

Sensor Web Enablement for Debris Flow Monitoring System in Taiwan

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Outline

- ① Debris Flow Monitoring System
 - Overview
 - New Approach
- ① OGC Standards
- ① Demo



Debris Flow Monitoring Stations

01. 白布帆站 (Baibufan Station)
02. 九份二山站 (Jiufen-Ershan Station)
03. 神木站 (Shenmu Station)
04. 上安站 (Shang-An Station)
05. 郡坑站 (Jyunkeng Station)
06. 豐丘站 (Fongciou Station)
07. 大粗坑站 (Dacukeng Station)
08. 鳳義坑站 (Fongyikeng Station)
09. 射馬干站 (Shemangan Station)
10. 華山站 (Huashan Station)
11. 大興站 (Dasing Station)
12. 豐山站 (Fongshan Station)
13. 松鶴站 (Songhe Station)
14. 坪頂站 (PingDing Station)
15. 蘇樂站 (Suru Station)
16. 玉峰站 (Yufong Station)
17. 下田埔站 (Shiatainpu Station)

Debris Flow Monitoring Station × 17
Landslide Monitoring Station × 1
Sediment Concentration Monitoring Station × 3
Mobile Debris Flow Monitoring Station × 3
Grid Debris Flow Monitoring Station × 14



Challenges on Extreme Weather Condition

-- after Typhoon Calamity of Morakot



Compound Hazards occurred simultaneously:

✓ *Compound hazards observed at Xiao-lin Village, Jia-xien, Kaoshiung:*

- Flooding
- Shallow landslide
- Debris flow
- Deep landslide
- Barrier dam
- Dam bursting

