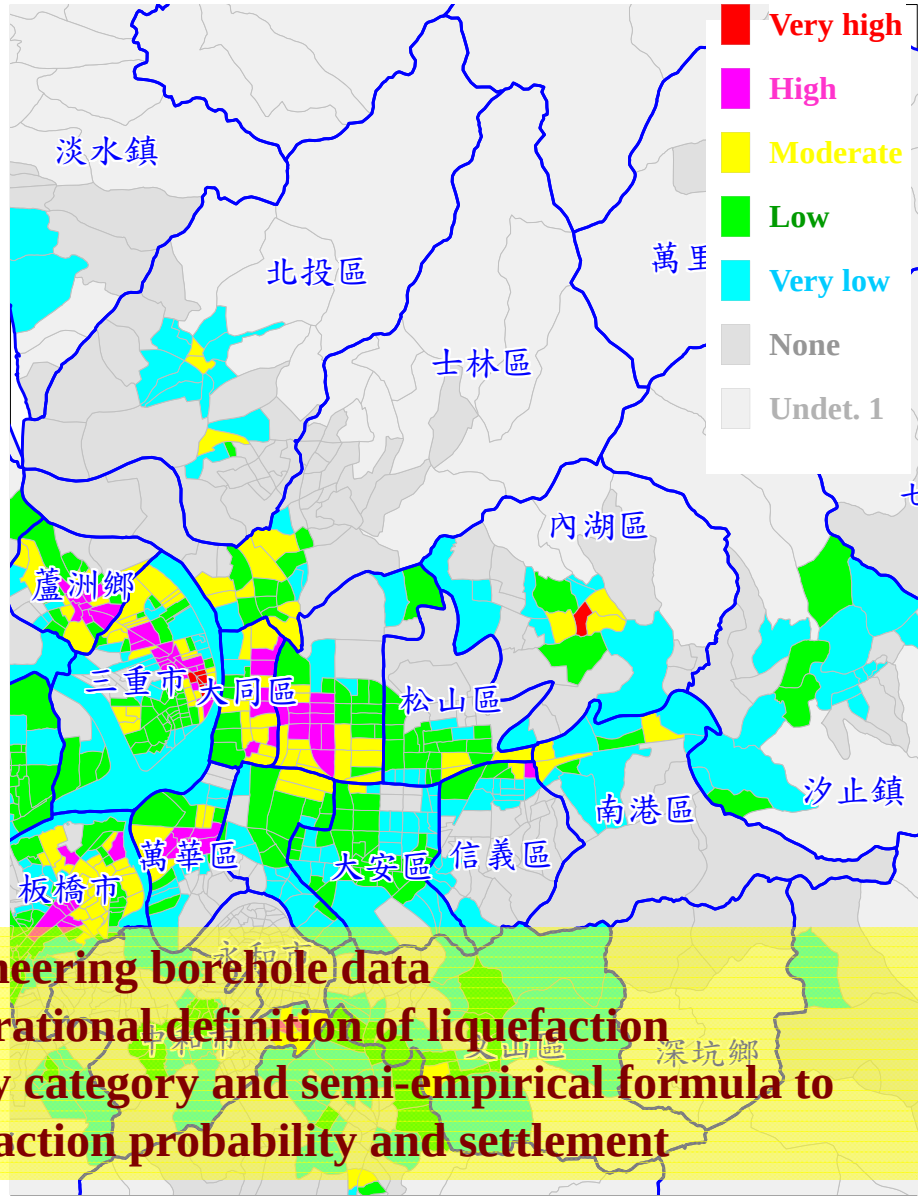
Arbitrary Fault



Chelongpu Fault

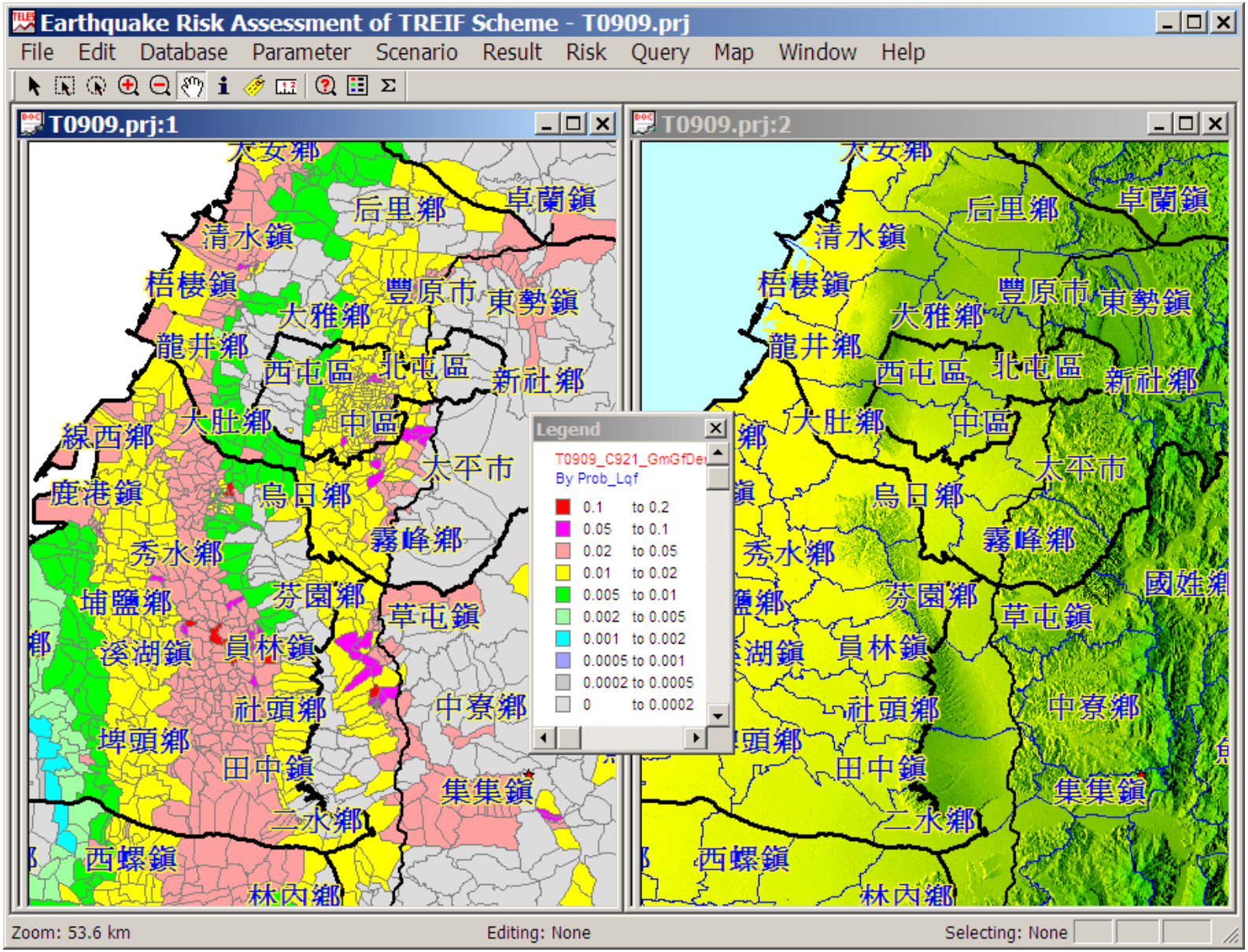
Liquefaction Susceptibility Category Map



