香港天文台
HONG KONG OBSERVATORY

Research Forum 2018

GREAT Smart Cities
GREAT Smart Cities Center

Transfer Learning: From Landslide Identifications and Predictions to Weather Observations and Forecasting using Big Data and Artificial Intelligence

Prof. Wang Yu-Hsing and DESR Lab

Department of Civil and Environmental Engineering

DESR lab
Data-Enabled Scalable Research Laboratory

香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

Oct. 18 , 2018

GREAT Smart Cities Center

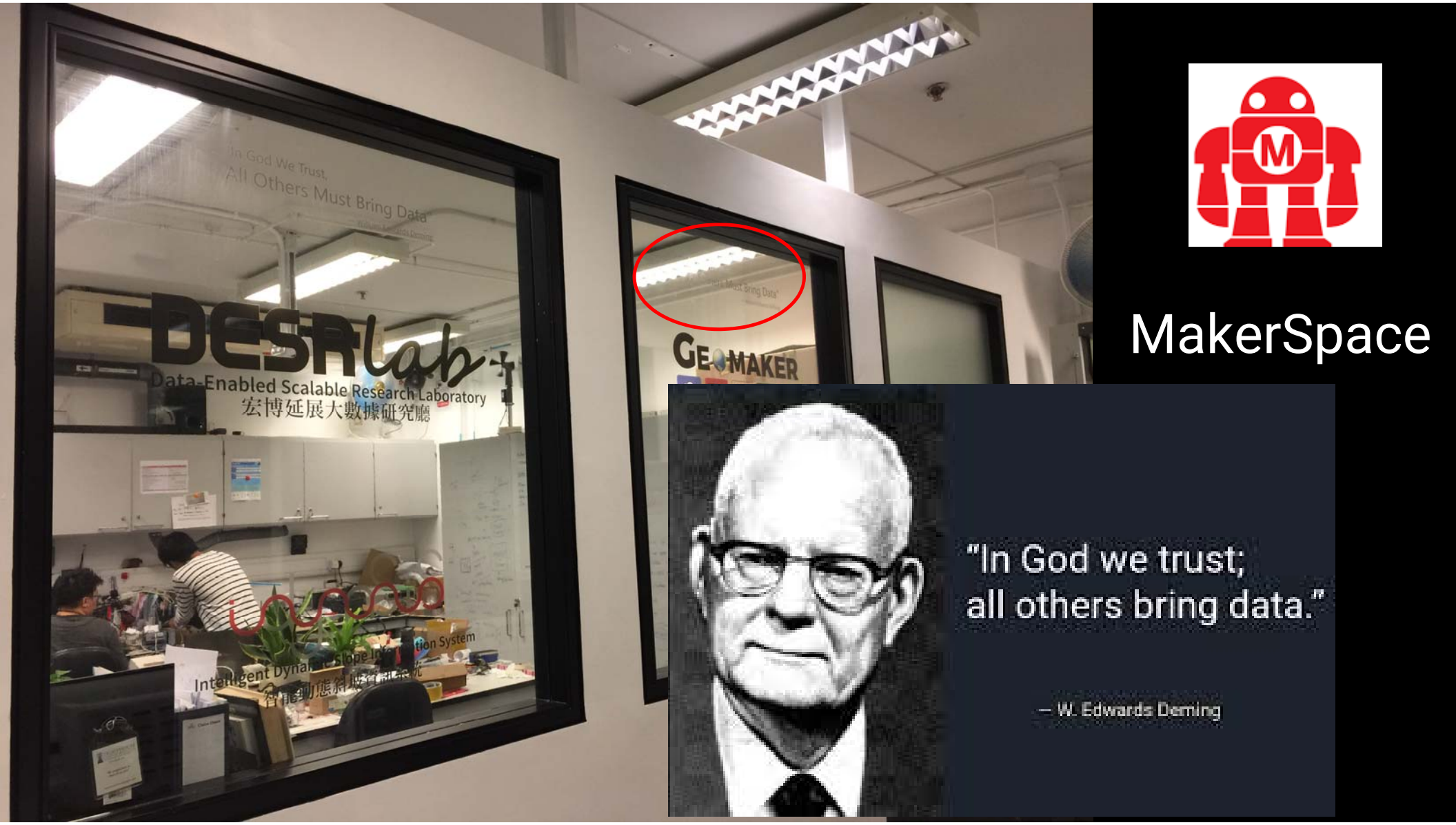
DESRlab
Data-Enabled Scalable Research Laboratory

D Data

E Enabled

S Scalable

R Research


In God We Trust,
All Others Must Bring Data
DESRlab
Data-Enabled Scalable Research Laboratory
宏博延展大數據研究廳
GEOMAKER
"In God we trust;
all others bring data."
– W. Edwards Deming

MakerSpace

Our mission:

innovating fundamental Smart City infrastructural technologies to connect citizens and decision-making.

DESRlab
Data-Enabled Scalable Research Laboratory

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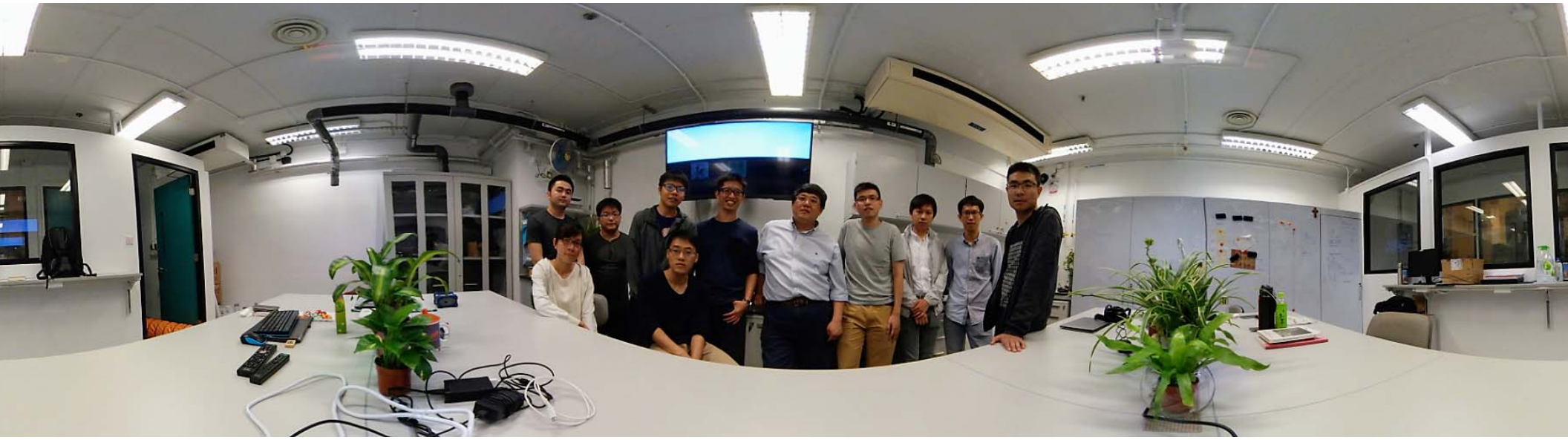
MakerSpace



MakerSpace

Blue:
Represents the colour of the sky

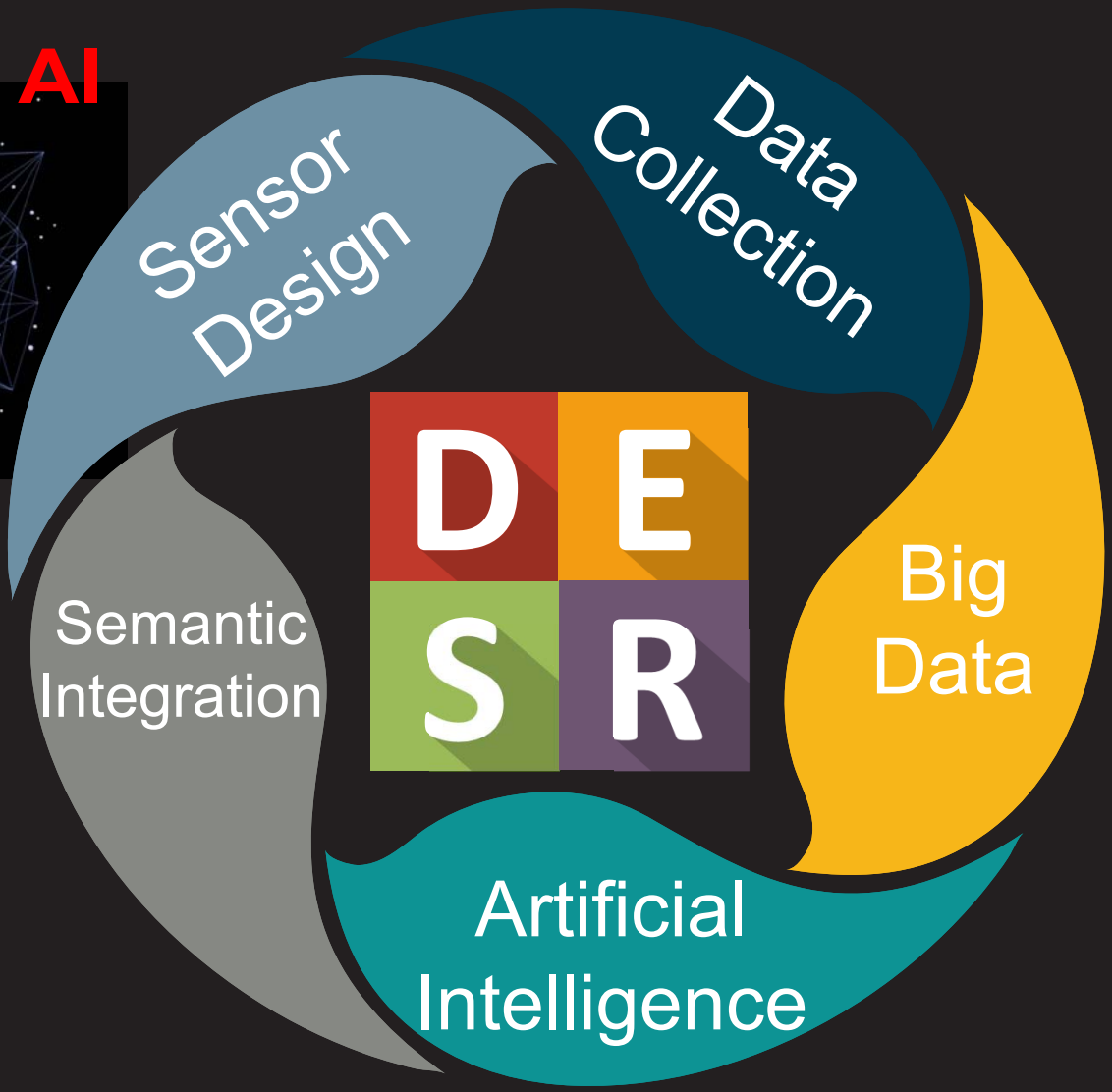
White:
Represents the spiral rain bands of typhoons

Embrace technology in the digital age

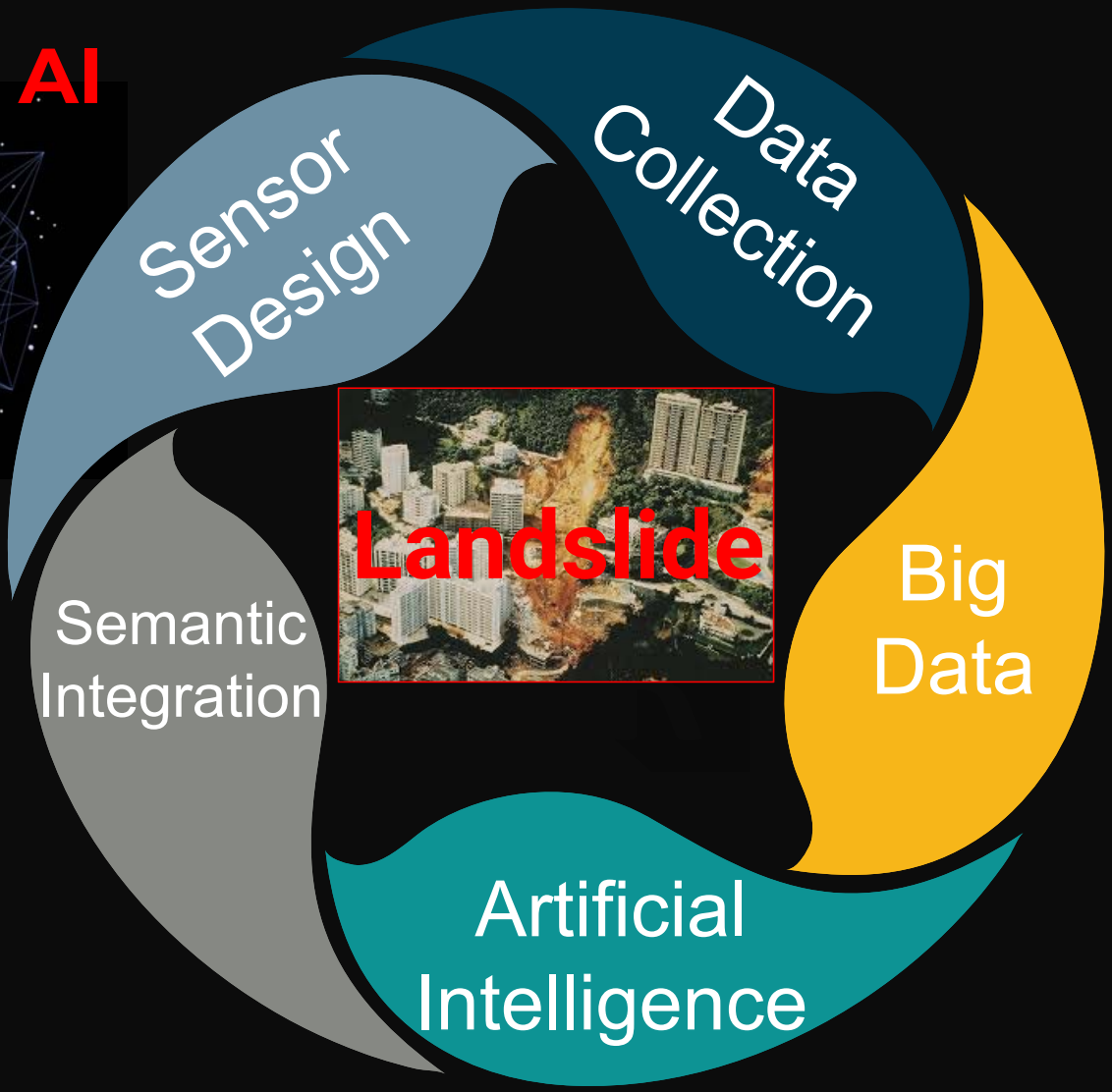
SmallGrids:
Represents the pixels on radar images, it also implies the Observatory embraces technology in the digital age.

Cross:
Represents the Observatory's target to make accurate forecasts

VERTICAL AI

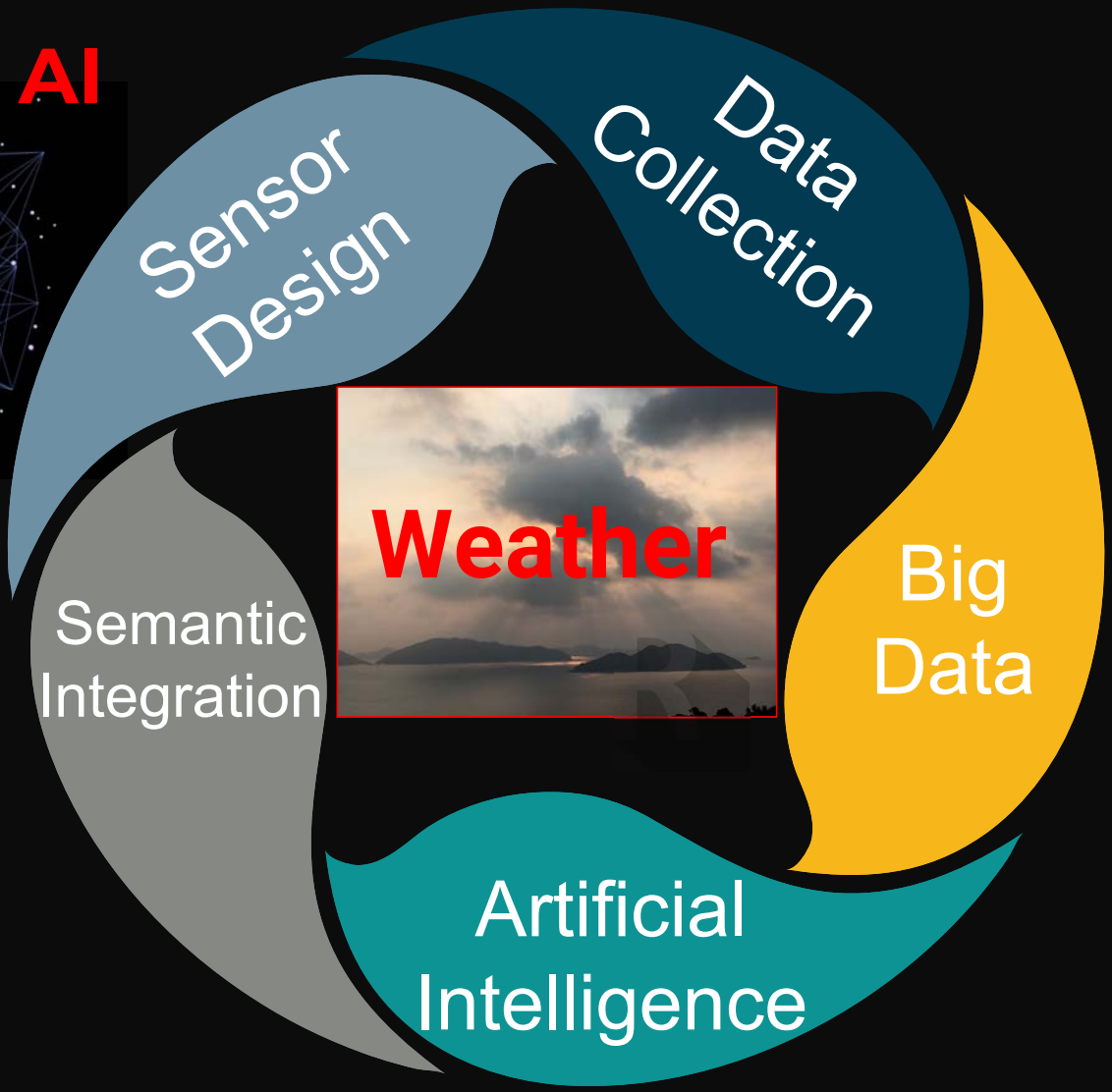

Sensor Design
Data Collection
Big Data
Artificial Intelligence
Semantic Integration
D
E
S
R

VERTICAL AI


Sensor Design
Data Collection
Big Data
Artificial Intelligence
Semantic Integration
Landslide

