

Internet of Things Technologies for Smart Living

C.H. Cheng

Department of Systems Engineering & Engineering Management
The Chinese University of Hong Kong

1



Service Science and Innovation Group

www.se.cuhk.edu.hk/~ssi

Our Strength

- Computer Science
- Hardware Design Engineering
- Operations Research
- Operations Management
- Systems Engineering

Funding Sources

- Asian Institute of Supply Chain & Logistics
 - General Research Fund, RGC, Hong Kong
 - Innovation and Technology Fund, ITC, Hong Kong
 - Service Contracts (from Government Agencies)
- Total ongoing funding support \approx HK\$9 million

Application Research & Projects (supported by ITC or service contracts)

- **Environmental Sensing** for antique display and management at **Hong Kong Museums**
- **Image object detection** for managing resources at **Hong Kong International Airport**
- **Land slide warning** for slope monitoring at **Civil Engineering & Development Department**
- **People & equipment tracking** for risk management at **Prince of Wales Hospital**

Theoretical Research (supported by RGC)

- Network epidemiology modeling of dynamic human behaviors for controlling hospital acquired diseases
- Effective control strategies against healthcare associated infections via optimization approaches
- Integration of renewable energy resources with the sustainable water systems in Hong Kong: models and algorithms

Outline

- Landslide Detection Systems in Sham Tseng
- Trolley Detection in Hong Kong International Airport

Landslide Detection at Sham Tseng

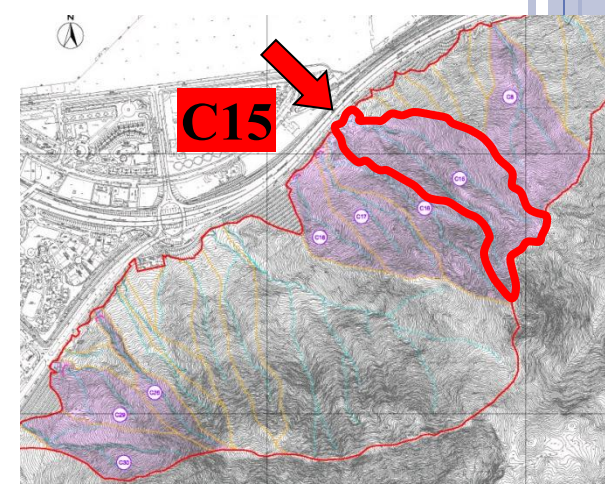
○ Project Scope

- Develop a real-time landslide detection system; both software and hardware
- Develop system specification for future contract work

○ Funding

- Developing the detailed specifications of landslide detection system for natural terrain mitigation measures, Civil Engineering and Development Department, HKSAR Government, HK\$1,170,000.

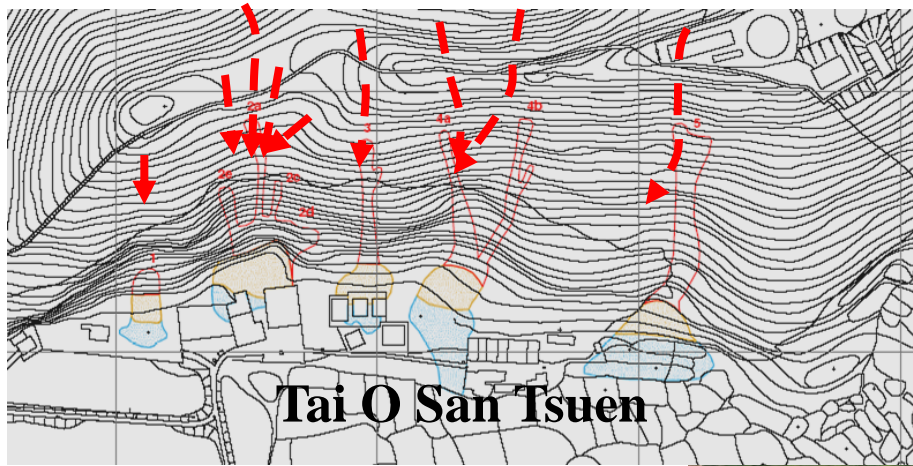




- Source volume : 500 m^3
- Vertical Drop : 311 m
- Run-out Distance crown to toe : 920 m
- Debris on NLE : $100\text{-}200 \text{ m}^3$