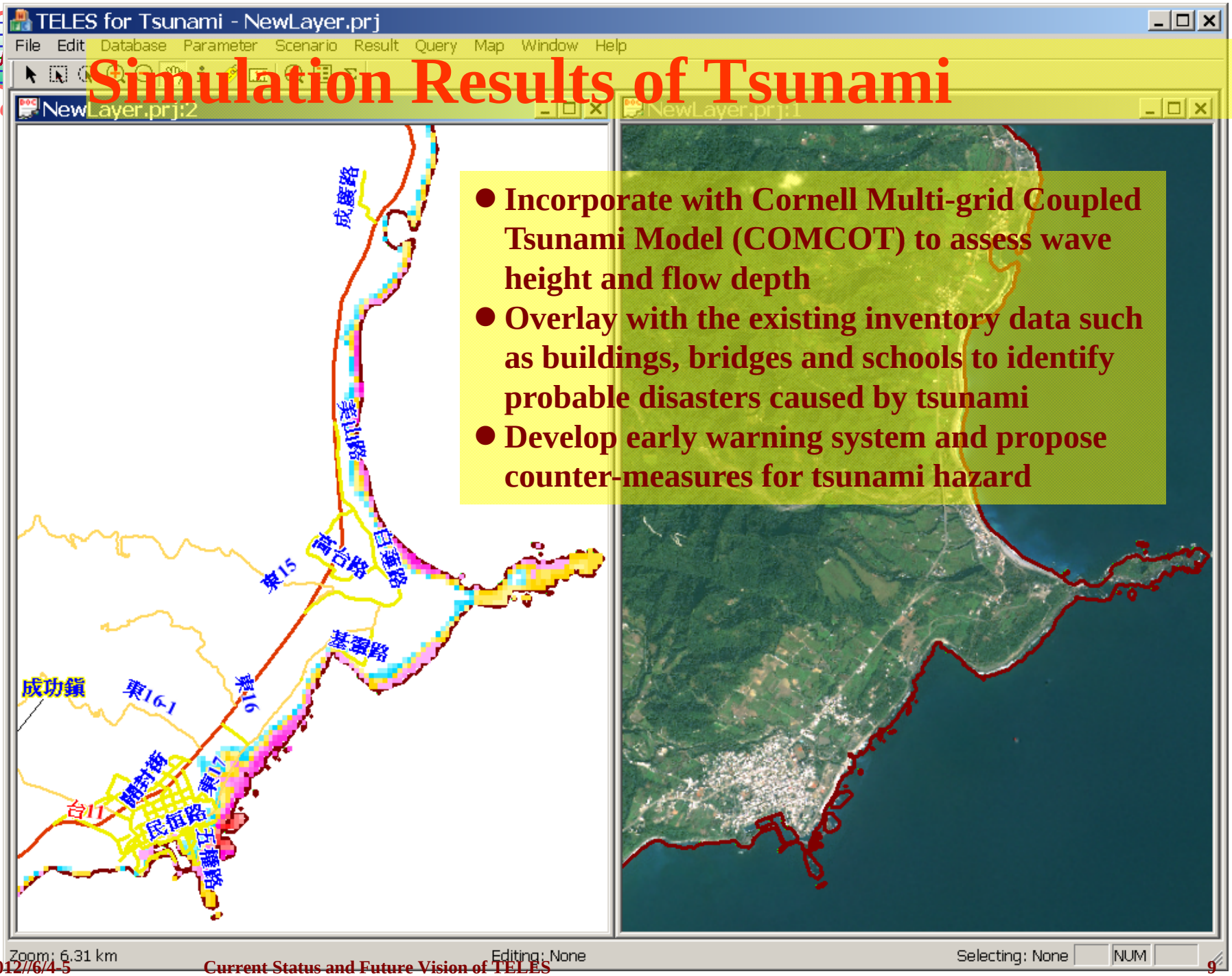


- Collect engineering borehole data
- Propose operational definition of liquefaction susceptibility category and semi-empirical formula to assess liquefaction probability and settlement

