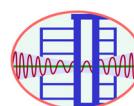




Seismic Preparedness and Emergency Response of Water Systems — Visions and Experiences

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National Center for Research on Earthquake Engineering

Preparedness: Seismic Evaluation and Retrofit

Dr. G.Y. Liu (Karl)

Database

- **Inventory of facilities and pipelines in GIS (geographic information system) format**
- **Attributes of facilities and pipelines**
 - location, service capacity, seismic ability, buried depth, pipe size, material-joint type, construction year, and so on**

Length of Pipelines

Class	Range of pipe diameter (mm)	Total length (km)
Raw water	Transmission pipelines	≥ 700 335
	Transmission pipelines	≥ 800 2,163
Treated water	Sub-transmission pipelines	(500, 800) 2,535
	Distribution pipelines	(100, 500) 53,493

Taiwan Water Corporation

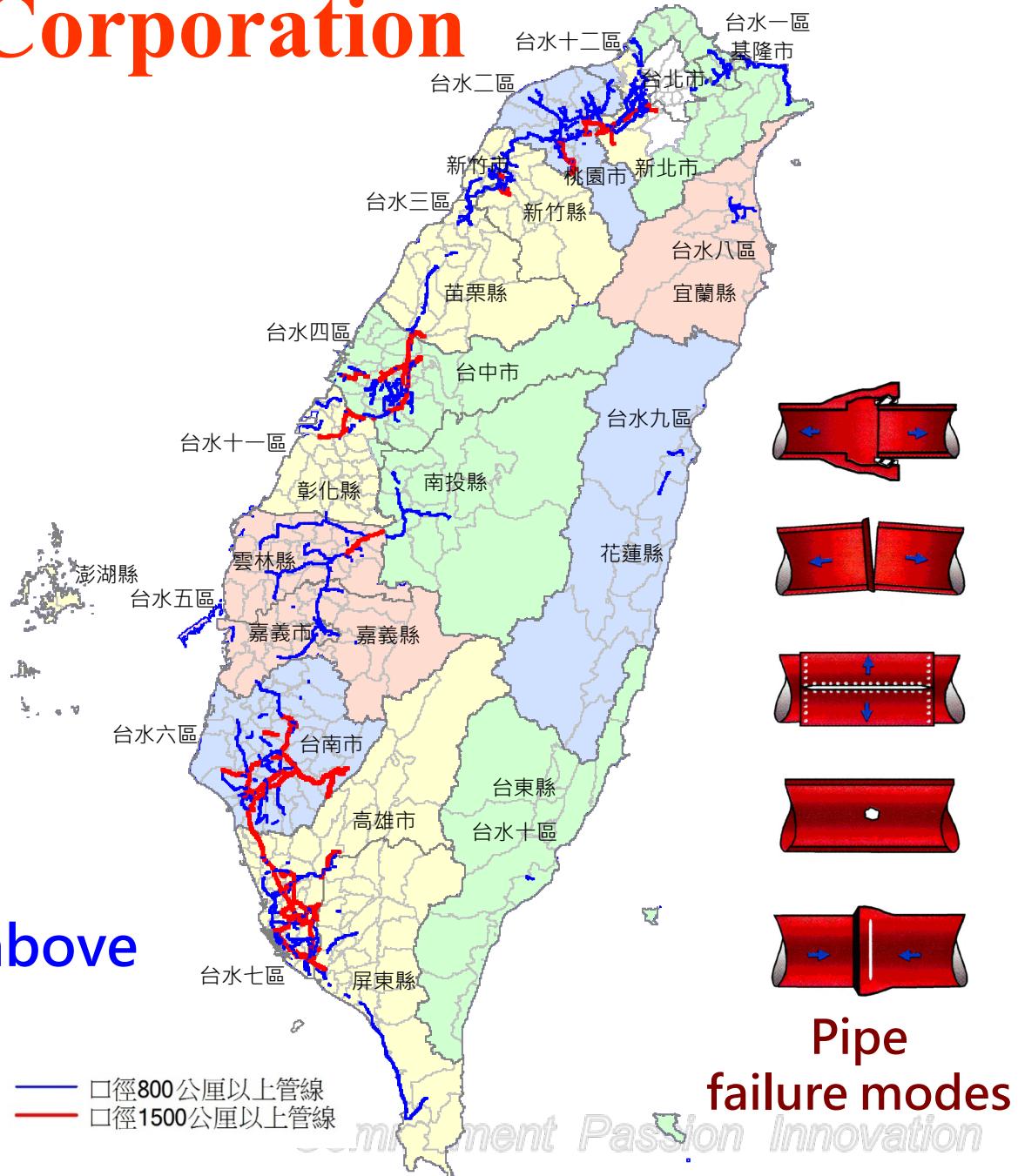
Households: 6,375,451

Population: 17,876,689

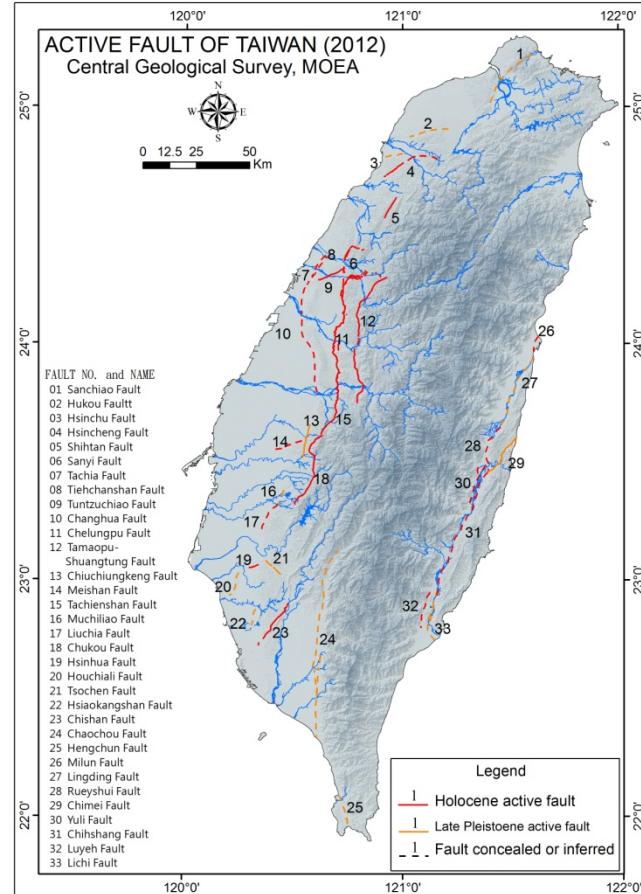
Daily water supply:
8,544,961 m³

Total pipeline length
59,972 km

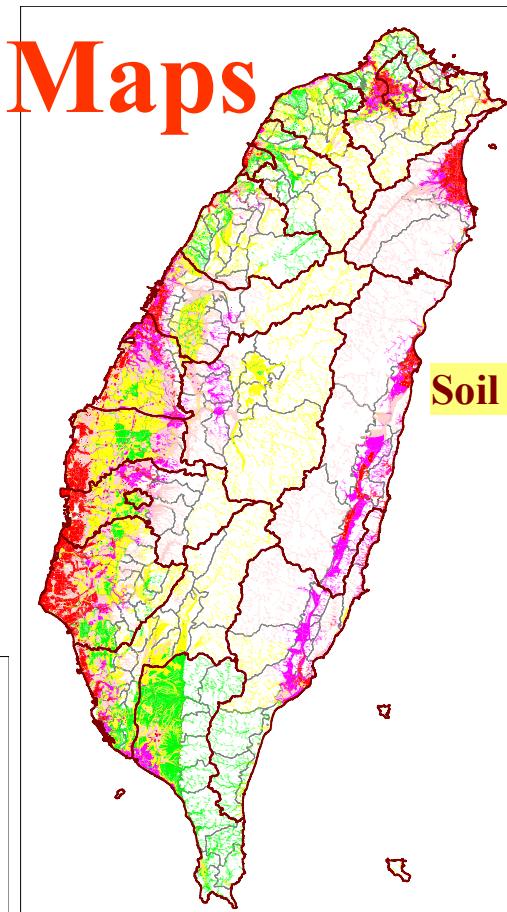
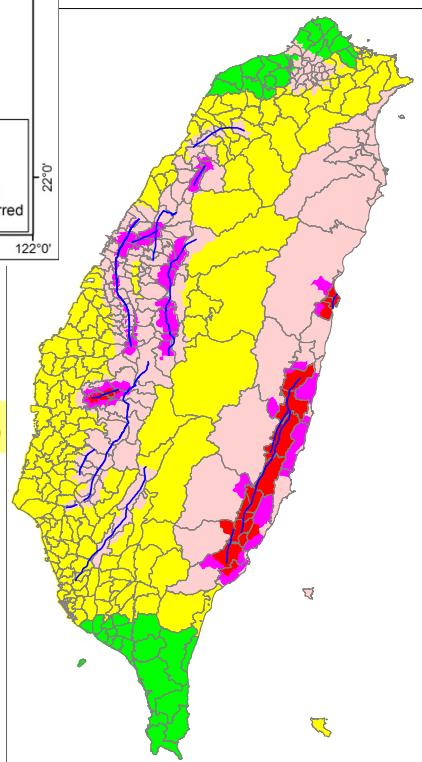
Length of pipeline with
diameter 800mm and above
2,130 km



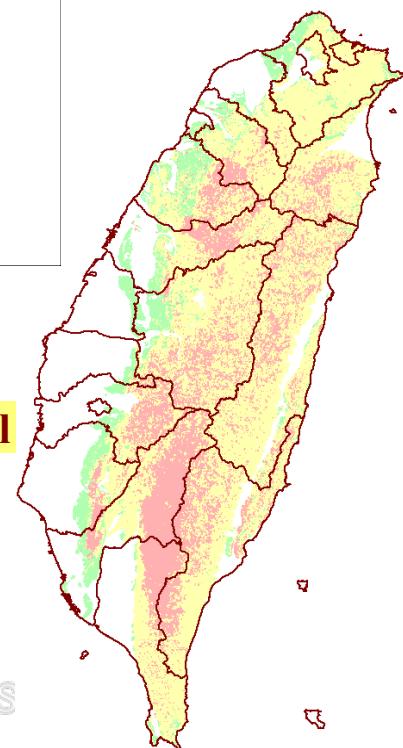
Hazard Maps



Active faults



Land slide potential



Seismic Upgrading Plan

- Overlay water system maps (facility and pipelines) and hazard maps (PGV, soil liquefaction, active faults, and landslide)
- Prioritize sequence of seismic evaluation and retrofit
- Upgrade seismic performance year by year according to annual budget