Pre-typhoon

2008/11



Post-Morakot

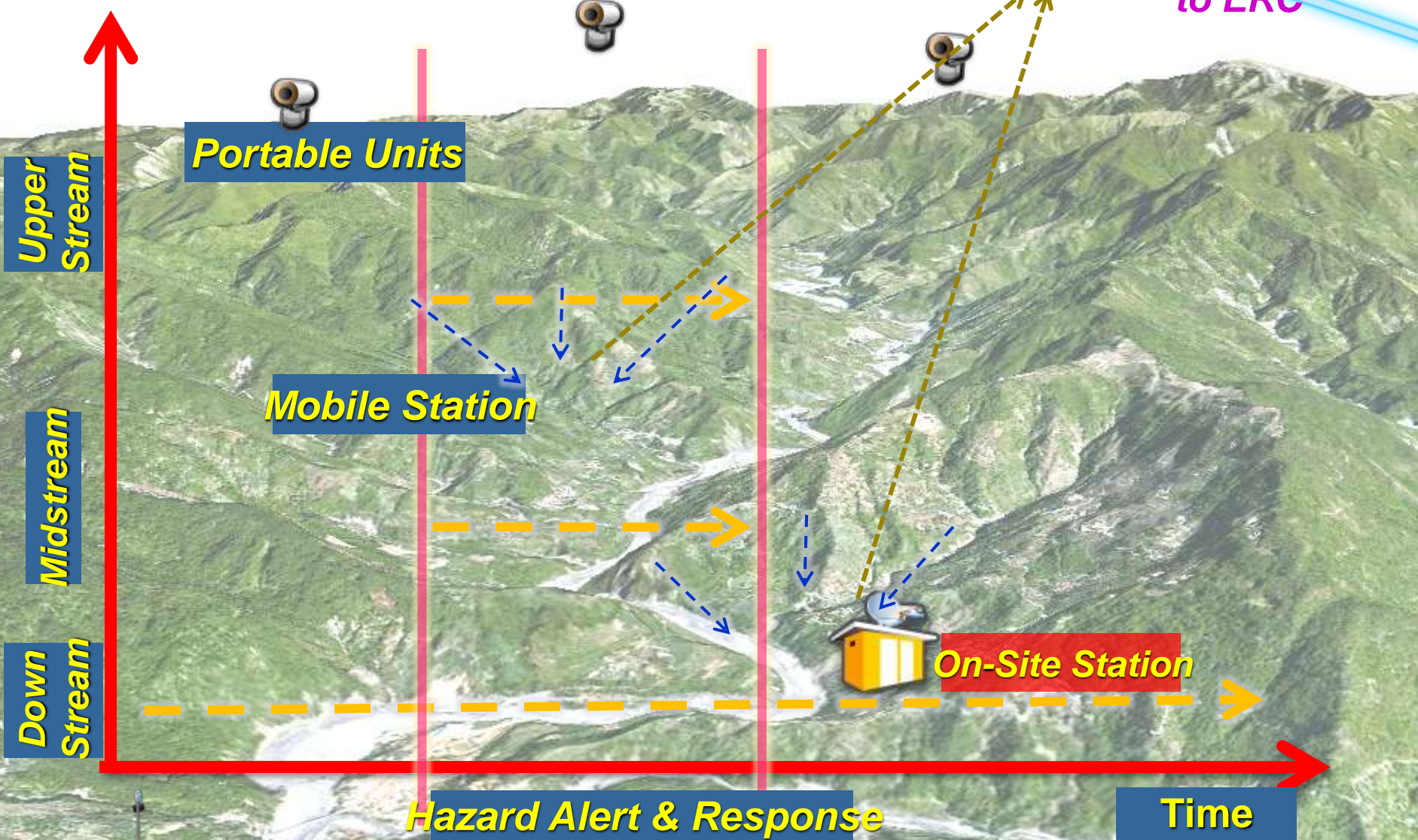
2009/8



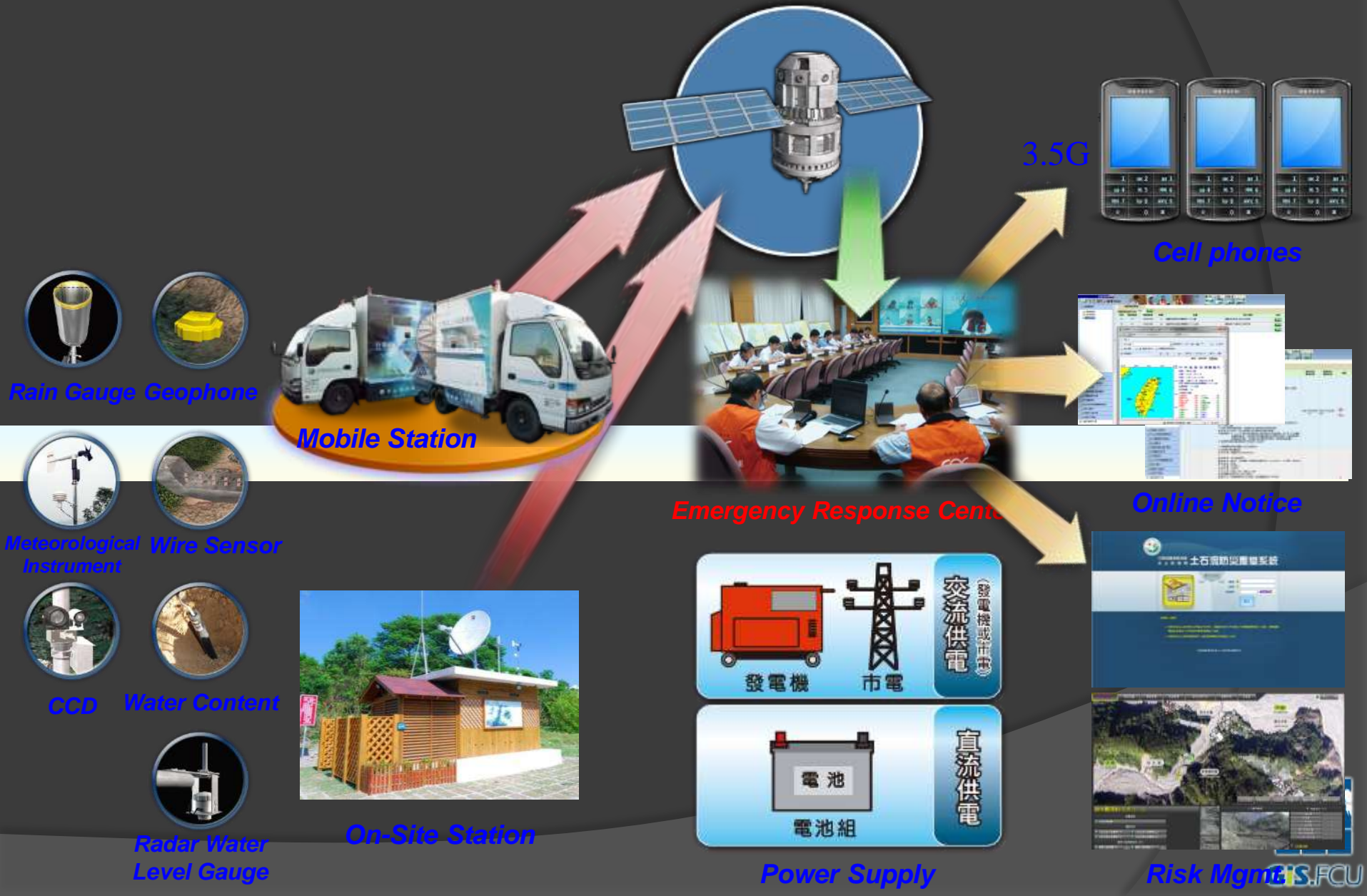
Watershed-oriented Monitoring Network



Transmitting
to ERG



Current Debris Flow Monitoring System



Debris flow monitoring station



CCD



Geophone



Water level meter



wire sensor

Satellite communication

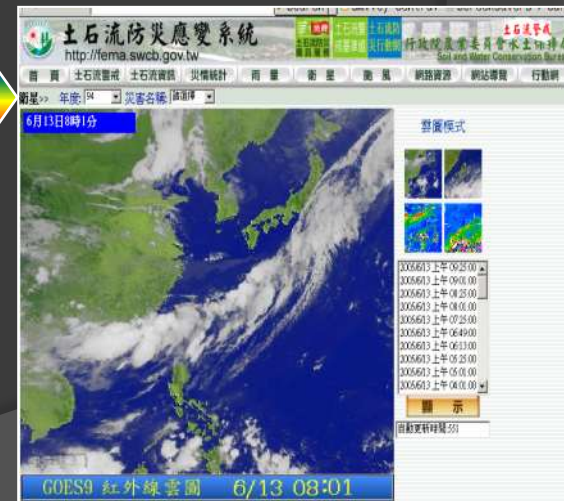
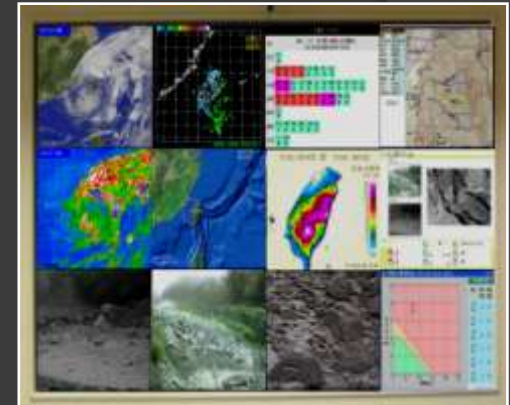


Data-receiving center
Jiufenershan field trip site



Mobile monitoring station

Debris Flow
Information System



Case History – Shenmu Station 2009

CCD image (front view) of Aiyuzi downstream

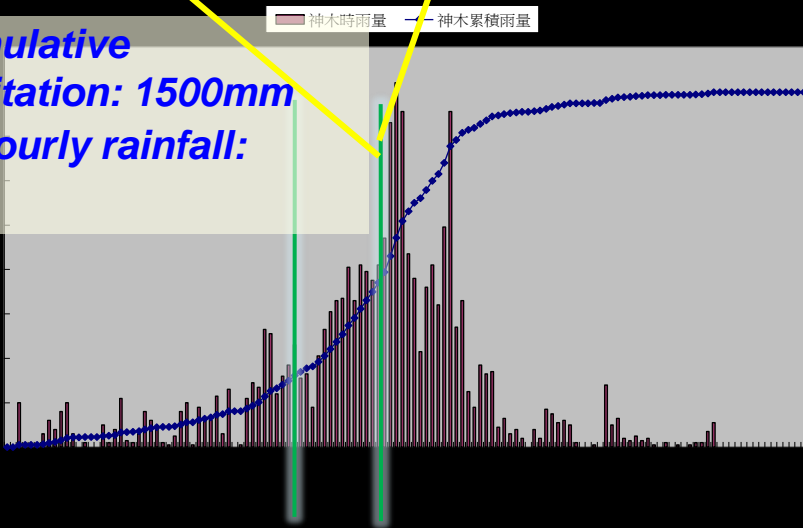
CCD image (sideview) of Aiyuzi upper stream