Est. Liq. Prob. in Chi-Chi Earthquake

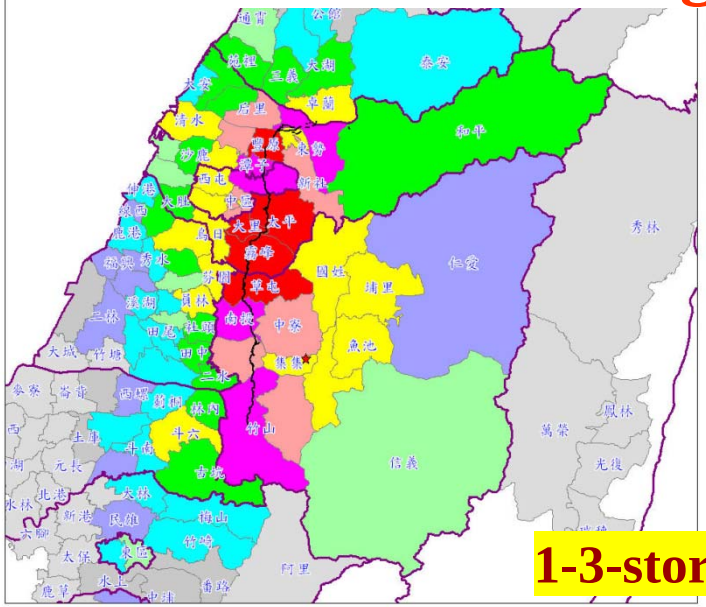


Simulation Results of Tsunami

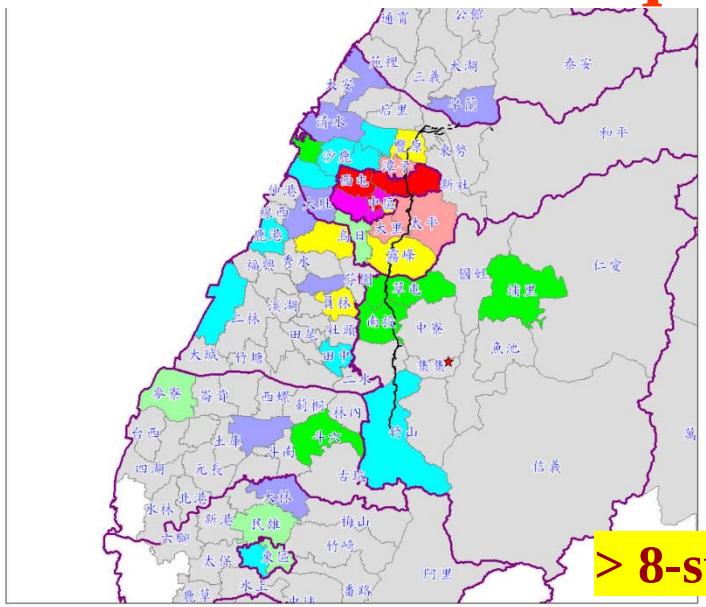


- Incorporate with Cornell Multi-grid Coupled Tsunami Model (COMCOT) to assess wave height and flow depth
- Overlay with the existing inventory data such as buildings, bridges and schools to identify probable disasters caused by tsunami
- Develop early warning system and propose counter-measures for tsunami hazard

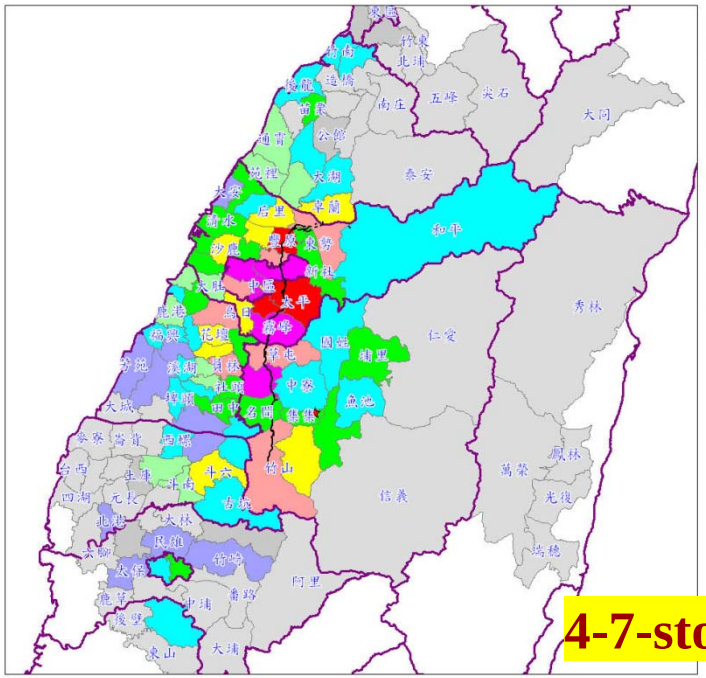
Estimated Building Damages in Chi-Chi Earthquake