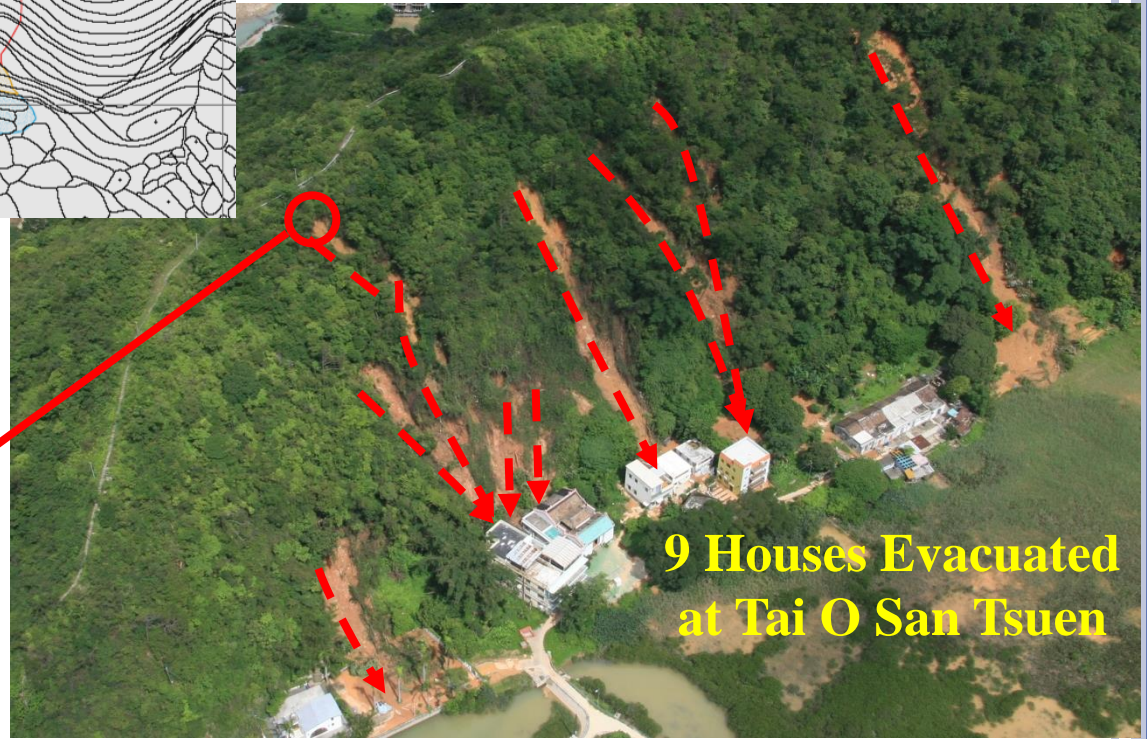
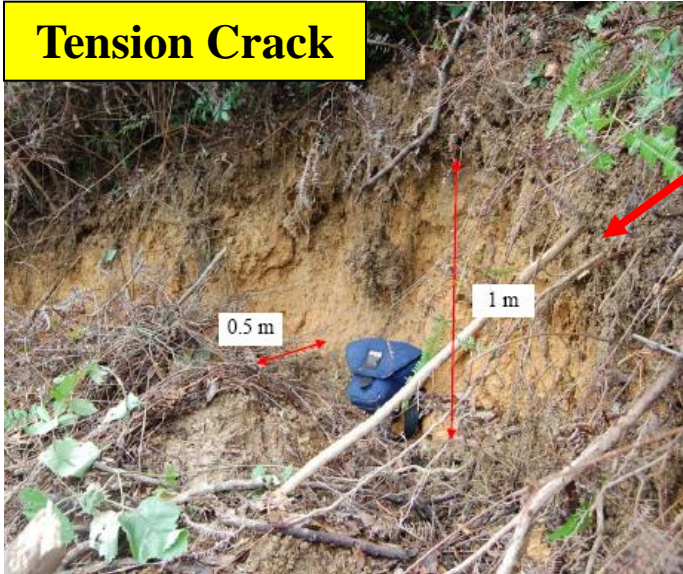


