APRICOT 2007

Experience of Emergency Management in Response to the Earthquake

Hong-Ren Lo
Chunghwa Telecom
Feb. 28, 2007

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2. 2006 Hengchun Earthquake
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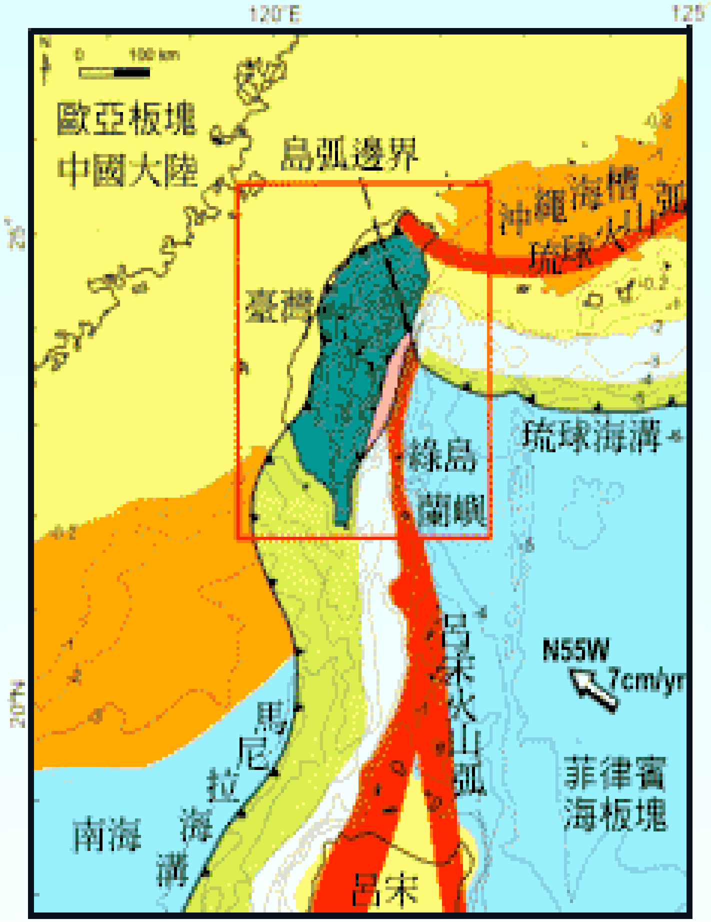
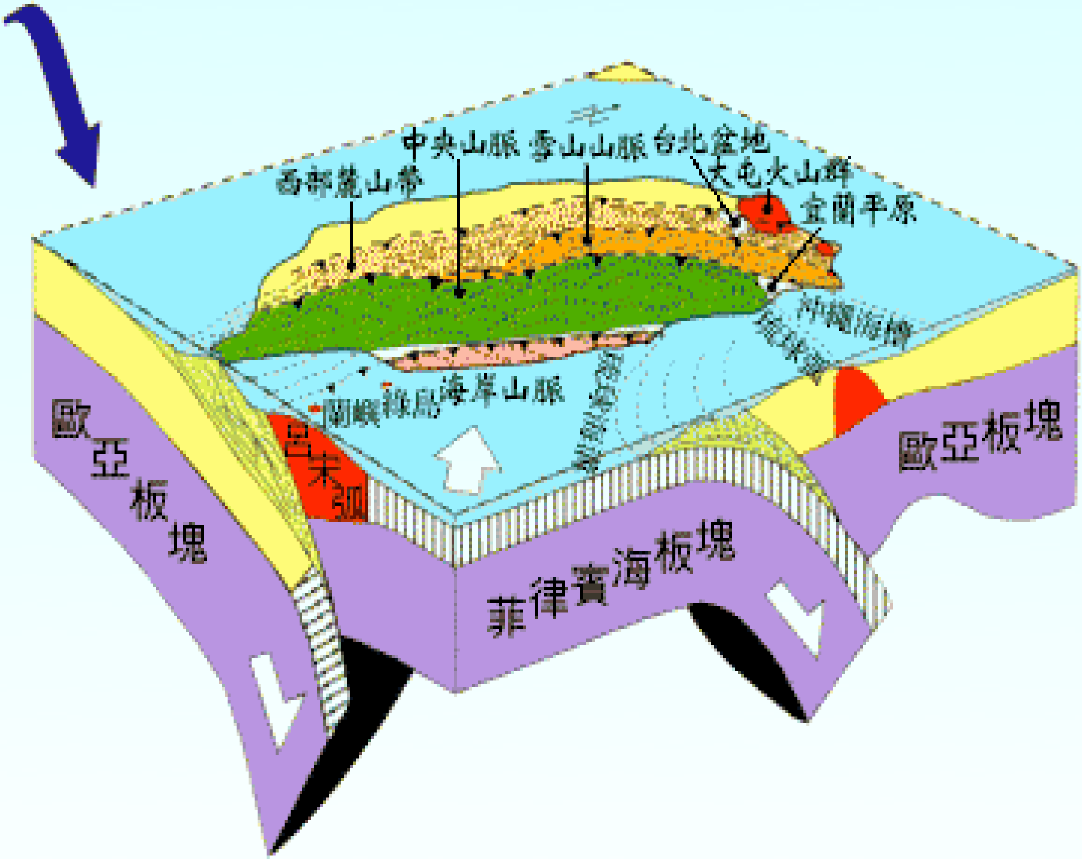
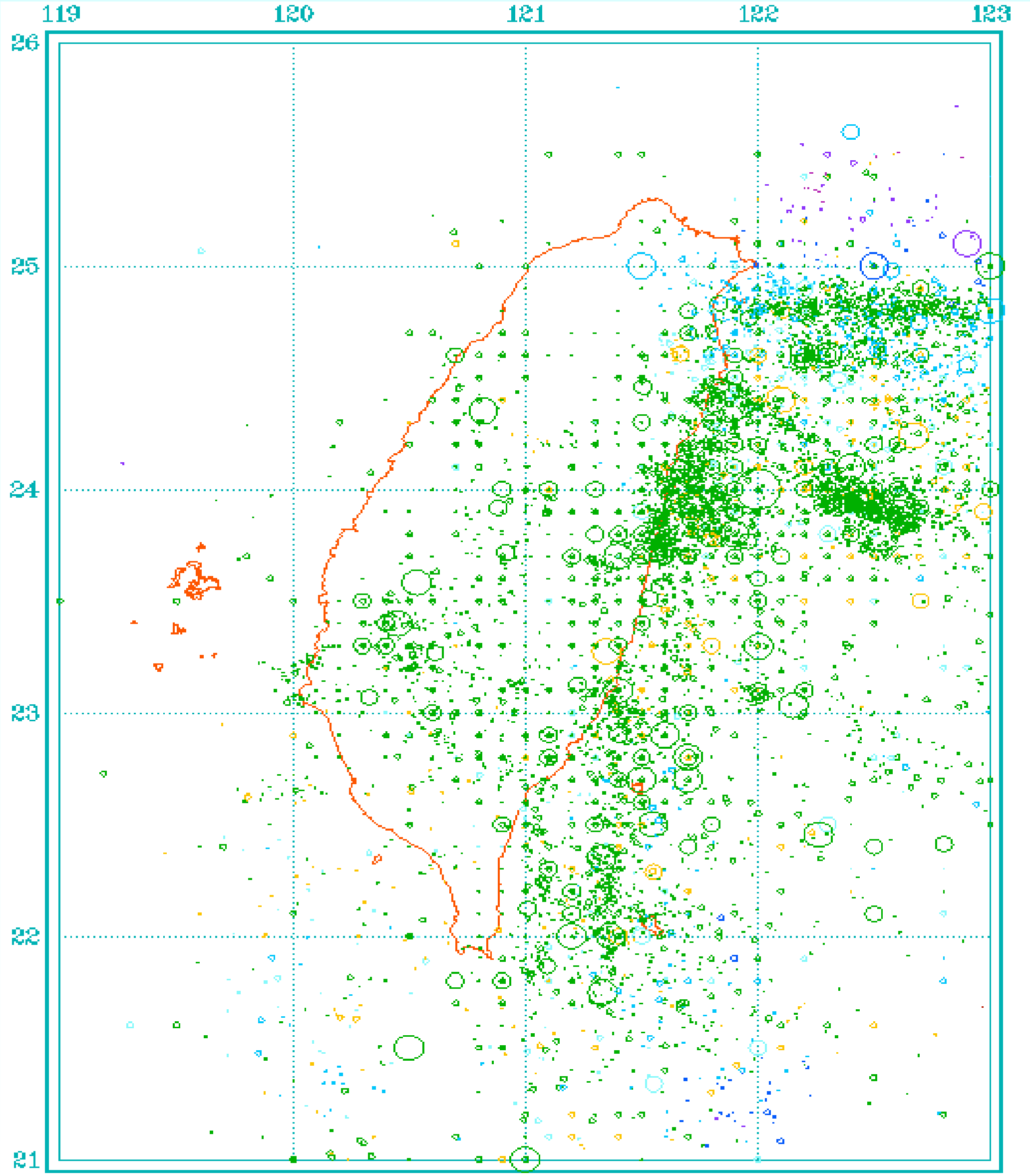
1.The Earthquake & Its Damage

The earth strata around Taiwan


120°E
125°
N
0 100 km
25°
20°N
歐亞板塊
中國大陸
島弧邊界
沖繩海槽
琉球火山弧
臺灣
琉球海溝
綠島
蘭嶼
呂宋火山弧
N55W
7cm/yr
馬尼拉海溝
菲律賓
海板塊
南海
呂宋