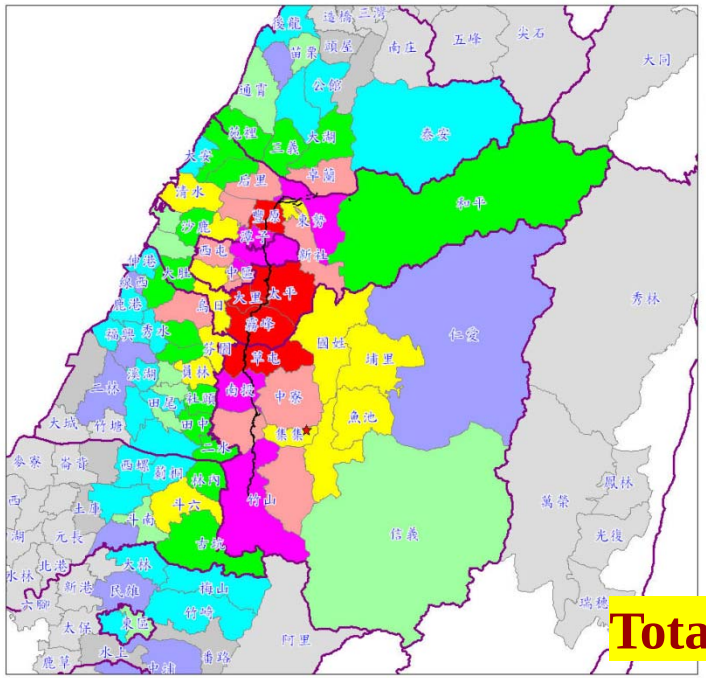
1-3-story: 37,000



> 8-story: 180

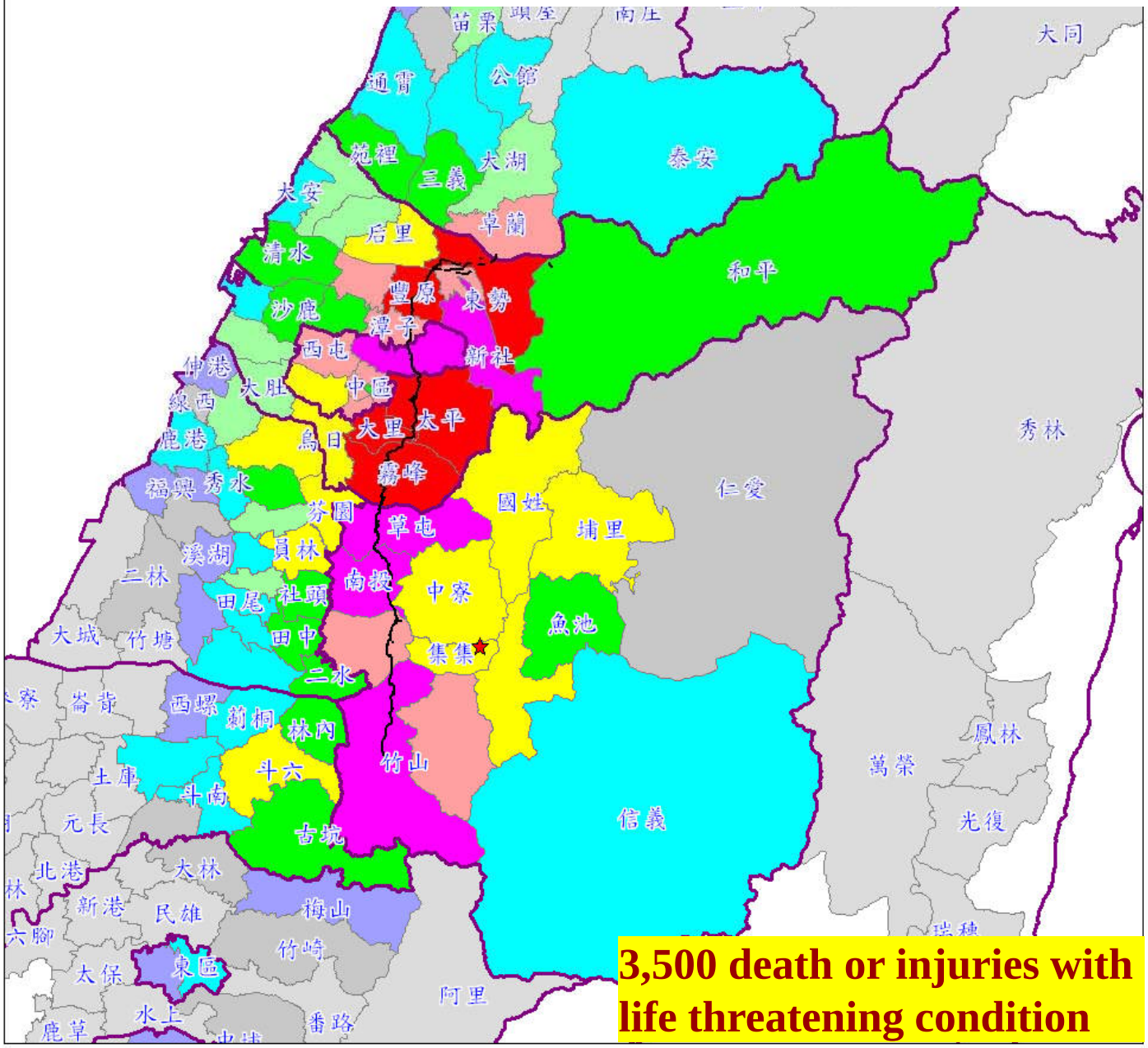


4-7-story: 3,100



Total: 40,000

Estimated Casualties in Chi-Chi Earthquake



芮氏規模： 7.30
震央經度： 120.81
震央緯度： 23.85
震源深度： 7.00 公里
活動斷層： 車籠埔斷層
斷層線走向： 0 度
開裂面傾角： 30 度
開裂面長度： 100.00 公里
開裂面寬度： 18.00 公里

詳細評估結果
鄉鎮區之傷亡人數

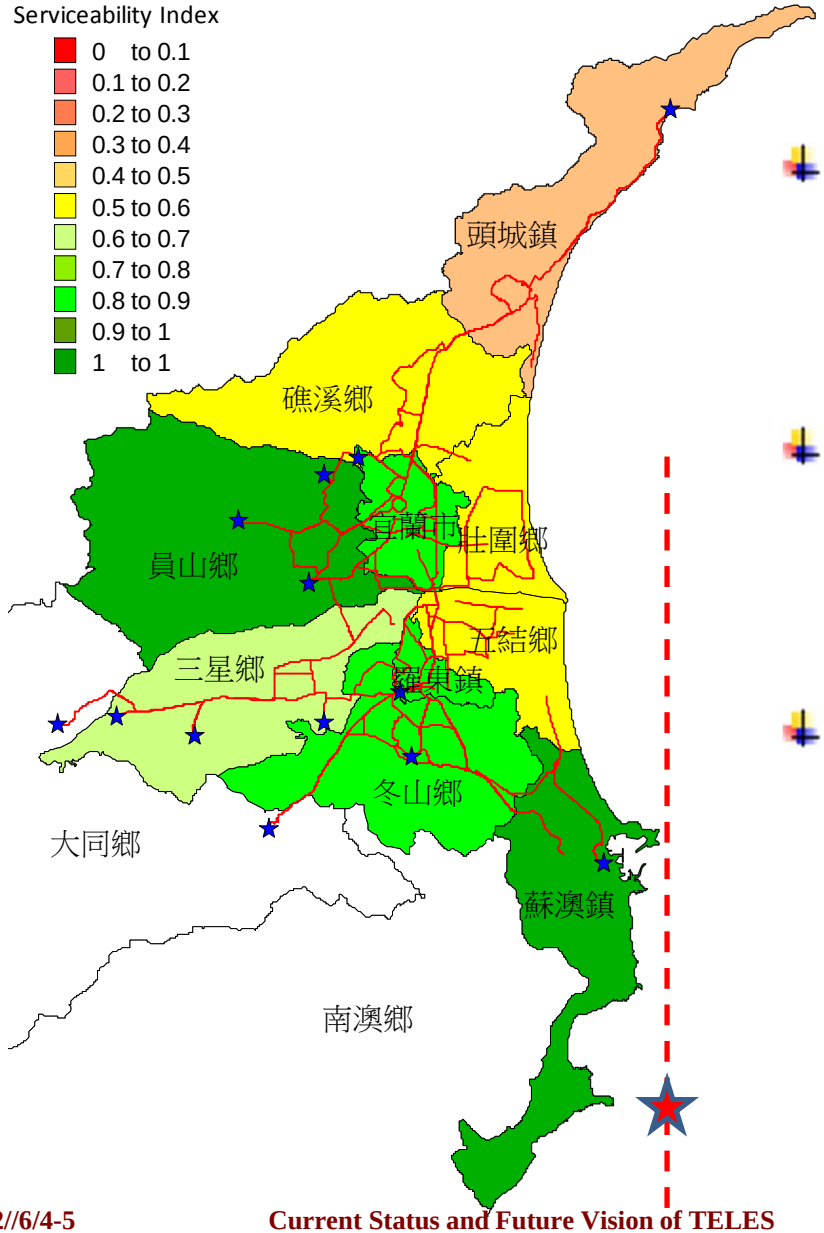
(A2) Town Casualty
By SubTotal

200	to	500	(5)
100	to	200	(5)
50	to	100	(11)
20	to	50	(12)
10	to	20	(14)
5	to	10	(9)
2	to	5	(17)
1	to	2	(9)
0.5	to	1	(11)
0	to	0.5	(46)