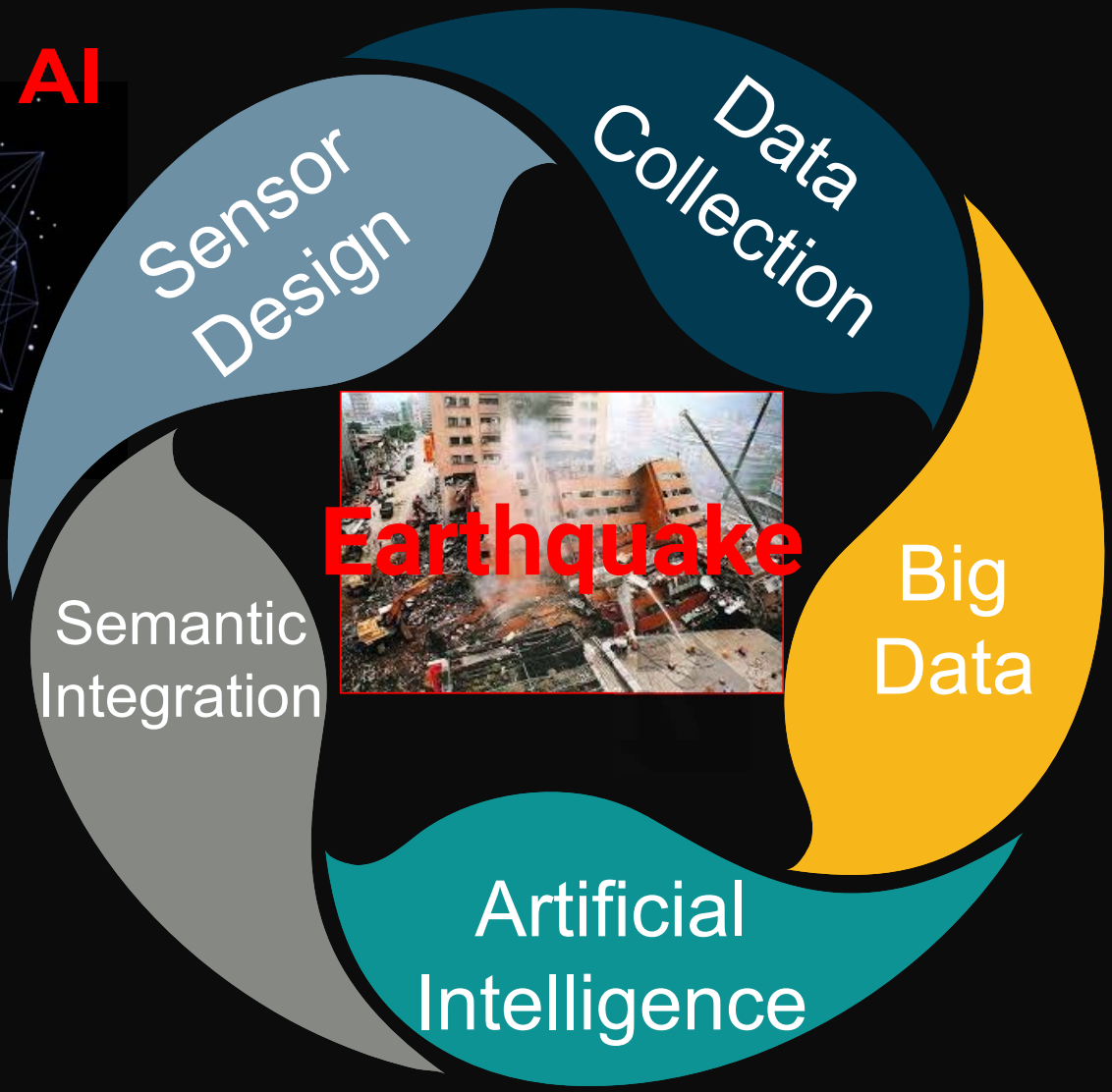
VERTICAL AI

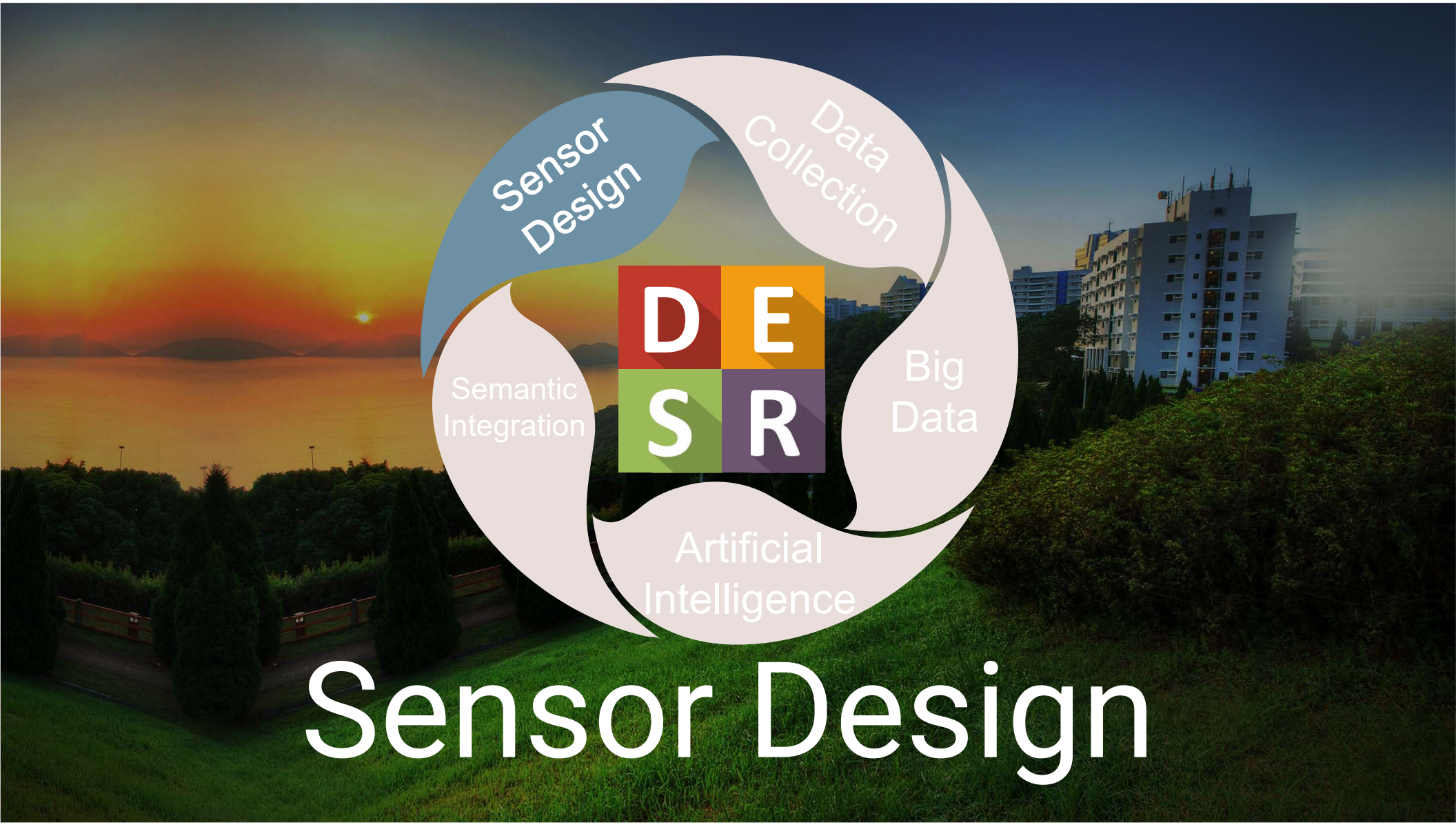
Transfer Learning

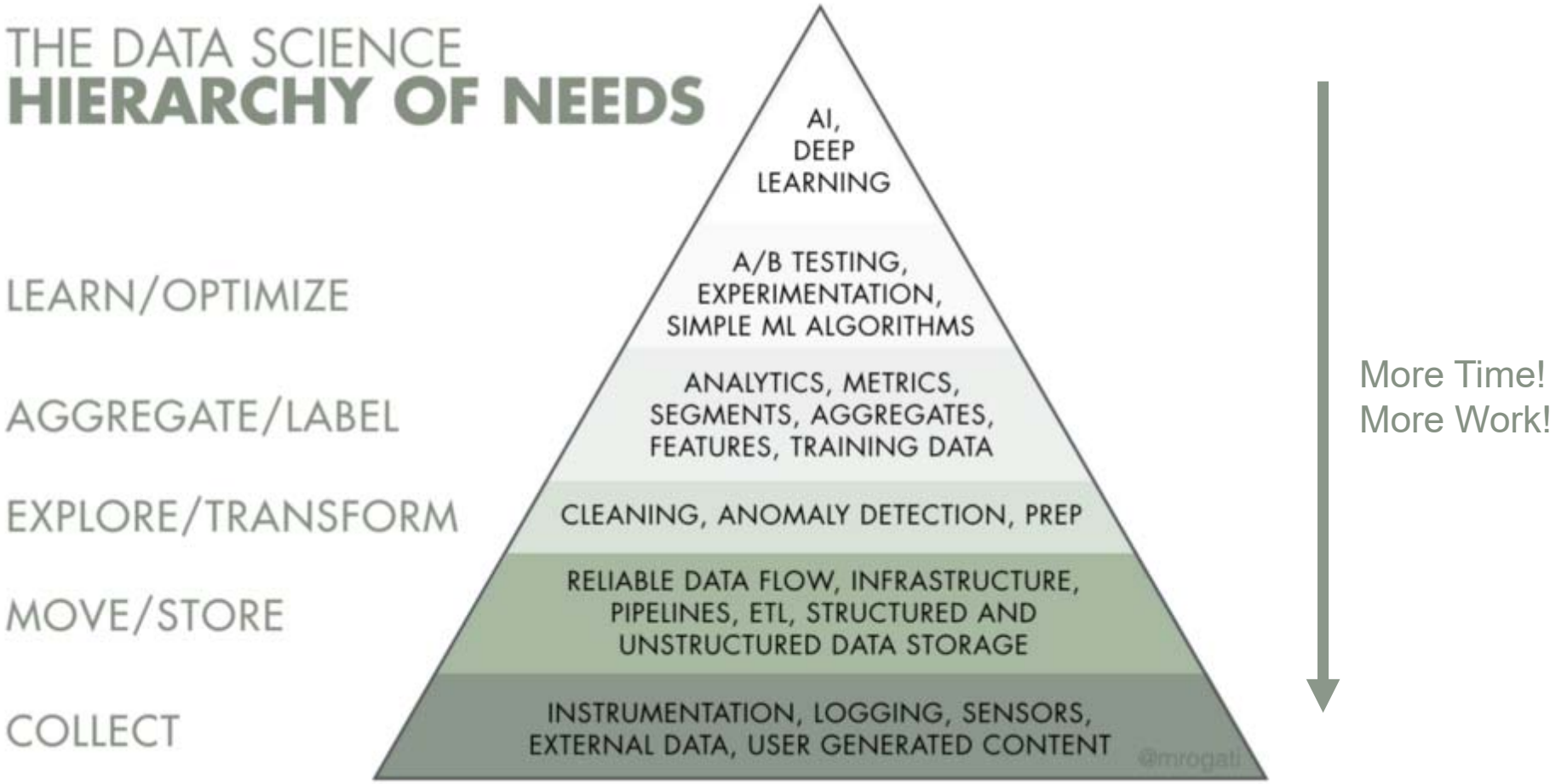


VERTICAL AI

Transfer Learning




Sensor Design
Data Collection
Big Data
Artificial Intelligence
Semantic Integration
D E
S R
Sensor Design

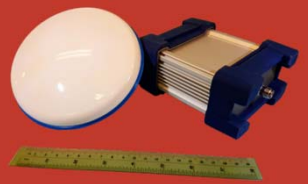


Data needs as illustrated by Monica Rogati

Monitoring Matrix

	Dynamic	Static
Permanent	Seismograph 	Data logger 
Portable	Geophone 	D-GPS 

Sensor Technology Matrix

	Dynamic	Static
Permanent	Geo-IoT 	DESR-node 
Portable	Marble 	RTK-GNSS 

Sensor Technology Matrix

	Dynamic	Static
Permanent	Geo-IoT 	DESR-node 
Portable	Marble 	RTK-GNSS 

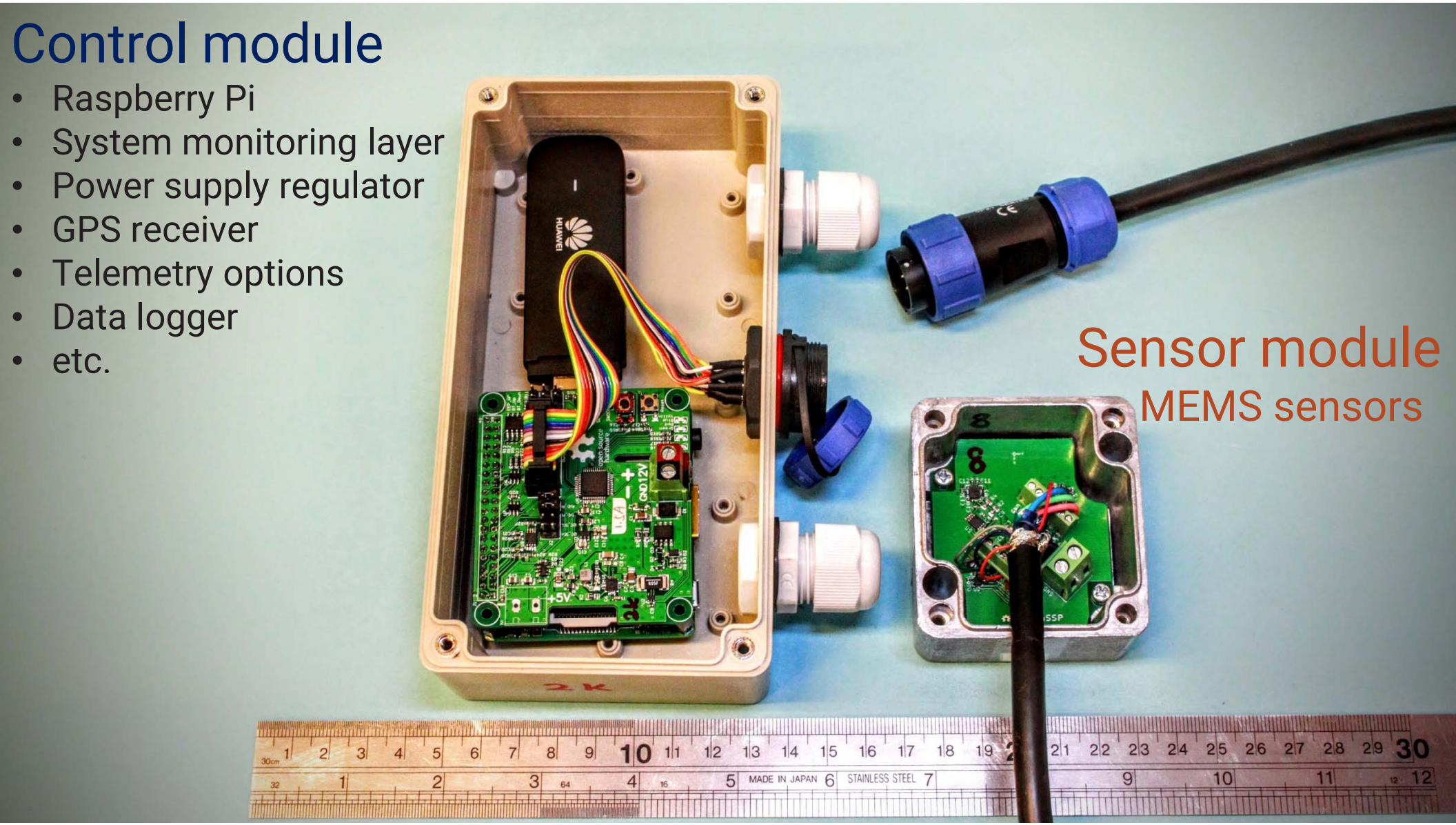
Geo-IoT: Internet of Things

in Geotechnical Engineering


GPS Antenna
Solar Panel
with Battery
Control Module
Sensor Module
Lu Shan, Taiwan

Control module

- Raspberry Pi
- System monitoring layer
- Power supply regulator
- GPS receiver
- Telemetry options
- Data logger
- etc.



Sensor module

MEMS sensors

GeoIoT
Generation 8
DeepVibes


Fault-tolerance
Inaccessible mountains
Sichuan, China
Real poor student
Real snow

How to achieve Fault-tolerance?

Resiliency is by Design

Full Protection Power Supply

- Redundant Power Supply
- Constant Self Monitoring and Recovery
- Reverse Current Blocking
- Surge Protection
- Over Current Protection
- Over/Under Voltage Protection
- Reverse Polarity Protection
- Thermal Shutdown
- Constant Voltage Ramp Rate

Redundant Sensors (COTS sensors)

Redundant Storage

Self-healing Software

- Supervision Tree
- Bulkhead Pattern
- Widely use in Ericsson (nine "9"s)

CEDD Contract No. GE/2013/16

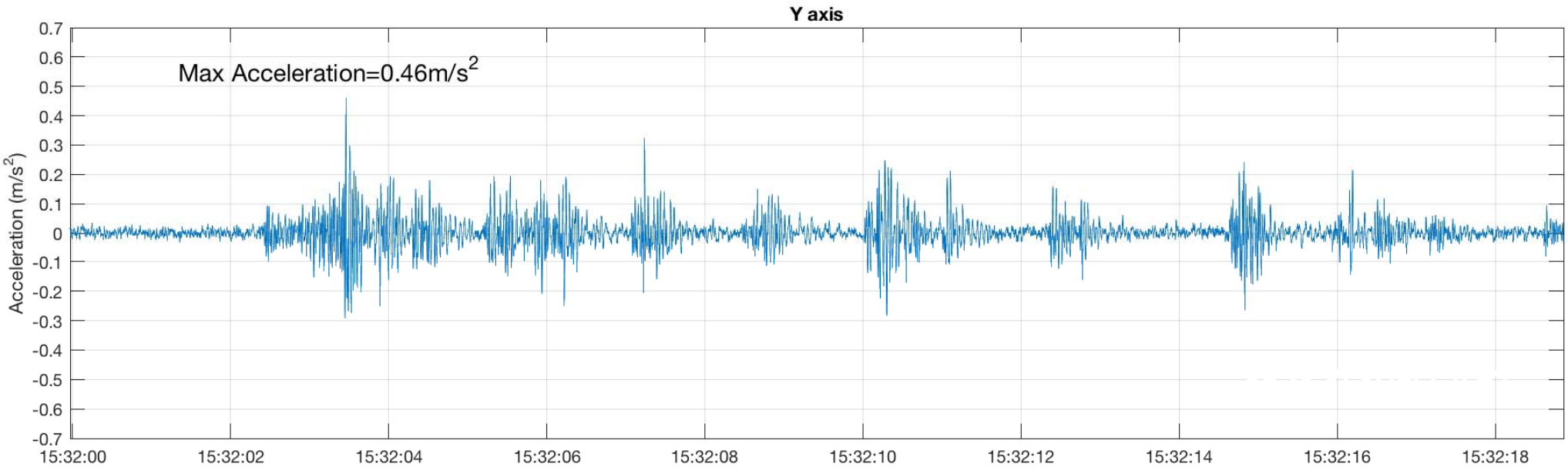
Landslip Prevention and Mitigation Programme, 2008, Package N, Landslip Prevention and Mitigation Works in Sham Wat, Tai O East, Upper Keung Shan and Keung Shan Road East in West Lantau