Catchment 15 - Debris Flood



11 nos. landslide sources
Total Failure Volume ~ 900 m³
Max. Vertical Drop ~ 50 m

Tension Crack



Open Hillslope Failures

Tai O San Tsuen





Jordan Valley 2009



The landslide was identified and reported to GEO 18 months after it had happened.

Tai Hang Road 2017



The scale of landslide was revealed 5 days after it had happened.

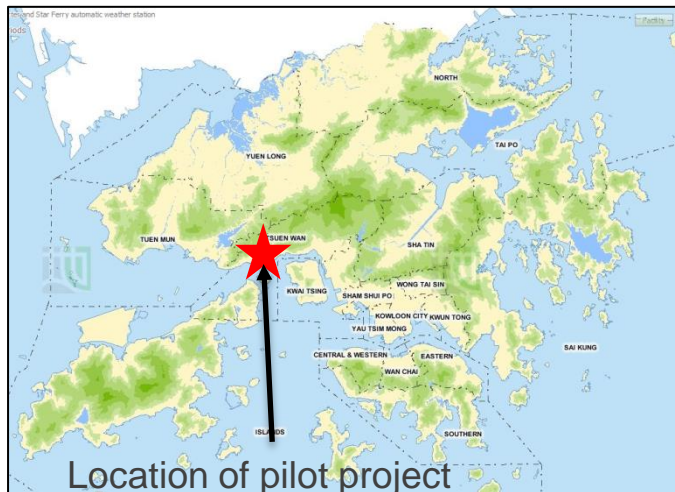


In both cases, the barriers effectively arrested most debris, leaving limited clues for detection of landslides downhill.

Can our barriers be “smart” enough to notify us once they are impacted?