台灣地震損失評估系統
Taiwan Earthquake Loss Estimation System
國家地震工程研究中心
National Center for Research on Earthquake Engineering

Estimated Damage of Highway Bridges

Serviceability of I-lan Water System



- M7.1 off-shore earthquake, focal depth 20 km, fault rupture length 84 km
- Results from the average of 100 runs by Monte Carlo simulations
- Identify the worst areas suffering water outage
  - Tou-cheng 0.35
  - Zhuangwei 0.51
  - Jiao-xi 0.54

Key Features of TELES

- Integrate **GIS-based** technology and provide user-friendly graphical interface
- Collect and calibrate various kinds of **nationwide** inventory databases
- Develop **standardized** and state-of-the-art methodology for hazard analysis, damage assessment, loss estimation and risk analysis
- Integrate with Taiwan Rapid Earthquake Information Release System (TREIRS) of CWB to develop Early Seismic Loss Estimation (**ESLE**), which can be used in emergency response
- Integrate with probabilistic seismic source model to develop Probabilistic Seismic Risk Assessment (**PSRA**) model, which can be used in disaster reduction, risk spreading and transfer

Some Practical Applications of TELES

- ESLE was developed for quick estimation of disaster scale and distribution soon after strong earthquakes to assist Central Emergency Operation Center (CEOC) in dispatching rescue, medical and other resources since 2003
- Every county/city government and associated organization use TELES as a tool to assist in proposing seismic disaster reduction plans and urban disaster reduction systems since 2005
- 2005-2008, Directorate General of Highways, MOTC adopted TELES risk assessment model to prioritize the seismic retrofit sequence of provincial highway bridges
- ESLE was applied in Taiwan Residential Earthquake Insurance Fund (TREIF) in 2007 and in highway bridges of DGH in 2011
- Develop TREIF-ERA to assess premium and PML of residential earthquake insurance in 2009-2010
- Cooperate with Water Resources Agency of MOEA to study post earthquake performance of potable water systems in Taiwan, 2010-now
- …

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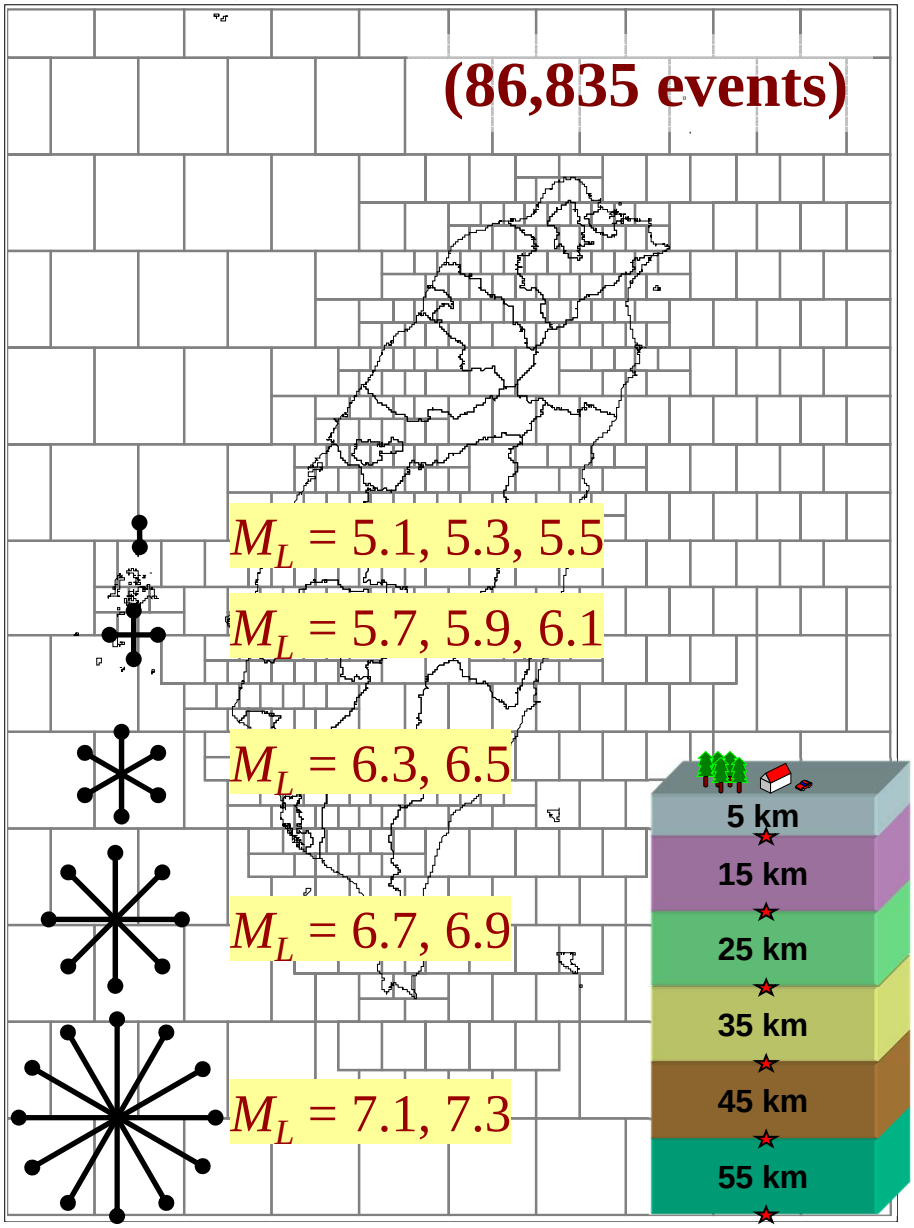
Early Seismic Loss Estimation