中央山脈
雪山山脈
台北盆地
西部麓山帶
大屯火山群
宜蘭平原
沖繩海槽
海岸山脈
蘭嶼綠島
呂宋弧
歐亞板塊
菲律賓海板塊
歐亞板塊

Previous Earthquakes in Taiwan Area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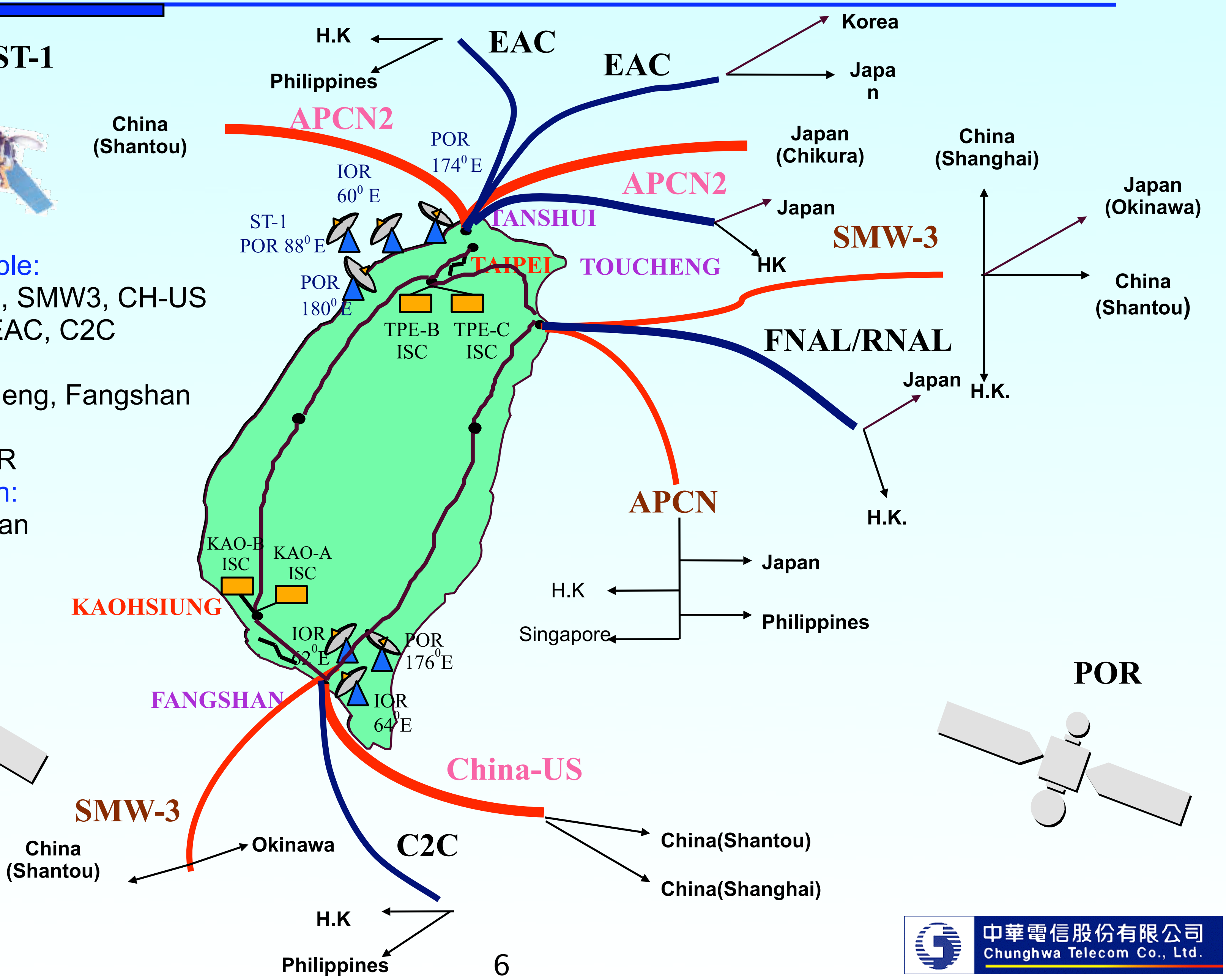
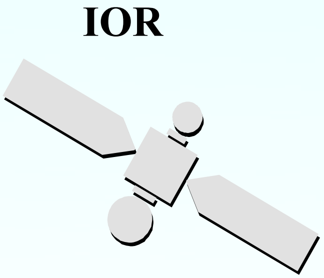
Recent Cable Failures

- **Mar. 31, 2002 Earthquake**
  - APC, APCN, SMW-3： Three outage points
- **Aug. 28-29, 2002 Earthquake**
  - APCN, APCN2, SMW-3, China-US：Four outage points.
- **Dec. 10, 2003 Earthquake**
  - APCN, APCN2, SMW-3, China-US：Six outage points
- **Dec. 26, 2006 Earthquake**
  - APCN, APCN2, SMW-3, China-US：Nine outage points, more serious than ever.

CHT International Network

Submarine Cable:
APCN2, APCN, SMW3, CH-US
FNAL/RNAL, EAC, C2C
Cable Station:
Tanshui, Toucheng, Fangshan
Satellite:
ST-1, POR, IOR
Satellite Station:
Taipei, Fangshan


H.K
Philippines
EAC
EAC
Korea
Japan
China
(Shantou)
APCN2
POR
174⁰ E
IOR
60⁰ E
ST-1
POR 88⁰ E
POR
180⁰ E
Japan
(Chikura)
China
(Shanghai)
APCN2
Japan
TANSHUI
HK
SMW-3
Japan
(Okinawa)
TAIPEI
TOUCHENG
China
(Shantou)
TPE-B
ISC
TPE-C
ISC
FNAL/RNAL
Japan
H.K.
H.K.
APCN
Japan
H.K
Philippines
Singapore
KAO-B
ISC
KAO-A
ISC
KAOHSIUNG
IOR
62⁰E
POR
176⁰E
IOR
64⁰E
FANGSHAN
China-US
POR
SMW-3
China
(Shantou)
Okinawa
C2C
China(Shantou)
China(Shanghai)
H.K
Philippines



2. 2006 Hengchun Earthquake

Time: December 26, 2006 at 12:26 UTC (20:26 local time)

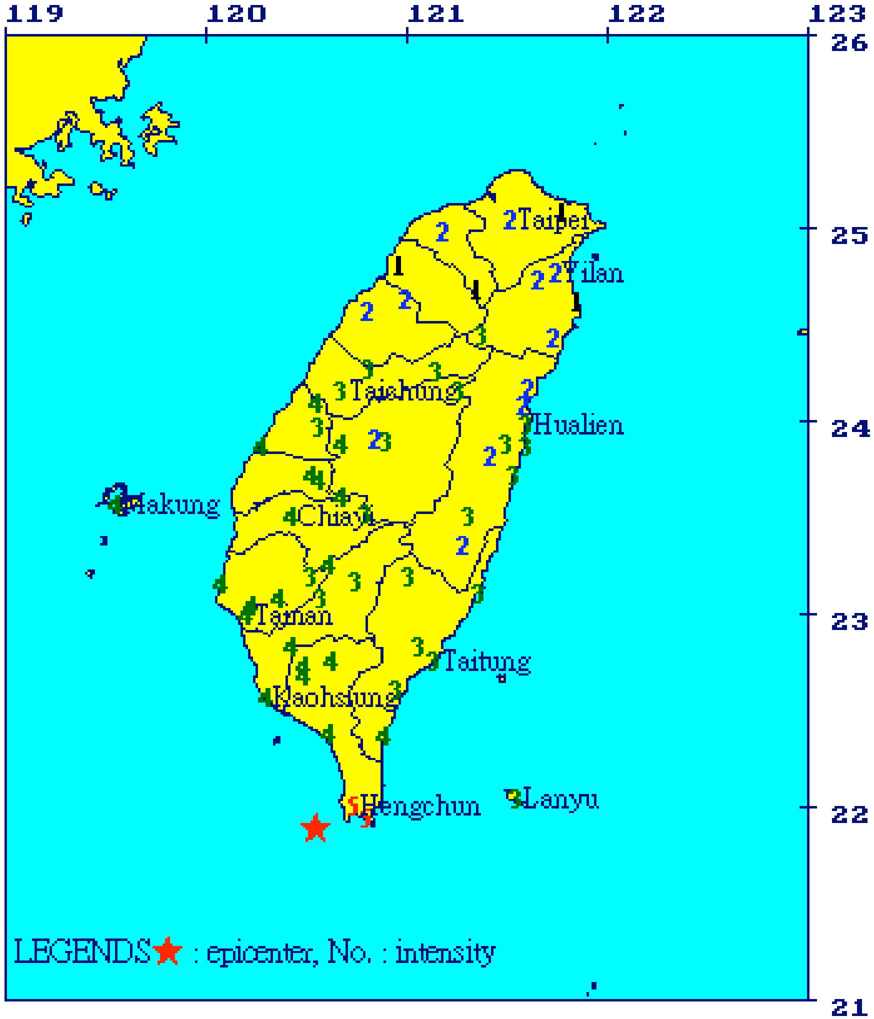
Location:
epicenter off the southwest coast of Taiwan (21.89° N 120.56° E), 22.8 km west southwest of Hengchun, Pingtung County, Taiwan

Depth:
hypocenter 21.9 km deep in the Luzon Strait, which connects the South China Sea with the Philippine Sea.

Magnitude:
Taiwan's Central Weather Bureau marked it at 6.7

News Reporting:
the strongest earthquake to hit Hengchun in one hundred years,
caused casualties and building damages,
damaged several undersea cables, disrupting telecommunication services in Asia.

Earthquake Report (1/2)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23
22
21
Taipei
Yilan
Taichung
Hualien
Makung
Chiayi
Tainan
Taitung
Kaohsiung
Hengchun
Lanyu
LEGENDS★ : epicenter, No. : intensity