Preparedness: Scenario-based Disaster Reduction Plan

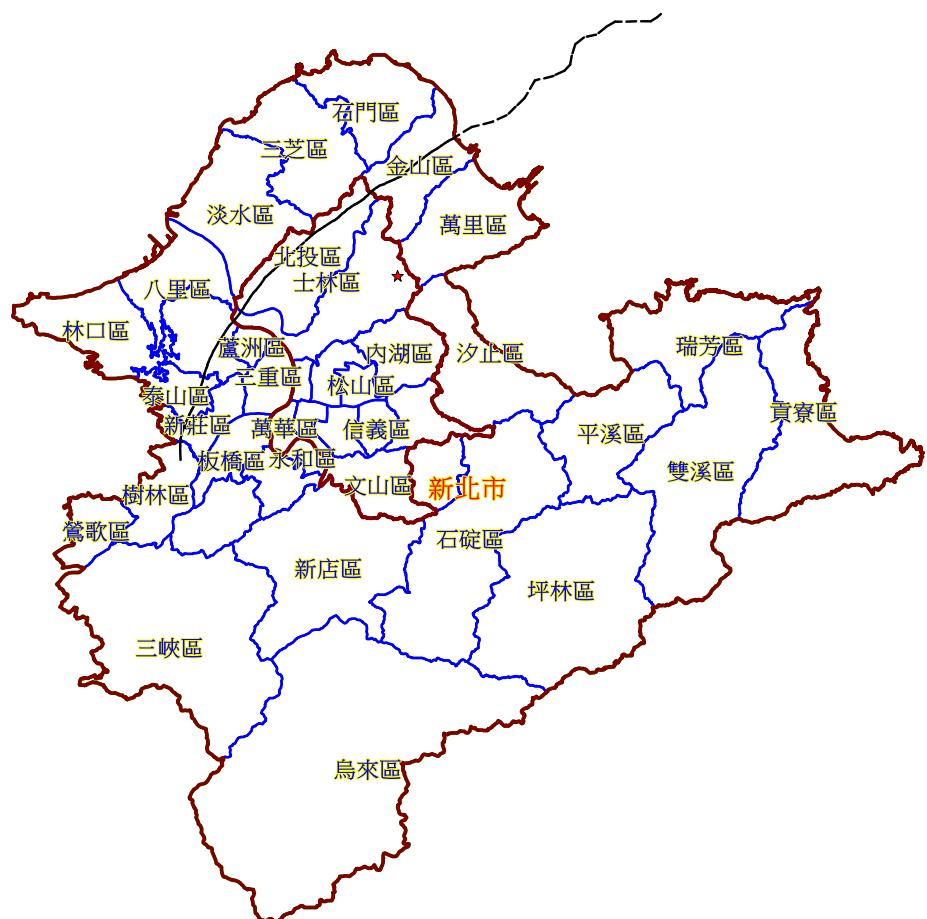
Dr. C.H. Yeh

Estimation of Losses and Resource Needs

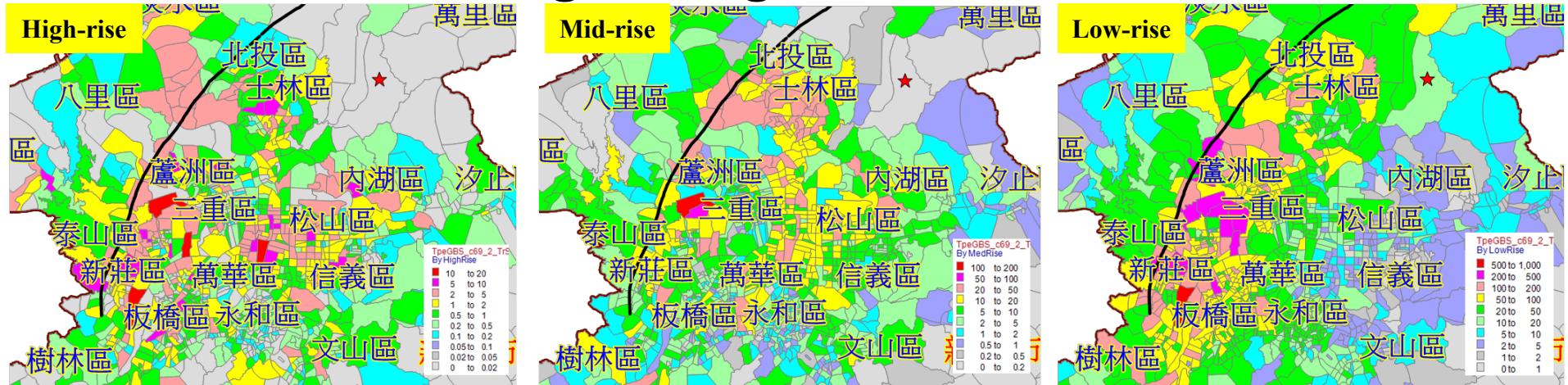
- Provide data in disaster planning and drills

- Case study

- Extreme large earthquake near Metropolitan Taipei
- Shanchiao fault rupture with M6.9, focal depth 8 km, epicenter in Shihlin district
(121.589E, 25.139N)
- Rupture length 56 km, width 20 km, dip 50°



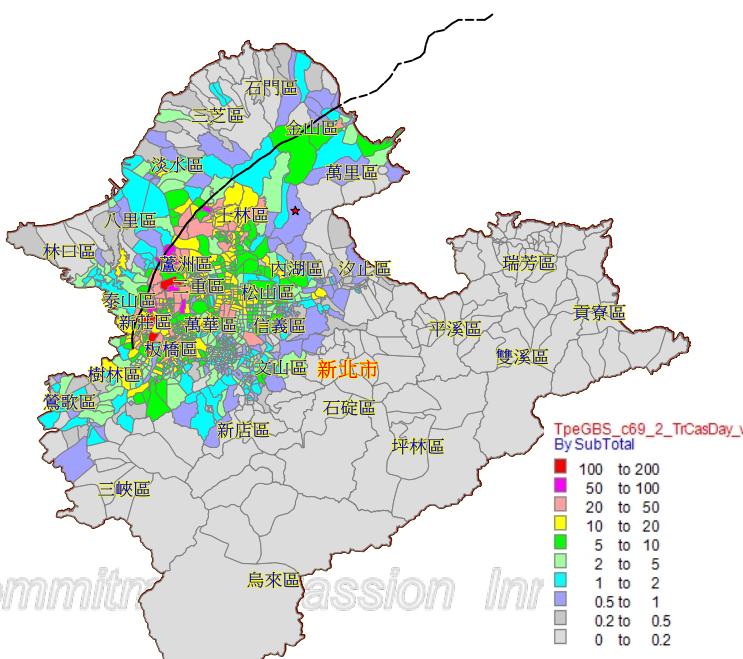
Estimates of Building Damages



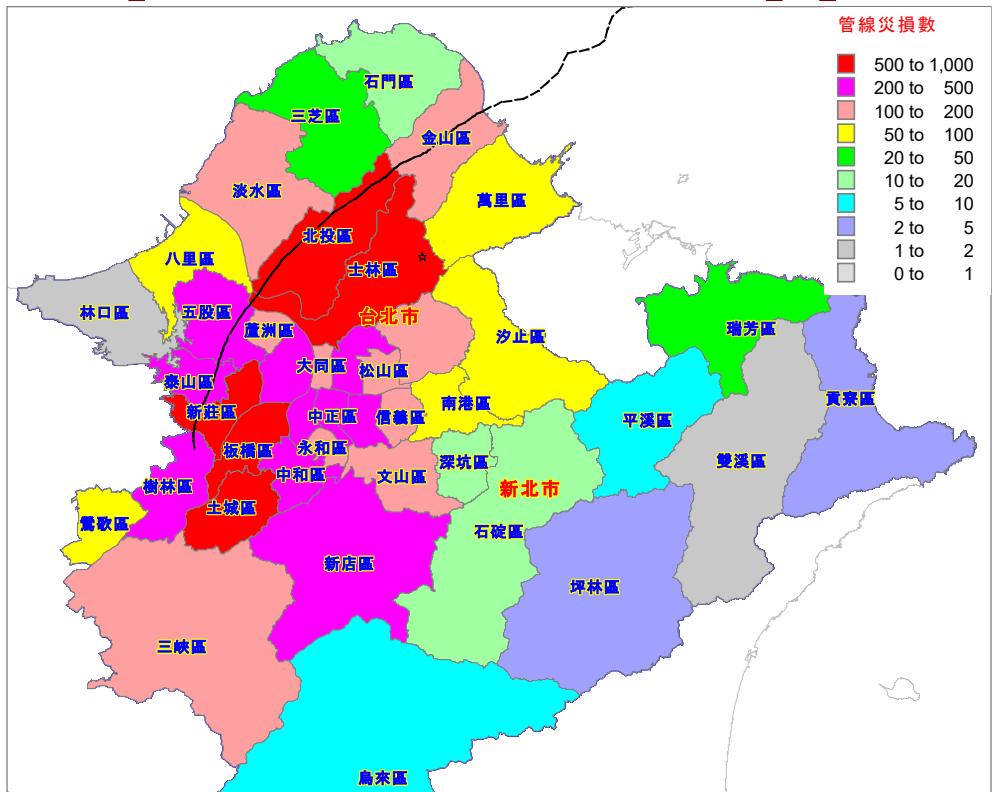
County	Number of building collapse			
	Low-rise	Mid-rise	High-rise	Subtotal
New Taipei	38,165	3,461	682	42,307
Taipei	7,491	4,615	539	12,645
Total	45,656	8,076	1,221	54,952

Estimates of Casualties (day-time)

County	Number of casualties				
	Minor injuries	Moderate injuries	Serious injuries	Death tolls	Subtotal
New Taipei	11,067	4,668	2,935	2,134	5,069
Taipei	7,220	2,800	1,723	1,245	2,968
Total	18,287	7,468	4,658	3,379	8,037