Fault-tolerance
Over the air
Flexible
Sichuan, China

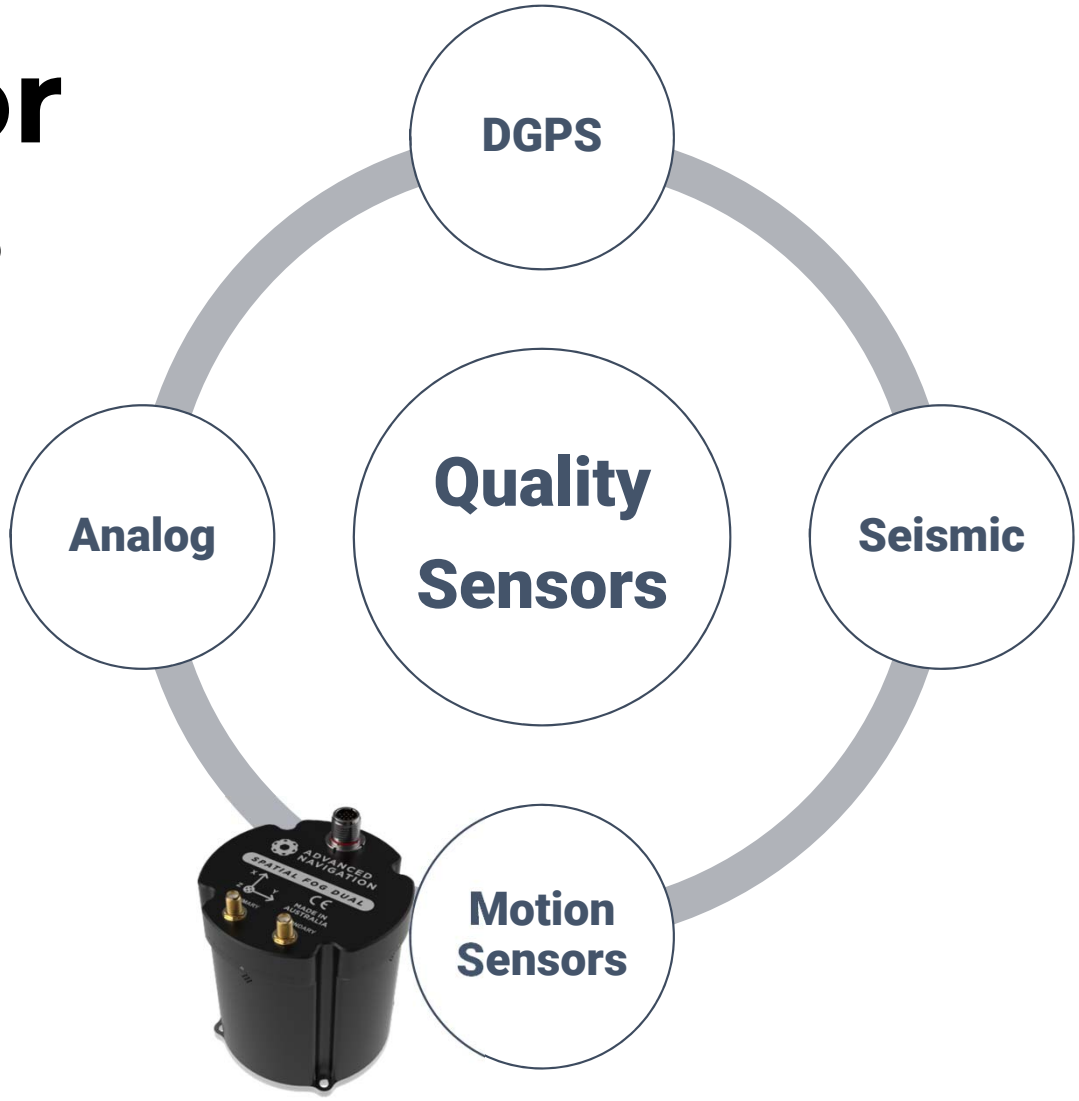
Flexible Installation

Site-specific Alteration

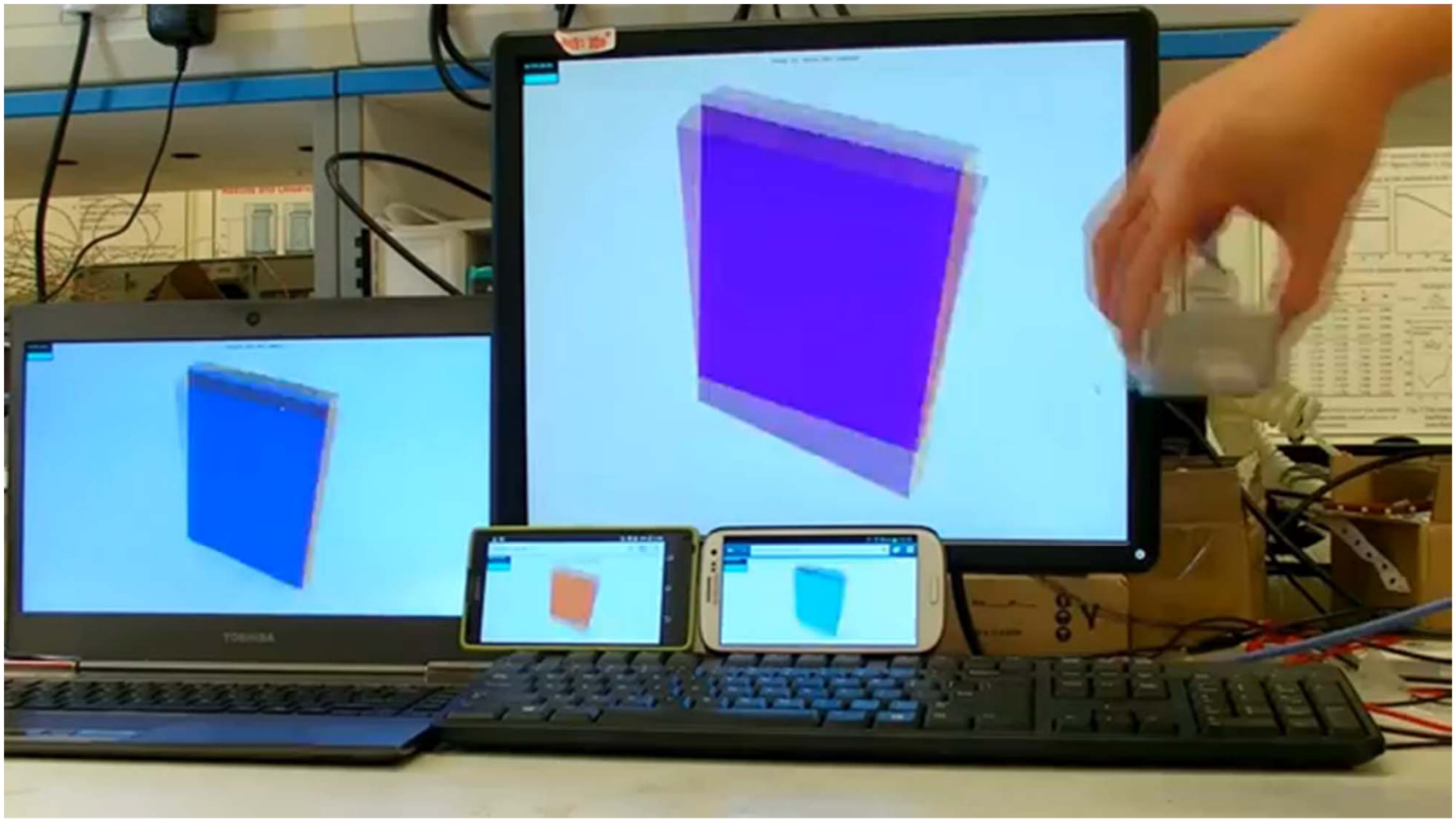
Always On
High Frequency & Continuous



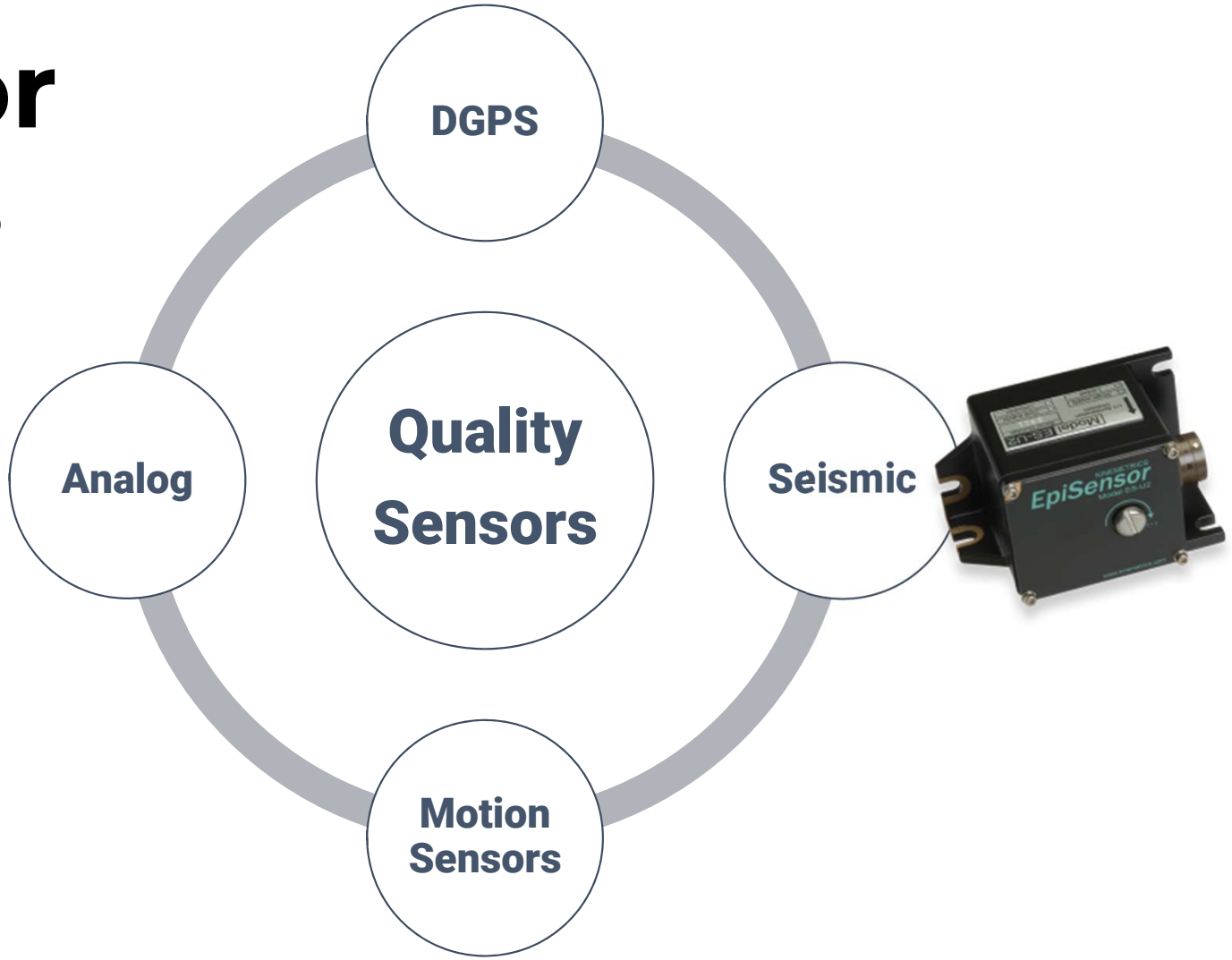
Sensor Types



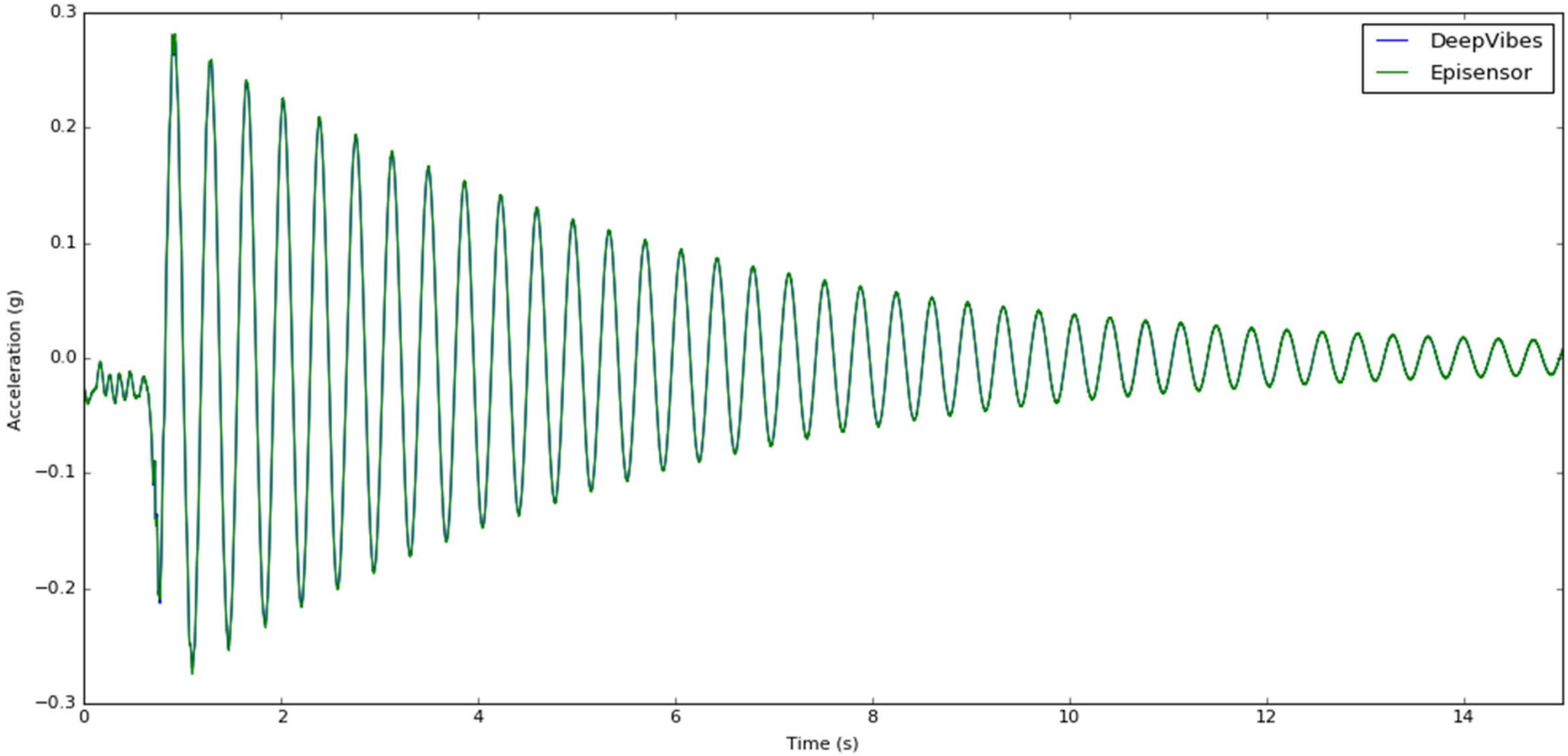
Motion Sensing

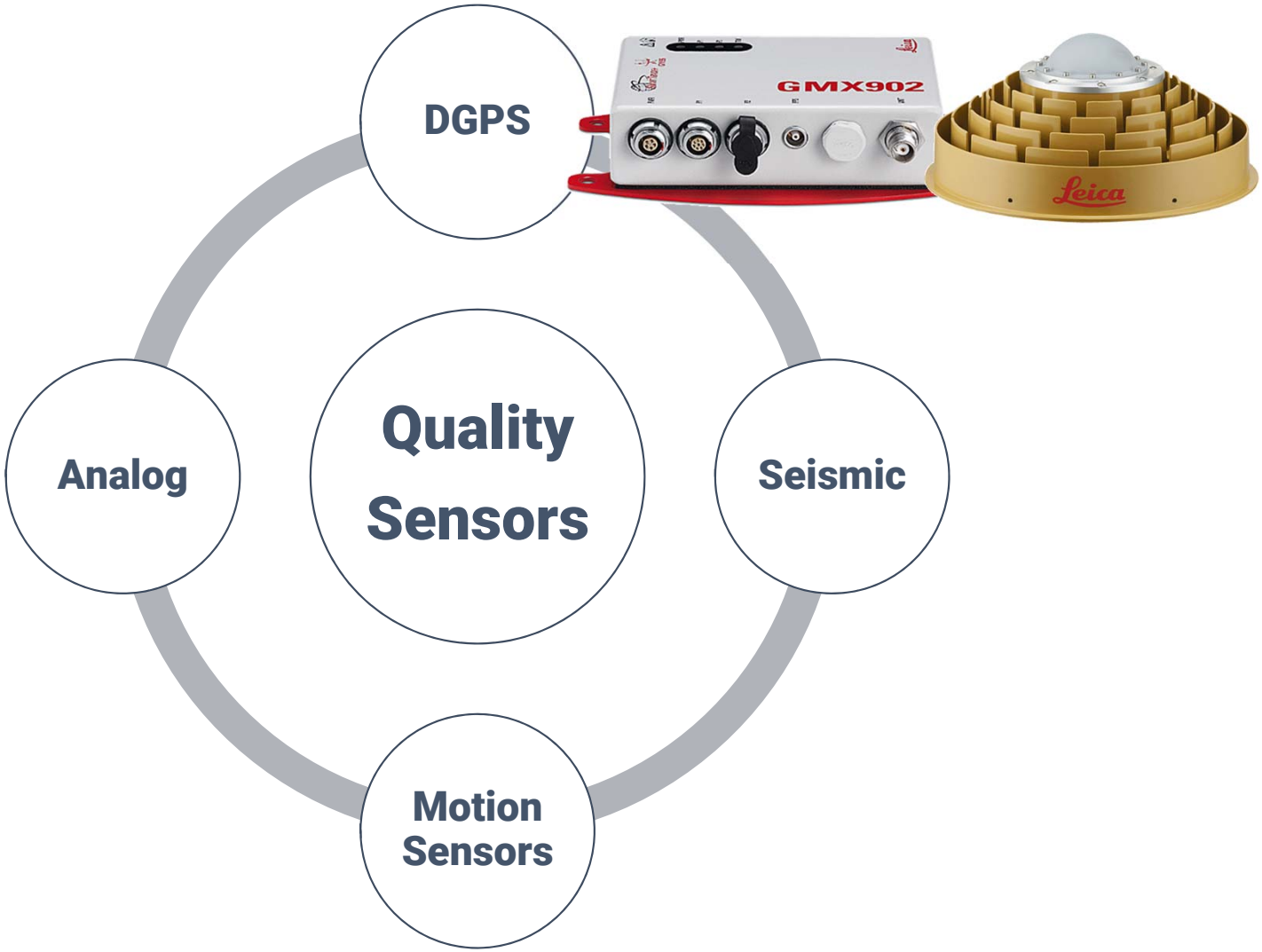


Sensor Types



Event-1: GhhsYlehv vs EpiSensor




DGPS
GMX902
Leica
Analog
Quality
Sensors
Seismic
Motion
Sensors

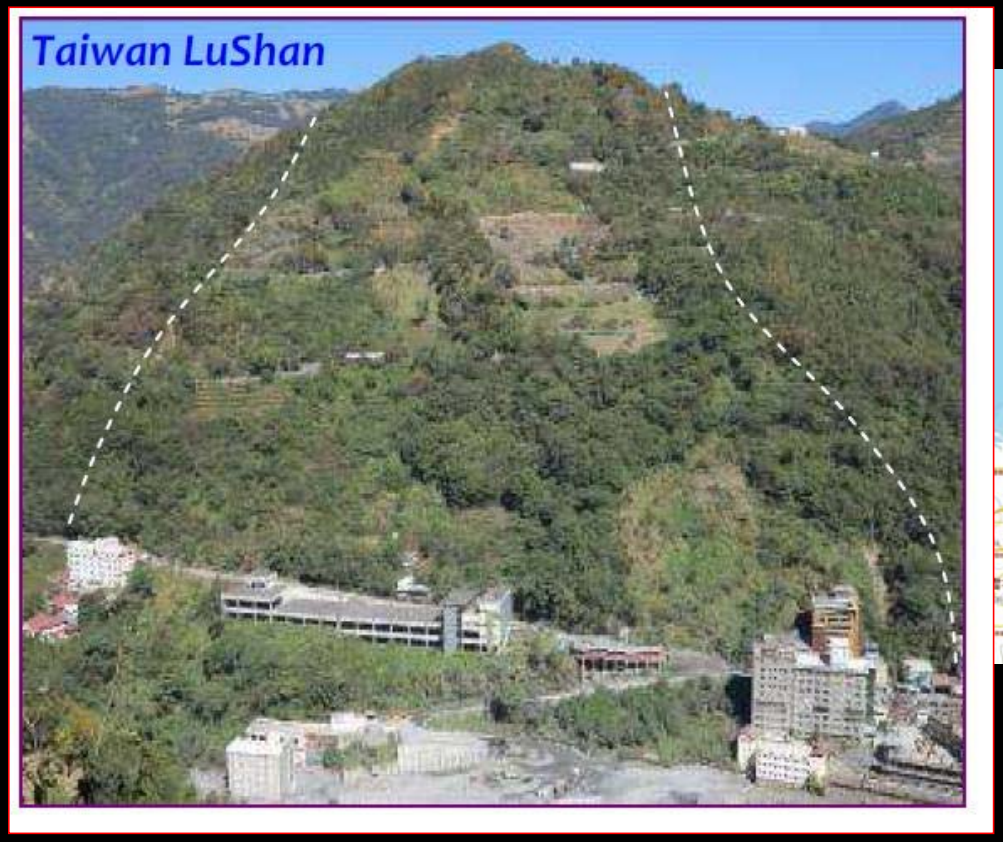
DGPS (compatible with different satellite systems)

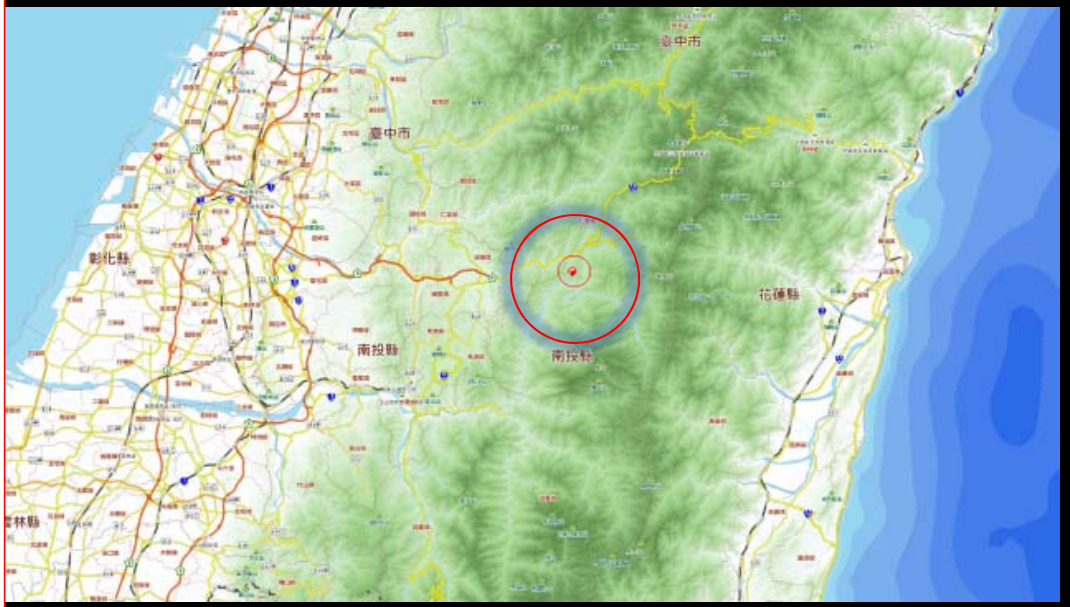
GPS L1 C/A, (USA)
GLONASS L10F (Russia)
BeiDou B1, (China)
Galileo E1B/C, (EU)
QZSS L1, (Japan)
SBAS L1 C/A: WAAS, EGNOS, MSAS, GAGAN

(Multiple frequencies)

Real time monitoring on a landslide-prone area

Monitoring site





Lushan,
Central Part of Taiwan

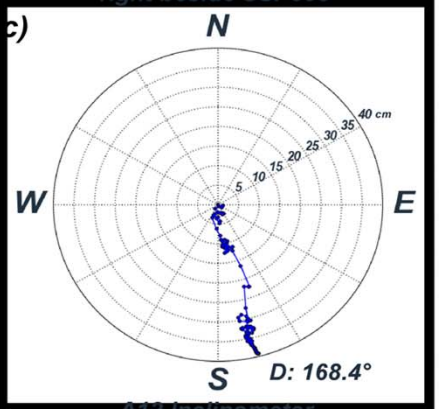
M 6.4 earthquakes, Feb. 6 2018

98 times of aftershocks

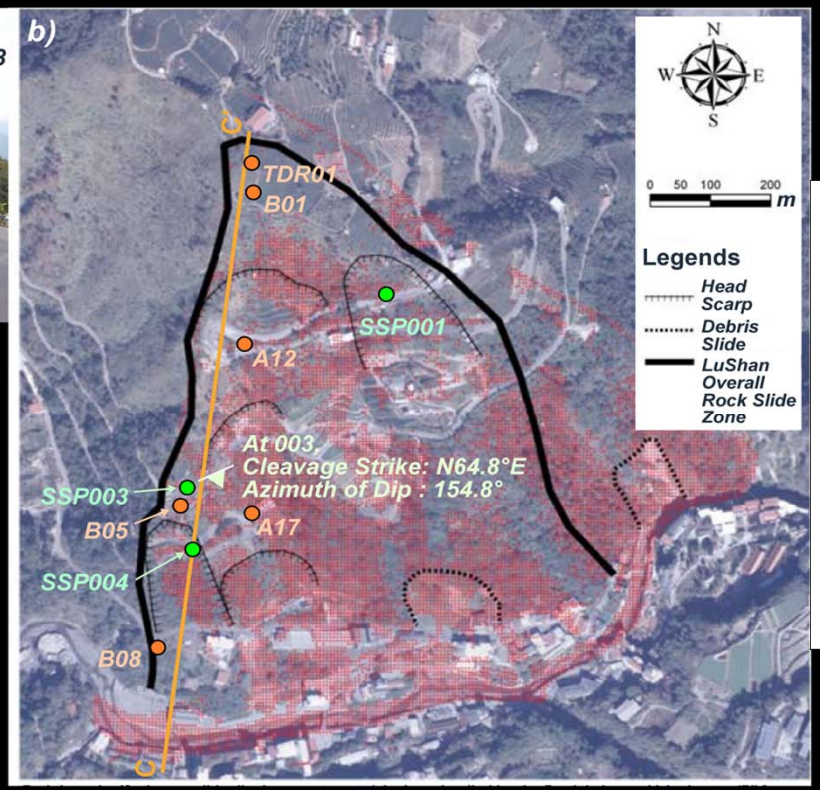
More than one thousand earthquakes per year

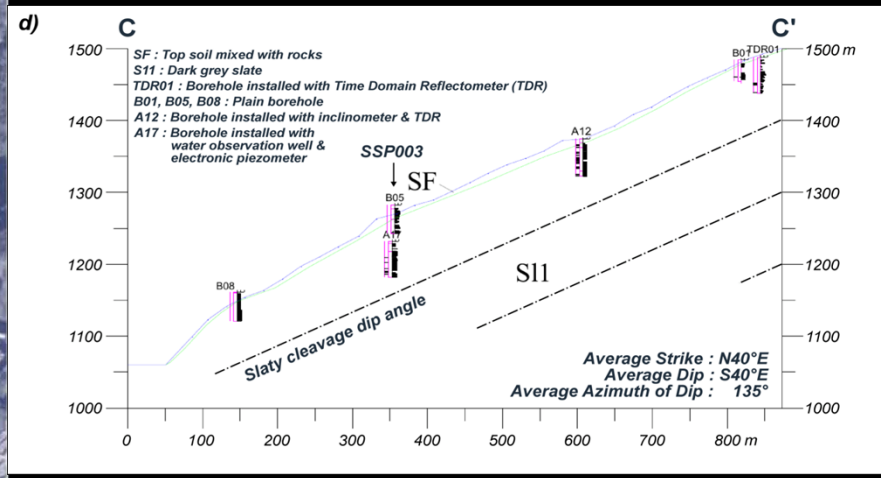
Point 003 at Lushan, Taiwan

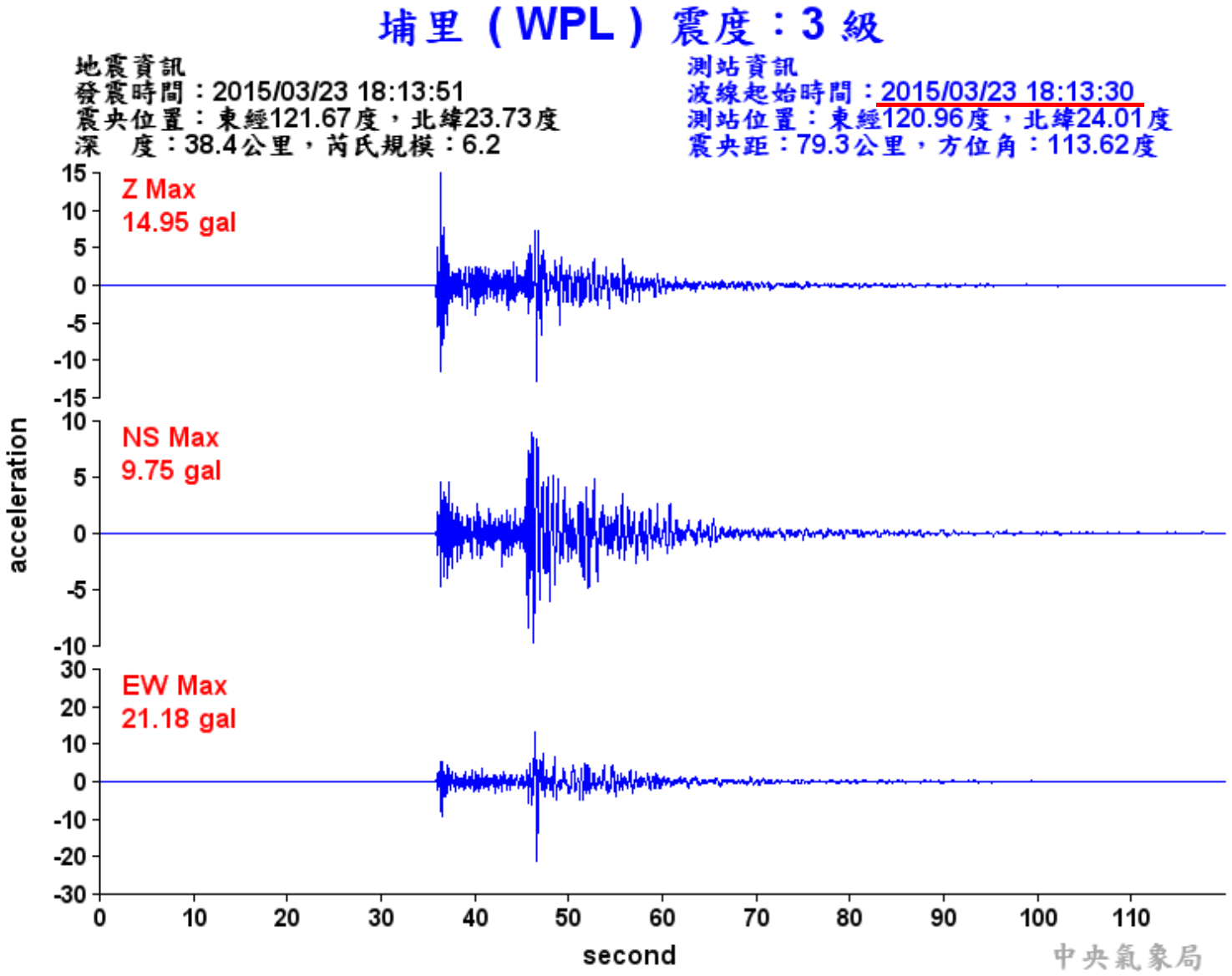
Huge Crack of the Retaining Wall right beside SSP003



A12 Inclinometer Displacement Projection







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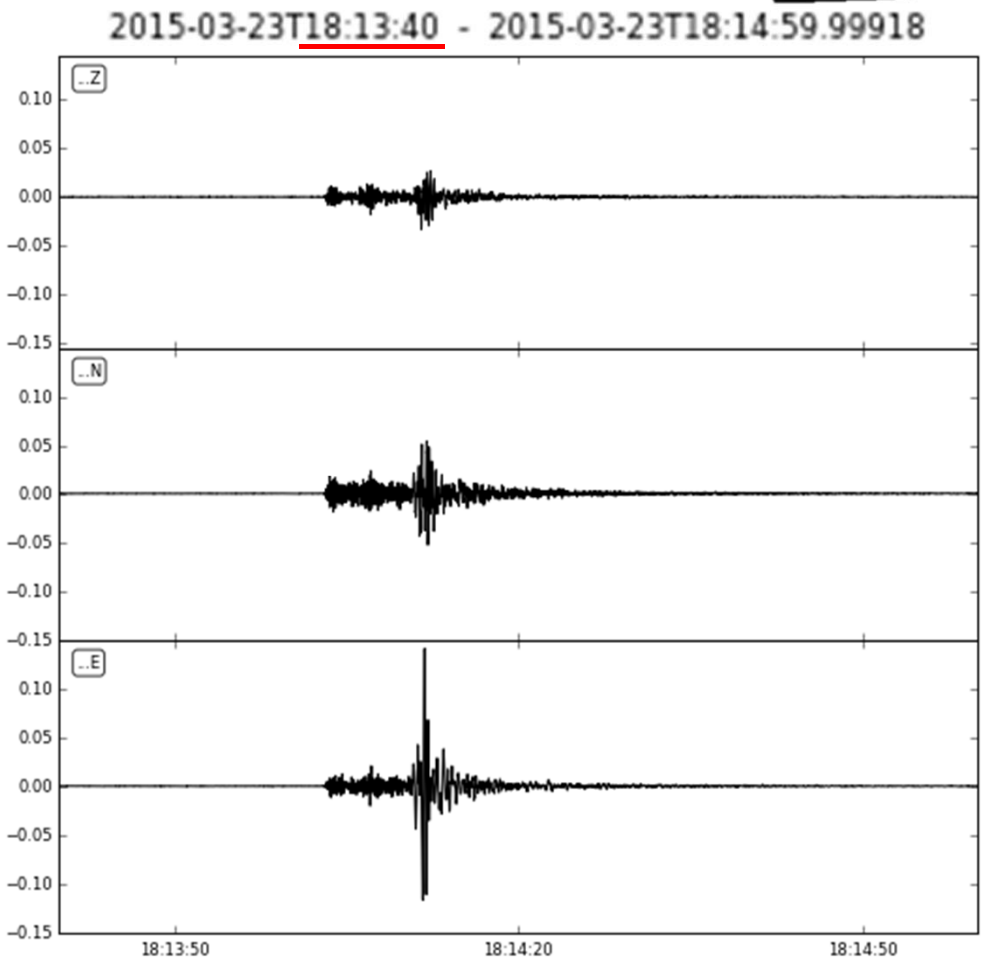
Earthquake signals