CWB EARTHQUAKE REPORT

Earthquake No.: 95106

Origin time (Taiwan Standard Time: GMT+08:00):
12/26/2006 20:26:24.9

Location: 21.89N, 120.56E
i.e. 22.8 km WSW of Hengchun, Pingtung

Depth : 21.9 km

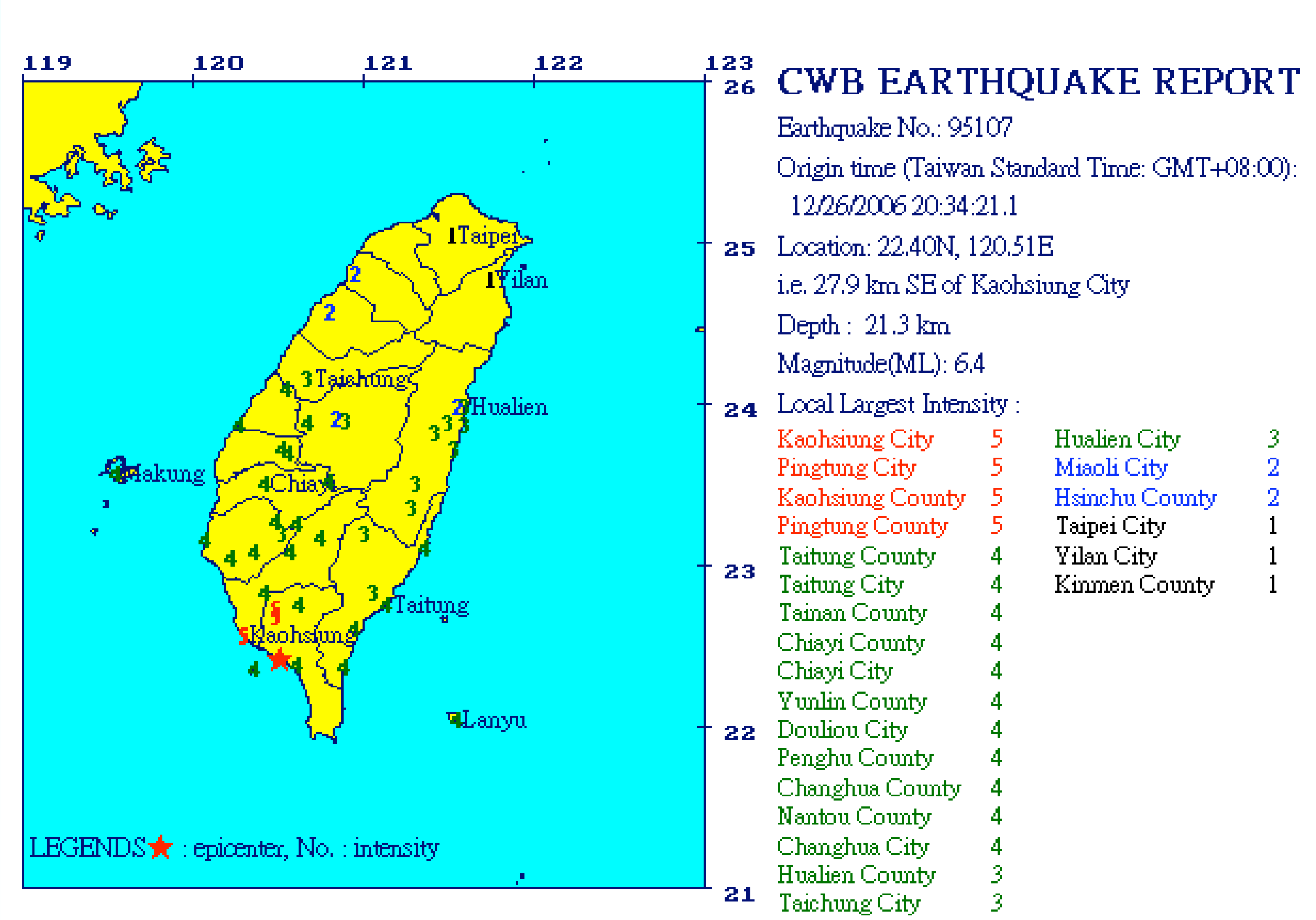
Magnitude(ML): 6.7

Local Largest Intensity :

Pingtung County	5	Taichung City	3
Taitung County	4	Hualien City	3
Kaohsiung City	4	Taichung County	3
Pingtung City	4	Yilan County	3
Kaohsiung County	4	Miaoli City	2
Tainan County	4	Miaoli County	2
Chiayi County	4	Yilan City	2
Chiayi City	4	Taoyuan County	2
Yunlin County	4	Taipei City	2
Douliou City	4	Hsinchu County	1
Penghu County	4	Taipei County	1
Changhua County	4		
Nantou County	4		
Tainan City	4		
Changhua City	4		
Taitung City	3		
Hualien County	3		

Source: Central Weather Bureau, Taiwan

Earthquake Report (2/2)


119
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24
23
22
21
1 Taipei
1 Yilan
2
2
3 Taichung
2 Hualien
23
4 Chiayi
Makung
3
3
3
5 Kaohsiung
5
4 Taitung
4 Lanyu
LEGENDS ★ : epicenter, No. : intensity

CWB EARTHQUAKE REPORT

Earthquake No.: 95107

Origin time (Taiwan Standard Time: GMT+08:00):
12/26/2006 20:34:21.1

Location: 22.40N, 120.51E
i.e. 27.9 km SE of Kaohsiung City

Depth : 21.3 km

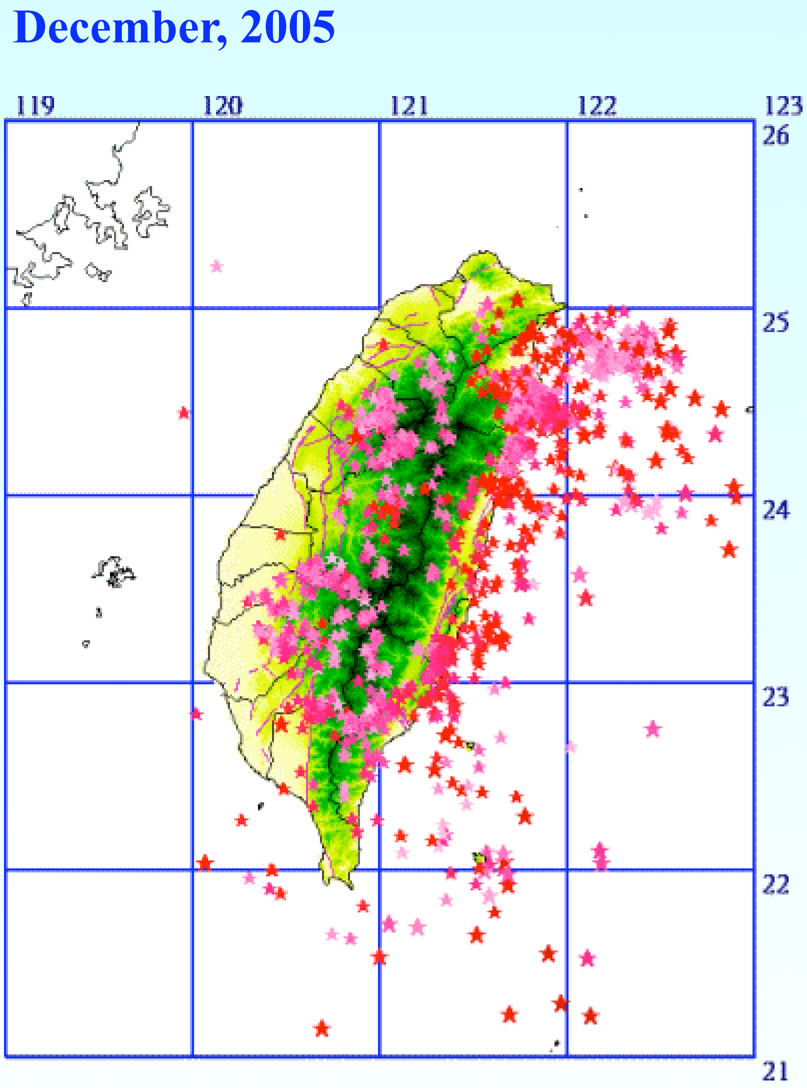
Magnitude(ML): 6.4

Local Largest Intensity :

Kaohsiung City	5
Pingtung City	5
Kaohsiung County	5
Pingtung County	5
Taitung County	4
Taitung City	4
Tainan County	4
Chiayi County	4
Chiayi City	4
Yunlin County	4
Douliou City	4
Penghu County	4
Changhua County	4
Nantou County	4
Changhua City	4
Hualien County	3
Taichung City	3
Hualien City	3
Miaoli City	2
Hsinchu County	2
Taipei City	1
Yilan City	1
Kinmen County	1

Source: Central Weather Bureau, Taiwan

Earthquake Statistics in December


December, 2005
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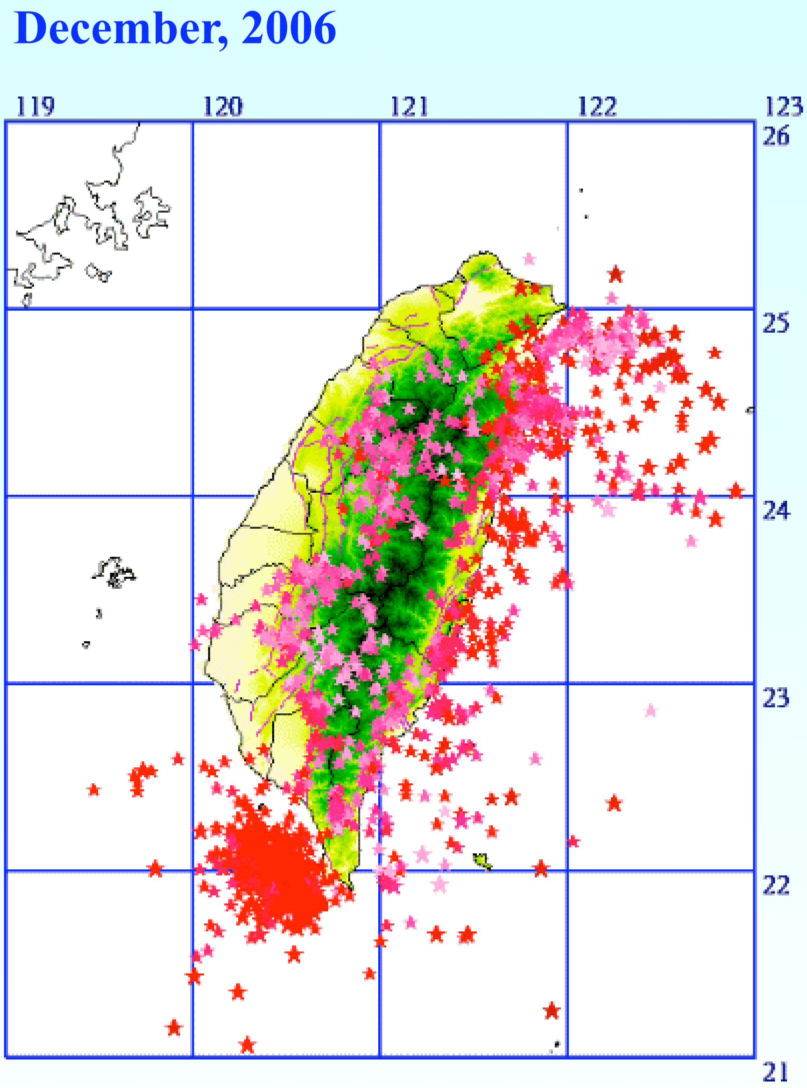
December, 2006
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Source: Central Weather Bureau, Taiwan