Velocity

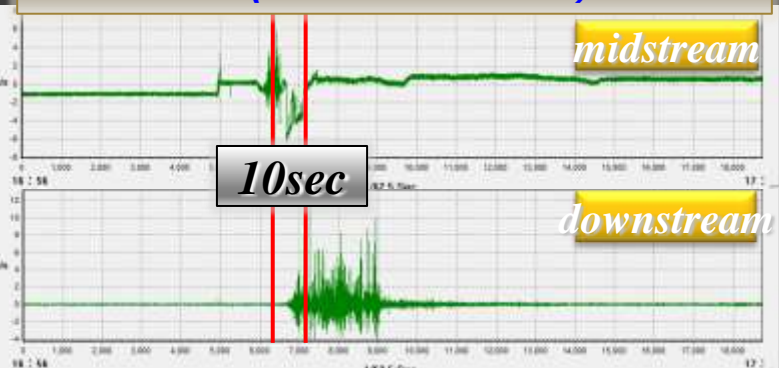


$$50\text{m}/3\text{sec}=17\text{m/s}$$

Accumulative precipitation: 1500mm
Max. hourly rainfall: 82mm



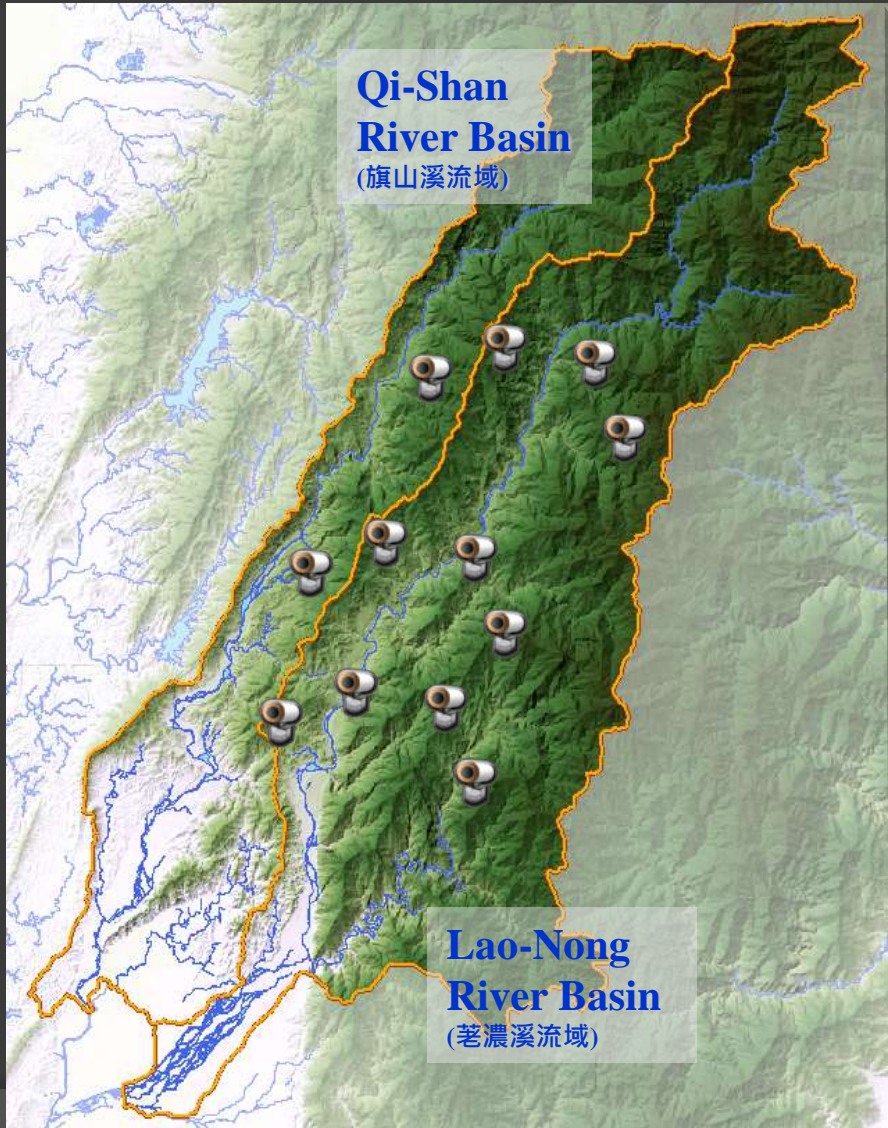
Geophone signal after wavelet transform (8/8 16:56~17:00)



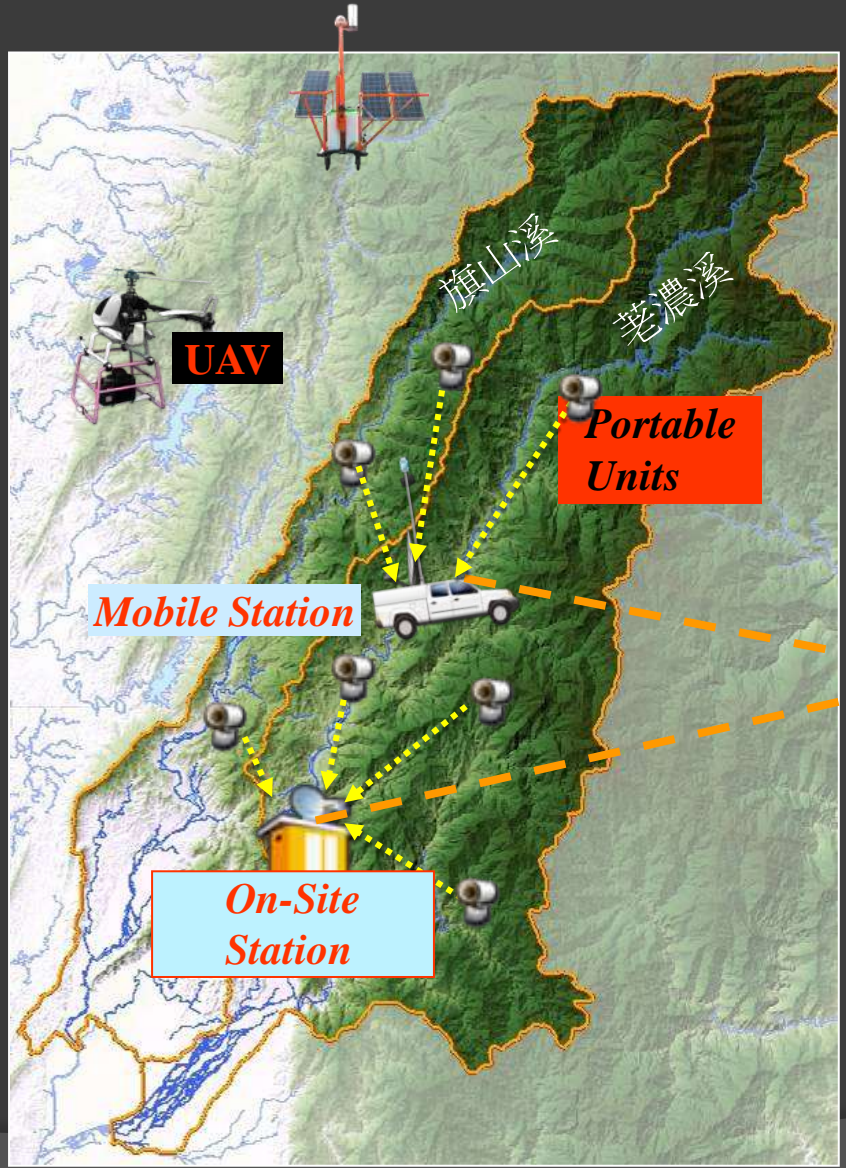
$$173\text{m}/10\text{sec}=17\text{m/s}$$

Basin-wide Monitoring System

Basin-wide Debris Flow Monitoring System



Basin-wide Debris Flow Monitoring System



- **Point** → **Line** → **Plane**
- **Combining mobile stations and portable units.**
- **Integrating data from different agencies.**



FEMA



Basin-Wide Monitoring Network

Qi-Shan & Lao-Nong Basins



Debris Flow Potential	Debris Flow Potential			Check Pt..	Total
	High	Moderate	Low		
Qi-Shan River	18	14	12	2	46
Lao-Nong River	19	6	4	1	30
Total	37	20	16	3	76

Monitoring Network: at most 18 stations (1 on-site, 3 mobile-, 14 grid-stations)

Basin-Wide Monitoring Network

Steps:

1. Determine monitoring **priority** for creeks and rivers.
2. Site investigation for station location and **communication quality**.
3. Evaluate the **networking criteria** to enhance data transmission.
4. Network analysis for potential debris flows and available monitoring stations.



Basin-Wide Monitoring Network

Step 1. Potential Debris Flow List

1. Based on the latest debris flow investigation reports.
2. Estimate the scores of each debris flow using weighting factors and dispatch models.
3. Top 30 scores are in the priority list for later site investigation.