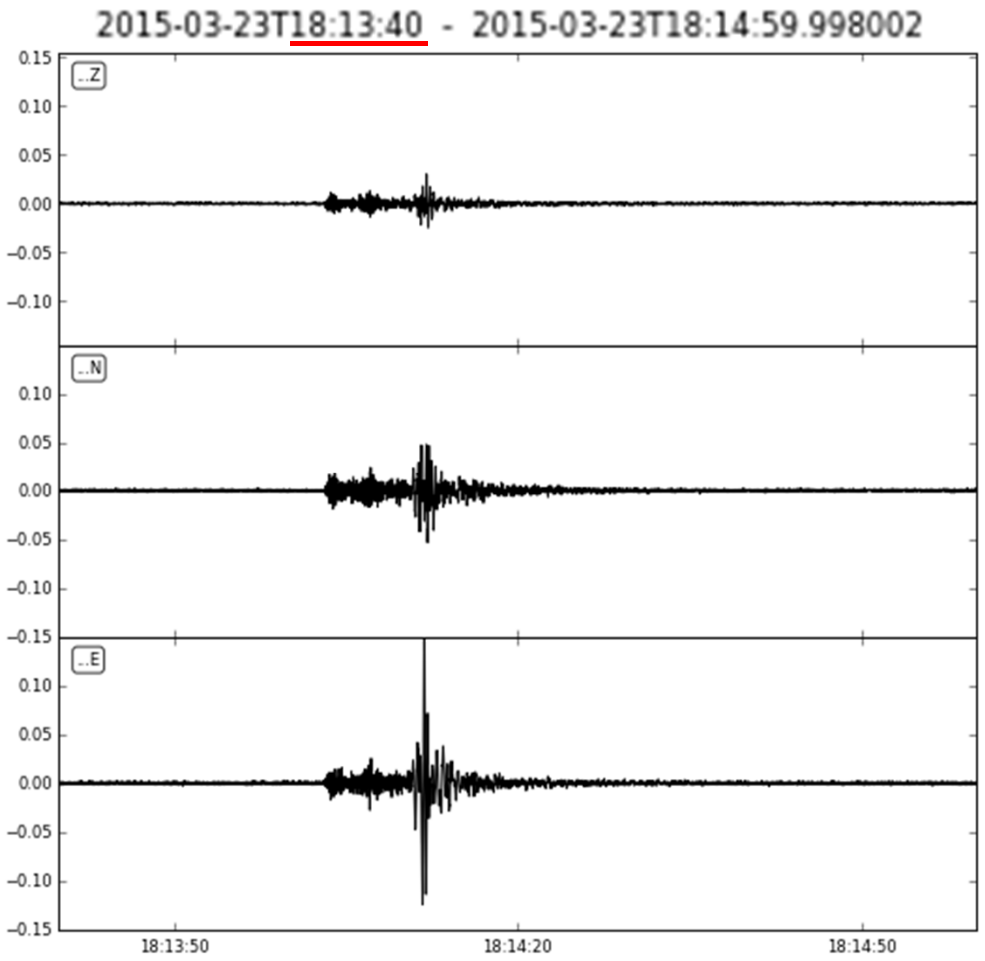
Silicon Designs (SDI003)

HK$ 15281

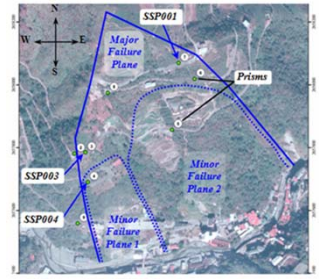


Bosch (BMA003)

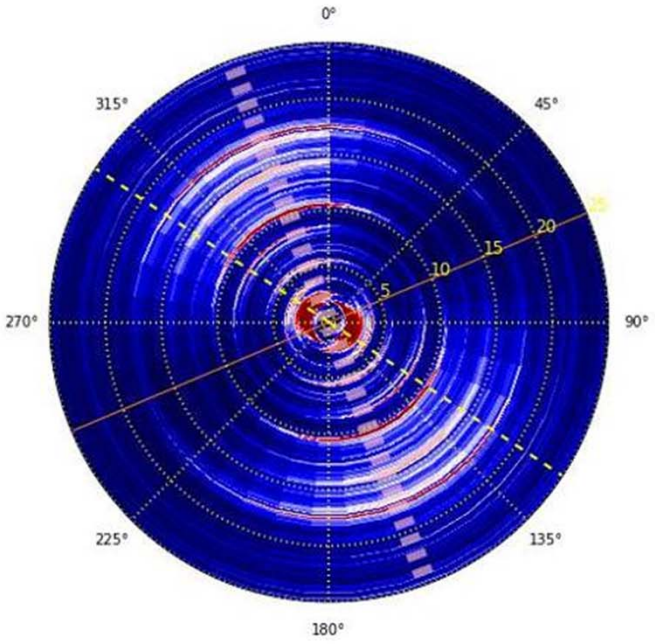
HK$ 10.47



HVSR during the 2015 March 23 Earthquake

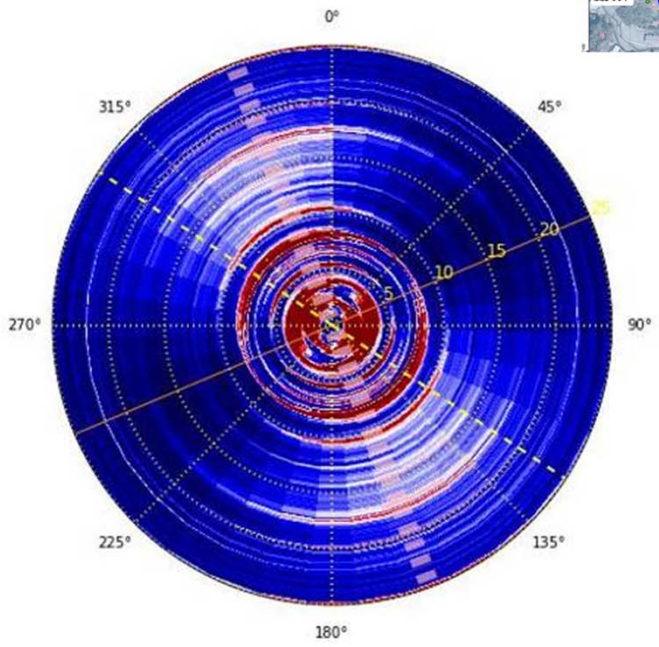


BMA003CH0



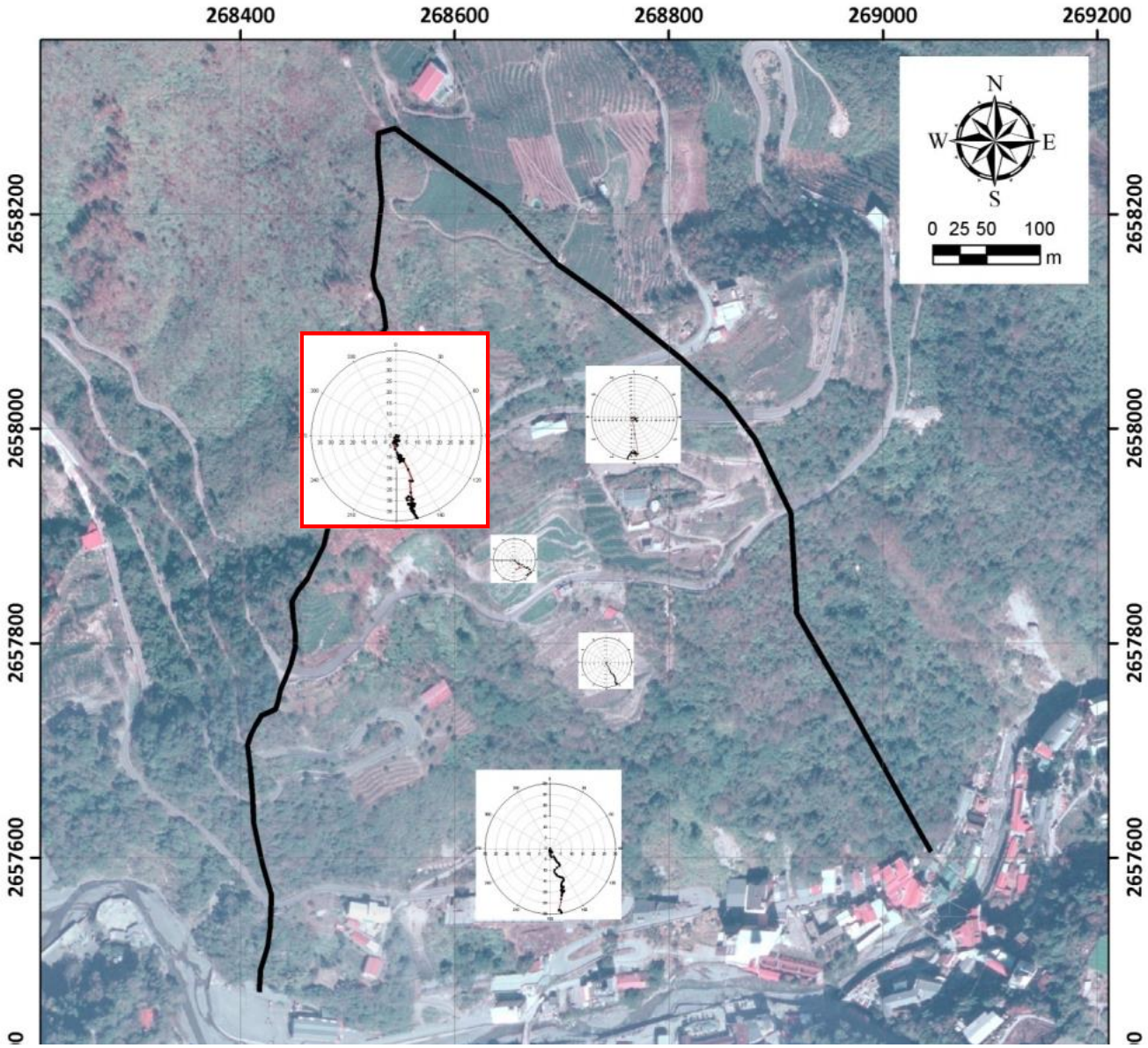
Directivity: 159.43

BMA003CH1



Directivity: 159.43

Del Gaudio and Wasoski (2007, 2011)



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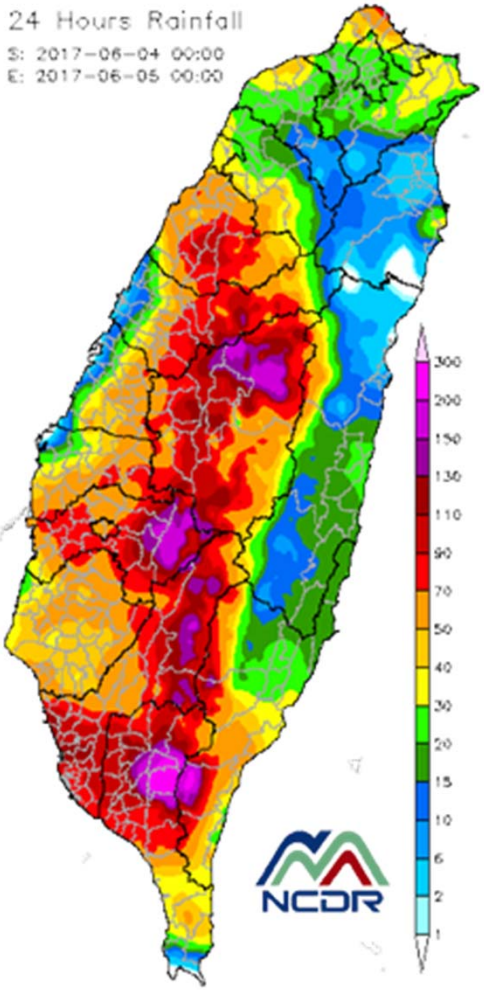
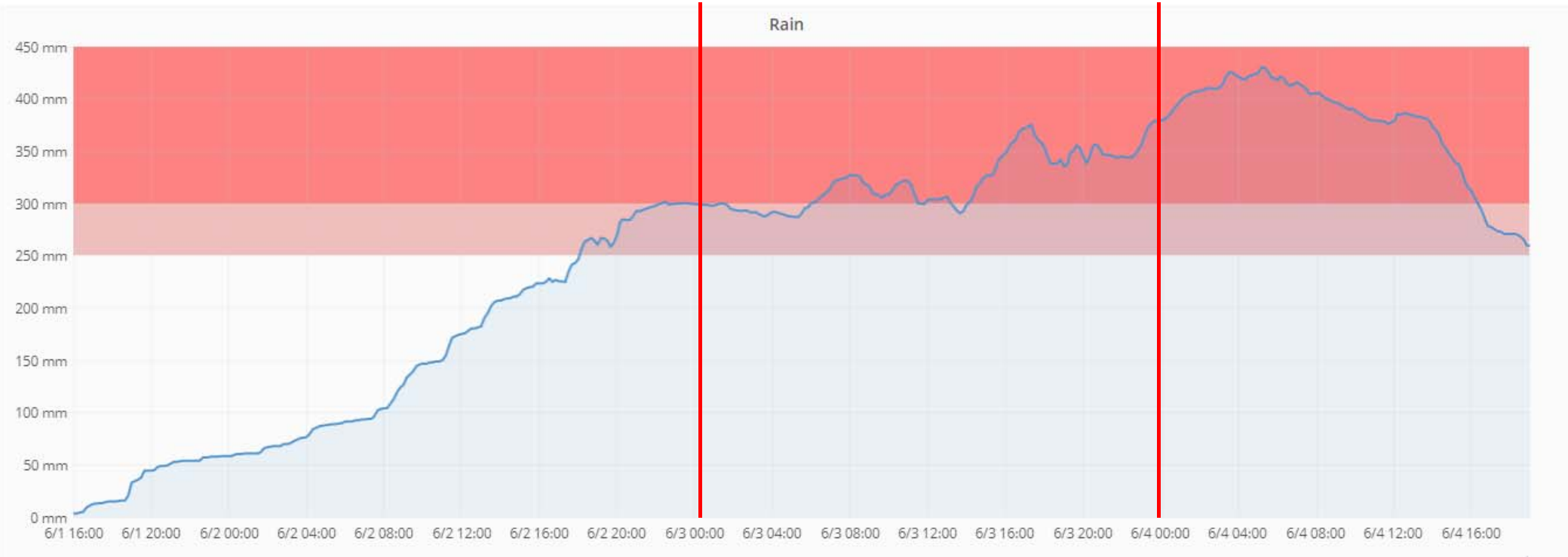
Landslide event, June, 2017



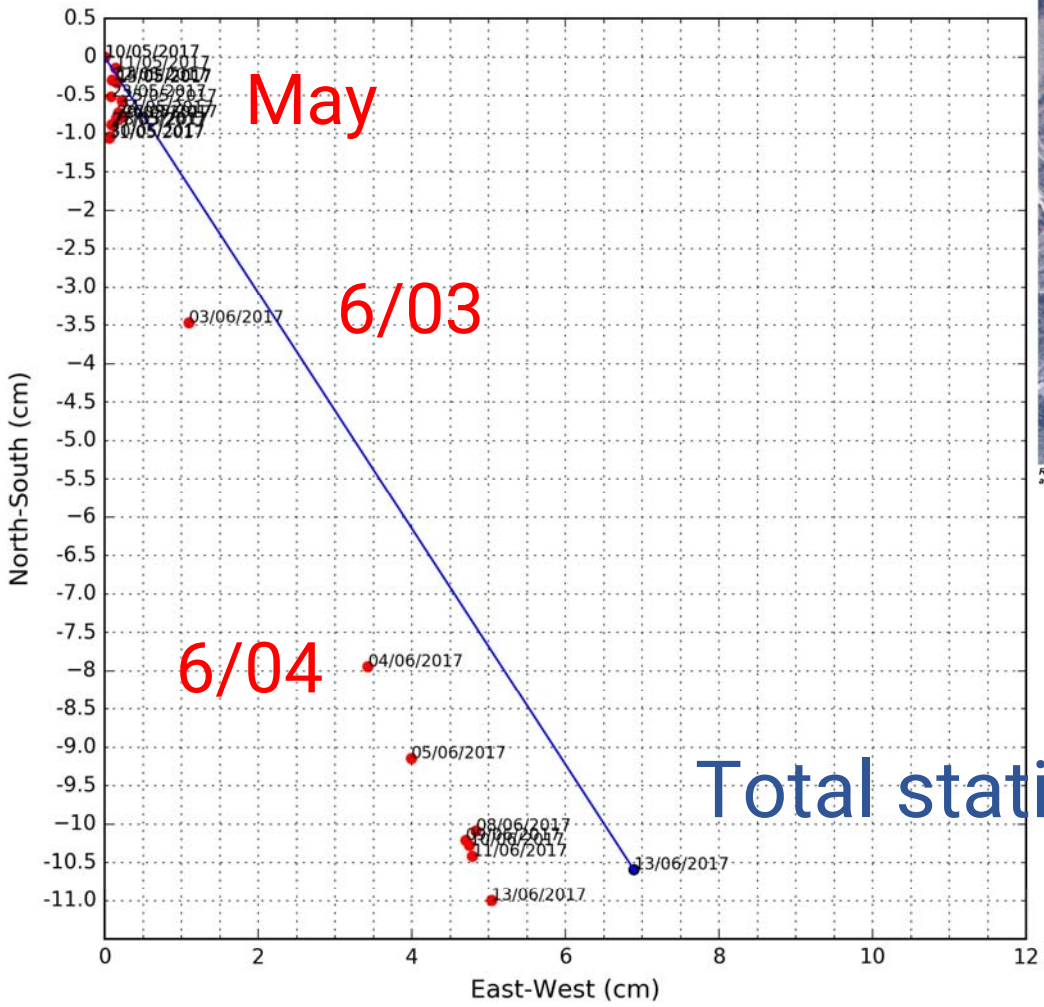
Rainfall Data

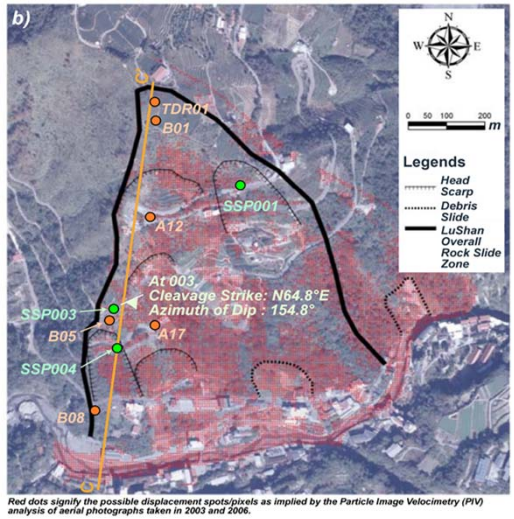
6 (June)/03

6/04



DGPS





Total station

Earthquake event in Hong Kong 31st July, 2016 (Magnitude 4.9)

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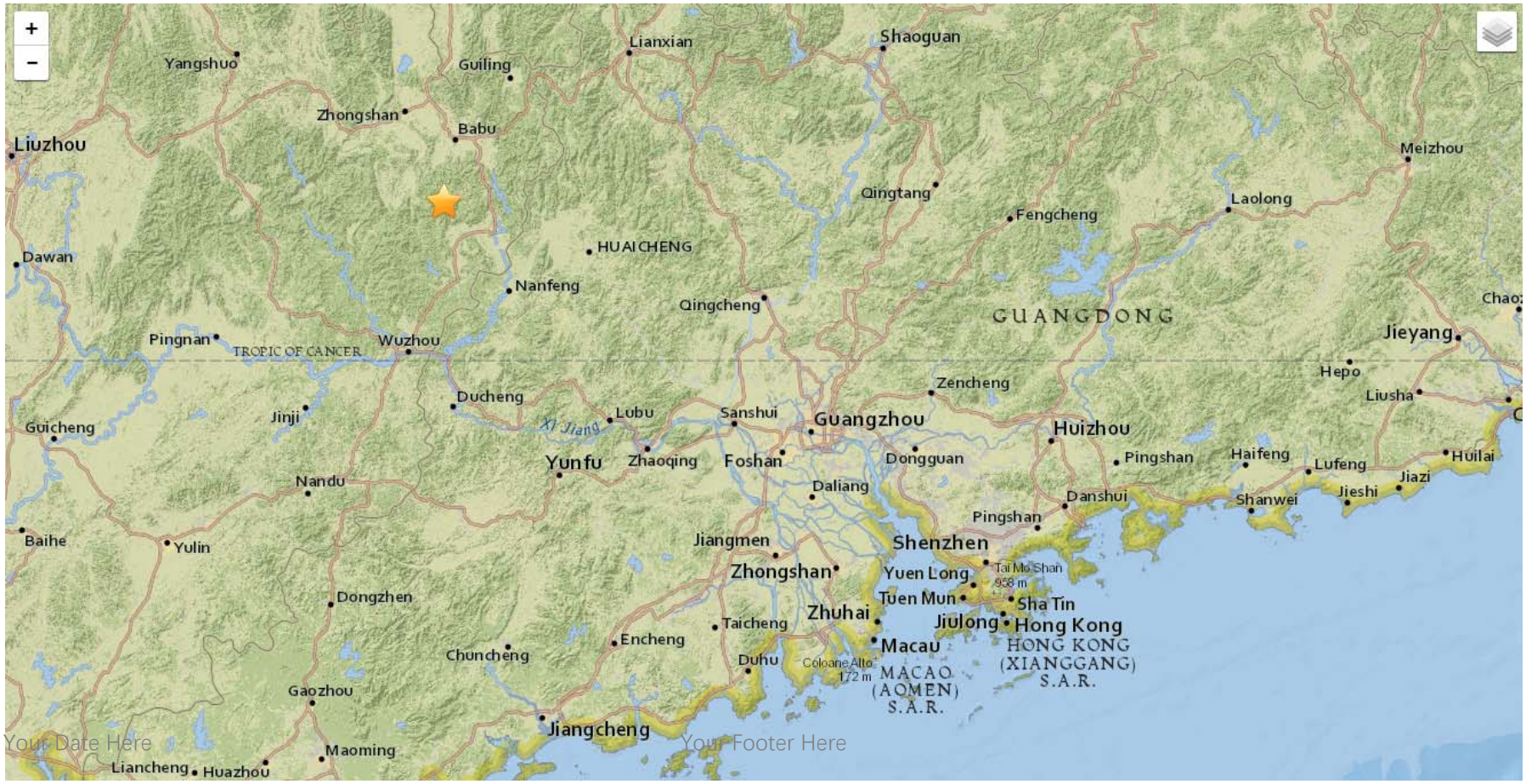

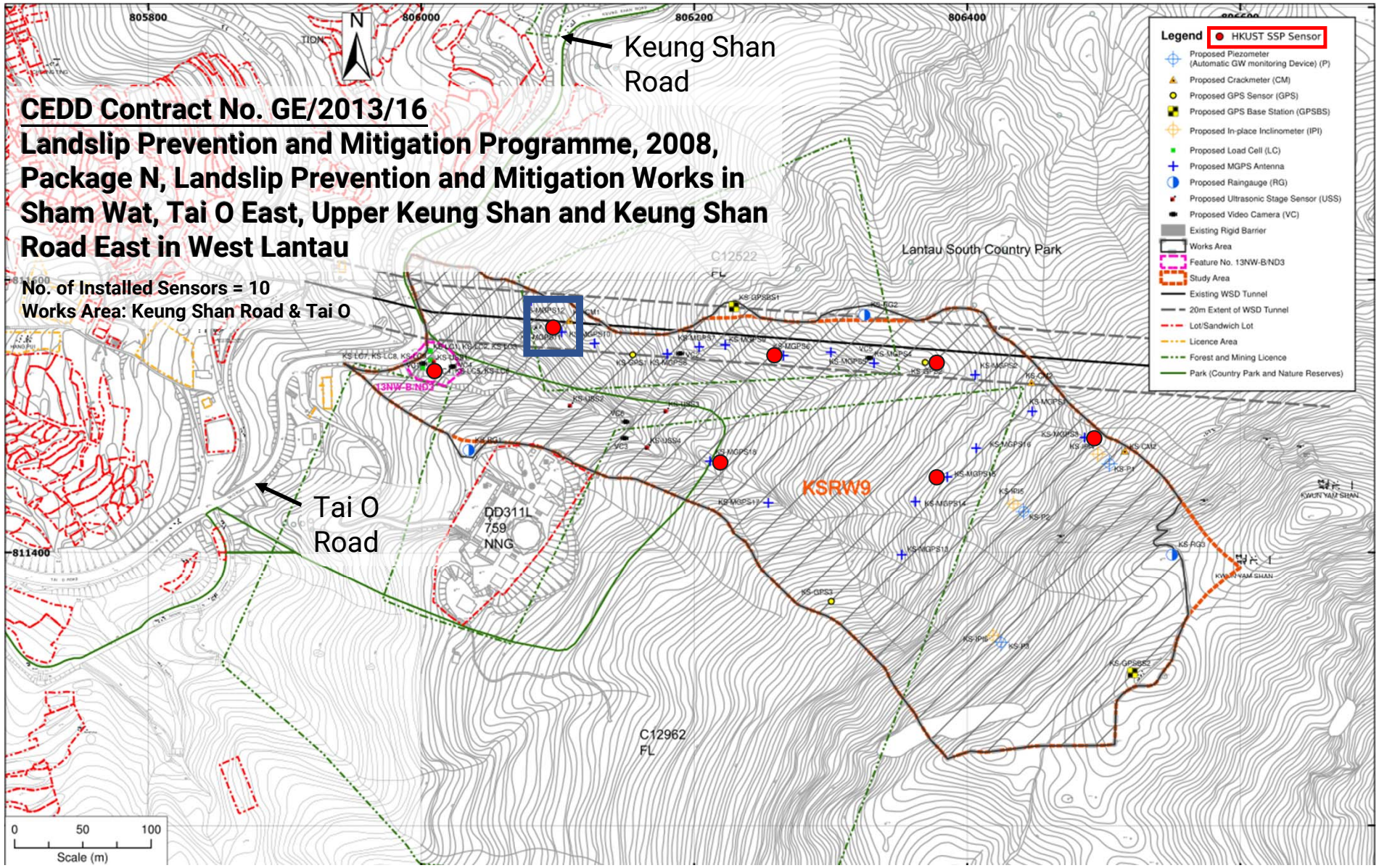
CEDD Contract No. GE/2013/16
Landslip Prevention and Mitigation Programme, 2008, Package N, Landslip Prevention and Mitigation Works in Sham Wat, Tai O East, Upper Keung Shan and Keung Shan Road East in West Lantau
No. of Installed Sensors = 10
Works Area: Keung Shan Road & Tai O
Keung Shan Road
Tai O Road
Lantau South Country Park
KSRW9
13NW-B/ND3
DD311L
759
NNG
C12522
C12962
FL
805800
806000
806200
806400
811400
N
0
50
100
Scale (m)
Legend
HKUST SSP Sensor
Proposed Piezometer (Automatic GW monitoring Device) (P)
Proposed Crackmeter (CM)
Proposed GPS Sensor (GPS)
Proposed GPS Base Station (GPSBS)
Proposed In-place Inclinometer (IPI)
Proposed Load Cell (LC)
Proposed MGPS Antenna
Proposed Raingauge (RG)
Proposed Ultrasonic Stage Sensor (USS)
Proposed Video Camera (VC)
Existing Rigid Barrier
Works Area
Feature No. 13NW-B/ND3
Study Area
Existing WSD Tunnel
20m Extent of WSD Tunnel
Lot/Sandwich Lot
Licence Area
Forest and Mining Licence
Park (Country Park and Nature Reserves)

Earthquake event in Hong Kong 31st July, 2016

CEDD Contract No. GE/2013/16
Landslip Prevention and Mitigation Programme, 2008, Package N, Landslip Prevention and Mitigation Works in Sham Wat, Tai O East, Upper Keung Shan and Keung Shan Road East in West Lantau

No. of Installed Sensors = 7
Works Area: Keung Shan Road

Sensor module is enclosed inside a waterproof aluminium box, which is mounted on a L-hinge steel then affixed on the concrete footing beneath.