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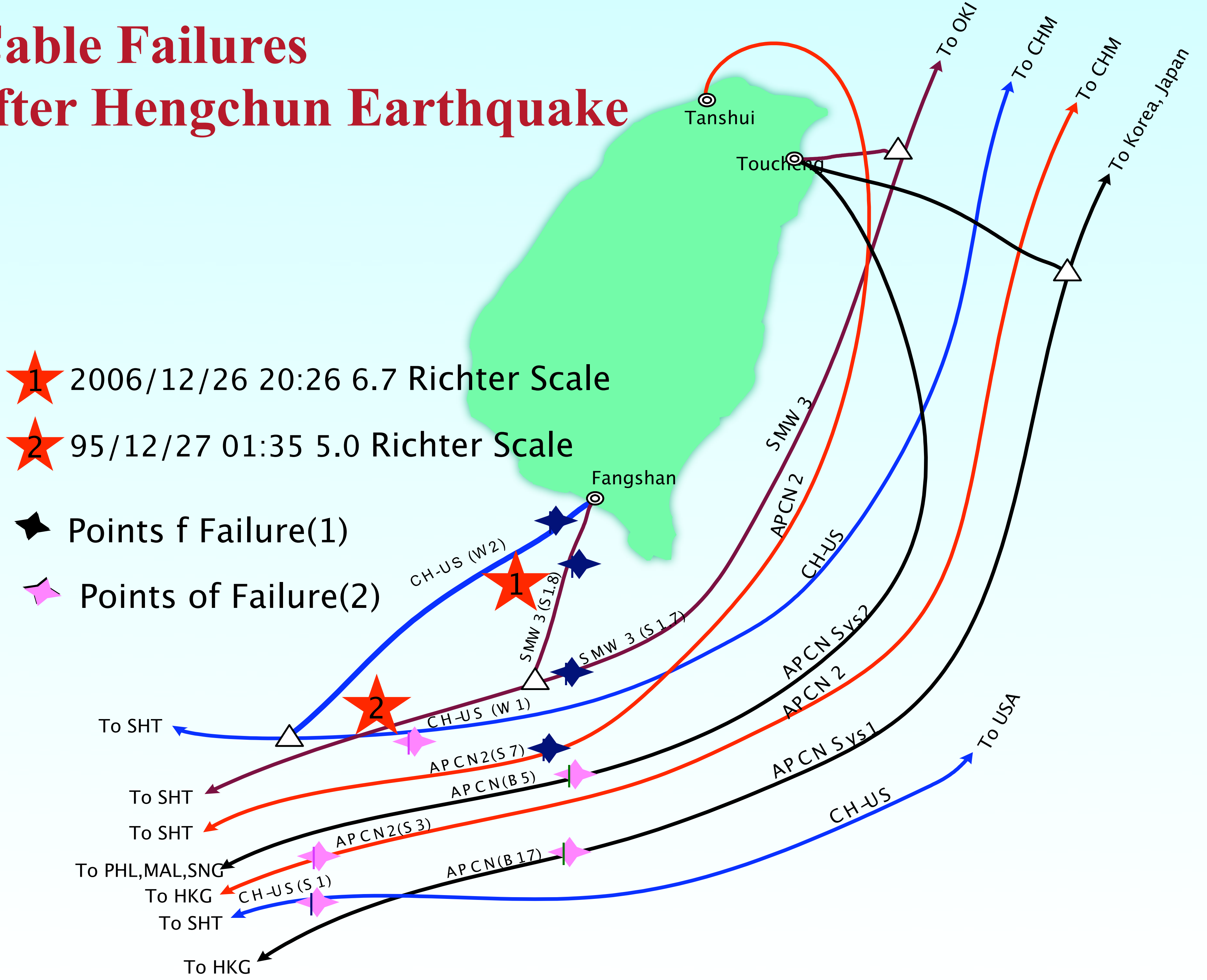
Chunghwa Telecom Co., Ltd.

Cable Failures after Hengchun Earthquake

Earthquake Time (Local Time, UTC+8)	Cable System	Failure Time (Local Time, UTC+8)
2006/12/26 20:26 ML 6.7 **2006/12/26 20:34 ML 6.4** 2006/12/26 20:40 ML 5.1 2006/12/26 22:53 ML 4.9 2006/12/26 23:41 ML 5.5	CH-US (W2)	2006/12/26 20:27
	SMW3 (S1.8)	2006/12/26 20:27
	SMW3 (S1.7)	2006/12/26 20:41
	APCN2 (S7)	2006/12/27 00:06
2006/12/27 00:10 ML 4.5 **2006/12/27 01:35 ML 5.0** 2006/12/27 06:54 ML 4.4 2006/12/27 07:10 ML 4.3 2006/12/27 10:30 ML 5.8	APCN2 (S3)	2006/12/27 02:00
	APCN System 1 (B17)	2006/12/27 02:16
	CH-US (S1)	2006/12/27 03:02
	APCN System 2 (B5)	2006/12/27 04:55
	CH-US (W1)	2006/12/27 10:04

Cable Failures after Hengchun Earthquake



★1 2006/12/26 20:26 6.7 Richter Scale

★2 95/12/27 01:35 5.0 Richter Scale

✦ Points f Failure(1)

✦ Points of Failure(2)

Tanshui
Toucheng
Fangshan
To OKI
To CHM
To CHM
To Korea, Japan
SMW 3
APCN 2
CH-US
CH-US (W 2)
1
SMW 3 (S 1.8)
SMW 3 (S 1.7)
2
CH-US (W 1)
To SHT
APCN Sys2
APCN 2
APCN2(S 7)
APCN(B 5)
To SHT
To SHT
APCN Sys1
To USA
CH-US
APCN2(S 3)
To PHL,MAL,SNG
APCN(B 17)
To HKG
CH-US (S 1)
To SHT
To HKG

3. Emergency Measures & Restoration

(1) Restoration Plan Consideration

- Backup Capacity for Voice and IPLC
- Universal Restoration Manual, URM
- Private Bilateral Restoration, PBR
- Ad hoc Restoration

(2) Impact on Communications

- Phone call completion rate: USA 40%、Japan 11%、China 10%、South East Asia < 5%
- International Private line: 275 links disrupted
- Internet (HiNet):
  Available capacity – USA 100%、Japan 98%、China 26%、Hong Kong 0%

(3) Emergency Measures

(a) Priority order: voice, air traffic control, financial sector

(b) Reroute traffic through other cables or rent capacity from private cable operators to connect to HK, China, Singapore, Malaysia

(c) Set up communication links with Singapore, Macau, Thailand and Indonesia via ST-1 & Intelsat satellites

(d) Detour int'l private lines through SingTel, CT, Reach, TM and other partners

(e) Install terrestrial links to transit traffic through Taiwan for other carriers

(3) Emergency Measures - HiNet

(a) Contact ITMC to confirm the status of submarine cables

(b) Monitor the traffic of direct peering partners by MRTG

(c) Monitor the BGP advertisement from peering partners

(d) Monitor the top 100 AS's traffic by netflow

(e) Monitor the network quality to the well known web sites by checking round trip time and packet loss rate

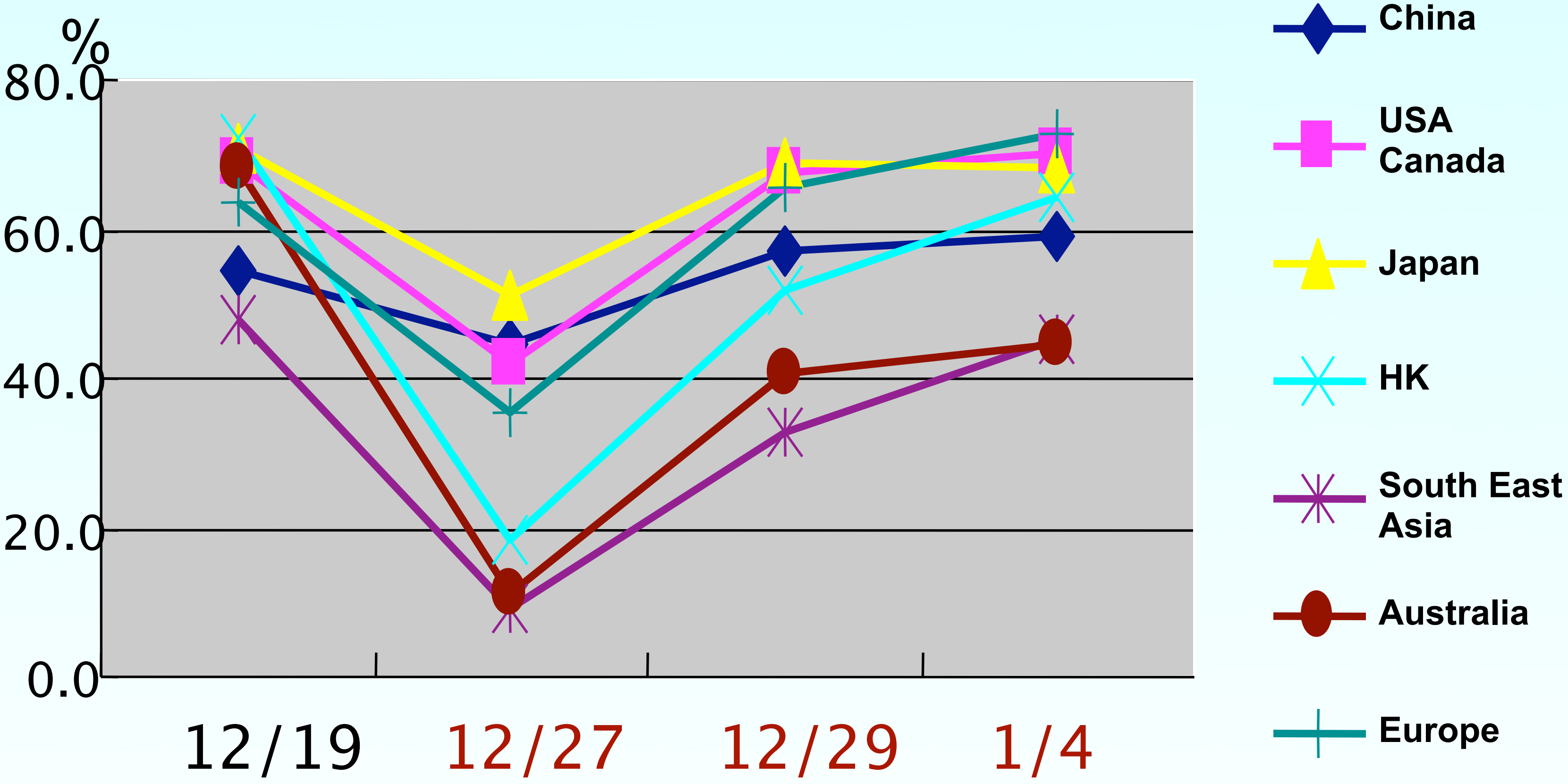
(f) Monitor the traffic volume of some well known applications which consume more bandwidth