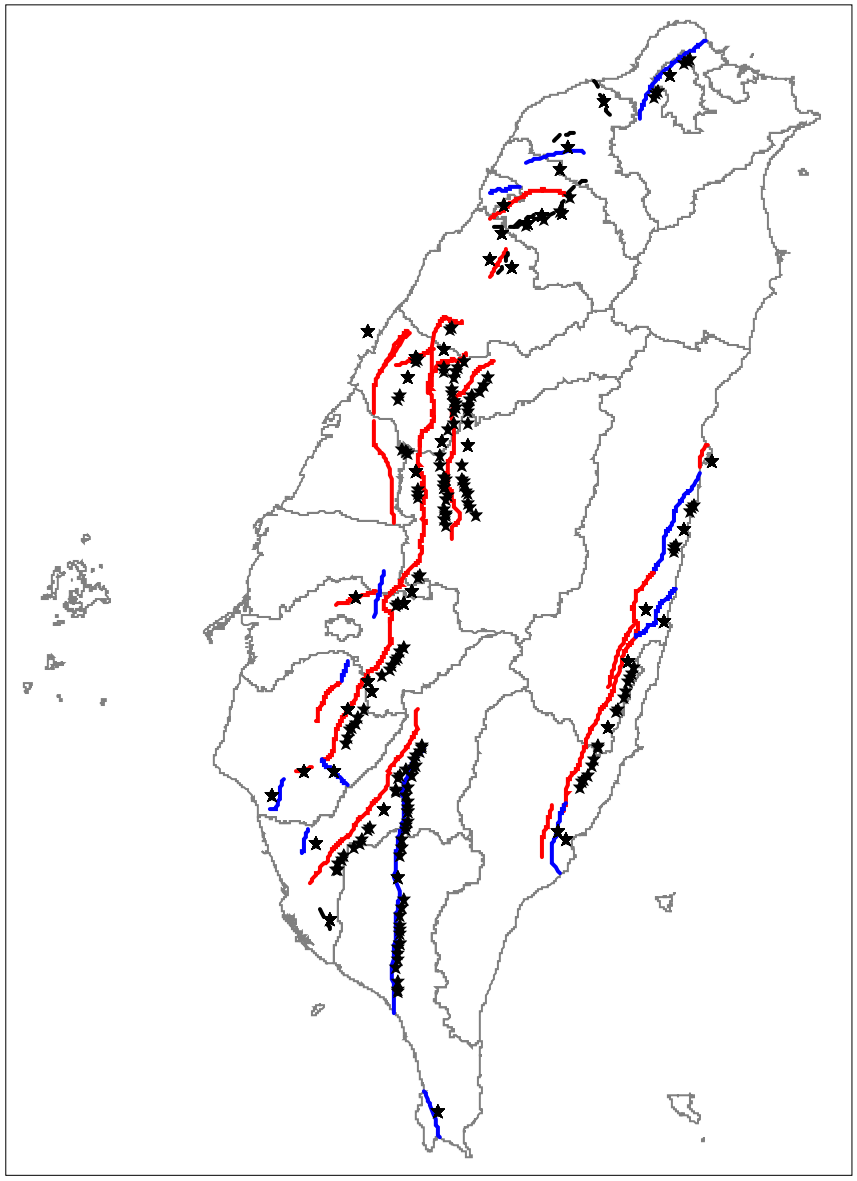
Establishment of TSSD (Area Sources)

- Scope:
  longitude 119˚-123˚
  latitude 21˚-26˚
- Grid size (0.1, 0.2, 0.4) according to exposure and seismicity
- Focal depth
  5, 15, 25, 35, 45, 55 km
- Line source model
- Various earthquake magnitudes and fault directions

$$L = \exp(1.5483M_L - 6.8251)$$



Establishment of TSSD (Active Faults)



- Reference the publications by Central Geological Survey Bureau in 2000 and 2010
- 40 active faults
- 557 seismic events

Early Seismic Loss Estimation

- CWB has developed TREIRS
  - Obtain point-source parameters (M, Ex, Ey, D) within 18.8±3.8 seconds
  - Send earthquake alerts to all clients
- ESLE module of TELES
  - Auto-trig when receive email from CWB
  - Obtain estimation results within 2 minutes and auto-output maps and tables
  - Dispatch short text messages to emergency personnel and send E-mail to provide more information
  - More information may be queried on the web-site http://teles.ncree.org.tw/tesle
  - Assist in decision-making about starting central or county/city EOC and dispatching various kinds of resources

Some Remarks of ESLE

- It is difficult to obtain accurate source parameters right after strong earthquakes
  - Immediately after earthquake, only point-source parameters (M, Ex, Ey, D) are obtained from TREIRS. It takes time to obtain fault-plane solutions
  - Fault rupture direction and length are essential to have accurate estimates, especially for large earthquakes
  - Applications of ground-motion predication model and/or interpolation of PGA at real-time stations are not good enough
- NCREE's approach in ESLE
  - Selects the optimal solutions from pre-calculated database by matching the simulated PGA with the real-time observed PGA
  - Adjust magnitude and/or depth if appropriate
- Advantages
  - Error tolerance of source parameters
  - Provide opportunities to verify analysis models and the associated parameter values after earthquakes
  - Provide quantitative information to initiate CEOC and enhance effectiveness of emergency response

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ESLE vs. Observed Results

Date (UT)	Mag.	Depth	X	Y	Bldg. Dmg		Casualty		Ins. Loss		Note
					Obs.	Est.	Obs.	Est,	Obs.	Est.	
2006/10/9	6.4	47	120.01E	20.75N	0	0	0	0	0.0	0.0	
2006/12/26	6.7	22	120.56E	21.89N	0	0	0	0	0.0	0.0	
2006/12/26	***6.3***	**21**	***120.51E***	***22.40N***	**3**	**72**	**2**	**4**	**0**	**20.0**	**屏東佳冬外海1公里**
2007/1/25	6.1	5	121.91E	22.86N	0	0	0	0	0.0	0.0	台東成功外海61公里
2007/9/6	6.6	27	122.43E	24.20N	0	0	0	0	0.0	0.0	宜蘭南澳外海69公里
2008/6/1	6.8	46	121.77E	19.93N	0	0	0	0	0.0	0.0	
2008/6/1	6.0	99	121.76E	24.95N	0	0	0	0	0.0	0.0	
2009/7/13	6.2	9	122.17E	24.07N	0	0	0	0	0.0	0.0	花蓮秀林外海51公里
2009/8/17	6.4	11	123.30E	23.30N	0	0	0	0	0.0	0.0	
2009/8/17	6.1	20	123.50E	23.36N	0	0	0	0	0.0	0.0	
2009/10/3	6.2	15	121.59E	23.66N	0	0	0	0	0.0	0.0	花蓮豐濱外海10公里
2009/12/19	**6.8**	**46**	**121.75E**	**23.78N**	**>0**	**6**	**0**	**0**	**0**	**3.8**	**花蓮壽豐外海18公里**
2010/2/7	6.2	15	123.09E	23.35N	0	0	0	0	0.0	0.0	
2010/3/4	**6.4**	***5***	**120.73E**	**23.00N**	**25**	**40**	**0**	**1**	**2.8**	**2.6**	**高雄縣桃源鄉**
2010/4/26	6.5	20	123.33E	22.52N	0	0	0	0	0.0	0.0	
2010/10/4	6.8	60	125.30E	23.75N	0	0	0	0	0.0	0.0	