Earthquake event in Hong Kong 31st July, 2016

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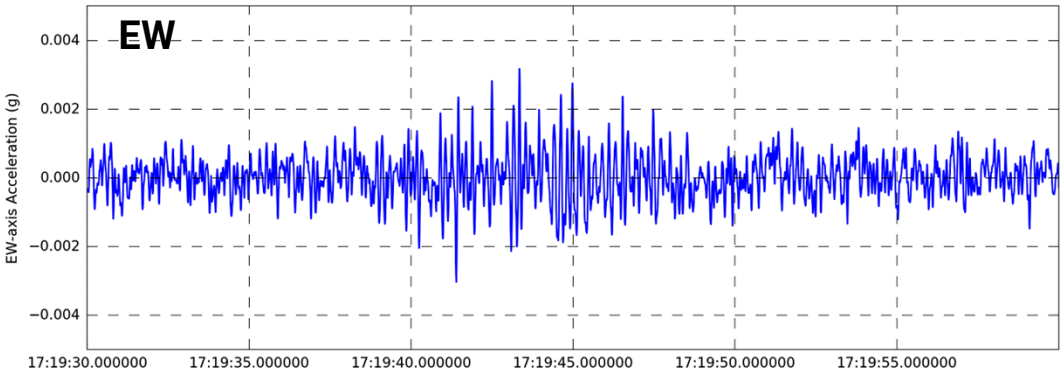
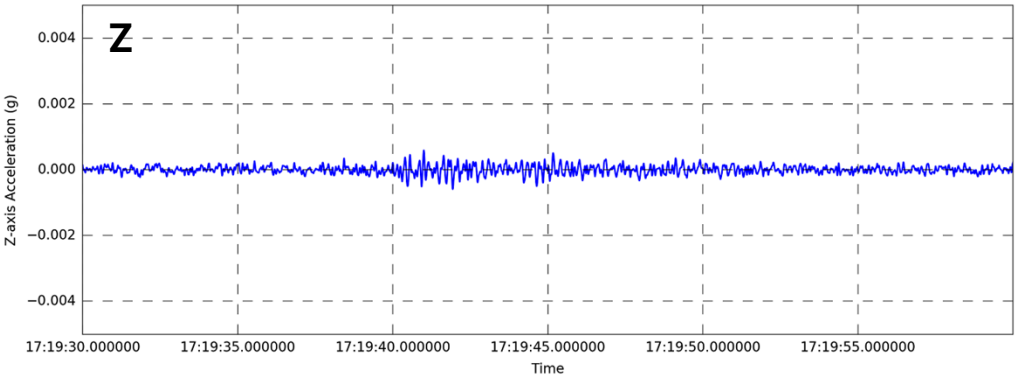
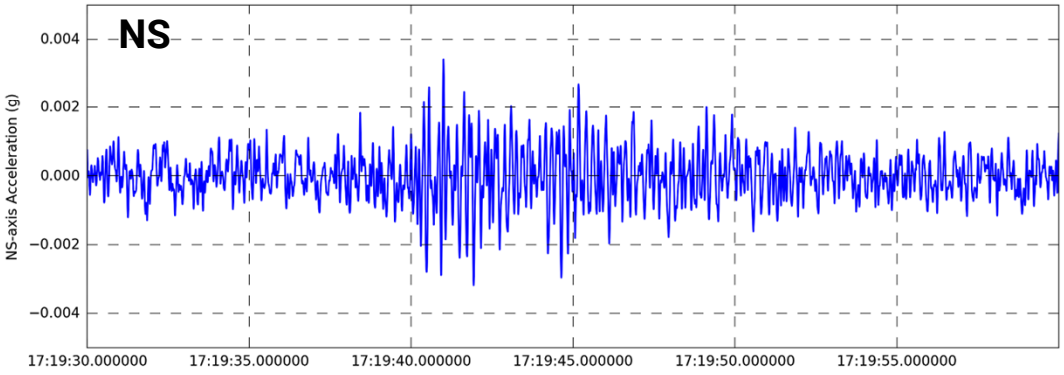
- Acceleration recorded was about 17:19:39. The earthquake originated 26km south of Babu China, at 17:18:13.

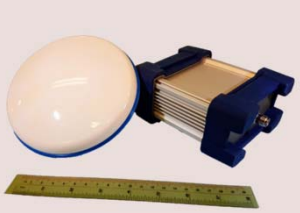






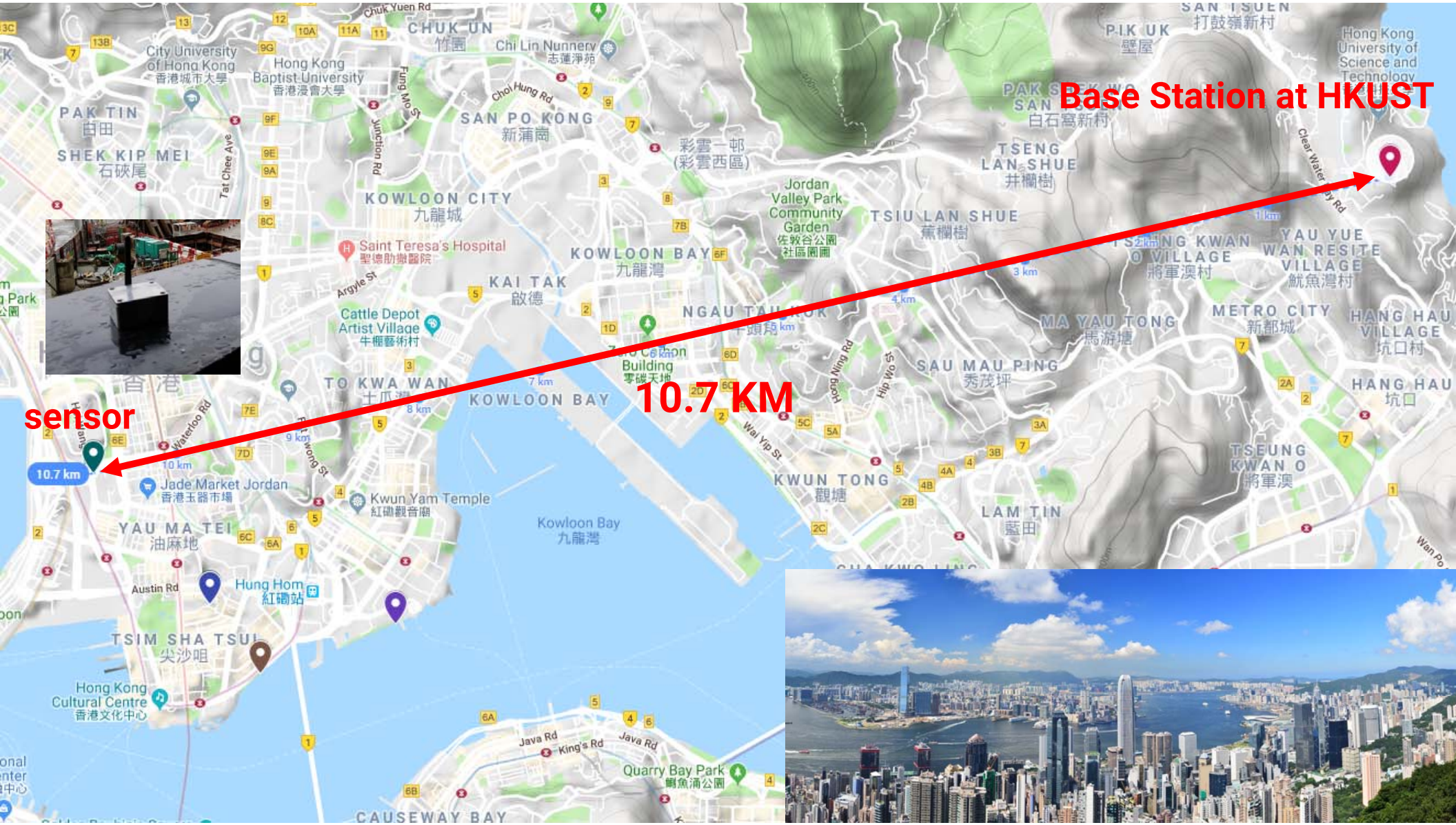
In vertical Z-axis, a peak acceleration of only 0.0006g was recorded

Sensor Technology Matrix

	Dynamic	Static
Permanent	Geo-IoT 	DESR-node 
Portable	Marble 	RTK-GNSS 

Existing devices

Crowdsensing

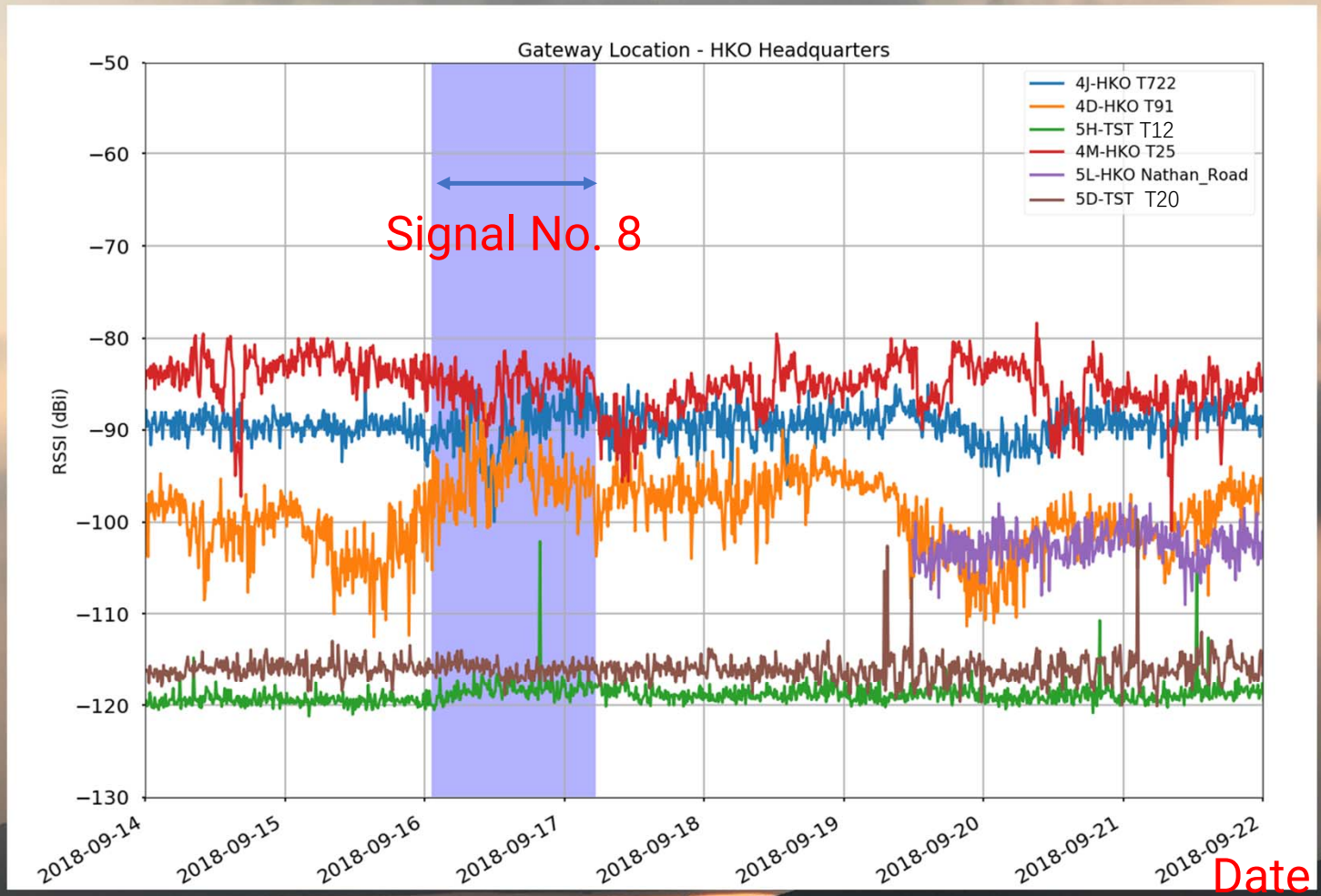

Base Station at HKUST
sensor
10.7 KM
10.7 km
CHUK UN
竹園
Chi Lin Nunnery
志蓮淨苑
City University of Hong Kong
香港城市大學
Hong Kong Baptist University
香港浸會大學
PAK TIN
白田
SHEK KIP MEI
石硤尾
SAN PO KONG
新蒲崗
KOWLOON CITY
九龍城
Saint Teresa's Hospital
聖德肋撒醫院
KOWLOON BAY
九龍灣
KAI TAK
啟德
Cattle Depot Artist Village
牛棚藝術村
TO KWA WAN
土瓜灣
Jordan Valley Park Community Garden
佐敦谷公園社區園圃
TSIU LAN SHUE
蕉欄樹
TSENG LAN SHUE
井欄樹
PIK UK
壁屋
SAN TSUEN
打鼓嶺新村
Hong Kong University of Science and Technology
NGAU TAU KOK
牛頭角
MA YAU TONG
馬游塘
METRO CITY
新都城
HANG HAU VILLAGE
坑口村
SAU MAU PING
秀茂坪
KWUN TONG
觀塘
LAM TIN
藍田
TSEUNG KWAN O
將軍澳
YAU MA TEI
油麻地
Jade Market Jordan
香港玉器市場
Kwun Yam Temple
紅磡觀音廟
Kowloon Bay
九龍灣
Austin Rd
Hung Hom
紅磡站
TSIM SHA TSUI
尖沙咀
Hong Kong Cultural Centre
香港文化中心
Java Rd
King's Rd
Quarry Bay Park
鰂魚涌公園
CAUSEWAY BAY

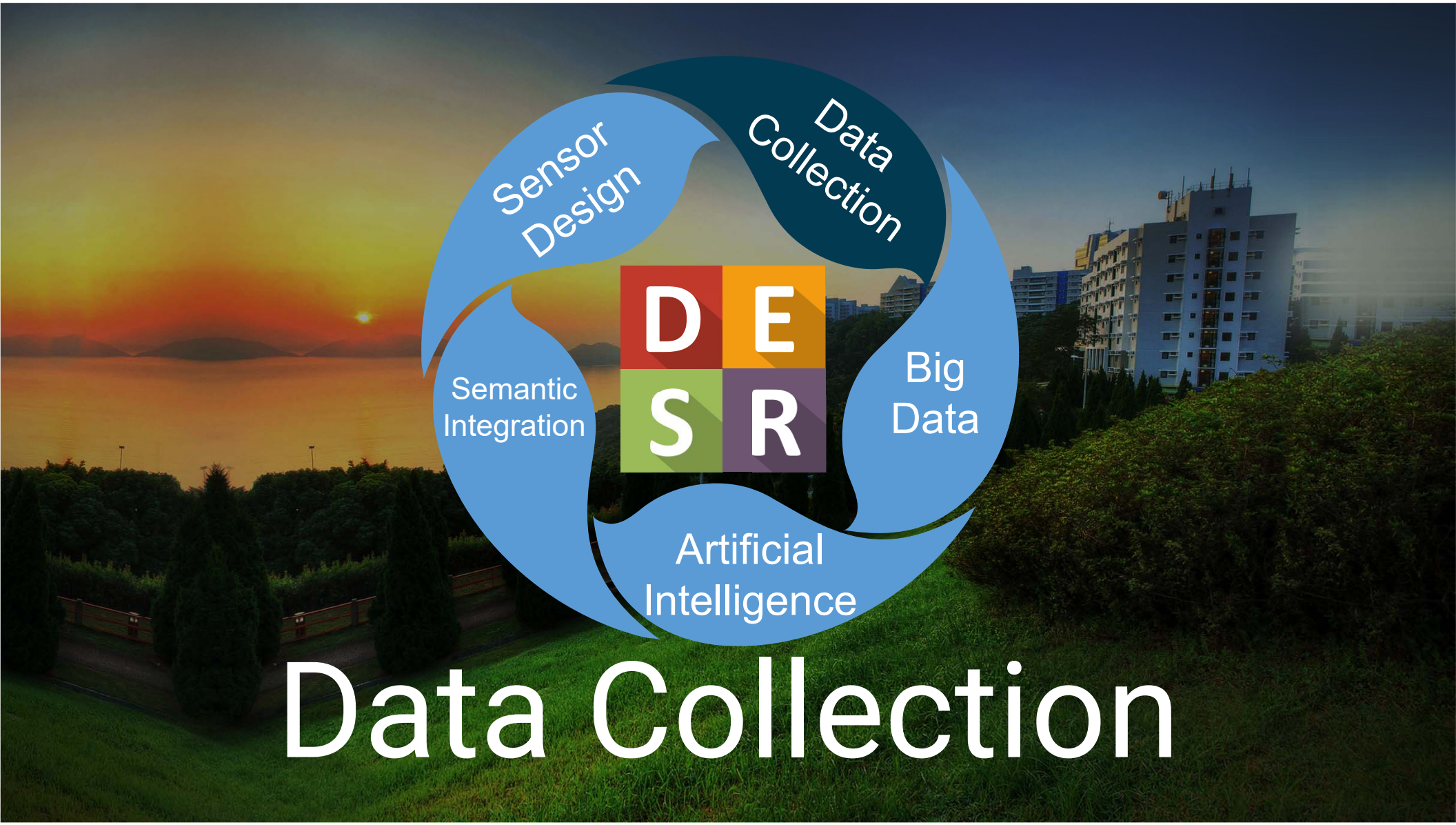
Typhoon Mangkhut

Sea front of the HKSUT

Typhoon Mangkhut

Performance during typhoon Mangkhut




Sensor Design
Data Collection
Big Data
Artificial Intelligence
Semantic Integration
D E
S R
Data Collection