Debris Flow Basic Info	高縣 DF020	
	Original	Latest (2009)
Landslide Ratio	<1%	2.28% Update
Upstream Slope	60%~120%	60%~120%
Landslide Scale	Not evident	Small areas
Wood deposit	>30 cm	8cm~30cm
Vegetation	Dense	Mod. sparse
Potential	Low	Low

Basin-Wide Monitoring Network

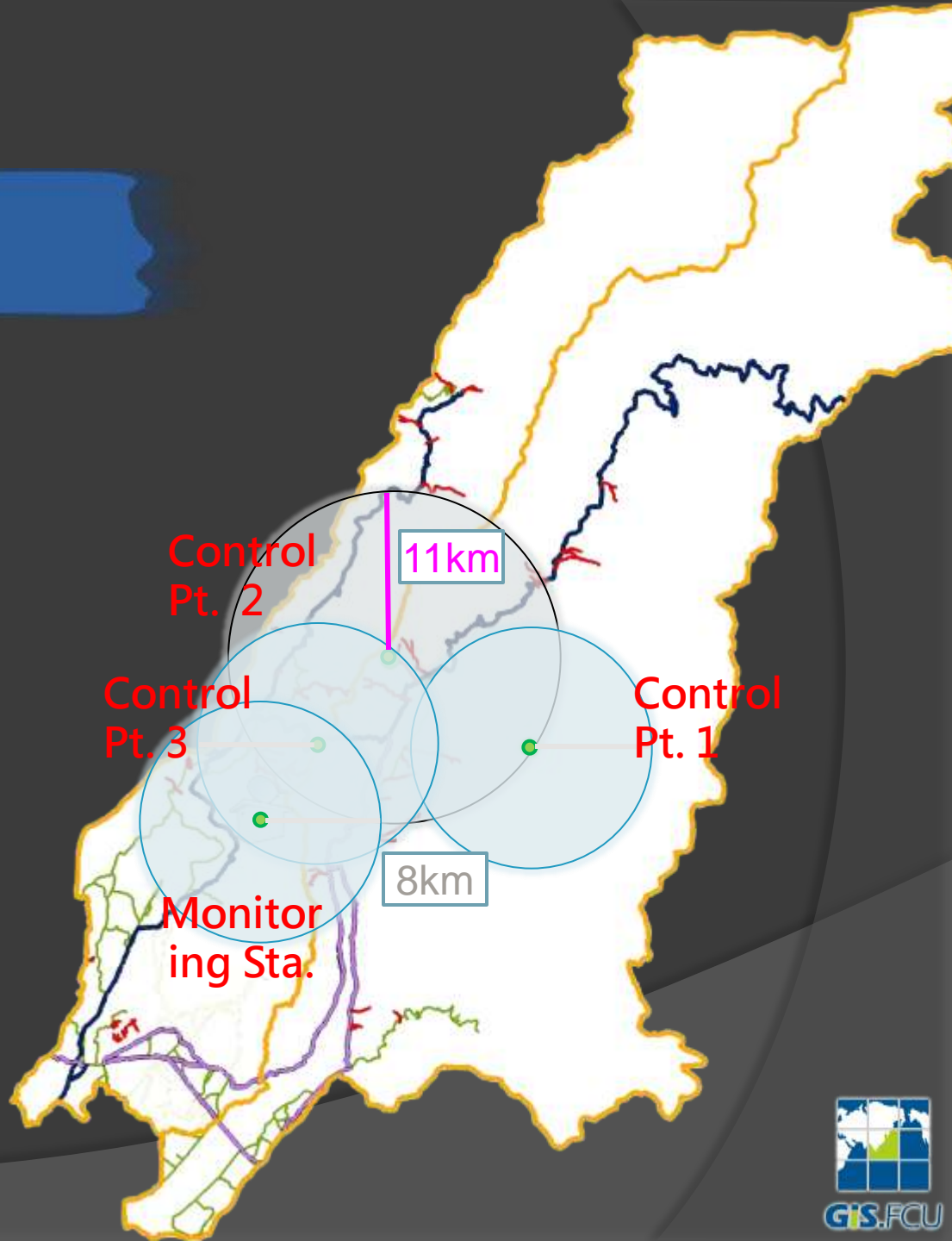
Step 2. Site Investigation

1. What to check: communication quality and status, road and traffic, safety and security, instrument applicability and CCD images.
2. Prepare “Site Investigation Report”



現勘調查紀錄			
交通狀況	道路可及性	■可 □不可	
	替代道路	■有 _____ □無	
通訊	無線電	與鄰近固定站距離: _____ m	
	3G/GPRS	GPRS: 90 kpbs	
	無線通訊	1.2GHz	■可 □不可
		2.4GHz	■可 □不可
安裝位置(97)	X坐標	X: 258519	Y坐標(97)
			Y: 2528595
適合觀測設備	雨量計	■可 □不可	
	CCD攝影機	■可 □不可	
	地聲檢知器	■可 □不可	
	土壤含水量計	■可 □不可	
溪流照片			
地理位置圖			
備註			