(g) Contact peering partners to arrange detour

(h) Contact peering partners to see if needing any help

(4) Service Disruption & Restoration

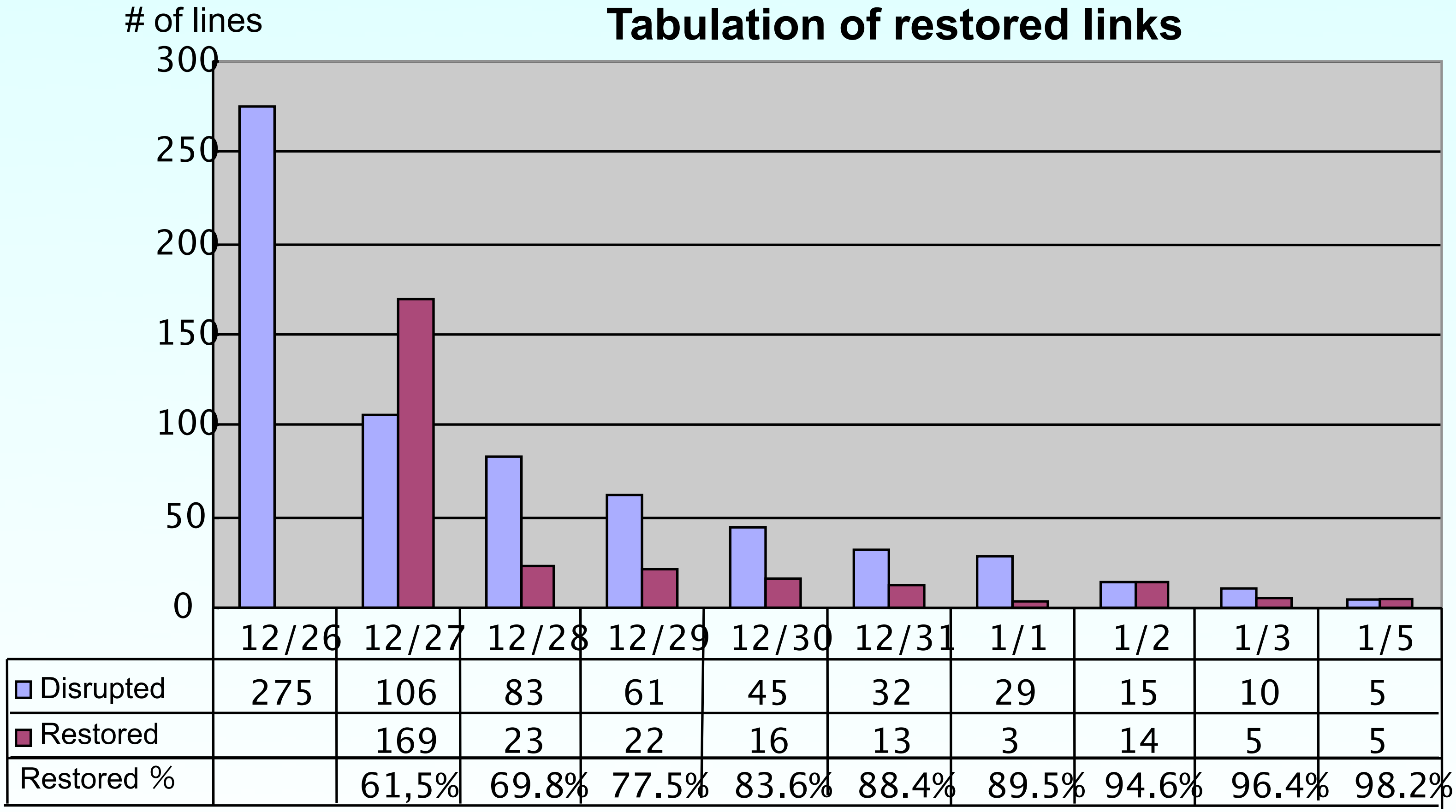
- **Voice**



(4) Service Disruption & Restoration

IPLC & IP-VPN

- 275 CHT's corporate data lines affected
- Most of them restored up to 1/6 with only two still under repair



Tabulation of restored links

	12/26	12/27	12/28	12/29	12/30	12/31	1/1	1/2	1/3	1/5
□ Disrupted	275	106	83	61	45	32	29	15	10	5
■ Restored		169	23	22	16	13	3	14	5	5
Restored %		61,5%	69.8%	77.5%	83.6%	88.4%	89.5%	94.6%	96.4%	98.2%

(4) Service Disruption & Restoration

Internet (HiNet)

Availability of HiNet International Links

Area	12/26	12/27	12/28	1/5	1/31
USA	**100%**	**100%**	**100%**	**100%**	**100%**
Japan	**100%**	**98.08%**	**98.08%**	**98.08%**	**100%**
China	**100%**	**25.83%**	**41.94%**	**45.17%**	**100%**
Hong Kong	**100%**	**0%**	**27.28%**	**27.28%**	**100%**
Total	**100%**	**76.92%**	**82.67%**	**82.97%**	**100%**

(4) Service Disruption & Restoration

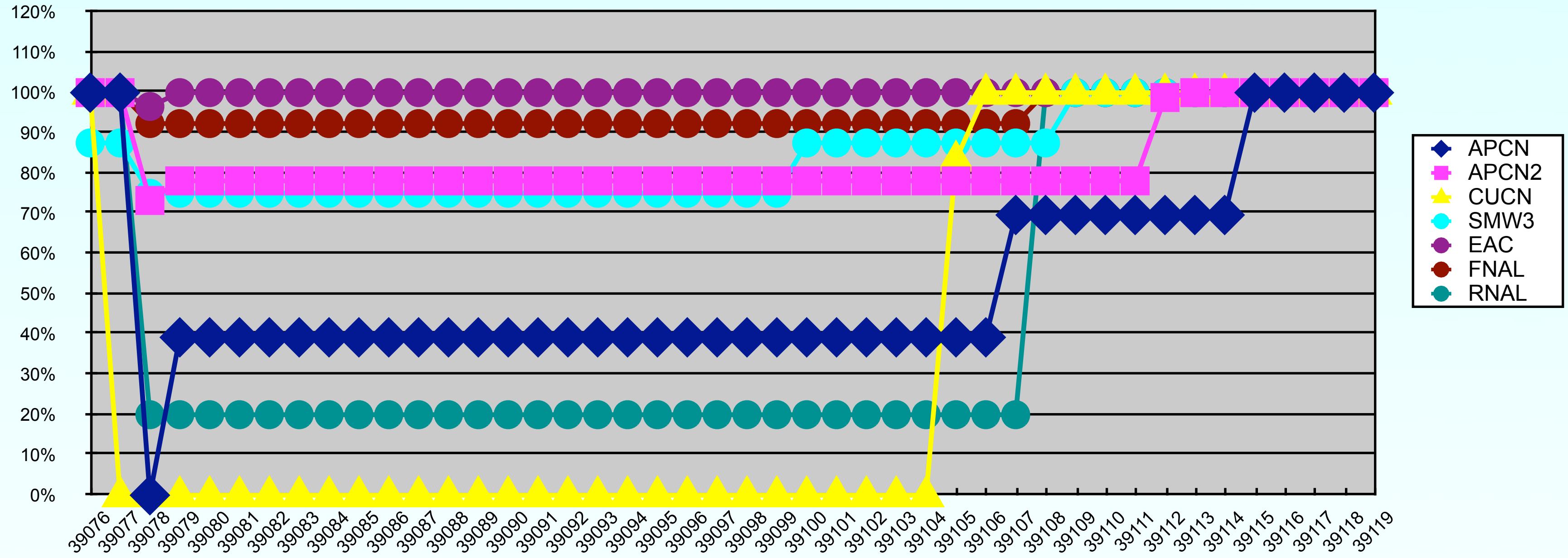
Internet (HiNet)

Traffic changes between HiNet and major Asia Pacific Countries after / before 2006/12/26 Hengchun Earthquake

Country/Area	**US+ others**	**JP**	**KR**	**HK**	**CN**	**SG**	**AU**	**MA**	**Total**
Traffic thru direct links **before earthquake** 2006/12/25 23:00 (Mbps)	16,706	8,034	1,210	5,433	9,446	307	152	279	41,567
Traffic thru direct links **after earthquake** 2006/12/27 23:00 (Mbps)	19,376	8,735	1,069	1761	2,405	193	222	72	33,833
Traffic Ratio **after/before**	115.98 %	108.73 %	88.35 %	32.41 %	25.46 %	62.87 %	146.05 %	25.81 %	81.39 %

(4) Service Disruption & Restoration

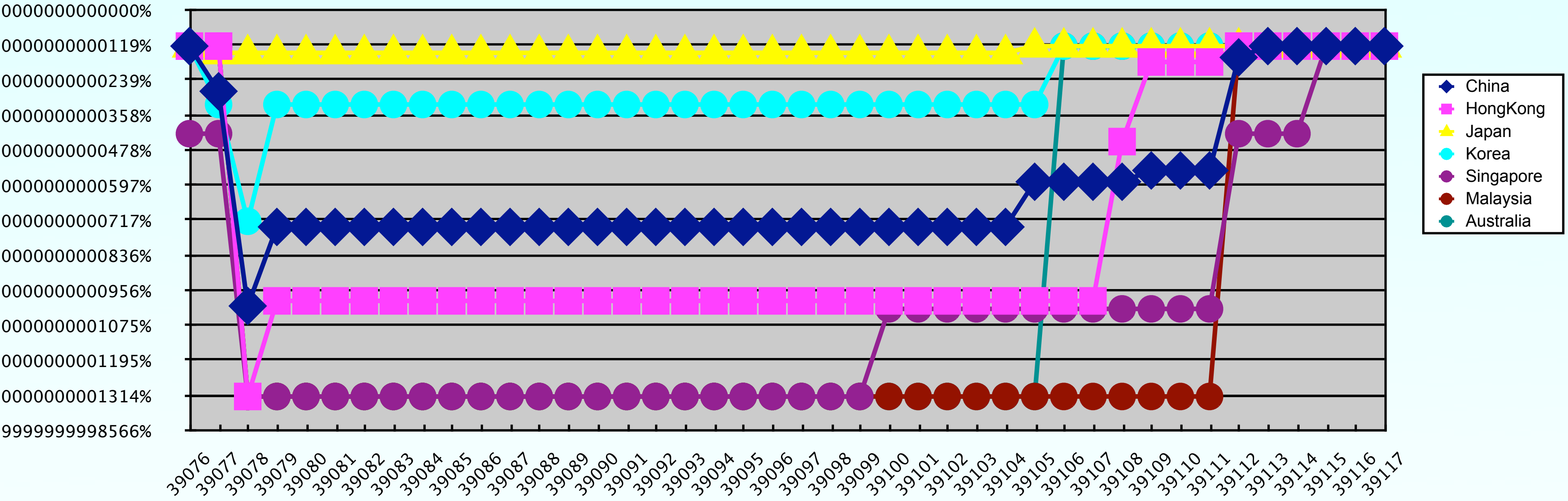
■ Internet (HiNet)



中華電信股份有限公司
Chunghwa Telecom Co., Ltd.