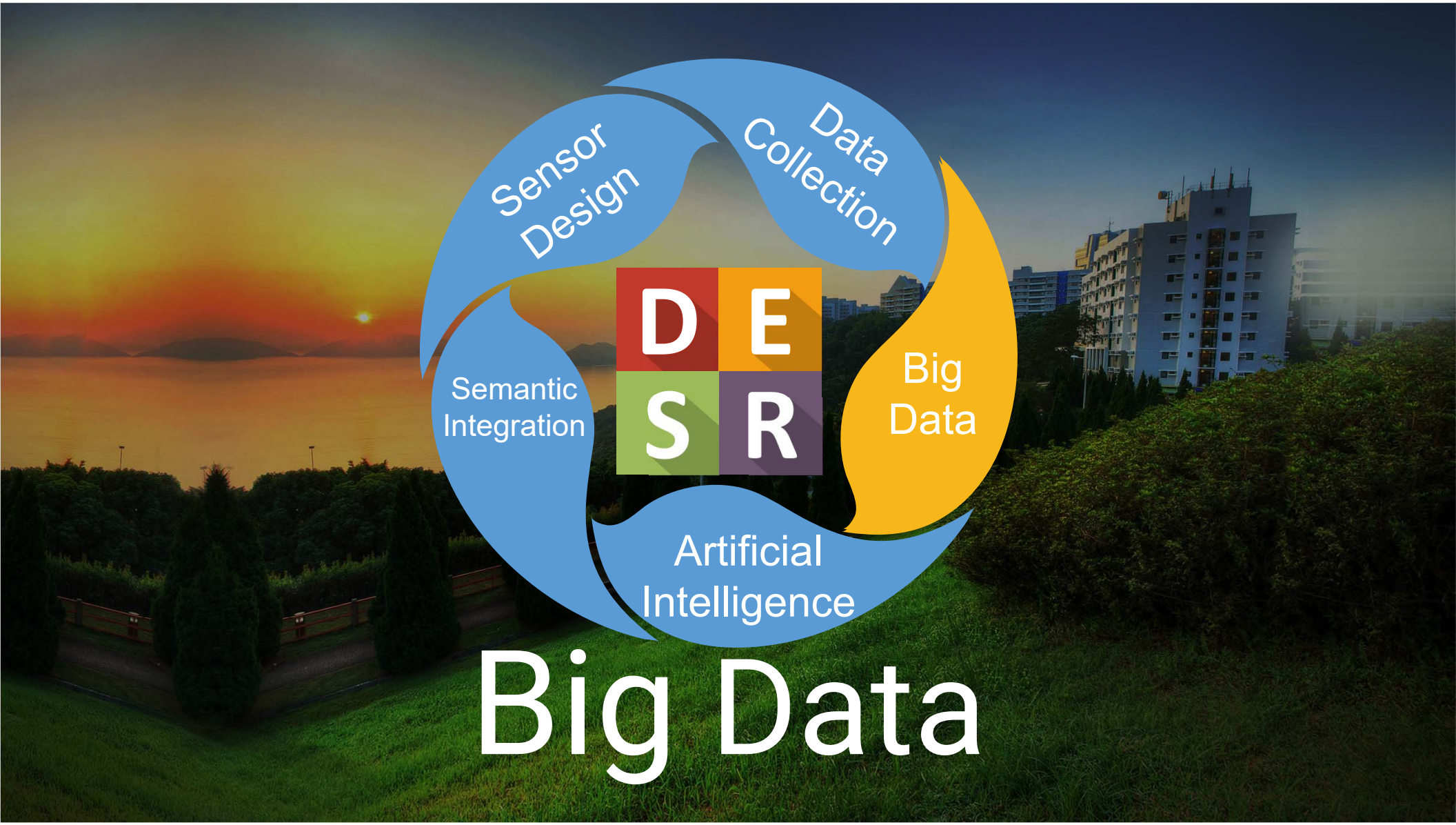
Agnostic integrator

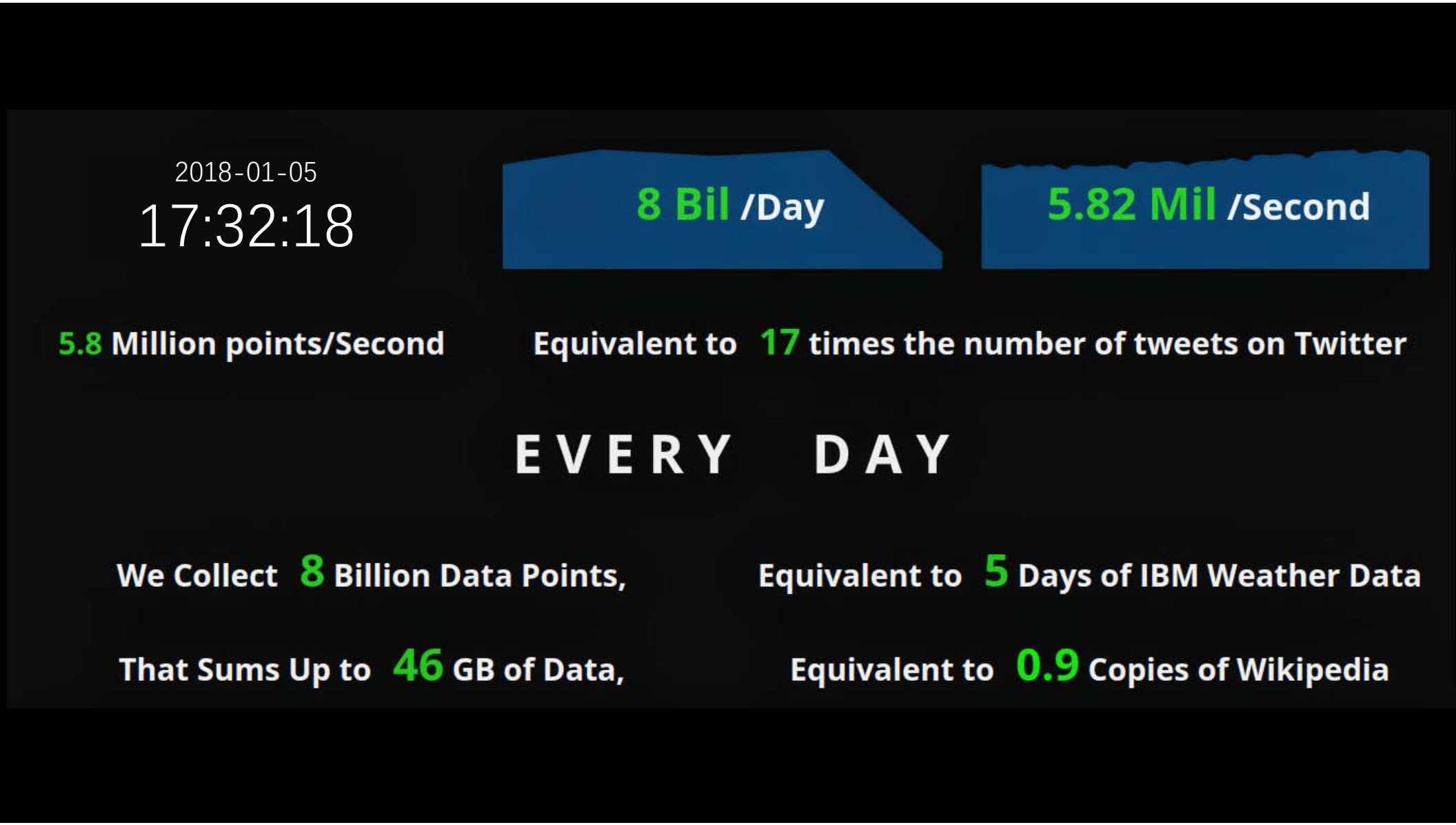
RS232

Other Sensors

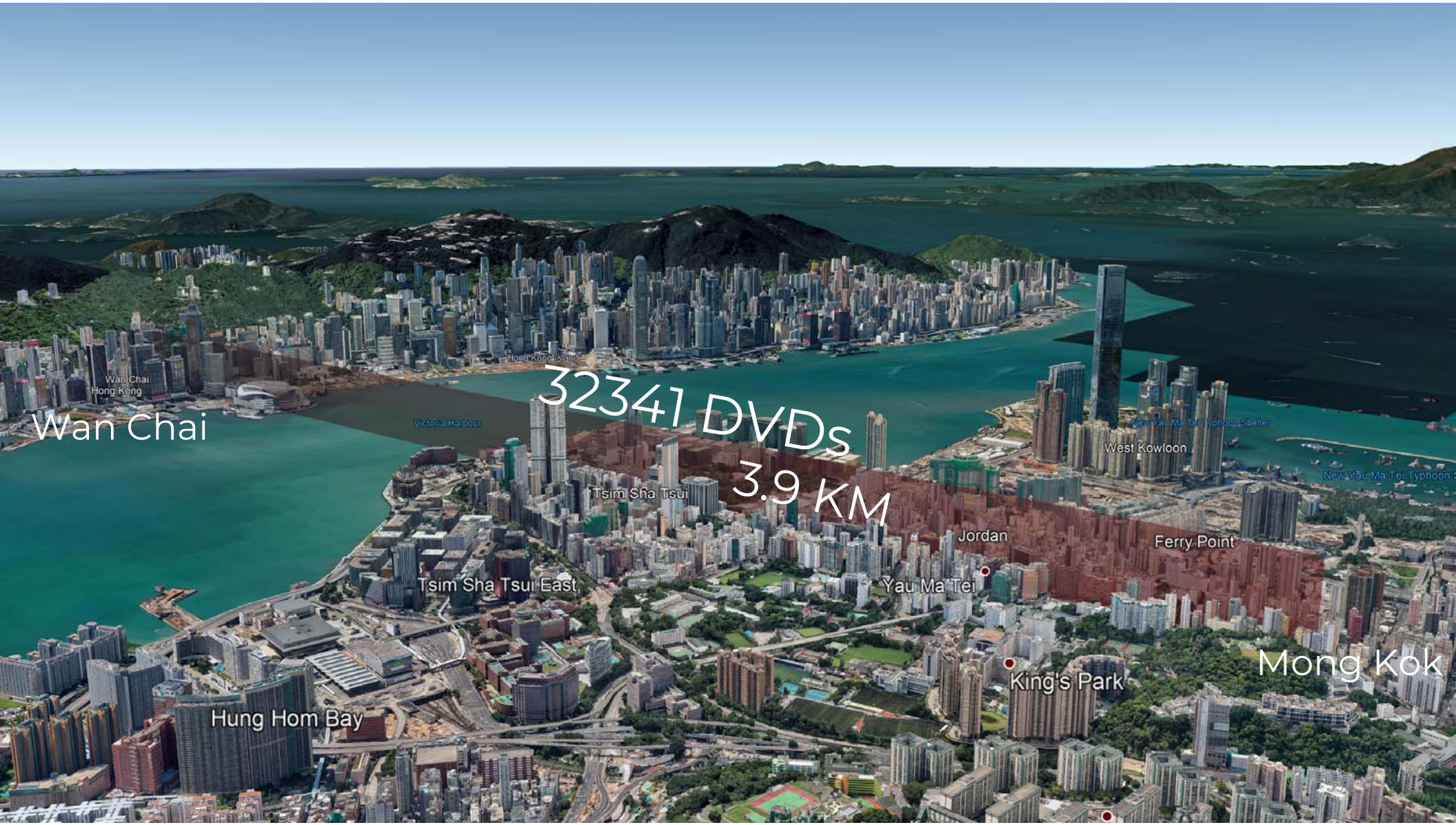
Patent-pending Military Grade Trusted Data Loggers

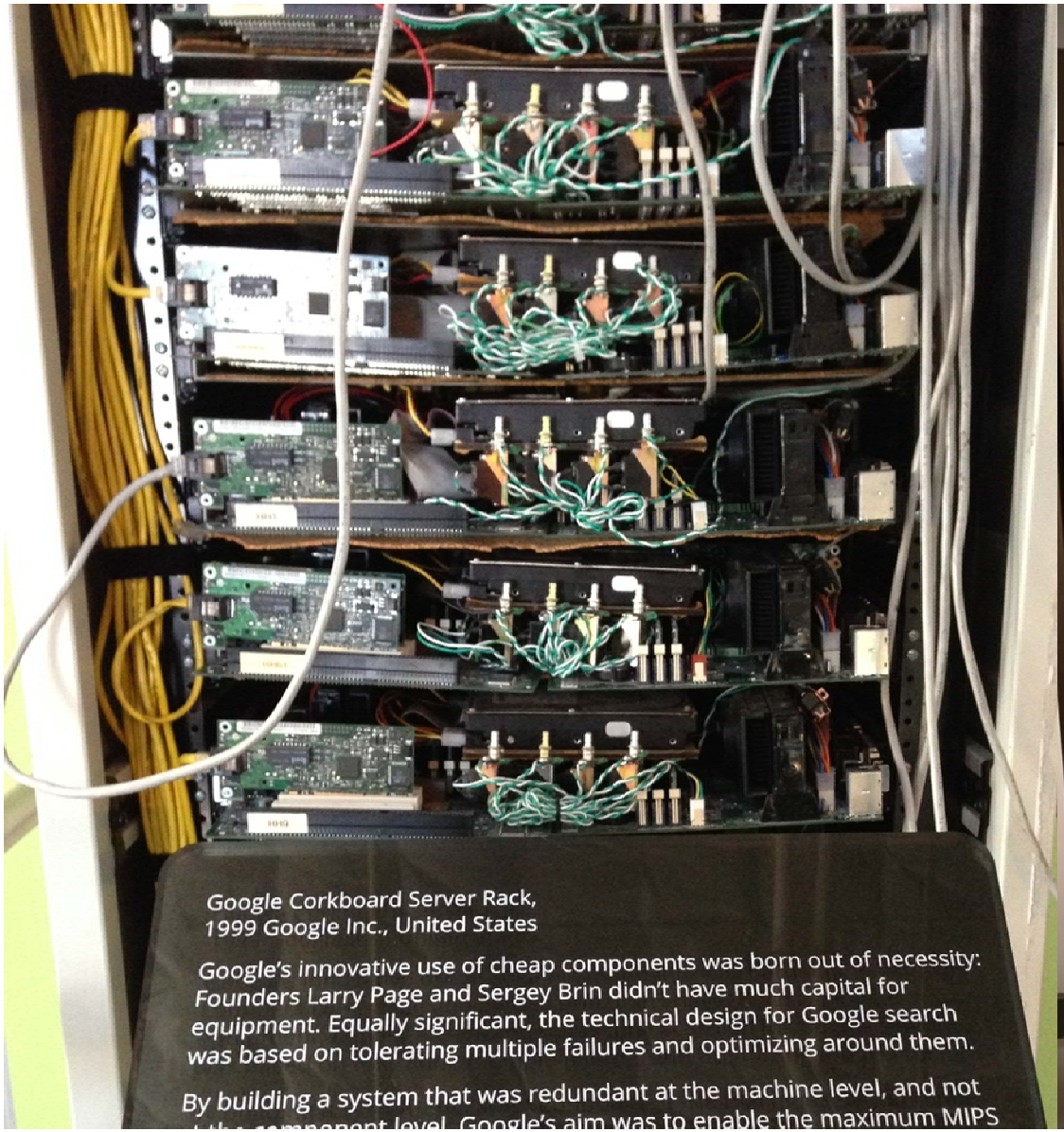
- On-device battery, DGPS location
- uarantied Delivery to Server
- GPS Time Sync
- Data Compression
- Redundant CPU, Storage, Power, Sensor, Networking
- Self-monitoring and recovery
- Trusted Platform Modules-based security architecture
- Secure Boot
- Trusted Computing Group (TCG) standards
- Common Criteria (EAL4+) and FIPS security certification
- Transport Layer Security (TLS) for all data transfer


Sensor Design
Data Collection
Big Data
Artificial Intelligence
Semantic Integration
D E
S R
Big Data


2018-01-05
17:32:18
8 Bil /Day
5.82 Mil /Second
5.8 Million points/Second
Equivalent to 17 times the number of tweets on Twitter
EVERY DAY
We Collect 8 Billion Data Points,
Equivalent to 5 Days of IBM Weather Data
That Sums Up to 46 GB of Data,
Equivalent to 0.9 Copies of Wikipedia


32341 DVDs
152TB

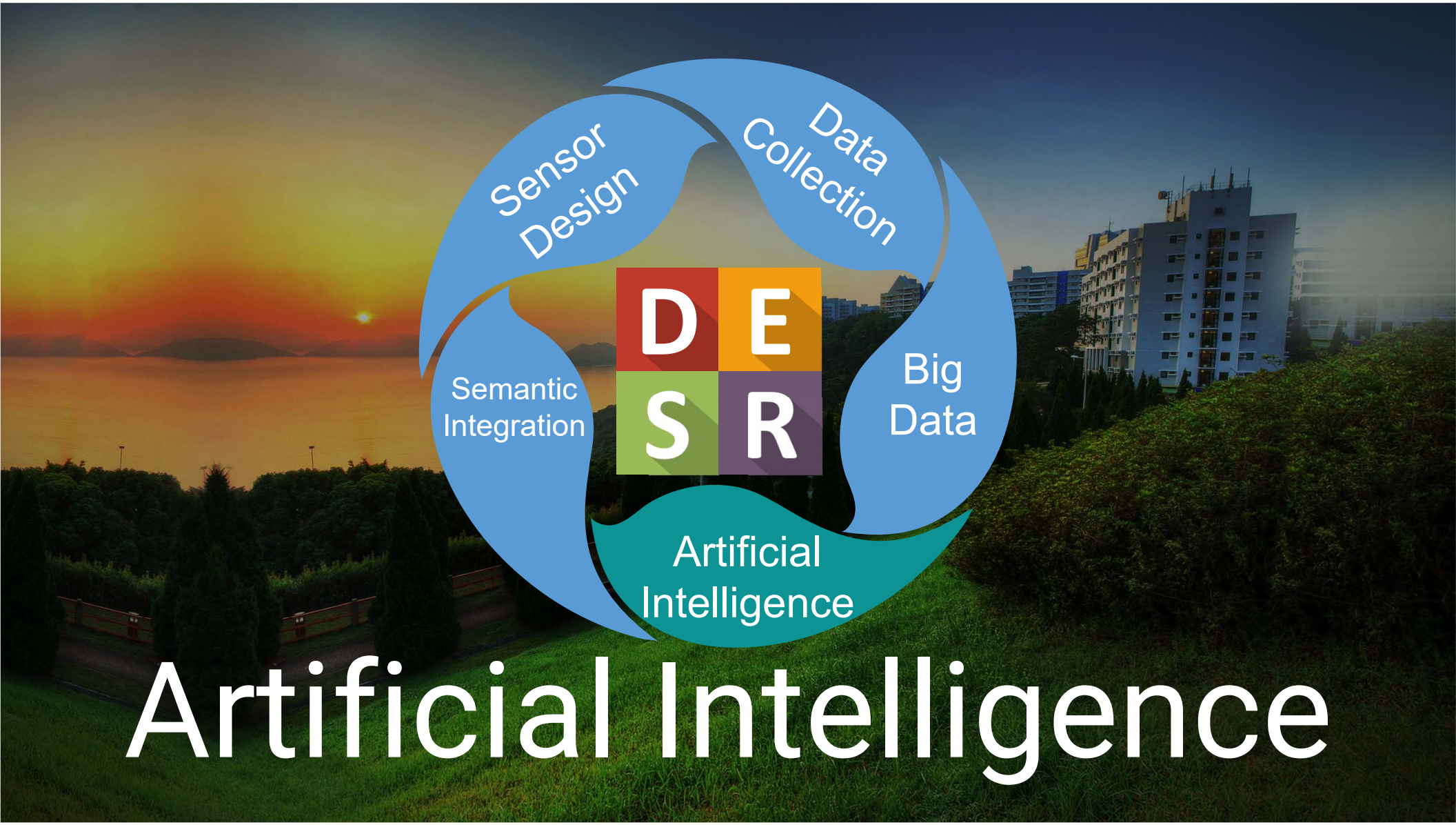

Wan Chai
Hong Kong
Wan Chai
Victoria Harbour
Hong Kong Island
32341 DVDs
3.9 KM
Tsim Sha Tsui
Tsim Sha Tsui East
Hung Hom Bay
Jordan
Yau Ma Tei
Ferry Point
West Kowloon
King's Park
Mong Kok



Google Corkboard Server Rack,
1999 Google Inc., United States

Google's innovative use of cheap components was born out of necessity: Founders Larry Page and Sergey Brin didn't have much capital for equipment. Equally significant, the technical design for Google search was based on tolerating multiple failures and optimizing around them.

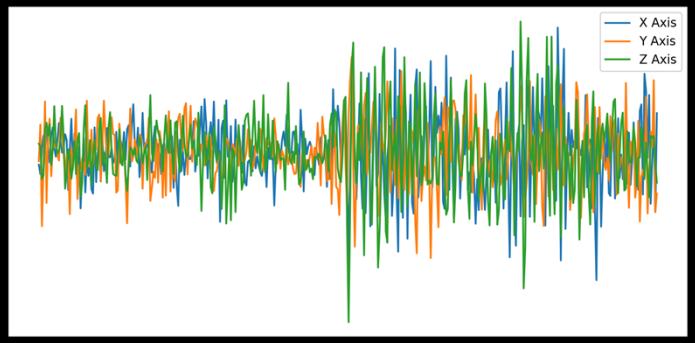
By building a system that was redundant at the machine level, and not


Sensor Design
Data Collection
Big Data
Artificial Intelligence
Semantic Integration
D E
S R
Artificial Intelligence


AlphaGo
Deep Learning

To process…

Time series data (frequency domain)



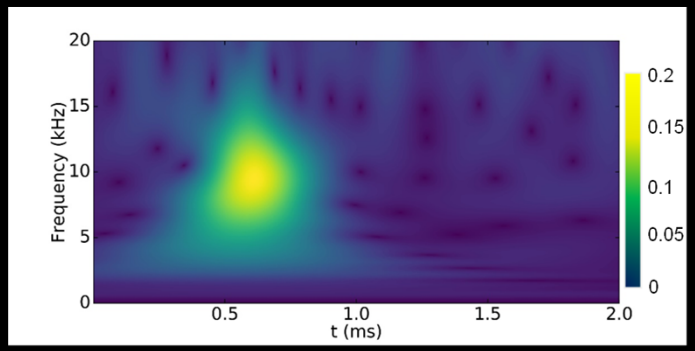
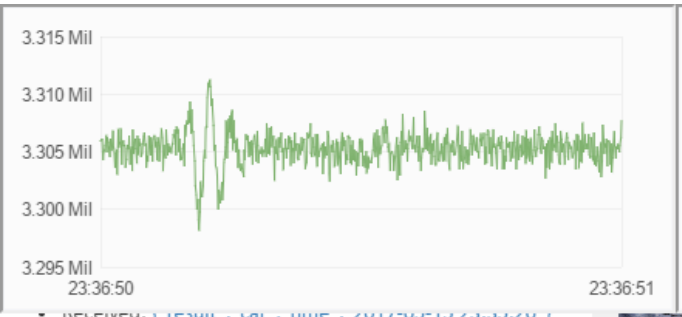
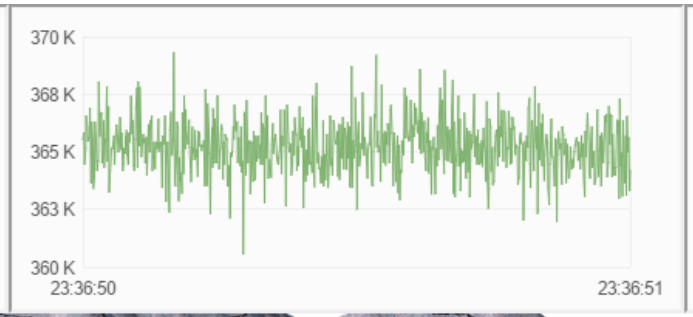
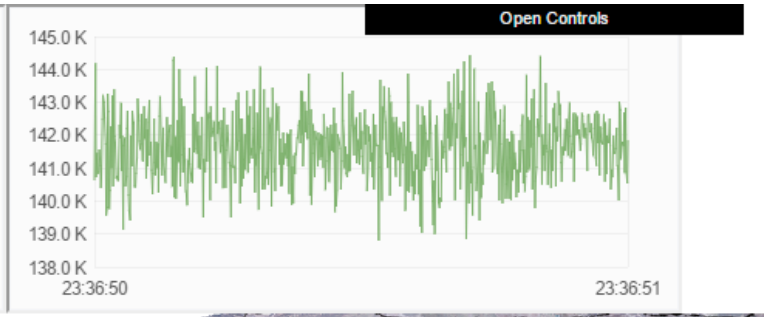


Image data



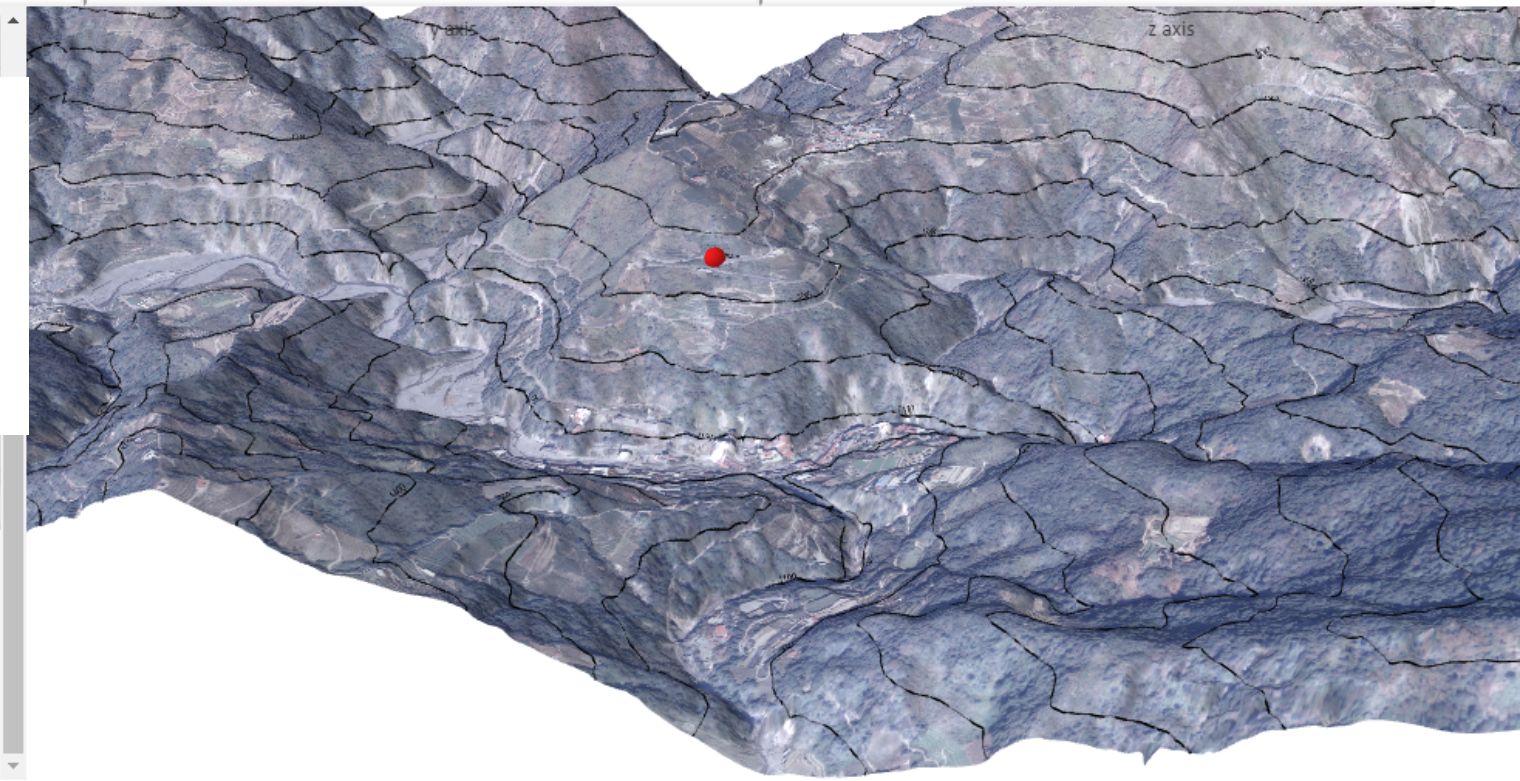




- Received: {"result":"abnormal wave","time":"2017-05-15 23:35:22"}

Vibration data measured at the slopes (Lushan, Taiwan)

- Received: {"result":"car","time":"2017-05-15 23:36:22"}
- Received: {"result":"abnormal wave","time":"2017-05-15 23:36:24"}
- Received: {"result":"car","time":"2017-05-15 23:36:29"}
- Received: {"result":"car","time":"2017-05-15 23:36:33"}
- Received: {"result":"car","time":"2017-05-15 23:36:35"}
- Received: {"result":"car","time":"2017-05-15 23:36:41"}
- Received: {"result":"car","time":"2017-05-15 23:36:43"}
- Received: {"result":"abnormal wave","time":"2017-05-15 23:36:50"}