Repair estimates of water pipelines



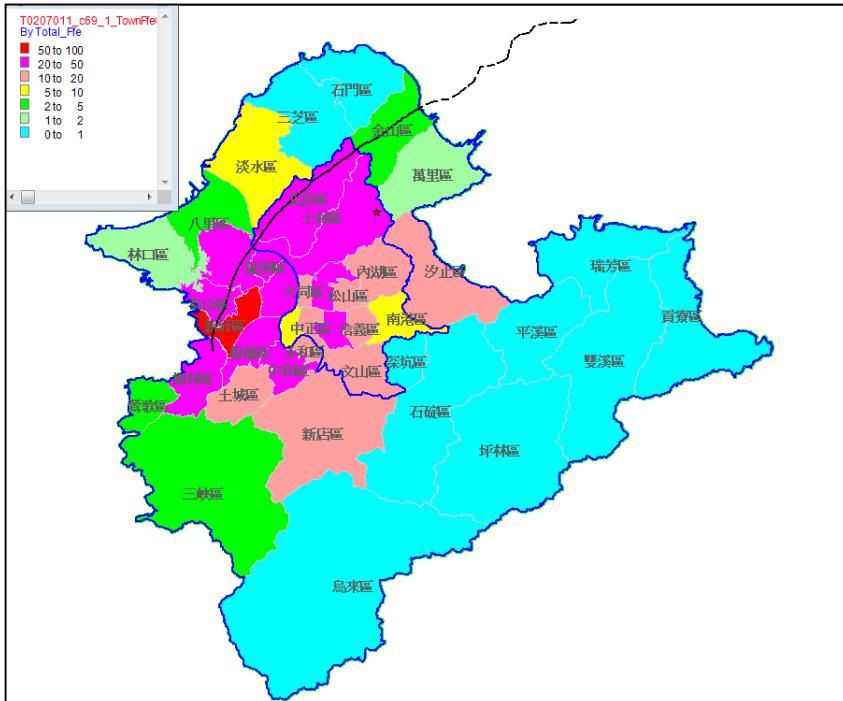
No. of repairs

Transmission pipeline: 185

Distribution pipeline: 5,826

Other pipeline: thousands

Number estimates of post-quake fires



County	Number of ignitions
New Taipei	368
Taipei	203
Total	571

Estimates of Rescue and Medical Resource Needs

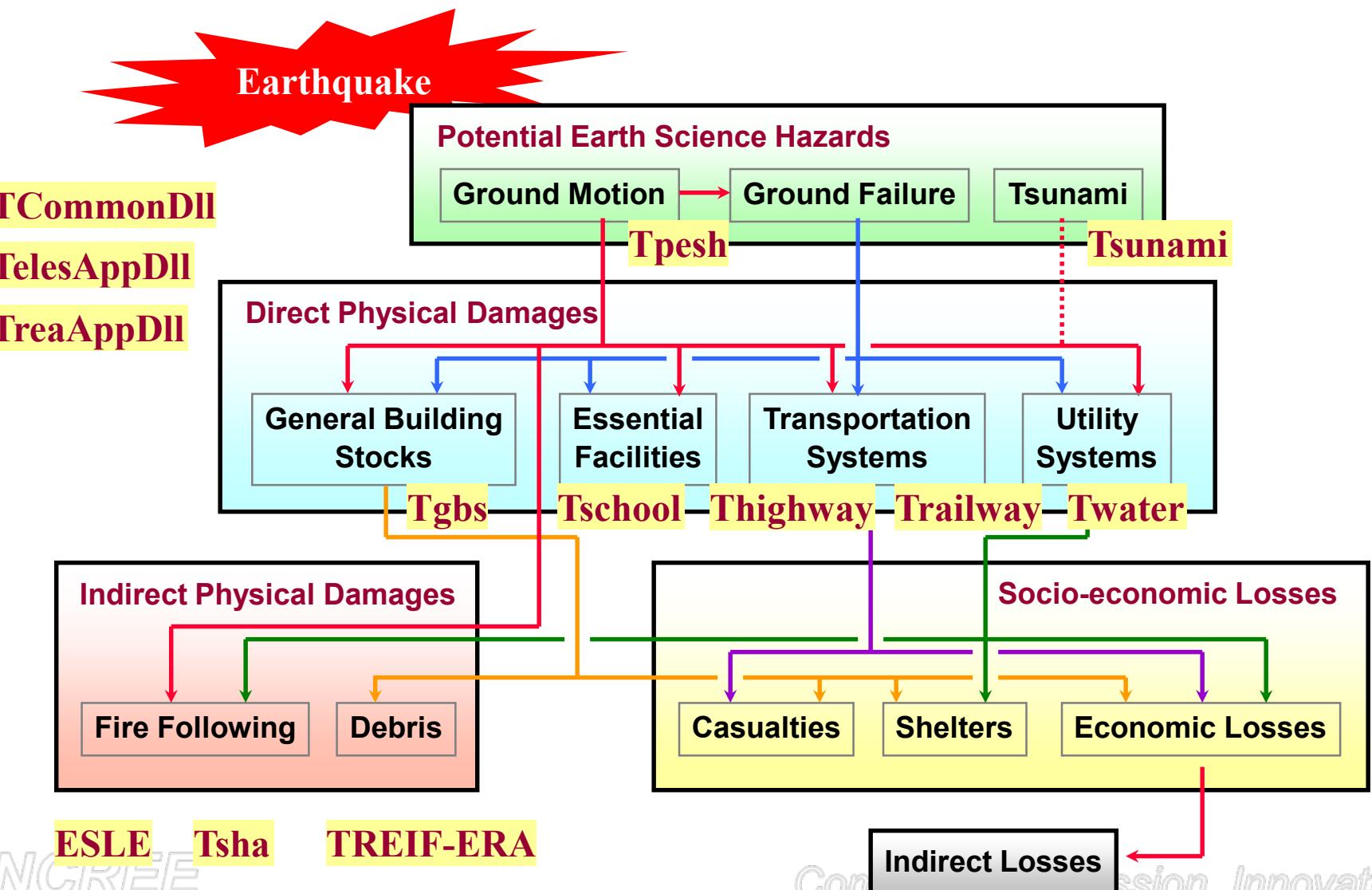
county	Day Time						
	Entrap People	Rescue Teams (12 H, teams)	Rescue Teams (24 H, teams)	Hospital beds	Corpse bags	Ambulance	
New Taipei	340	170	85	7,817	2,721	902	507
Taipei	200	100	50	4,647	1,590	481	297
Total	540	270	135	12,464	4,311	1,383	804

county	Night Time						
	Entrap People	Rescue Teams (12 H, teams)	Rescue Teams (24 H, teams)	Hospital beds	Corpse bags	Ambulance	
New Taipei	388	194	97	8,923	3,111	1,003	579
Taipei	205	103	51	4,760	1,642	489	306
Total	593	297	148	13,683	4,753	1492	885

county	Commute Time						
	Entrap People	Rescue Teams (12 H, teams)	Rescue Teams (24 H, teams)	Hospital beds	Corpse bags	Ambulance	
New Taipei	342	171	86	7,866	2,741	890	510
Taipei	188	94	47	4,386	1,502	451	280
Total	530	265	133	12,234	4,243	1341	790