(4) Service Disruption & Restoration

■ Internet (HiNet)



(4) Service Disruption & Restoration

■ Internet (HiNet)

Cable System	Failure Time	Recovery Time	Effect
CH-US	2006/12/26 20:28	2007/01/23 21:49 2007/01/24 17:47	China, Japan Korea
SMW3	2006/12/27 00:07 2006/12/29 02:17	2007/01/27 09:40 2007/01/18 07:24	China, Japan
APCN2	2006/12/27 00:07 2006/12/27 02:01	2007/01/30 17:58 2007/01/31 01:08	China, HK, Singapore, Malaysia China, HK, Singapore
APCN	2006/12/27 02:16 2006/12/27 04:56	2006/12/27 20:47 2007/01/24 17:43	Korea Singapore, Australia
EAC	2006/12/27 01:29 2006/12/27 06:18 2006/12/27 11:31	2006/12/27 21:46	China, Japan
RNAL	2006/12/27 03:42	2007/01/26 23:25 2007/01/27 03:13	Hong Kong

4. Cable Repair Work

From Jan. 3rd, **five repair ships** (**KOL, Retriever, KPL, Segero, Restorer**) reached damage sites separately to conduct repair work. It will take 2~3 weeks to complete the work.

Cable	Failure Point	Failure Point	Failure Point
CH-US	**Point #1**	**Point #2**	**Point #3**
SMW3	**Point #4**	**Point #5**	
APCN2	**Point #6**	**Point #7**	
APCN	**Point #8 (System 2)**	**Point #9 (System 1)**	

KDD OCEAN LINK

Arrived on Jan.3rd
CUCN (W1, W2)

Arrived on Jan.2nd
SMW3 (S1.7, S1.8)

Cable Retriever

Arrived on Jan. 6th
CUCN (S1)

Arrived on Jan. 9th
APCN2 (S7, S3)

KDD PACIFIC LINK

Arrived on Jan. 10th
APCN (B5, B17)

ASEAN Cableship

- Submarine Cable Laying
- Submarine Cable Repair & Maintenance
- Jointing Support
- Cable Engineering Consultancy

ASEAN RESTORER

Lloyd's Register
ISM CERTIFIED 1997
DNV

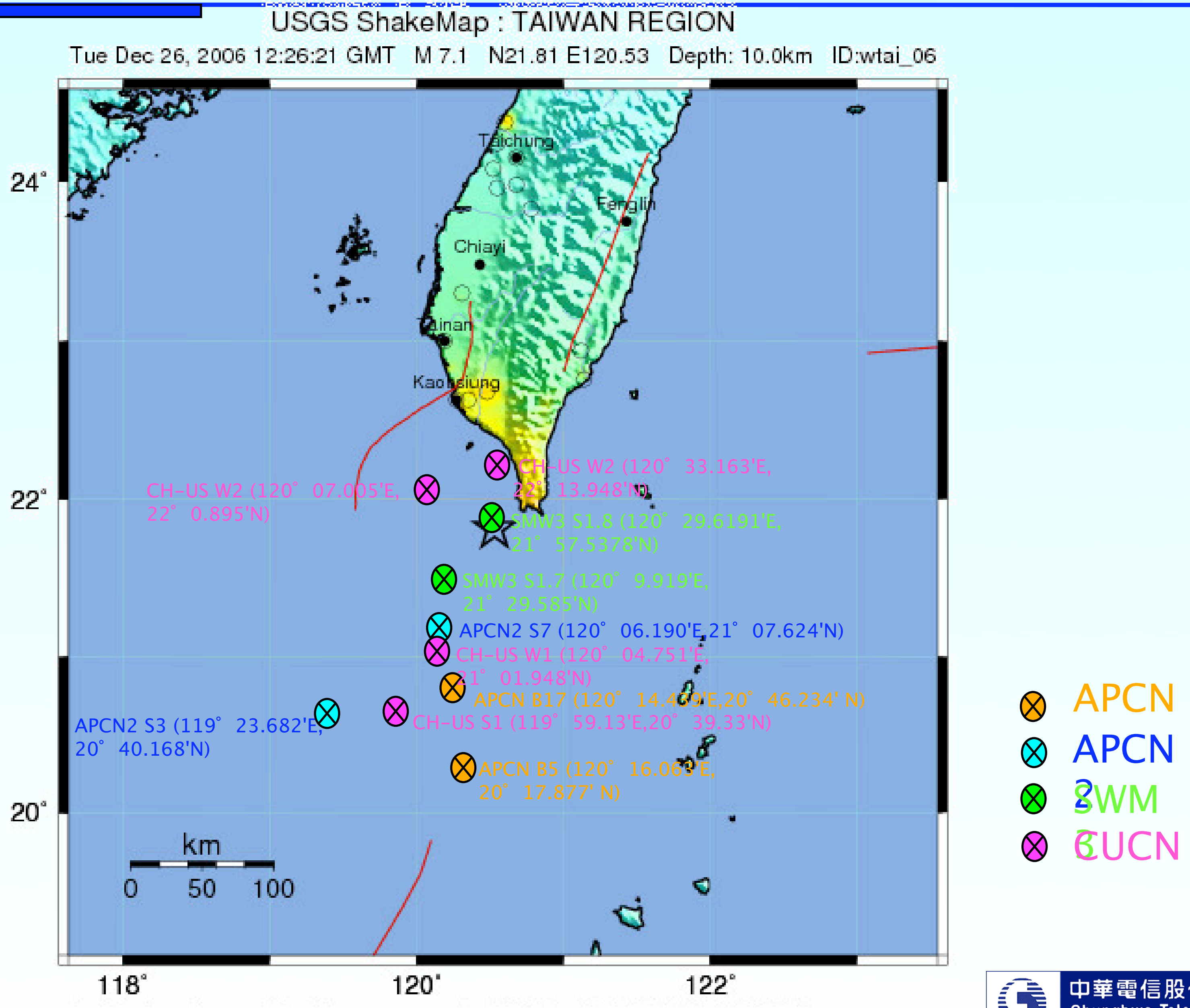
Cable Repair Information (1/2)

Point	Cable System	Location	Depth (m)	Repair Start Time	Repair Finish Time	Cable Ship
1	CH-US (W1)	152 KM south of Fangshan	3,307	2007/01/04	2007/01/11	KDD OCEAN LINK
2	CH-US (W2)	11.1 KM SW of Fangshan	562	2007/01/11		
		68.5 KM SW of Fangshan	1,928		2007/01/23	
3	CH-US (S1)	192 KM south of Fangshan	3,700	2007/01/06	2007/01/14	SEGERO
4	SMW3(S1.7)	100 KM south of Fangshan	2,700	2007/01/02	2007/1/18	CS Retriever
5	SMW3(S1.8)	44 KM south of Fangshan	900		2007/01/27	

Cable Repair Information (2/2)

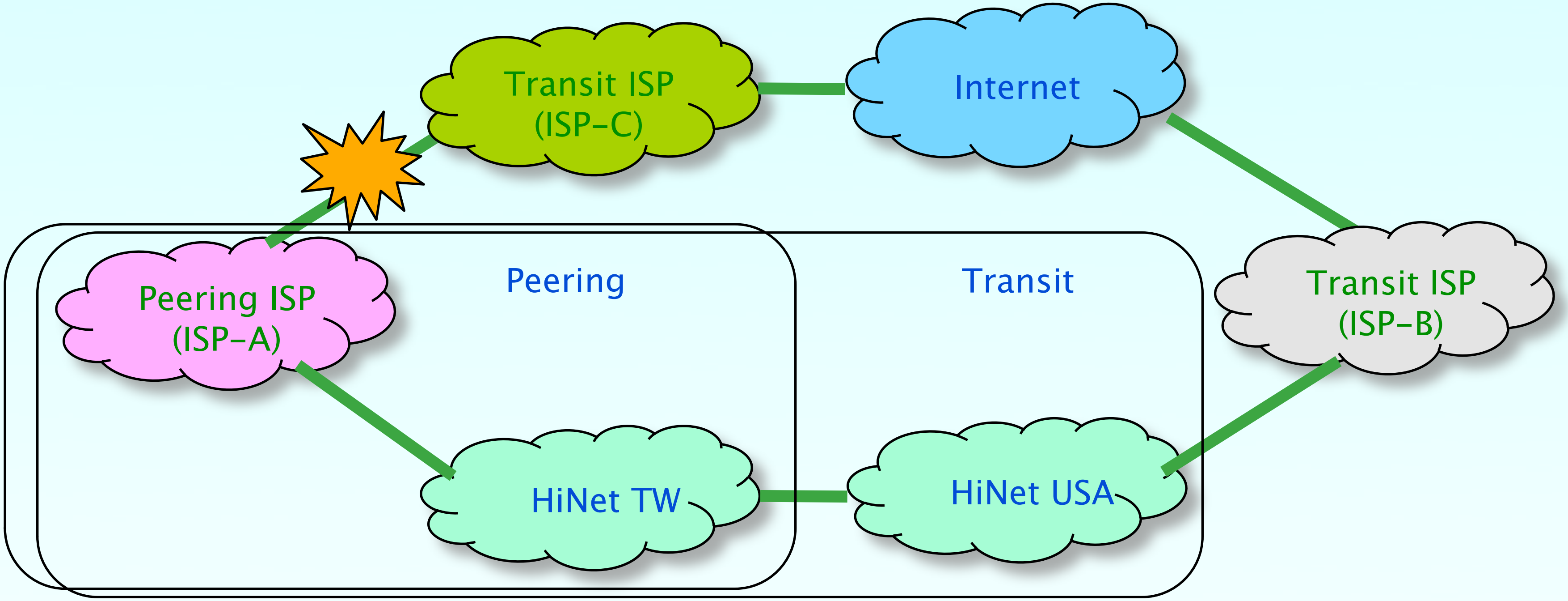
Point	Cable System	Location	Depth (m)	Repair Start Time	Repair Finish Time	Cable Ship
6	APCN2 (S3)	218 KM SSW of Fangshan	2,894	2007/1/29	2007/2/10	KDD Pacific Link
7	APCN2 (S7)	904.5 KM away from Tansui	3,243	2007/1/11	2007/1/30	
8	APCN System 1 (B17)	180 KM south of Fangshan	3,444	2007/01/10	2007/1/24	Asean Restorer
9	APCN System 2 (B5)	220 KM south of Fangshan	3,500	2007/01/25	2007/02/02	