Step 2. Communication Test

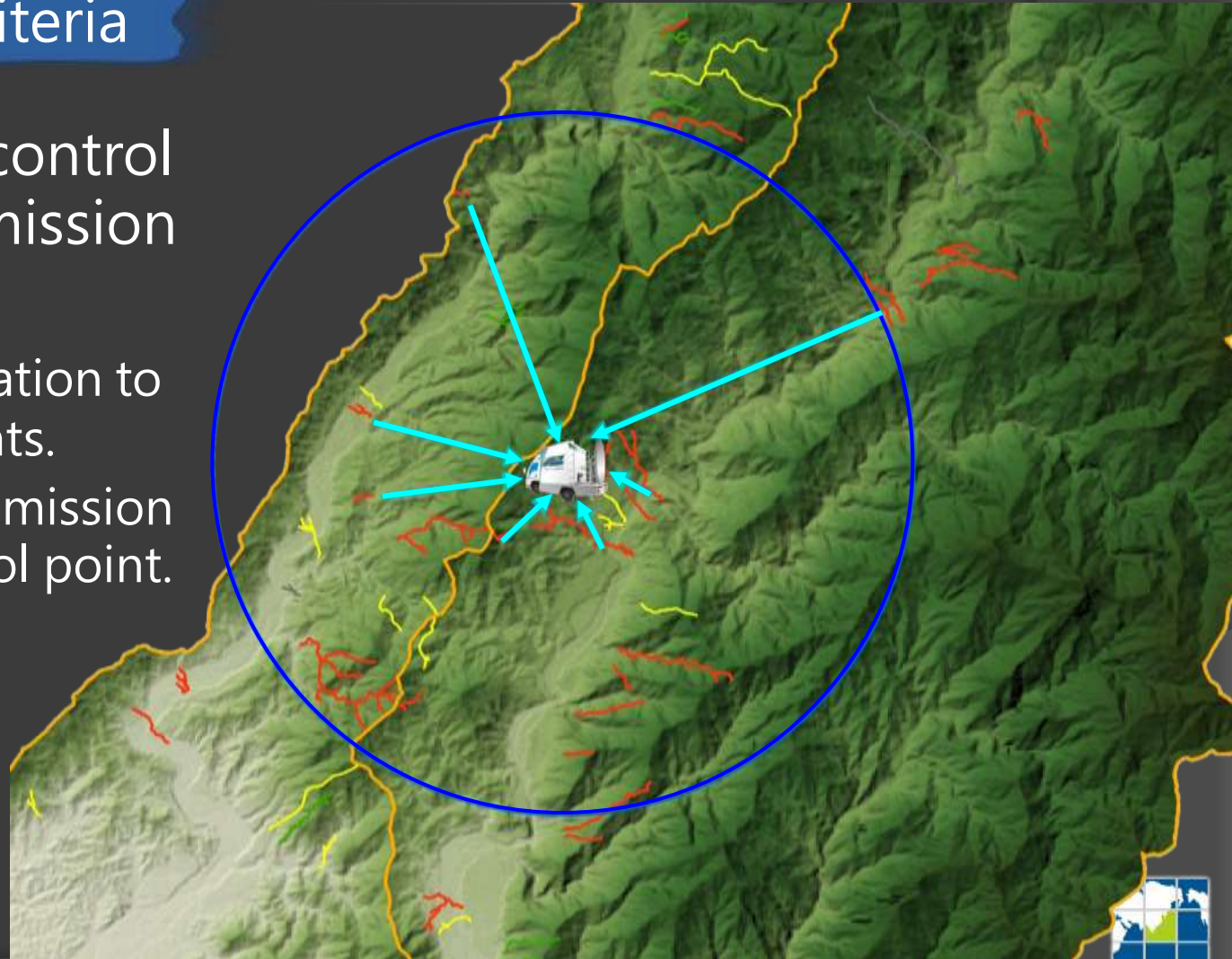


Basin-Wide Monitoring Network

Step 3. Networking Criteria

Use accessible control points as transmission hubs.

- ⦿ send mobile station to the control points.
- ⦿ or set up a transmission hub at the control point.



Basin-Wide Monitoring Network

Step 3. Networking Criteria

- **Capability of Monitoring Sta.**
 1. On-site and mobile stations: **receive** and **transmit** data.
 2. Portable Units: Use GPRS/3G/3.5G, or with help of transmission hubs (within distance of 3-5 km). **Receive data only.**
 3. Transmission Hubs: receive data from grid stations within the radius of 11km.



Basin-Wide Monitoring Network

Step 4. Network Planning

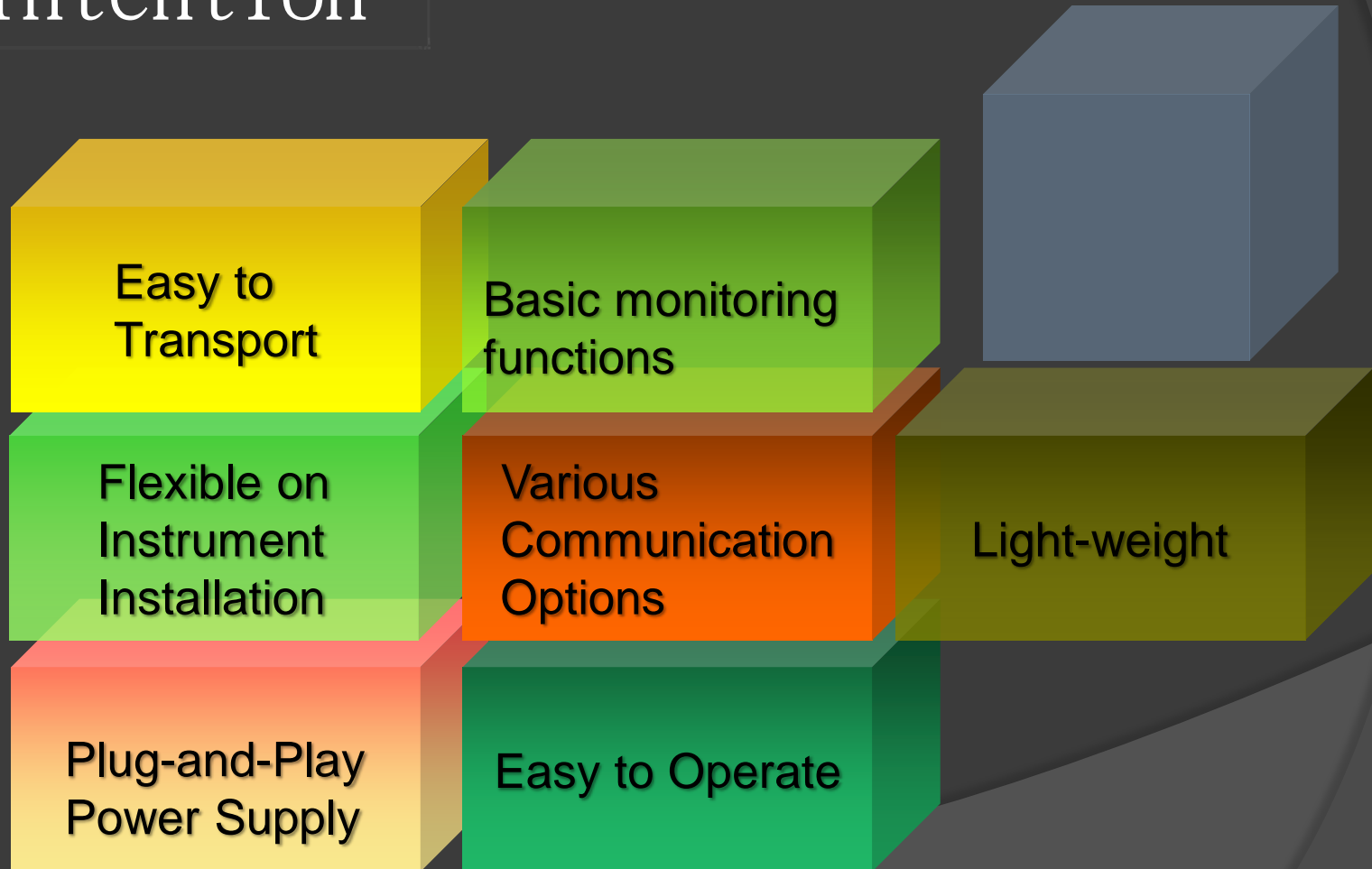
Assumptions:

- Case 1: mobile station not available
 - ✓ When no mobile station is available during typhoon season.
 - ✓ Use transmission hubs to replace mobile stations, and connect to grid stations.
- Case 2: mobile station is available
 - ✓ At most 3 mobile stations are available, with one on-site station.
 - ✓ Use full-function grid stations at locations of high scores and available 2.4GHz wireless.