Analysis Framework and TELES Family

Database, Analysis Models and Application Software



Comprehensive Scenario Simulations

- Interactions among various kinds of transportation and utility systems after disastrous earthquakes
- Disaster reduction plan based on scenario simulations

Emergency Response: Early Seismic Loss Estimation and Notification System

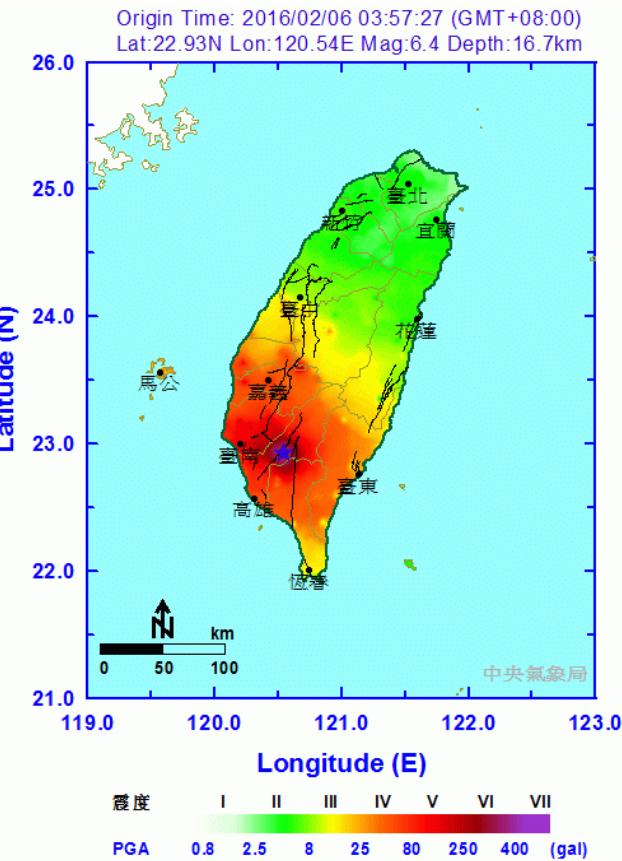
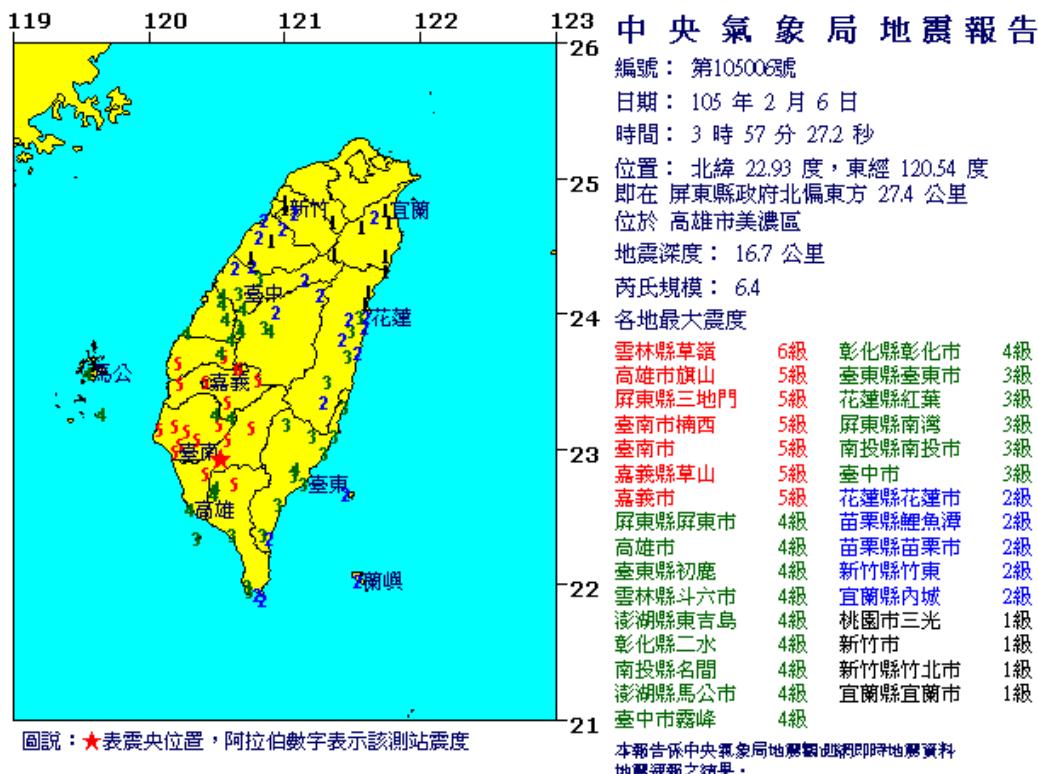
Dr. C.H. Yeh

Necessity of Early Seismic Loss Estimates

- + Right after earthquakes, emergency response personnel of governments and enterprises need information to **assess severity due to the earthquakes**
- + Once emergency operation centers (EOC) initiated, it is required to **assess probable distribution of disasters a.s.a.p.** in order to **dispatch rescue resources**
- + ESLE can be **auto-triggered by email from CWB**, complete estimation and send messages to response personnel within 2 minutes

Case Study of Meinong Earthquake

- Time: 3:57 a.m. on 2016/2/6
- $M_L = 6.4$ (6.6)
- Epicenter: Meinong, Kaohsiung
- Focal depth: 16.7 km
- Maximum intensity 6 in Tsaoling, Yunlin



Stage 1: Automatic

- ESLE was auto-triggered by receiving E-mail from CWB
- Completed estimation and sent messages to emergency response personnel within one minute

SMS: brief Info.



Customizable content in SMS and E-mail

E-Mail: detailed Info.

Ar_SummaryGBS.txt - 記事本

台灣地震損失評估系統的推估結果：
臺灣受災的村里數 1045
預估傷亡人數
12 (5 - 30)

*** 模擬地震事件 1; Scen_ID : kj6530
震央經度：120.3500
震央緯度：23.0500
芮氏規模：6.50
震源深度：15.00 公里
斷層走向：北偏東 0 度
斷層長度：25.50 公里

震災早期評估結果：
全半倒建築物
1-3層樓房 302 棟
4-7層樓房 46 棟
8層以上樓房 9 棟
總計 357 棟

人員傷亡
重傷 7 人
死亡 4 人
總計 12 人

根據中央氣象局之地震速報系統（電子郵件）：
日期：2016/2/6
時間：3:57:27.10
芮氏規模：6.40
震央經度：120.5400
震央緯度：22.9300
震源深度：16.60 公里
最大震度：6
震央在 高雄市美濃區