Cable Failure Position


USGS ShakeMap : TAIWAN REGION
Tue Dec 26, 2006 12:26:21 GMT M 7.1 N21.81 E120.53 Depth: 10.0km ID:wtai_06
Taichung
Fenglin
Chiayi
Tainan
Kaohsiung
24˚
22˚
20˚
118˚
120˚
122˚
km
0
50
100
CH-US W2 (120˚ 33.163'E, 22˚ 13.948'N)
CH-US W2 (120˚ 07.005'E, 22˚ 0.895'N)
SMW3 S1.8 (120˚ 29.6191'E, 21˚ 57.5378'N)
SMW3 S1.7 (120˚ 9.919'E, 21˚ 29.585'N)
APCN2 S7 (120˚ 06.190'E,21˚ 07.624'N)
CH-US W1 (120˚ 04.751'E, 21˚ 01.948'N)
APCN B17 (120˚ 14.439'E,20˚ 46.234' N)
CH-US S1 (119˚ 59.13'E,20˚ 39.33'N)
APCN2 S3 (119˚ 23.682'E, 20˚ 40.168'N)
APCN B5 (120˚ 16.063'E, 20˚ 17.877' N)
APCN
APCN 2
SMW 3
CUCN

5. Case Study #1 (1/3)

Set up a transit route for a peering partner

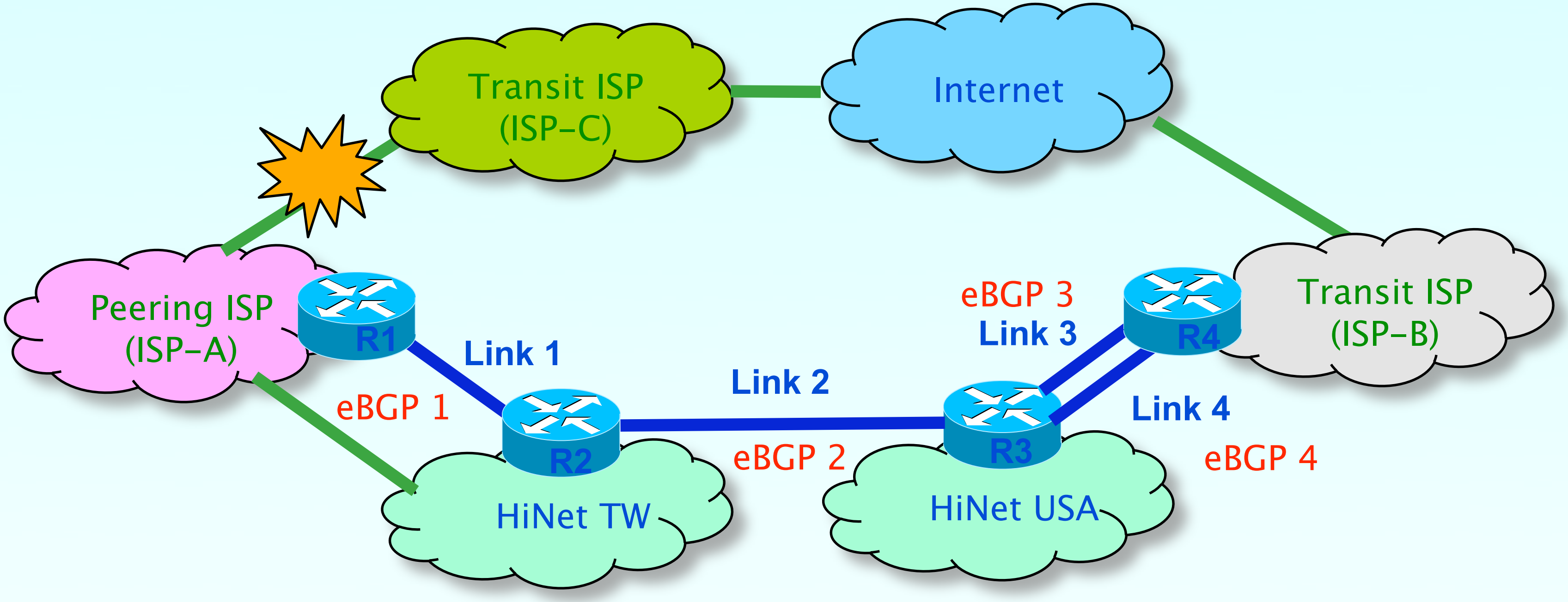

Transit ISP
(ISP-C)
Internet
Peering
Transit
Peering ISP
(ISP-A)
Transit ISP
(ISP-B)
HiNet TW
HiNet USA

Origination:

- Peering ISP lost significant amount of capacity to the Internet after the undersea cable cut.
- Peering ISP asked for HiNet’s assistance to set up a transit route to Internet

5. Case Study #1 (2/3)

Set up a transit route for a peering partner

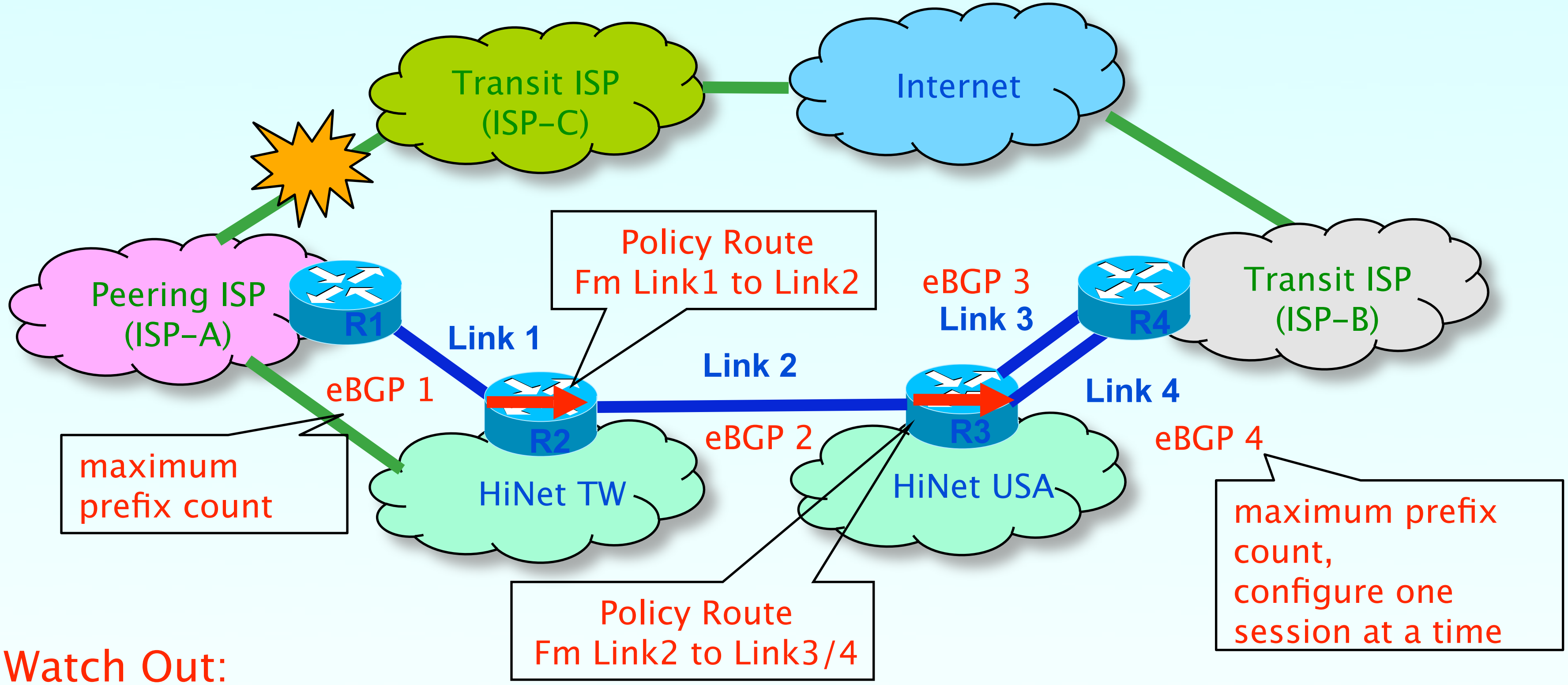

Transit ISP
(ISP-C)
Internet
Peering ISP
(ISP-A)
R1
Link 1
eBGP 1
R2
Link 2
eBGP 2
eBGP 3
Link 3
R4
Transit ISP
(ISP-B)
R3
Link 4
eBGP 4
HiNet TW
HiNet USA

Arrangement:

- Peering ISP (ISP-A) arranged a new undersea cable (Link 1) to Taiwan
- ISP-A and HiNet set up a new eBGP on Link1
- HiNet USA learned ISP-A’s prefixes thru existing eBGP on Link 2 between HiNet TW and HiNet USA
- HiNet USA advertised ISP-A’s prefixes to Transit ISP (ISP-B) thru eBGP 3 and eBGP4