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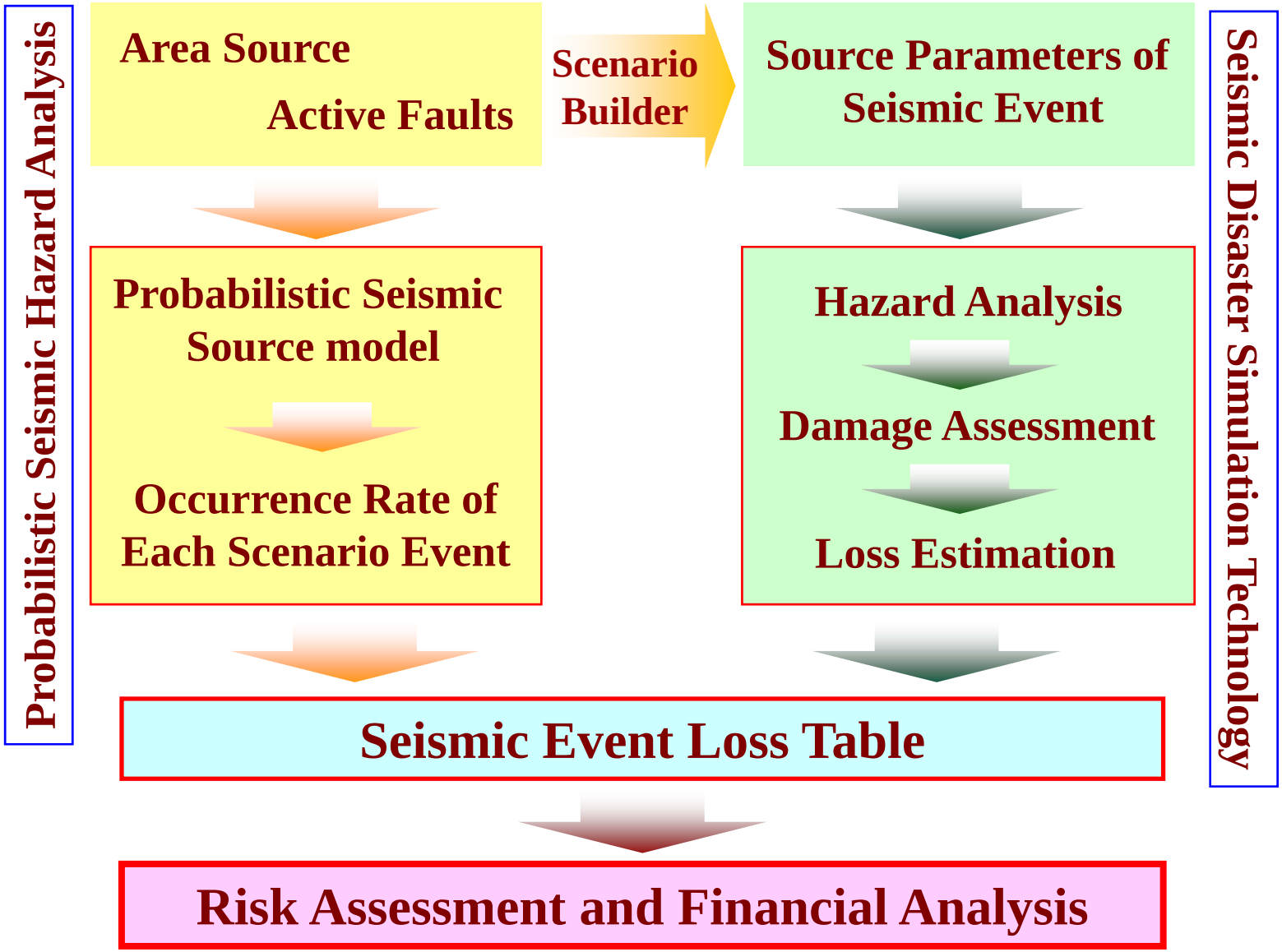
Probabilistic Seismic Risk Assessment

Schematic Diagram of PSRA



Seismic Event Loss Table

- Summarize event specific information
- Used for calculation of statistics

ID	Source Parameters	ν	L	σ	X
1	$M_1, E_1, N_1, d_1, l_1, \theta_1$	ν_1	L_1	σ_1	X_1
2	$M_1, E_1, N_1, d_1, l_1,$	ν_2	L_2	σ_2	X_2
…			…		
j	$M_j, E_j, N_j, d_j, l_j,$	ν_j	L_j	σ_j	X_j
…			…		
J	$M_J, E_J, N_J, d_J, l_J, \theta_J$	ν_J	L_J	σ_J	X_J
	magnitude, epicenter location, focal depth, rupture length, angle	annual occurrence rates	expected losses	uncertainty, standard deviations	total exposures

discrete scenarios

seismic source model

seismic disaster simulation

uncertainty analysis

inventory database

Average Annual Loss (AAL) & Its Standard Deviation (STD)

Seismic source models

$$AAL = \sum_{i=1}^{N} (L_i \cdot \nu_i)$$

$$STD = \sqrt{\sum_{i=1}^{N} \left[(L_i^{\,2} + \sigma_i^{\,2}) \cdot \nu_i \right]}$$

Seismic scenario simulation

L_j = expected loss due to scenario earthquake *j*

σ_j = standard deviation of loss due to scenario earthquake *j*

ν_j = annual occurrence rate of scenario earthquake *j*

Prioritization of Seismic Retrofit of Highway Bridges

- **Risk indicator I_r**
  - **AAL before retrofit L_c, remaining years before retrofit N_c, rebuild cost C_b**

$$0 \le I_r = \frac{L_c \cdot N_c}{C_b} \le 1$$

- **Beneficial indicator I_e**
  - **AAL before and after retrofit: L_c, L_r; retrofit cost: C_r; remaining years after retrofit: N_r**

$$0 \le I_e = \frac{L_c - L_r - (C_r / N_r)}{L_c} \le 1$$

- **Importance indicator**
- **Preliminary investigation score**

Example of Insurance Pricing

- **Premium = (AAL + $\alpha \times$ STD + Fixed Expenses) / (1 - Variable Expense Factor)**
  - **The variable expenses for excess of loss are typically assumed to be around 10% for brokerage and 3% for taxes**