台灣地震損失評估系統的推估結果請參考附件

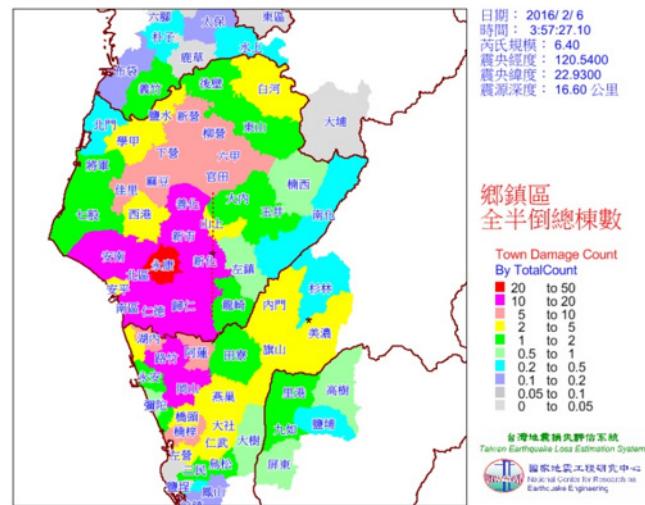
By County City General Building Damage Statistics:

縣市	1-3樓 (棟)	4-7樓 (棟)	8樓以上 (棟)	損害棟數 (棟)	傷亡人數 (人)	建物損失 (百萬元)
臺南市	228	35	5	268	8	21,435.4
高雄市	68	11	4	83	4	11,595.7
屏東縣	4	0	0	4	0	629.6
嘉義縣	2	0	0	2	0	505.9

By Township General Building Damage Statistics:

鄉鎮區	1-3樓 (棟)	4-7樓 (棟)	8樓以上 (棟)	損害棟數 (棟)	傷亡人數 (人)	建物損失 (百萬元)
臺南市永康區	26	6	1	34	1	3,123.8
臺南市東區	12	4	1	18	1	2,021.2
臺南市安南區	15	2	0	17	1	1,667.4

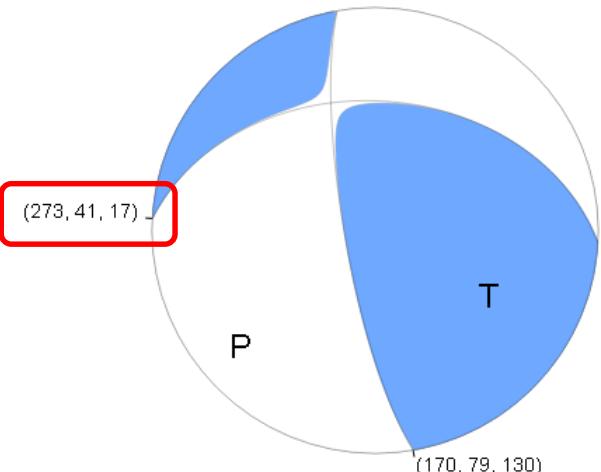
Web Page: with GIS map



No. of building damages (357)

- 1-3 floors (302)
- 4-7 floors (46)
- Above 8 floors (9)