Portable Monitoring Unit

Grid Monitoring Station R&D

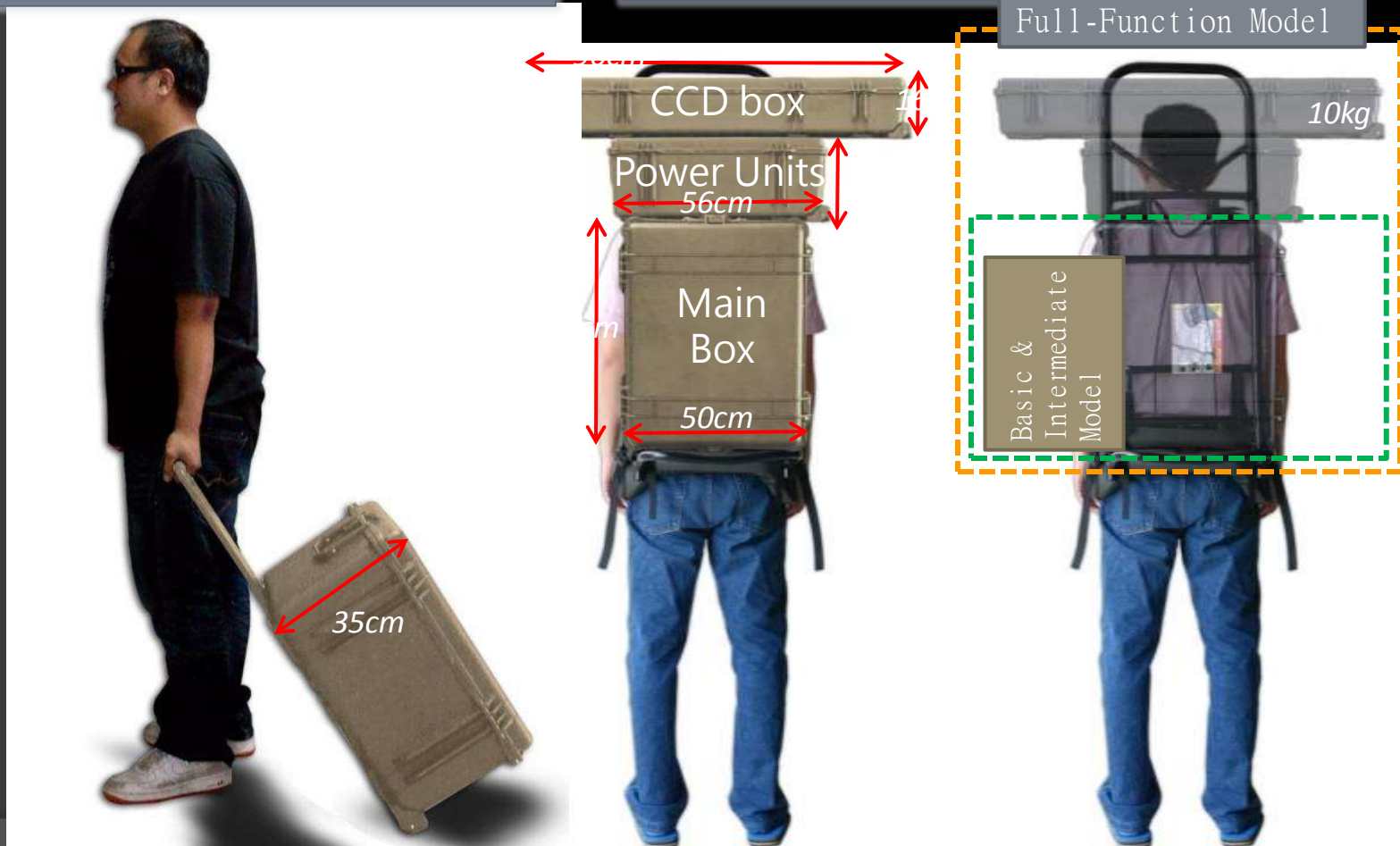
Intention



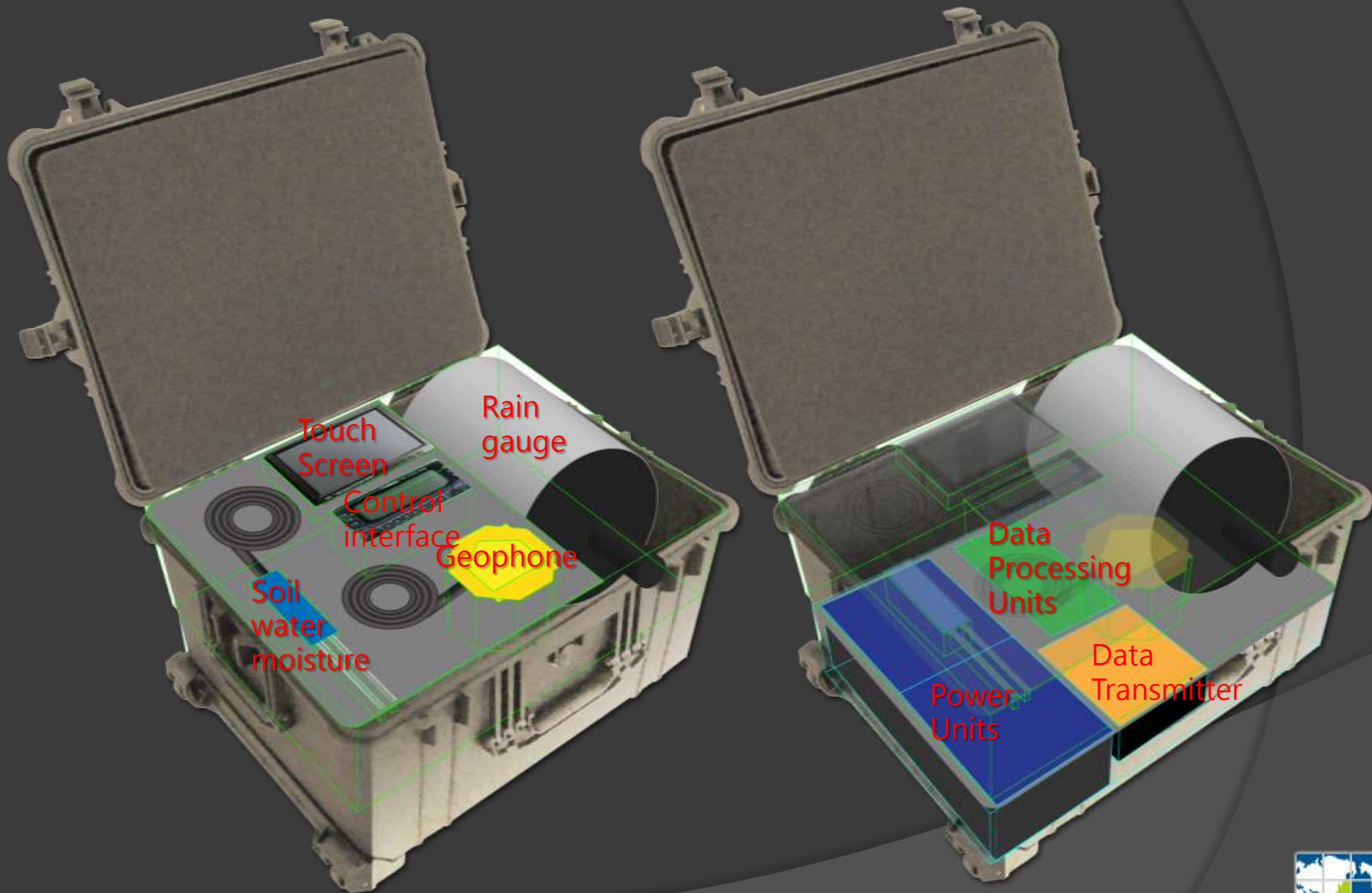
Grid Monitoring Station R&D

- ◆ Military-standard box
- ◆ Use cables and nails to fix the box.