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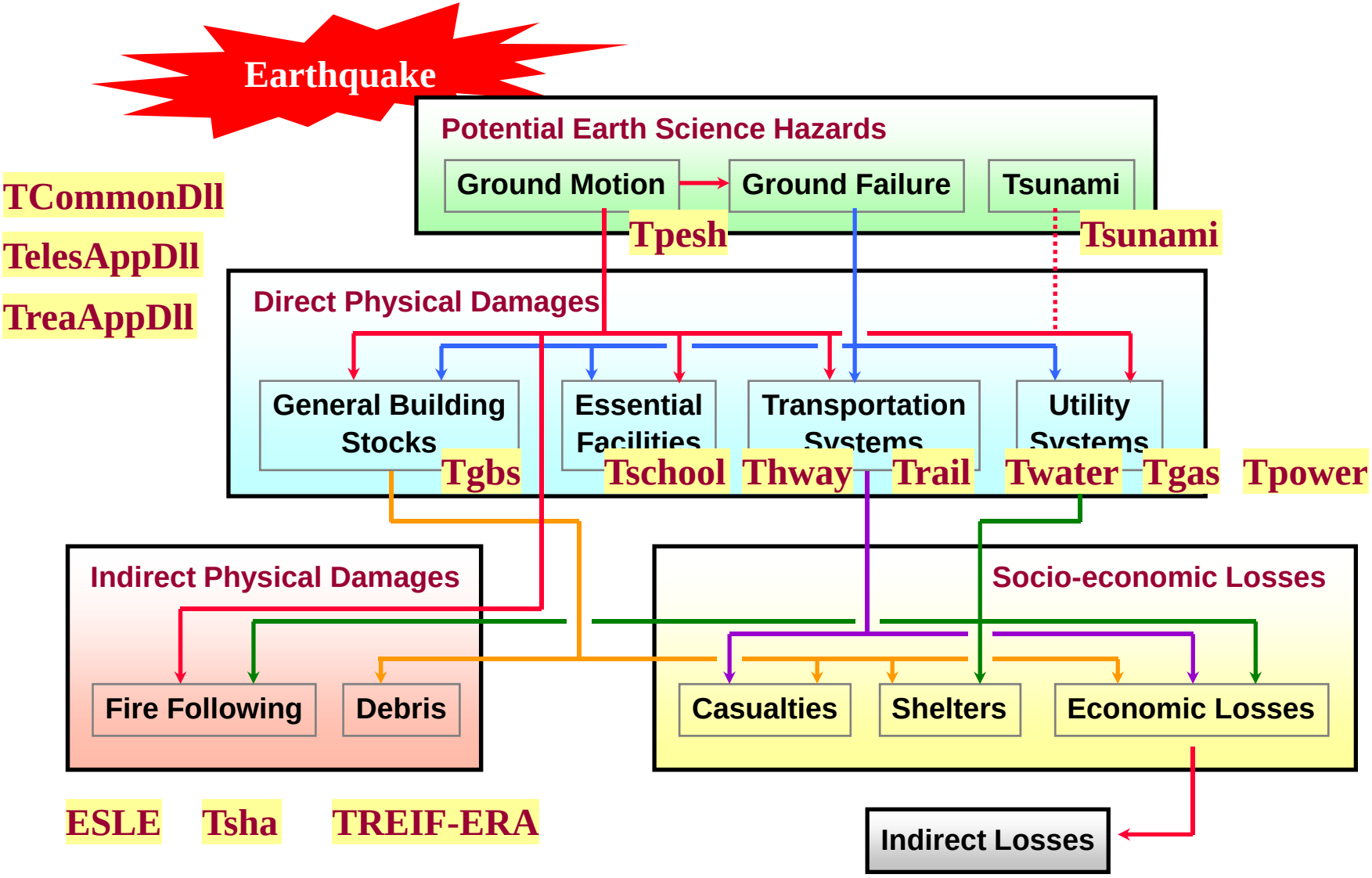
Future Vision

Current Status of TELES

- Collect various kinds of database including geological condition and exposures to be used in SDST and PSRA
- Propose various kinds of analysis models in SDST
- Balance data quality and model complexity
- Develop ESLE to be used in emergency response
- Corporate with CWB and CGS to propose reliable probabilistic seismic source model
- Apply PSRA in insurance pricing and prioritization of seismic retrofit of public facilities

Family of TELES-related Applications



Future Vision of TELES

- Promote ease of use
  - Develop customized user-interface for different purpose applications
  - Each sub-system has the same software architecture, shares the common library and data management framework
  - Each sub-system has its own inventory data but also shares some common geologic and hazard database
  - Each sub-system run independently. However, they may communicate with each other when various kinds of data are put in the same project folder
  - Each sub-system may be maintained by the experts in the field
- Collect and update database
  - Improve precision and content of inventory database, such as address-to-coordinates database and geo-coding algorithm
  - Integrate with National Geographical Information System (NGIS), which is supervised by the Council for Economic Planning and Development and the Ministry of Interior
- Corporate with academia, industry and government to develop analysis models for disaster scenario simulation and risk assessment
  - Emphasize the evaluation of post-quake performance of the whole system, such as network analysis of potable water system under a scenario event
  - Beside seismic hazards and structural vulnerability, emphasize the assessment of social impacts and economic losses, such as casualty, repair cost, restoration time, material and man-power, etc

Development of Web-sites for Seismic Disaster Prevention and Response

- Taiwan Seismic Scenario Database (TSSD) Website
  - Query and display scenario database established by TELES
  - Query exposure statistics in disastrous region under the selected event and other non-scenario basic information
  - http://teles.ncree.org.tw/tssd
- Taiwan Early Seismic Loss Estimation (TESLE) Website
  - Query and display ESLE results soon after M≧5 earthquakes
  - Assist in disaster analysis due to the newly occurred event
  - http://teles.ncree.org.tw/tesle
- Earthquake Disaster Information Upload System (EDIUS) Website
  - Compile investigation by professionals and information from general public to build up the disaster database
  - Query disasters and provide statistical analysis of historical earthquakes
  - http://teles.ncree.org.tw/eqsurvey

Thank You for Attention