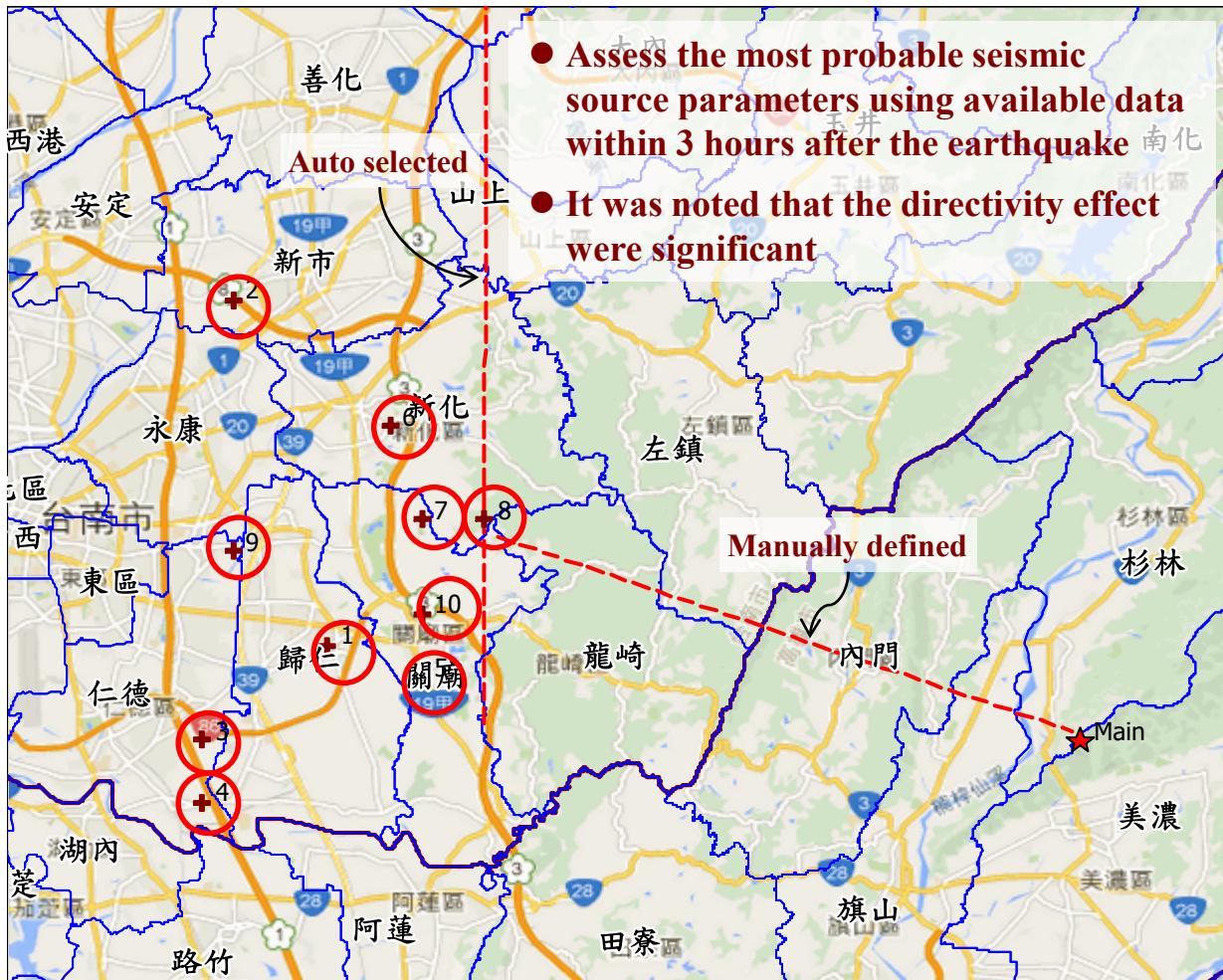
Stage 2: Manual



**Obtained fault plane solution
by USGS in 1 hour**

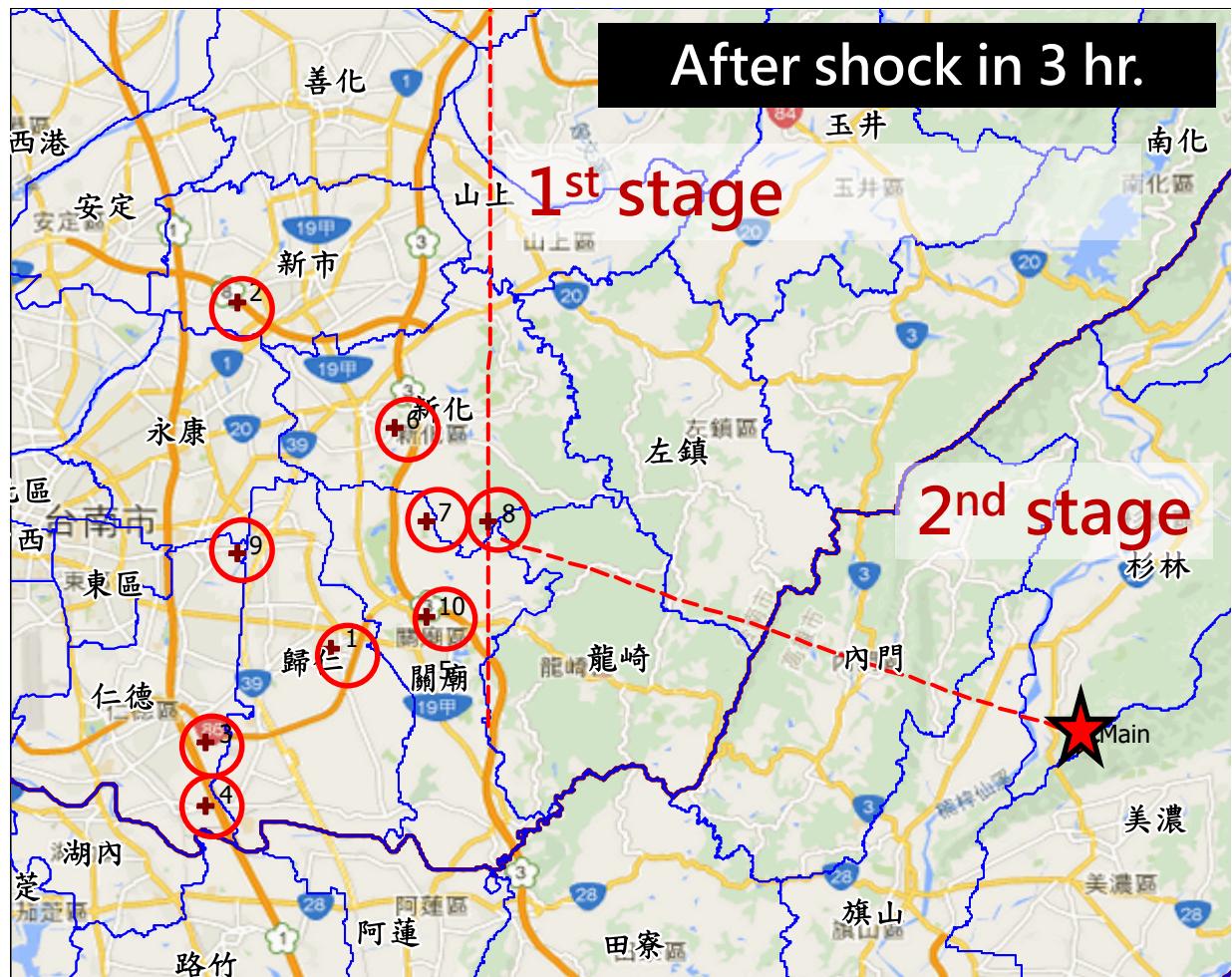
Seismic source parameters