Data Source Sensors

Data Ingestion

Scalable Message Broker

Distributed & Scalable Storage

Deep Learning Anomaly Detection Engine

Abnormal Data Filtering

Auto Updating

Classification Engine

NoSQL Database

Data Classification /Data Labeling

Prediction

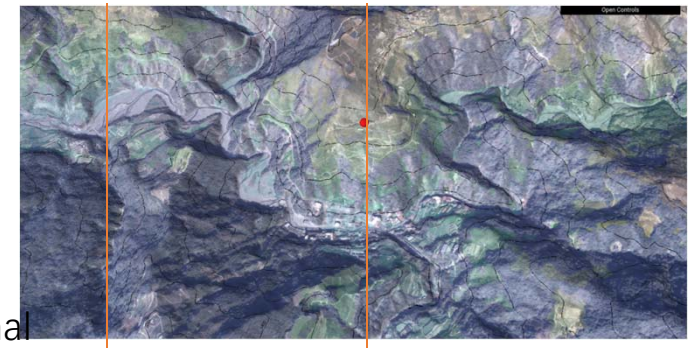
Domain Experts

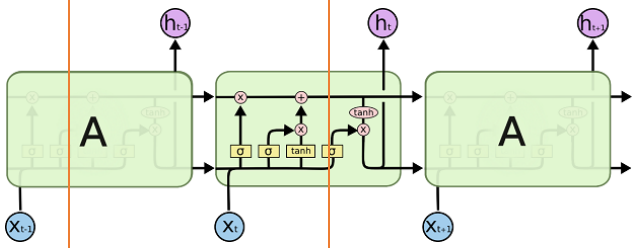
Verify Prediction

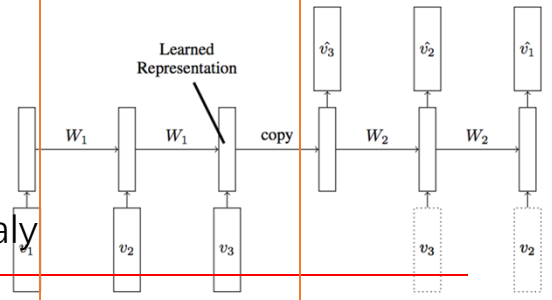
Save Modified Results

Real-time Interactive Dashboard

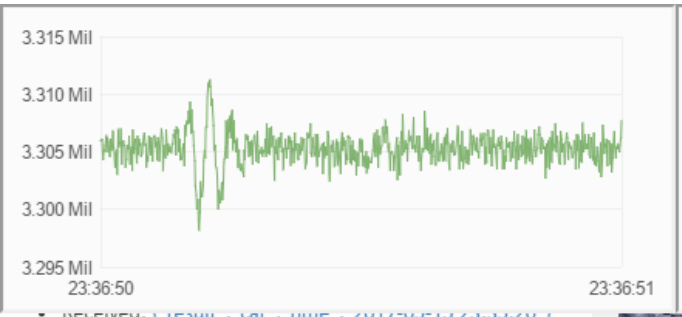
Sensor Signal

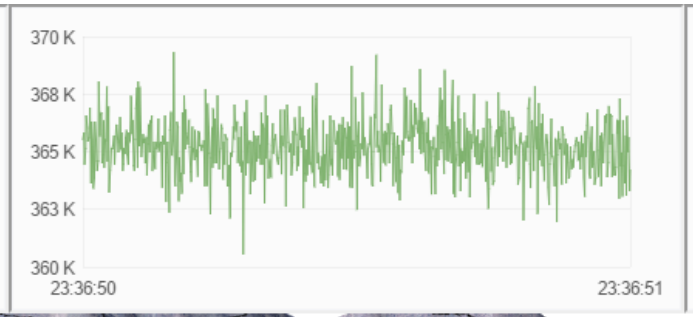


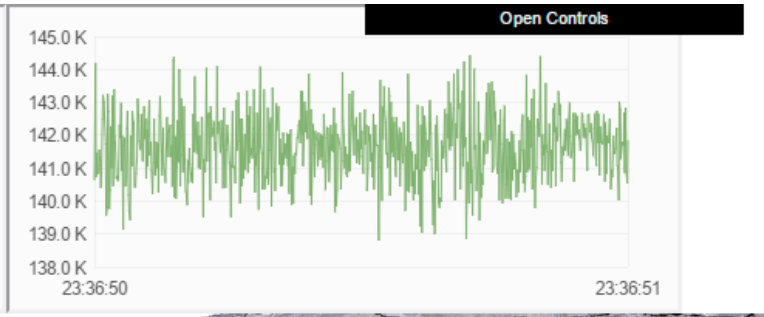




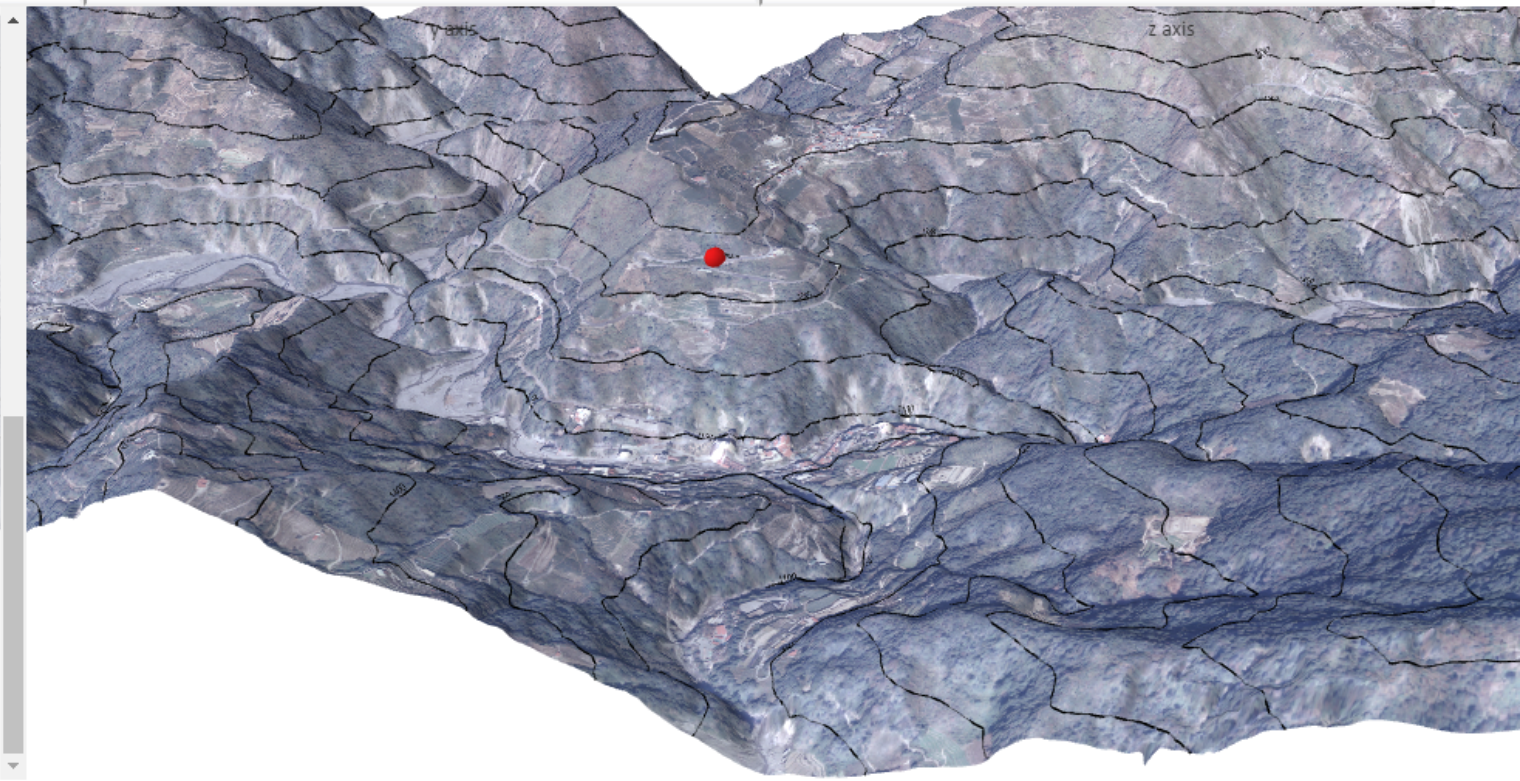
Detected Anomaly



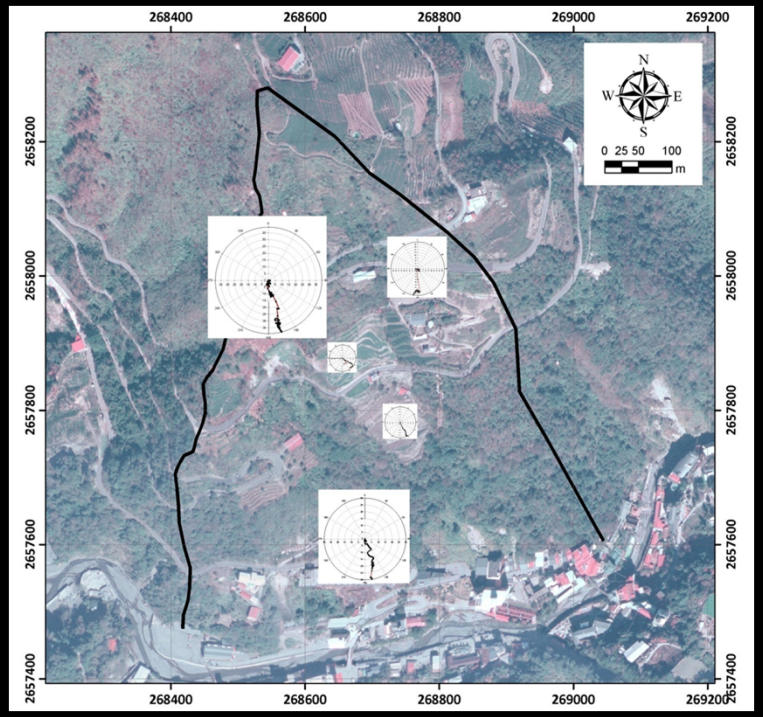


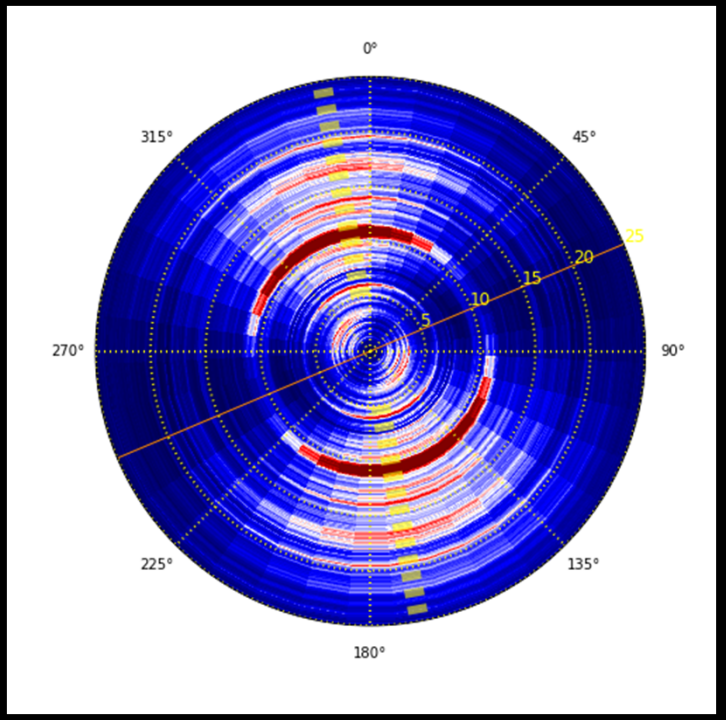


- Received: {"result":"abnormal wave","time":"2017-05-15 23:35:22"}
- Received: {"result":"car","time":"2017-05-15 23:35:24"}
- Received: {"result":"car","time":"2017-05-15 23:35:25"}
- Received: {"result":"car","time":"2017-05-15 23:35:27"}
- Received: {"result":"car","time":"2017-05-15 23:35:29"}
- Received: {"result":"earthquake","time":"2017-05-15 23:35:33"}
- Received: {"result":"car","time":"2017-05-15 23:35:35"}
- Received: {"result":"car","time":"2017-05-15 23:35:37"}
- Received: {"result":"car","time":"2017-05-15 23:35:41"}
- Received: {"result":"car","time":"2017-05-15 23:35:44"}
- Received: {"result":"car","time":"2017-05-15 23:35:51"}
- Received: {"result":"car","time":"2017-05-15 23:35:56"}
- Received: {"result":"car","time":"2017-05-15 23:36:22"}
- Received: {"result":"abnormal wave","time":"2017-05-15 23:36:24"}
- Received: {"result":"car","time":"2017-05-15 23:36:29"}
- Received: {"result":"car","time":"2017-05-15 23:36:33"}
- Received: {"result":"car","time":"2017-05-15 23:36:35"}
- Received: {"result":"car","time":"2017-05-15 23:36:41"}
- Received: {"result":"car","time":"2017-05-15 23:36:43"}
- Received: {"result":"abnormal wave","time":"2017-05-15 23:36:50"}



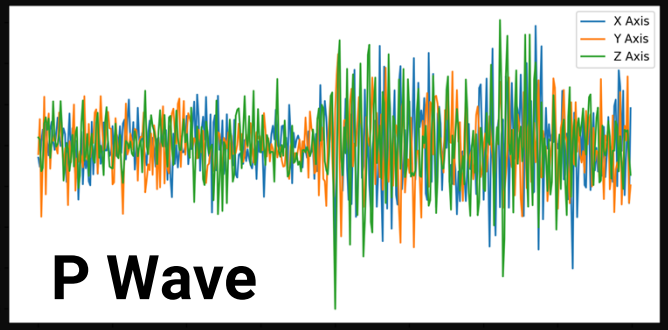
Real time HVSR, Directivity, etc.

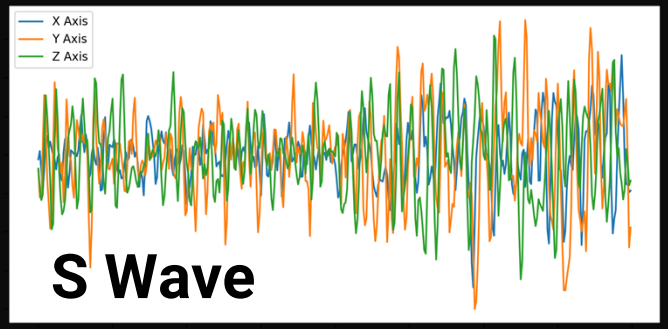


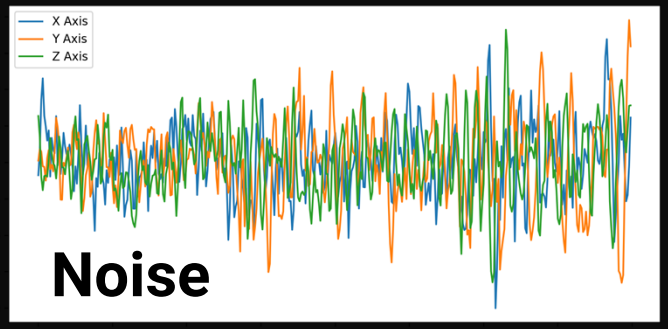


CNN for time-series data classifications

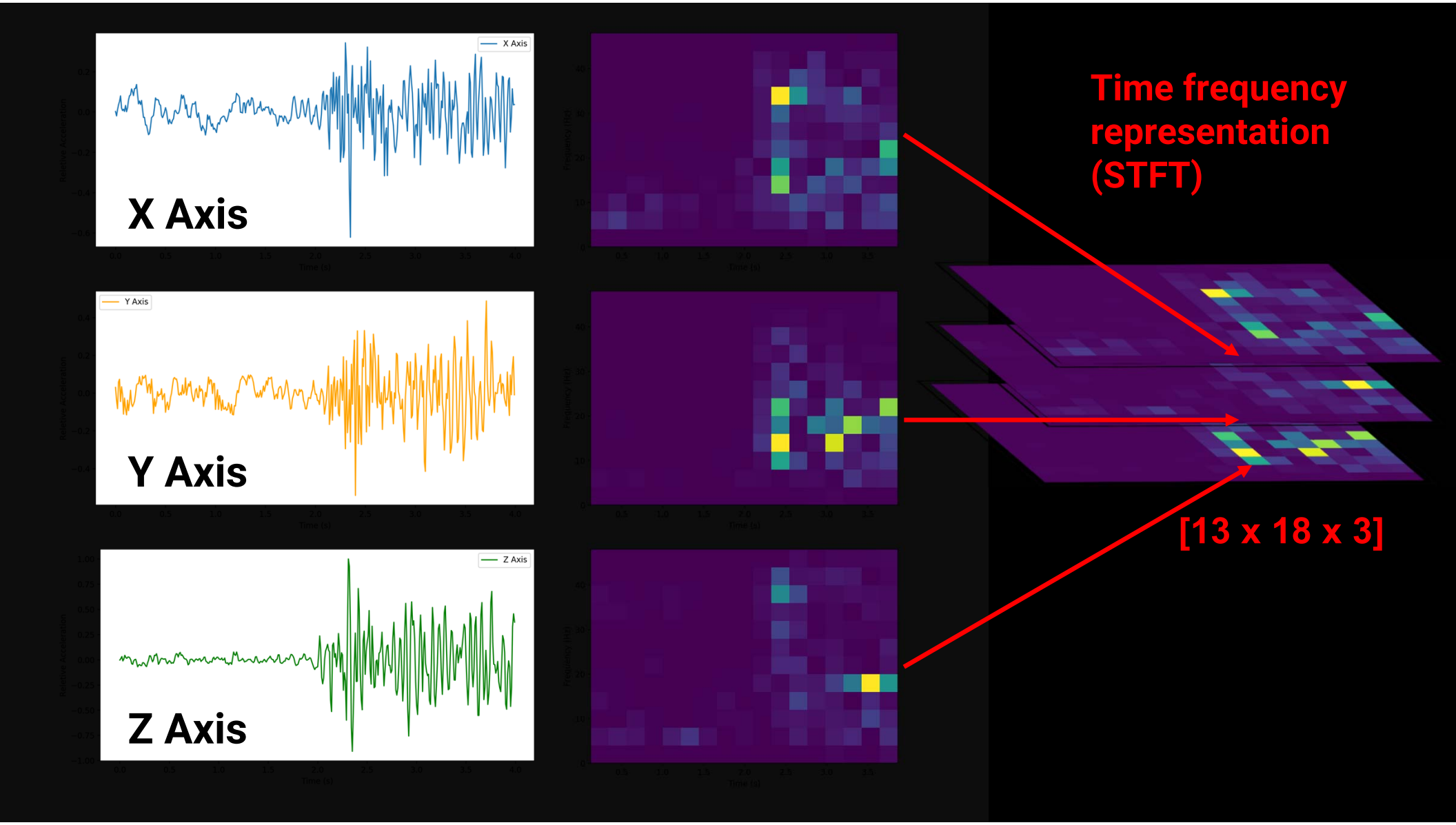
- **Data Source*:**
  Southern California Earthquake Data Center
- **Classes:** P wave, S wave, noise
- **Amount:** 4,773,750 records

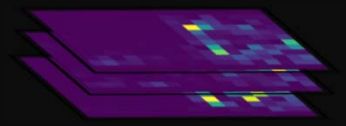






* Southern California Earthquake Data Center. Scsn. California Institute of Technology, Dataset, 2013.


X Axis
Y Axis
Z Axis
Time frequency representation (STFT)
[13 x 18 x 3]



A Simple CNN Model

CONV 3x3, 16

CONV 3x3, 32

MaxPool 2x2

CONV 3x3, 64

CONV 3x3, 64

MaxPool 2x2

CONV 3x3, 128

CONV 3x3, 128

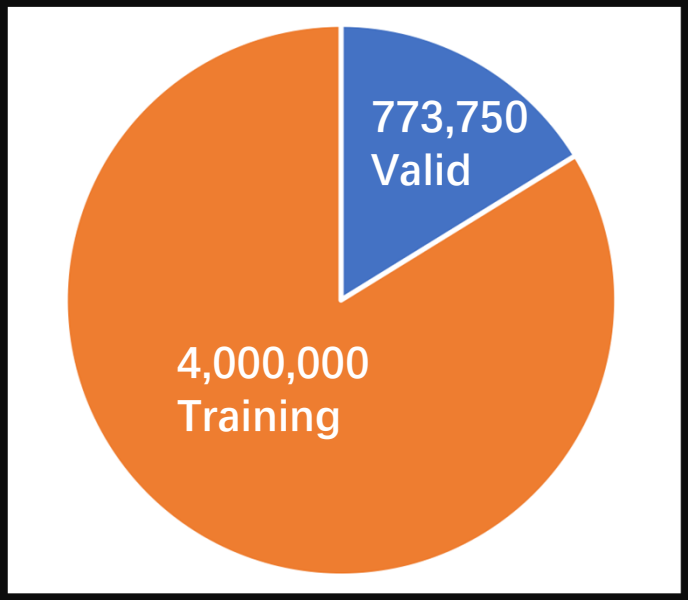
MaxPool 2x3

FC, 64

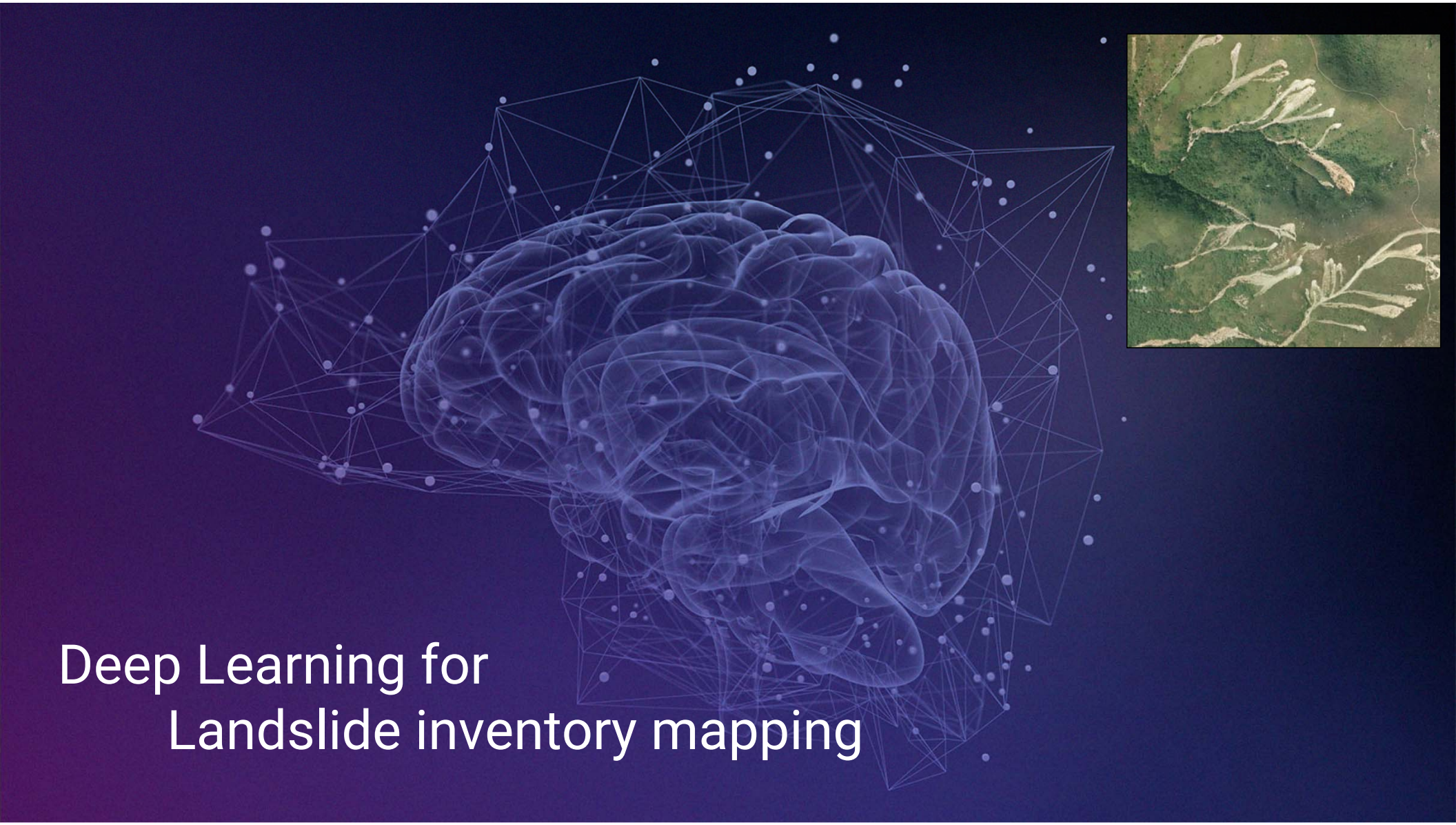
FC, 32

FC, 3

[P0 x P1 x P2]