- ◆ Aluminum-alloy carrier
- ◆ Carry on shoulder or drag by hand



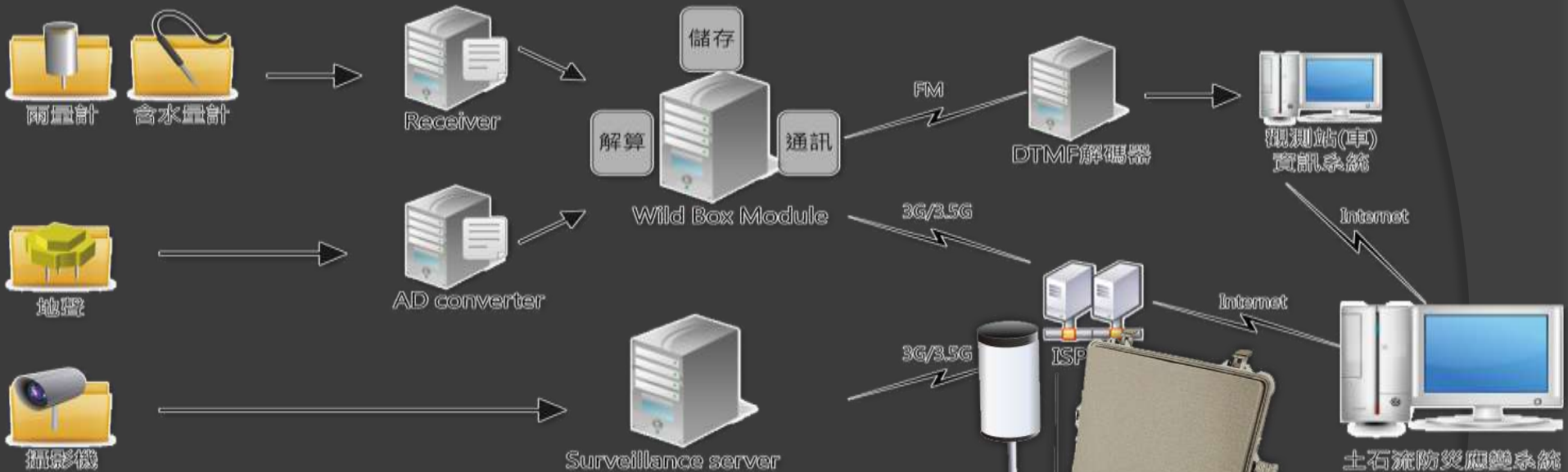
Grid Monitoring Station R&D



Upper Layer

Bottom Layer

Data Transmission



Full-Function Model



OGC Standards

OGC Standards

- ◎ Open Geospatial Consortium (OGC)
 - <http://www.opengeospatial.org>
- ◎ Standards
 - SWE: Sensor Web Enablement
 - SOS: Sensor Observations Service
 - SPS: Sensor Planning Service
 - SAS: Sensor Alert Service
- ◎ How to
 - Description of sensor
 - XML Schema



Overview

17 Stations

Each station has one IPC.

Shen-Mu Station



Shang-An Station



Jyun-Keng Station



Fong-Ciou Station



Each station has several sensors such as ...

CCD Camera

Rain Gauge

Geo Phone

Wire Sensor

Water Level Meter

Water Pressure Sensor

Each station sends observation data through ADSL or satellite

SWCB



Database

The database provide sensor data for services

SOS

(Sensor Observation Service)

SPS

(Sensor Planning Service)

SAS

(Sensor Alert Service)

Consumer



Consumer



Debris flow integration and display system



SOS Service - Microsoft Internet Explorer 是由 GIS.TW 提供

http://110.241.45.102/SOS/View/CCD.aspx?ObfocID=2&SensorType=1&SensorID=3

GetCapabilities DescribeSensor **GetObservation**

JiofenErshan_CCDCamera03	
SamplingTime :	2009-11-11T17:20:16+08:00
Latitude :	23.94937
Longitude :	120.854779

Request

```
<?xml version="1.0" encoding="UTF-8"?><GetObservation xmlns="http://www.openelis.net/sos/1.0">
```



Debris flow integration and display system

Service

按一下 [這裡](#) 以取得完整的作業清單。

RequestSOS

測試

若要以 HTTP POST 通訊協定測試作業，請按一下 [叫用] 按鈕。

參數	值
requestXML:	<input type="text"/>

SOAP 1.1

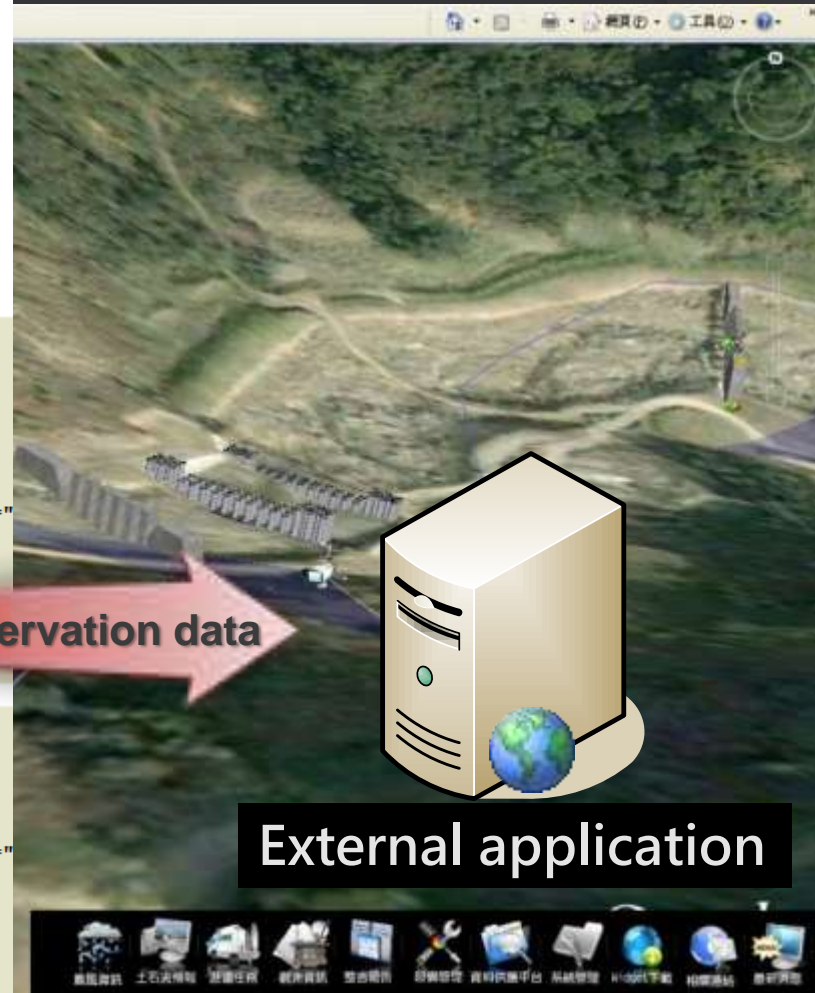
下列是 SOAP 1.1 要求與回應的範例。預留位置顯示之處必須代入實際的值。

```
POST /FCU_GIS_SOS/Service.asmx HTTP/1.1
Host: 210.241.45.102
Content-Type: text/xml; charset=utf-8
Content-Length: length
SOAPAction: "http://www.gis.fcu.edu.tw/RequestSOS"

<?xml version="1.0" encoding="utf-8"?>
<soap:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="
  <soap:Body>
    <RequestSOS xmlns="http://www.gis.fcu.edu.tw/">
      <requestXML>string</requestXML>
    </RequestSOS>
  </soap:Body>
</soap:Envelope>
```

```
HTTP/1.1 200 OK
Content-Type: text/xml; charset=utf-8
Content-Length: length

<?xml version="1.0" encoding="utf-8"?>
<soap:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="
  <soap:Body>
    <RequestSOSResponse xmlns="http://www.gis.fcu.edu.tw/">
      <RequestSOSResult>xml</RequestSOSResult>
    </RequestSOSResponse>
  </soap:Body>
</soap:Envelope>
```