Source	Stage 1	Stage 2
Magnitude	6.5	6.4
Depth	15	15
Direction	0	110
Dip Angle	90	90
Length	25	20



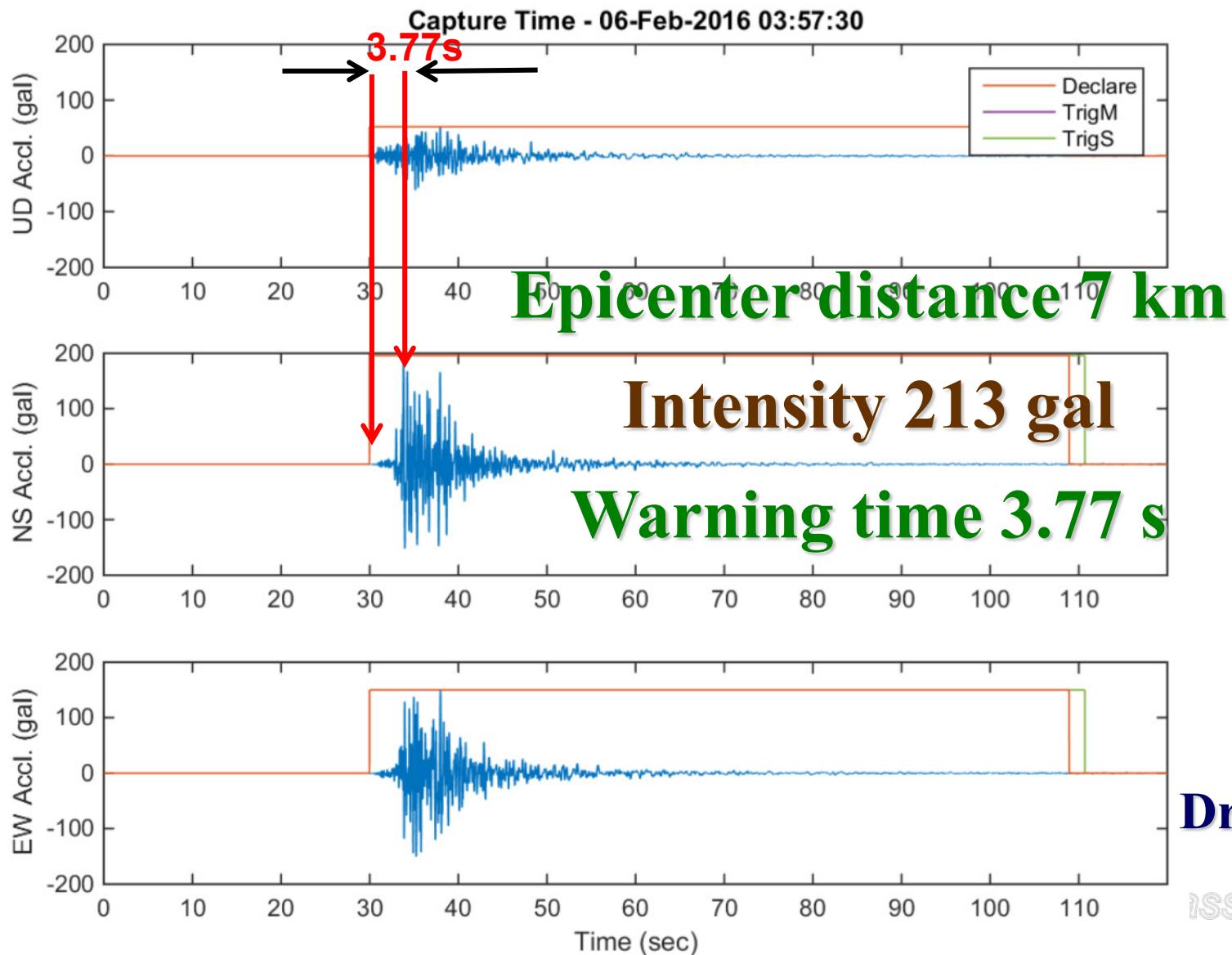
Damage Distribution (TWC district 6)