Validation Accuracy: 98.6%



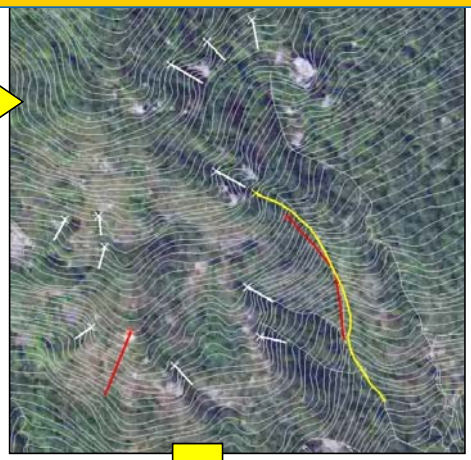
Deep Learning for Landslide inventory mapping

Landslide Inventory Map (the database)

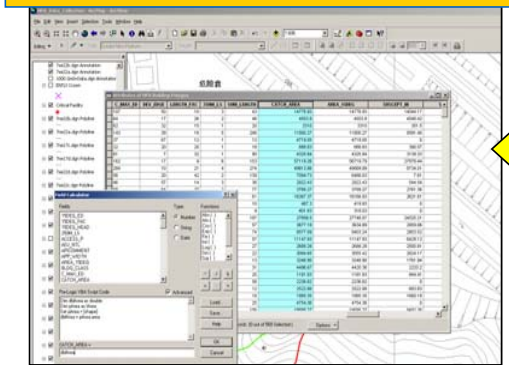
(1) Collection of available photos

(2) 30 interpreters review >105,000 photos

(3) ENTLI data were recorded using GIS-workstations, with ortho-photos and topo maps for placement of location

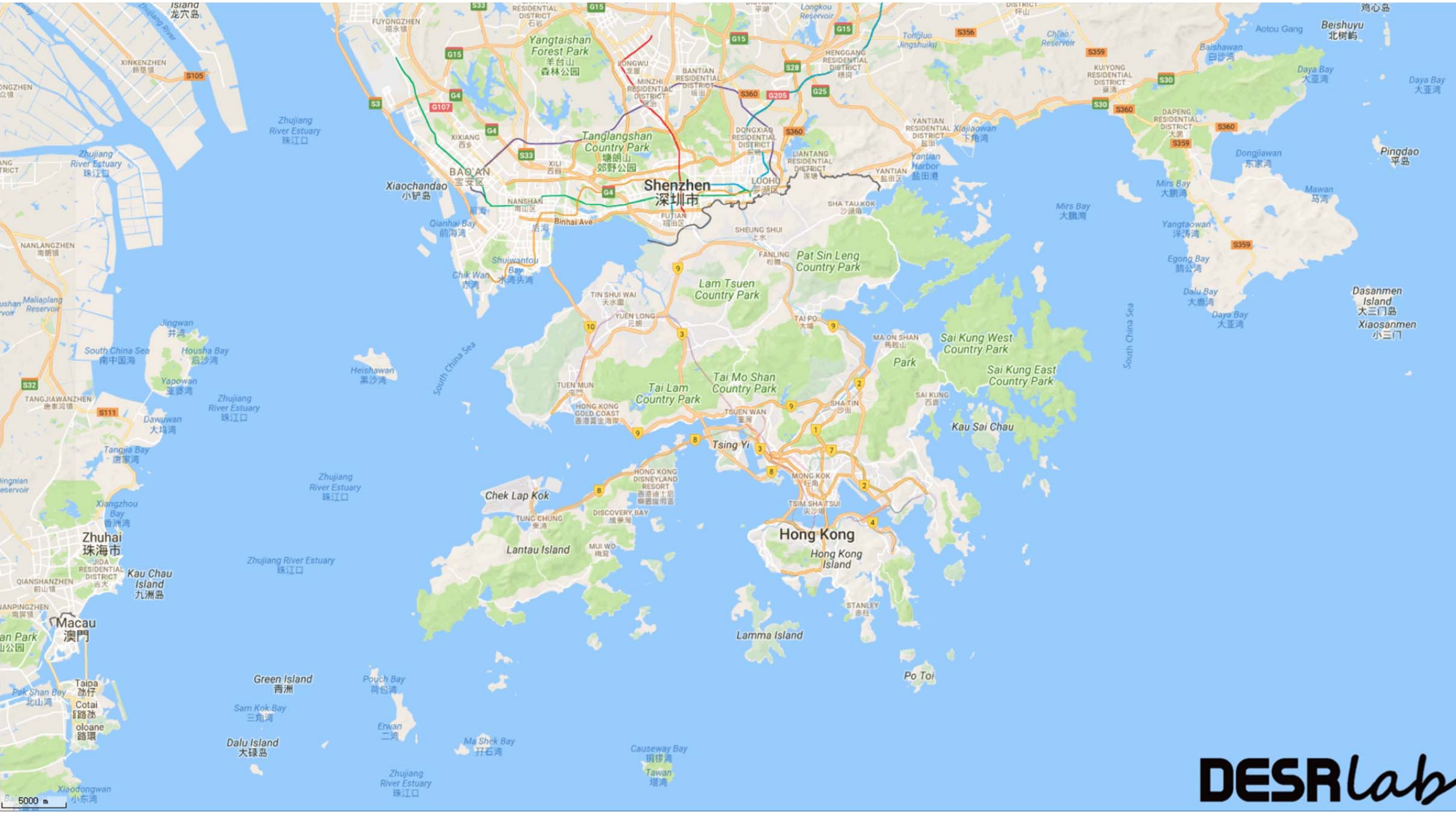


(4) Preparation of attribute tables and map sheet reports

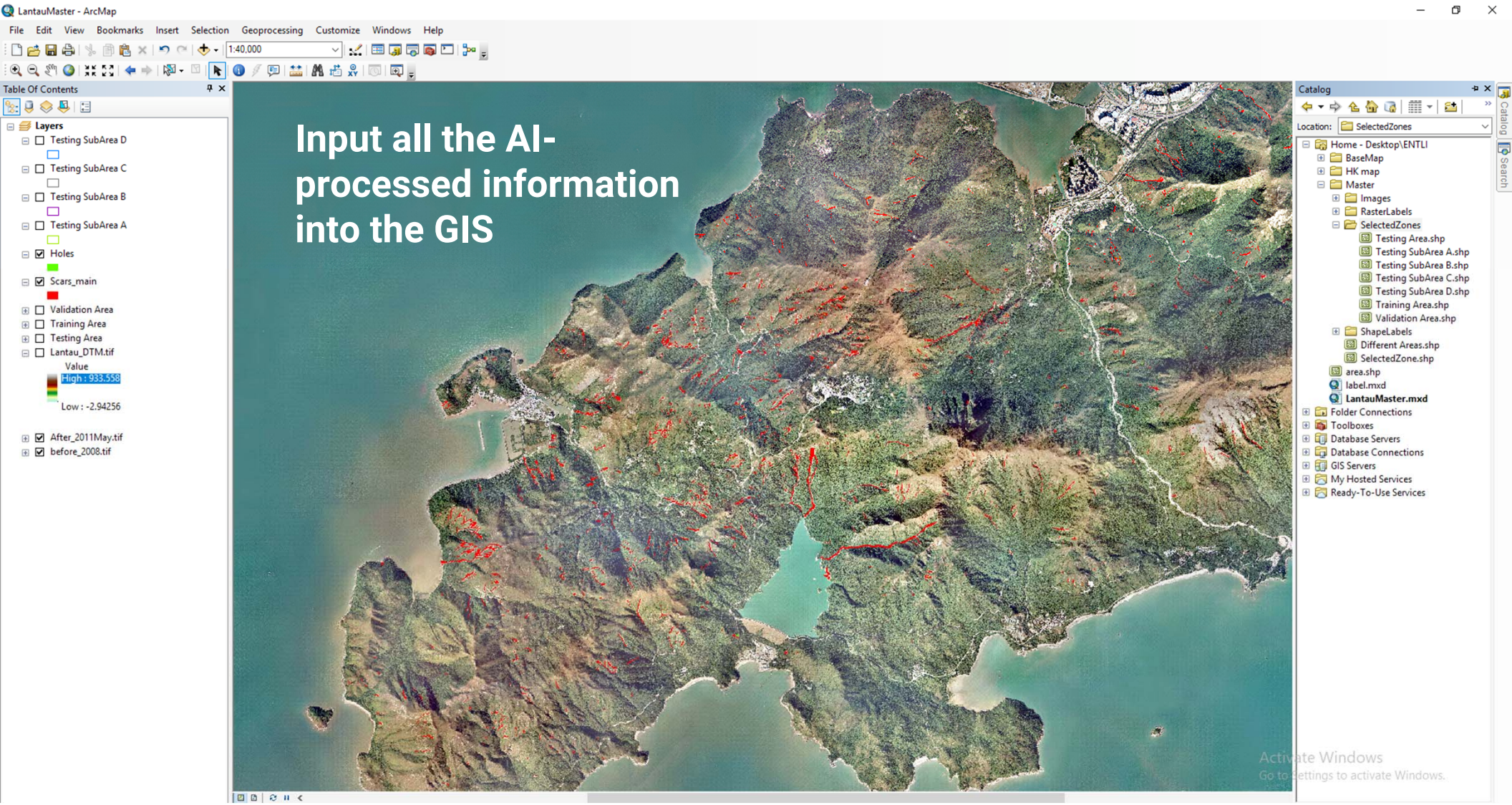


Ir Prof Ken Ho, Deputy Head of GEO, CEDD

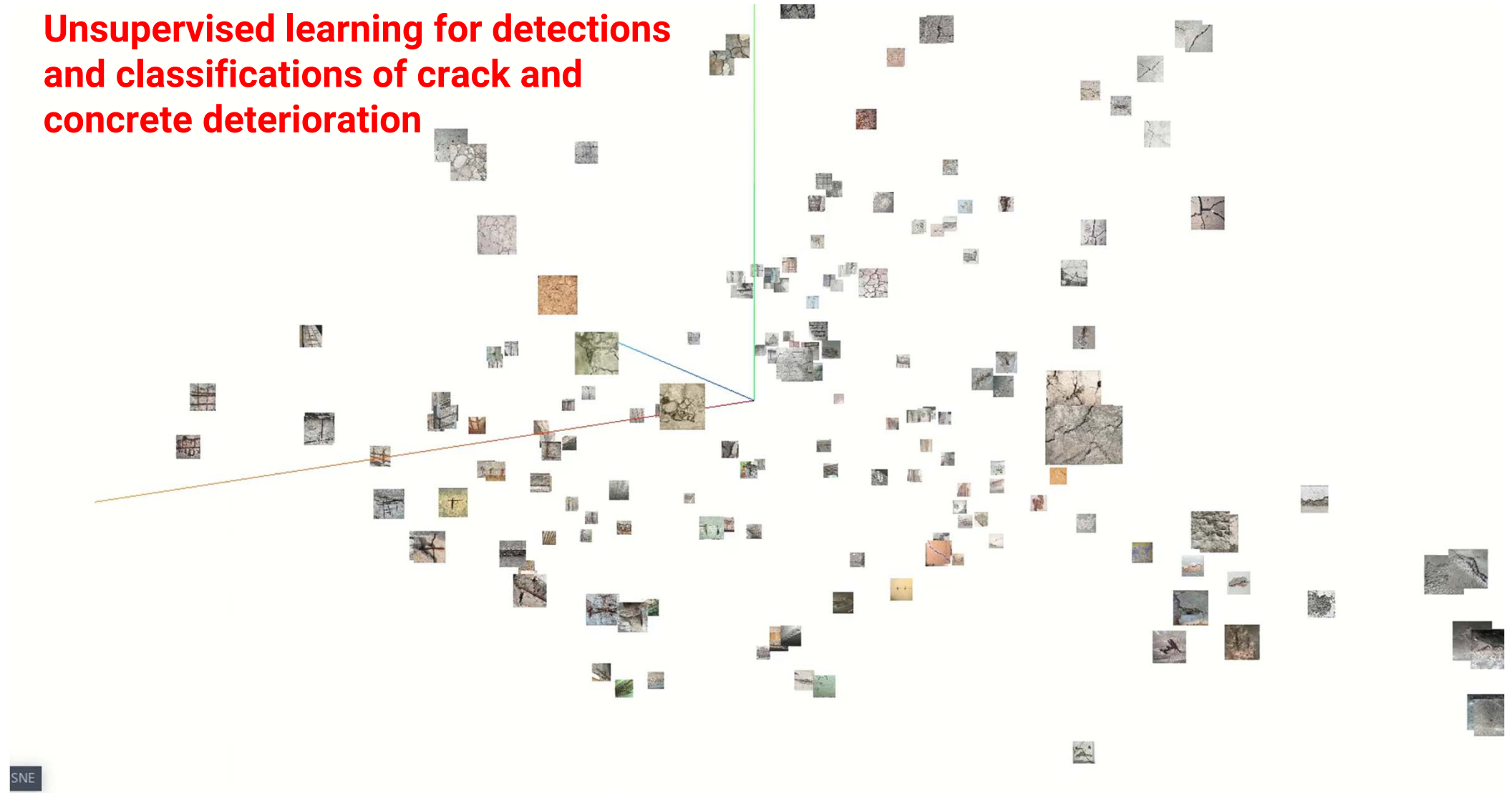
AI
(deep learning)



Shenzhen
深圳市
Hong Kong
Hong Kong Island
Zhuhai
珠海市
Macau
澳門
Lantau Island
Chek Lap Kok
Tsing Yi
Lamma Island
Po Toi
Kau Sai Chau
Yangtaishan Forest Park
羊台山森林公园
Tanglangshan Country Park
塘朗山郊野公园
Pat Sin Leng Country Park
Lam Tsuen Country Park
Tai Lam Country Park
Tai Mo Shan Country Park
Sai Kung West Country Park
Sai Kung East Country Park
Xiaochandao
小铲岛
Zhujiang River Estuary
珠江口
Kau Chau Island
九洲岛
Green Island
青洲
Dalu Island
大碌岛
Mirs Bay
大鹏湾
Pingdao
平岛
Dasanmen Island
大三门岛
Xiaosanmen
小三门
Beishuyu
北树屿
Aotou Gang
Binhai Ave
South China Sea
5000 m


LantauMaster - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:40,000
Table Of Contents
Layers
Testing SubArea D
Testing SubArea C
Testing SubArea B
Testing SubArea A
Holes
Scars_main
Validation Area
Training Area
Testing Area
Lantau_DTM.tif
Value
High : 933.558
Low : -2.94256
After_2011May.tif
before_2008.tif
Input all the AI-processed information into the GIS
Catalog
Location: SelectedZones
Home - Desktop\ENTLI
BaseMap
HK map
Master
Images
RasterLabels
SelectedZones
Testing Area.shp
Testing SubArea A.shp
Testing SubArea B.shp
Testing SubArea C.shp
Testing SubArea D.shp
Training Area.shp
Validation Area.shp
ShapeLabels
Different Areas.shp
SelectedZone.shp
area.shp
label.mxd
LantauMaster.mxd
Folder Connections
Toolboxes
Database Servers
Database Connections
GIS Servers
My Hosted Services
Ready-To-Use Services
Activate Windows
Go to Settings to activate Windows.

Unsupervised learning for detections and classifications of crack and concrete deterioration

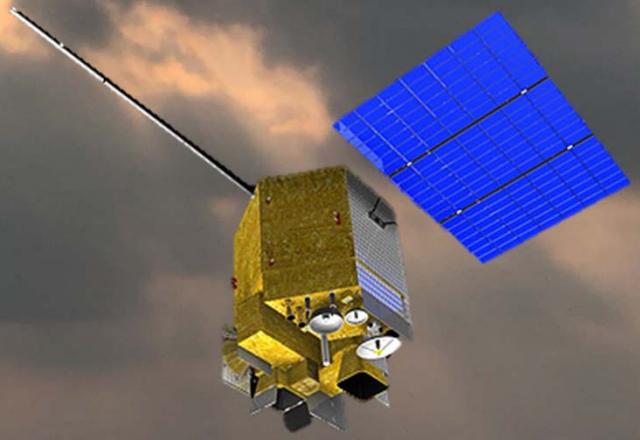


Applications to Weather Monitoring

- Image semantic segmentation
- Monitoring of cloud tops from geostationary satellite data (Detect severe weather conditions)

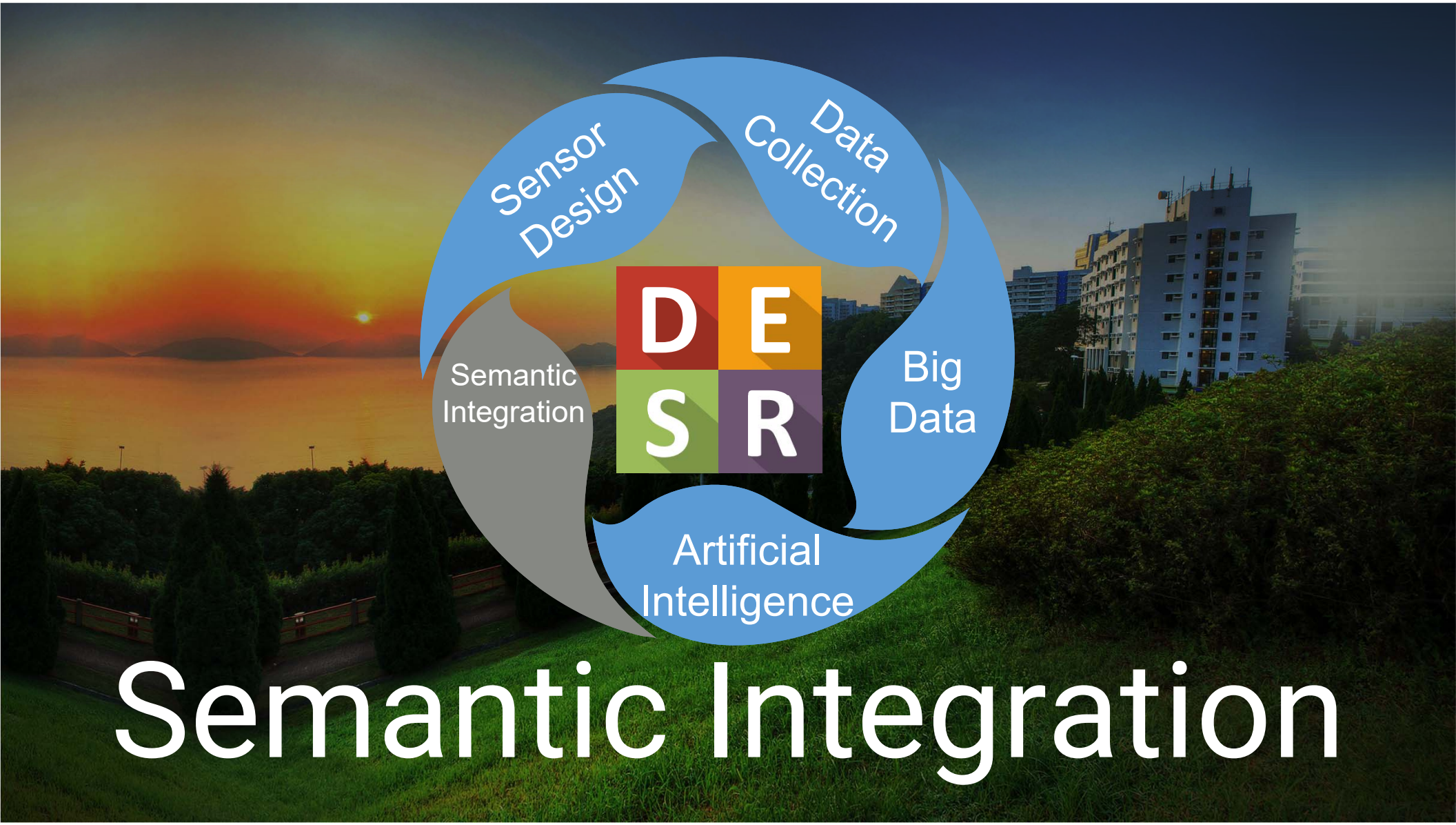
Himawari 8

Every 10 Minutes



FY-4A Satellite

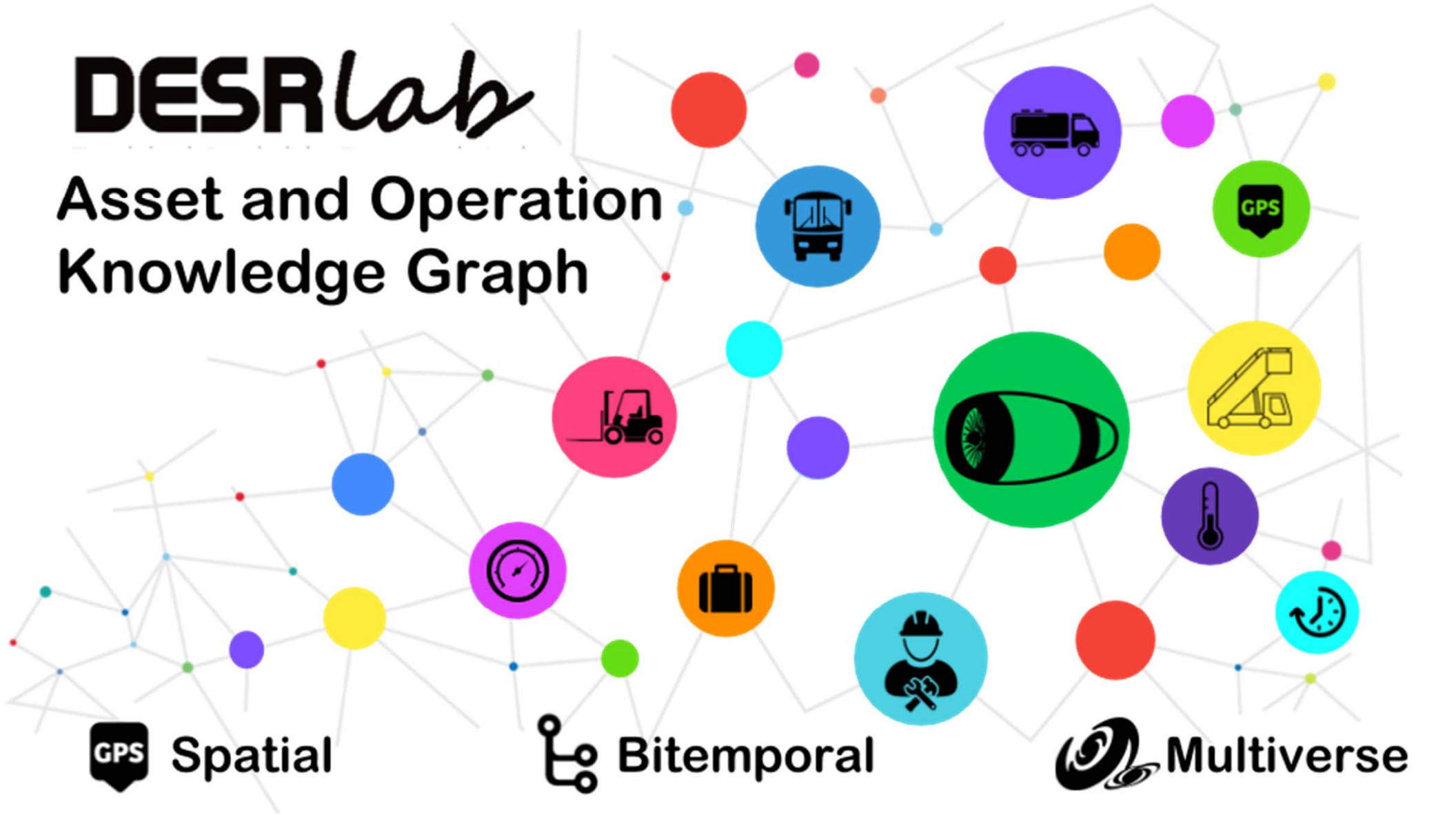
Every 15 Minutes


Sensor Design
Data Collection
Big Data
Artificial Intelligence
Semantic Integration
D E
S R
Semantic Integration


Operational knowledge (e.g., changing sensors, updating calibration, and even errors) will not be reported because they cannot be described in the current IoT database

DESRlab

Asset and Operation Knowledge Graph



GPS Spatial

Bitemporal

Multiverse

Accurate and Effective Decision Making

Sunrise at the HKUST

Human AI Partnership

Real-time Data Discovery
+
Predictive Modelling by AI

Human Guts for Decision-making


DESRlab
Data-Enabled Scalable Research Laboratory
Thank You
innovating today
imagining tomorrow
25
INNOVATING TODAY
IMAGINING TOMORROW
HKUST