Thank You



Typhoon MORAKOT

Shen-Mu Debris Flow Monitoring Station



The Debris Flow Event of Aiyuzi River (8/8 16:57)



Aiyuzi River CCD image (front)

Aiyuzi River CCD image (side)



UAV image

98/08/18



Aiyuzi River

The comparison of UAV images before and after the debris flow event at upstream



UAV Image_2006



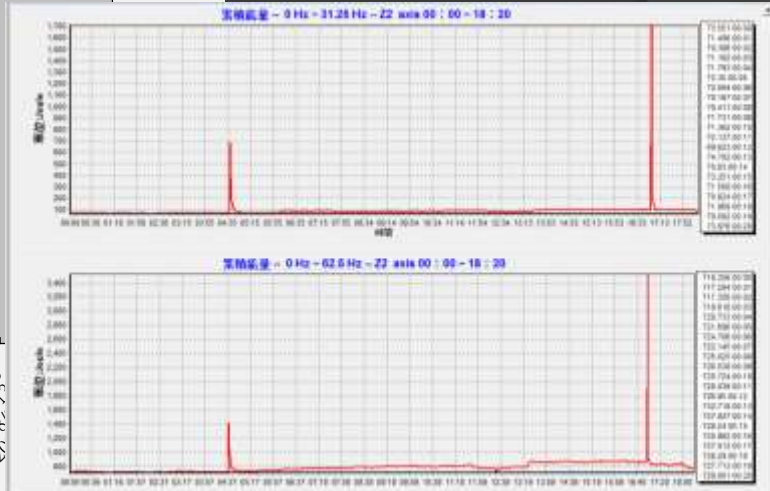
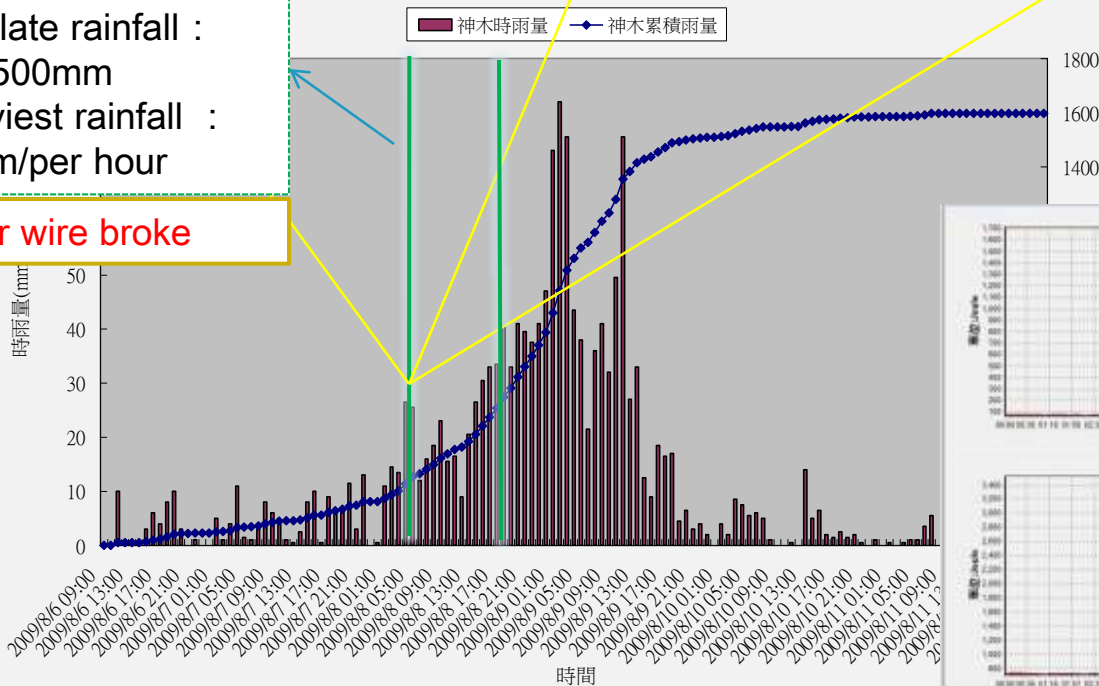
UAV
Image_2009/08/18

Aiyuzi River Debris Flow Event



Accumulate rainfall :
1500mm
The heaviest rainfall :
82mm/per hour

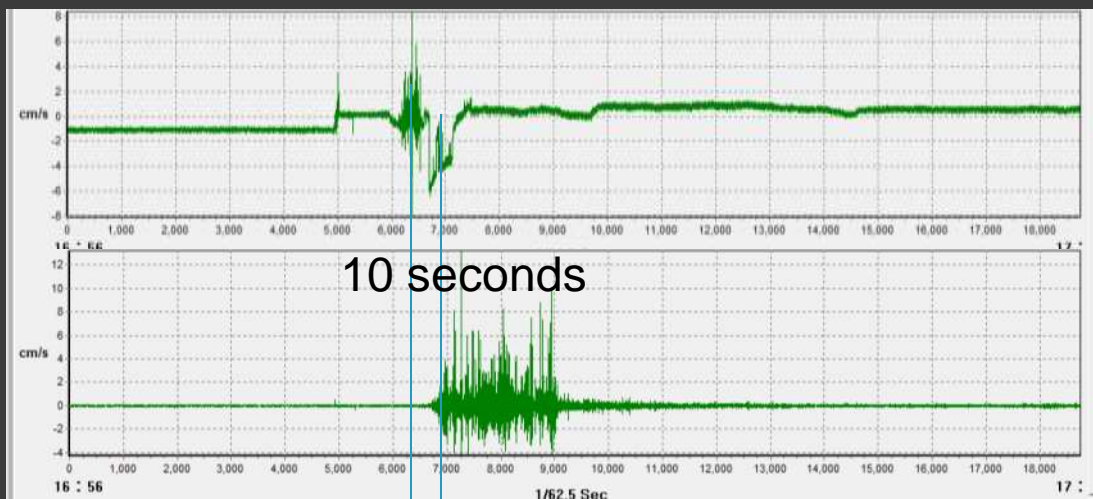
Aiyuzi River wire broke



Estimating of debris flow speed



$$50\text{m}/3\text{sec}=17\text{m/s}$$



$$173\text{m}/10\text{sec}=17\text{m/s}$$

The comparison of downstream and midstream Underground Sound analysis by Wavelet Transform at Shen-Mu station (8/8 4:36~4:42)