	Pipe dia. (≥ 100 mm) #damage
<u>In 1 min.</u> auto	409
<u>In 3 hr.</u> manual	206
actual	171



Emergency Response: Earthquake Early Warning

2016 Meinong EQ



高雄市
杉林區
7 km

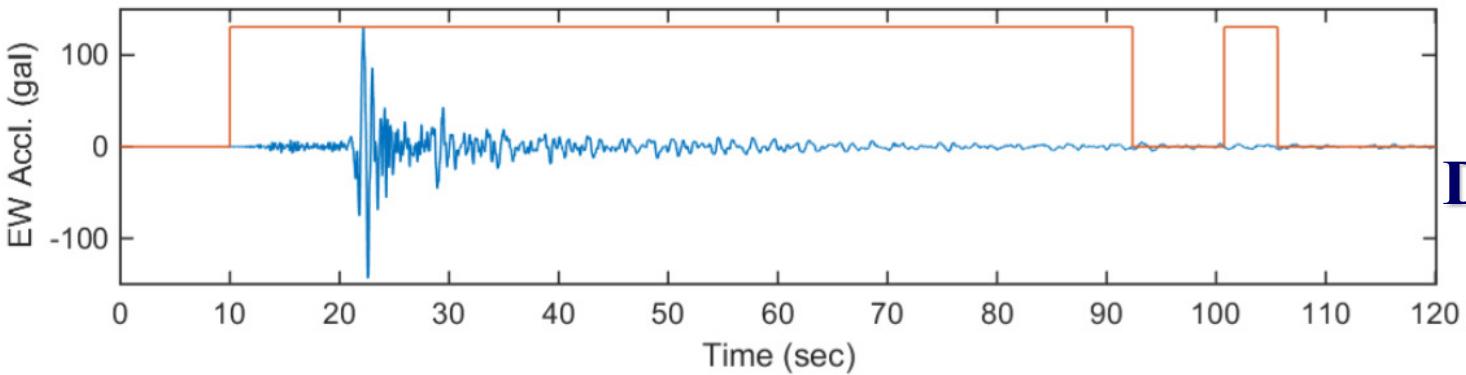
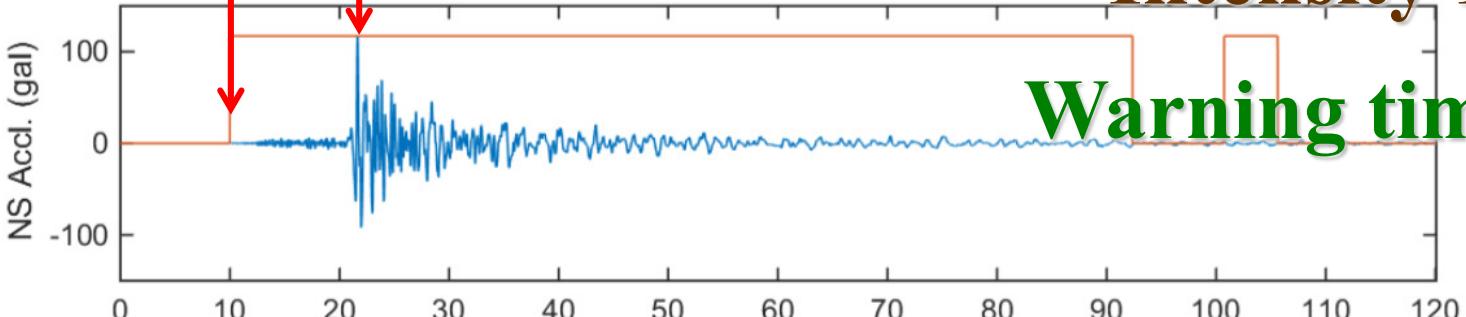
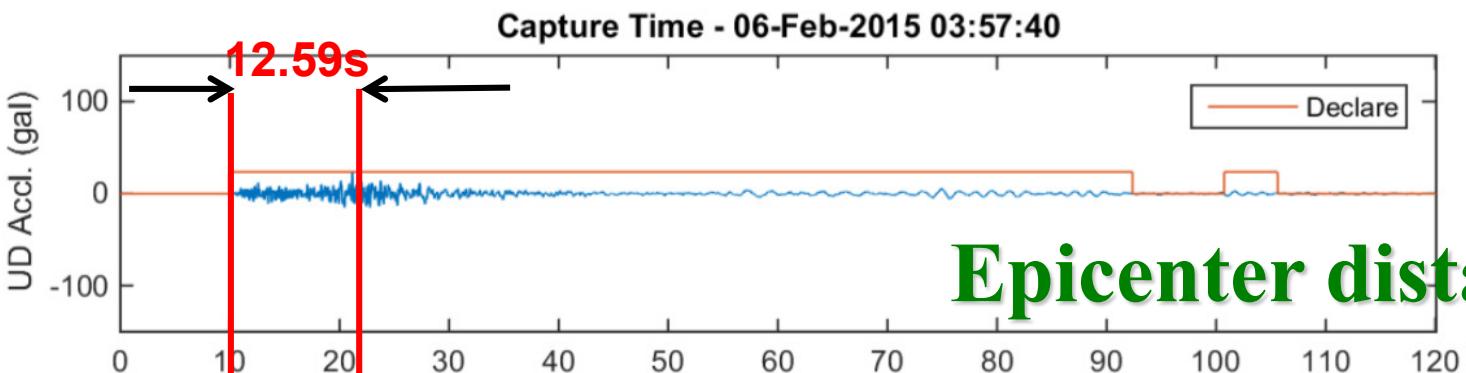


Dr. Pei-Yang Lin
(林沛暘)

Mission Innovation

2016 Meinong EQ

高鐵/雲林
77 km



Dr. Pei-Yang Lin
(林沛暘)

Innovation

Earthquake Early Warning

- Warning time varies from seconds, 10+ seconds, 20+ seconds depend on distance
- How to make use of early warning for water system?

- + **Preparedness**
seismic evaluation and retrofit
disaster reduction plan

- + **Emergency response**
early seismic loss estimation
early warning?

Thank you!

Water Resources Agency, MOEA
Taiwan Water Corporation
Taipei Water Department