5. Case Study #1 (3/3)

Set up a transit route for a peering partner


Transit ISP
(ISP-C)
Internet
Peering ISP
(ISP-A)
R1
Link 1
R2
Link 2
R3
Link 3
Link 4
R4
Transit ISP
(ISP-B)
eBGP 1
eBGP 2
eBGP 3
eBGP 4
HiNet TW
HiNet USA

Policy Route
Fm Link1 to Link2

maximum
prefix count

Policy Route
Fm Link2 to Link3/4

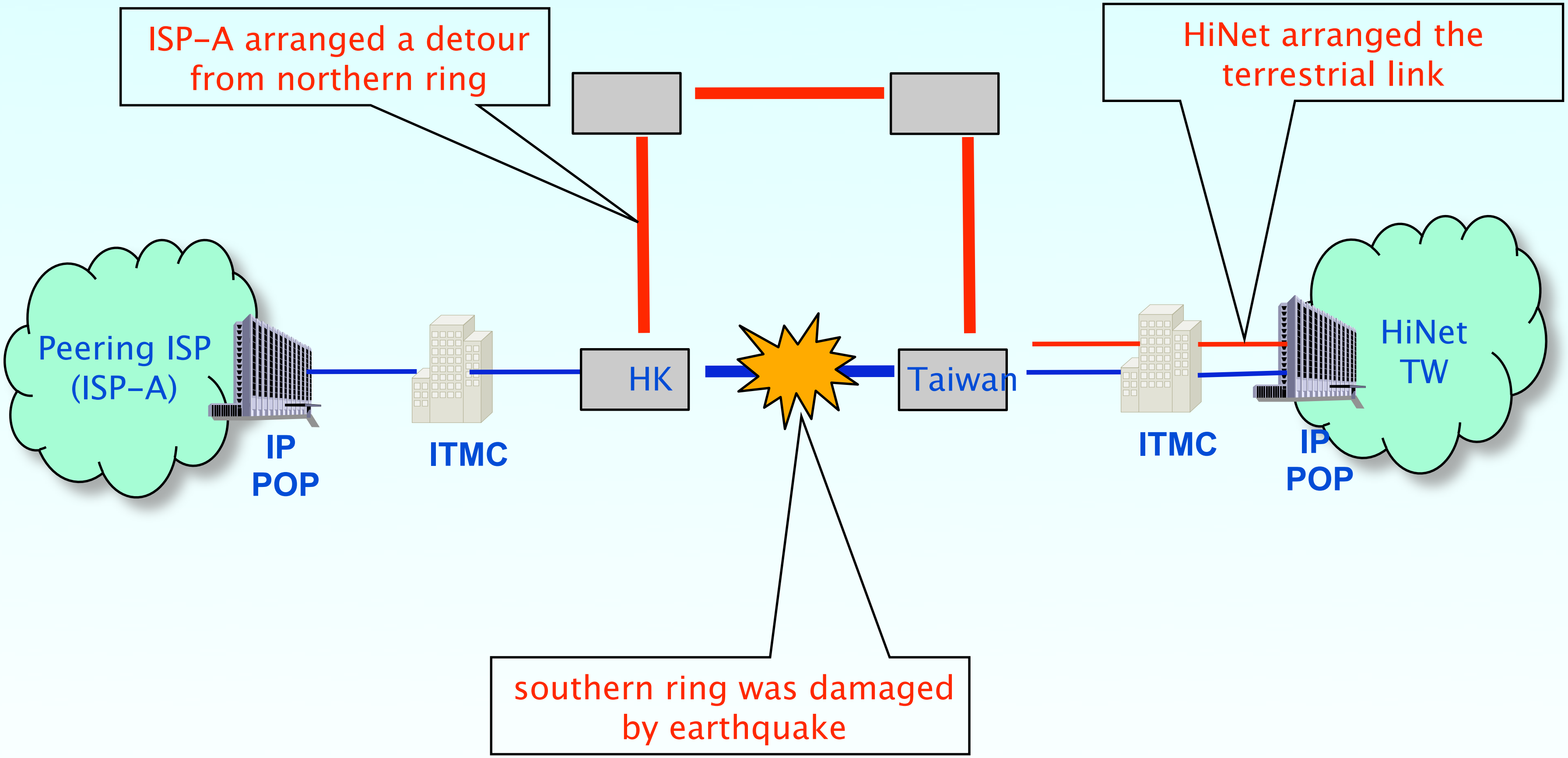
maximum prefix
count,
configure one
session at a time

Watch Out:

- Maximun prefix count should be careful in eBGP1
- Policy route should be implement in R2 and R3, but remember to exclude interface IP
- Maximun prefix count should also be careful in eBGP3 and eBGP4 and change the BGP configuration one session at a time

5. Case Study #2

Set up a detour from the same cable system to recover part of the peering connections between HiNet and its peering partner



ISP-A arranged a detour from northern ring

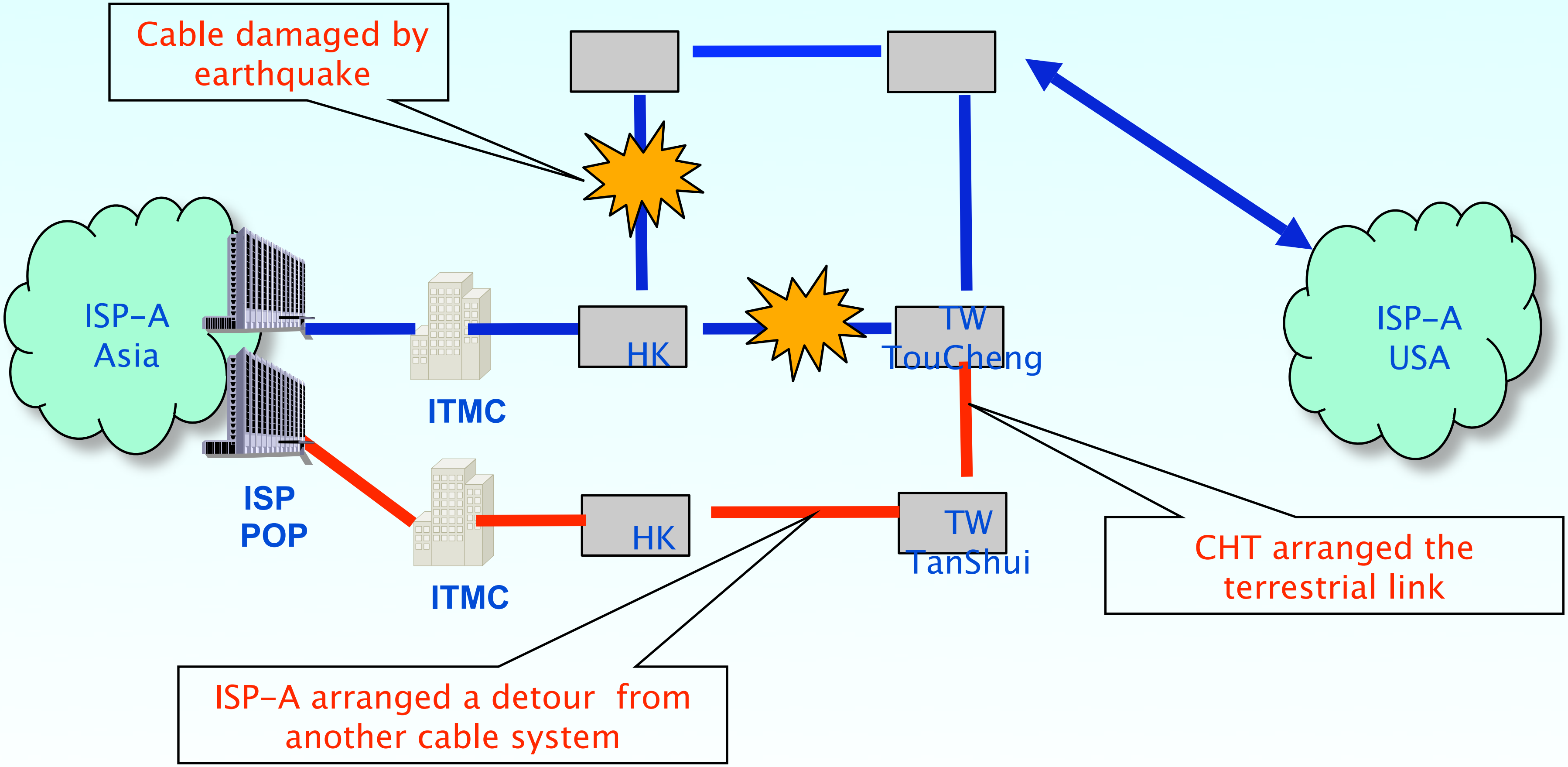
HiNet arranged the terrestrial link

southern ring was damaged by earthquake

Peering ISP
(ISP-A)
IP
POP
ITMC
HK
Taiwan
ITMC
IP
POP
HiNet
TW

5. Case Study #3

Set up a detour from different cable system to recover the links between POP in Asia and POP in US


ISP-A
Asia
ISP
POP
ITMC
ITMC
HK
HK
TW
TouCheng
TW
TanShui
ISP-A
USA

Cable damaged by earthquake

CHT arranged the terrestrial link

ISP-A arranged a detour from another cable system

6. Recommendations and Conclusion

(1) Establish a Mechanism to Share Communications Resources

- Mutual backup between consortium & private cables
- Terrestrial link backup for submarine cable
- Reciprocal backup between satellite and cable systems

(2) Set up a Function within Int’l Organizations to facilitate the restoration work

- Working groups to map out detailed restoration procedures
- Update and share the contact information
- Consider the use of satellite phone

6. Recommendations and Conclusion

(3) Construct the network with disperse routes and more detailed restoration plan

- Construct the international connections on different cable systems to alleviate the damage from the natural disaster or accident
- Consider higher ratio of traffic exchanged in local Asia Pacific region
- HiNet uses multiple links to single peering partner on different cable systems

(4) Enhance the cooperation between peering partners when experiencing damage from disaster

- Consider the Private Bilateral Restoration (PBR) between Internet peering partners, like cable operators
- Provide mutual temporary transit, terrestrial link backup for peering partners or third party
- Prioritize the important customers or services for peering partners when exchange traffic under emergency conditions
- HiNet shares its resources and helps its peering partner to transit the traffic to Internet in this cable cut accident

Thank You