Pilot study at Sham Tseng

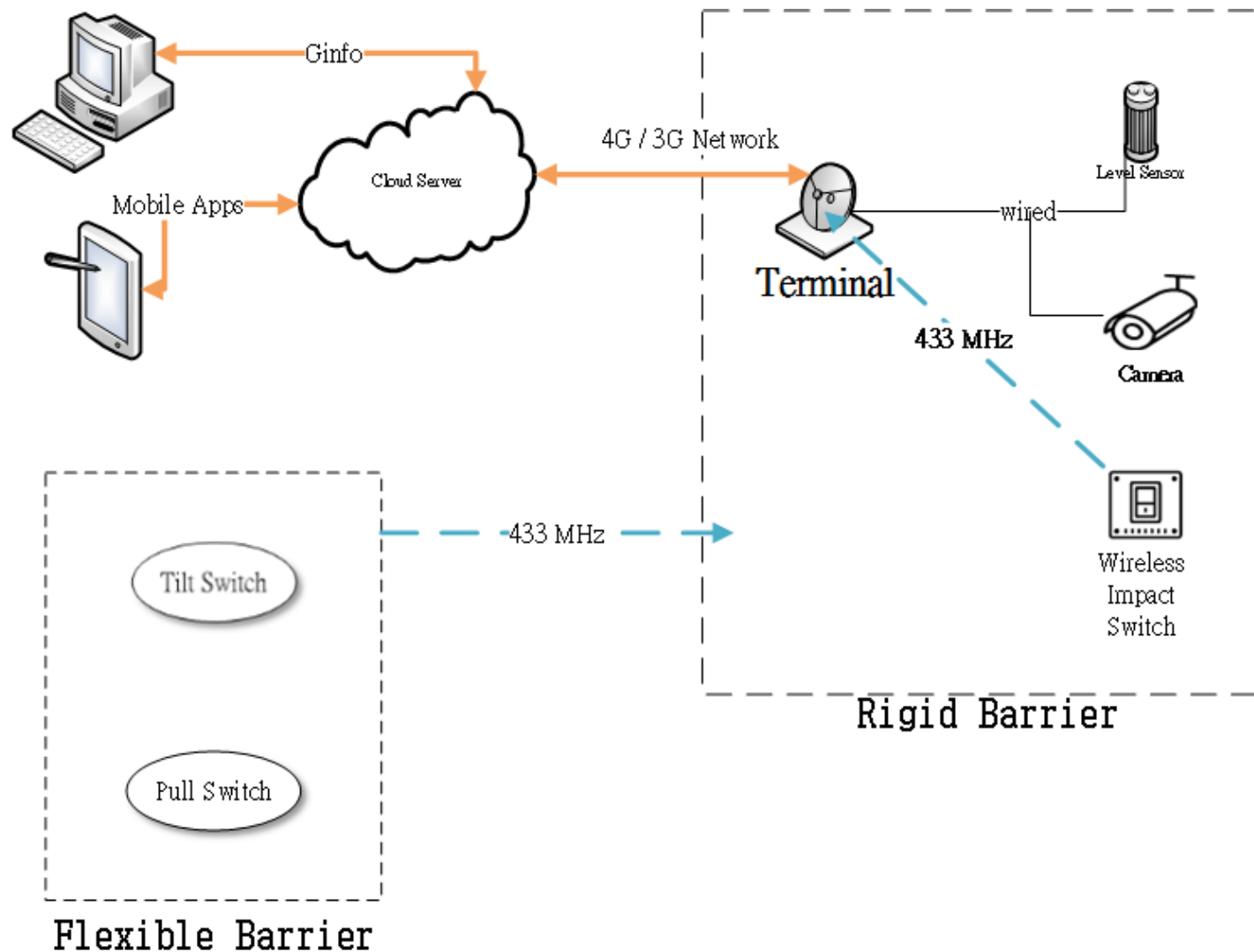


Rigid debris-resisting barrier
(2 nos.)



Flexible debris-resisting barrier
(2 nos.)

System Overview

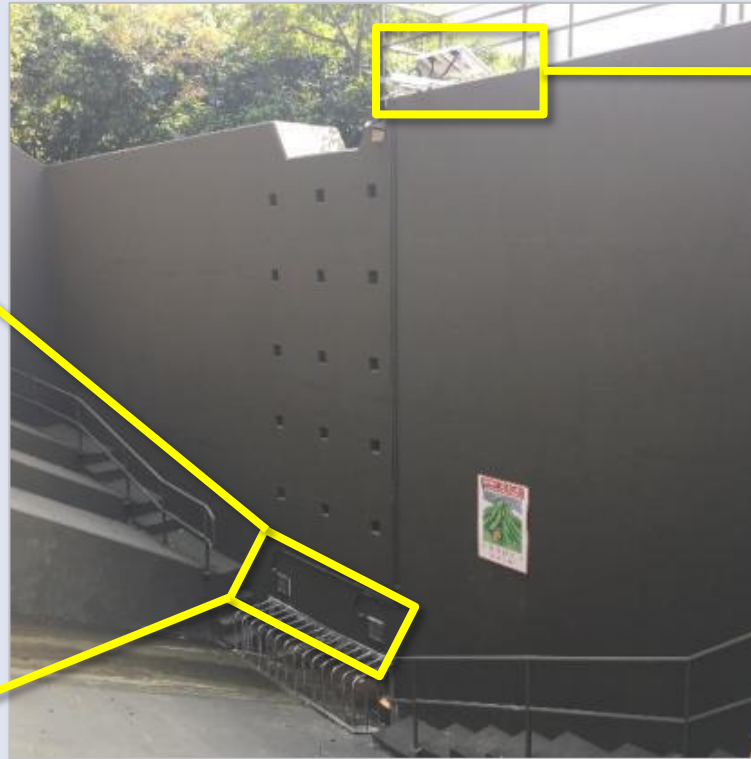




Wireless Impact switches



Impact switch

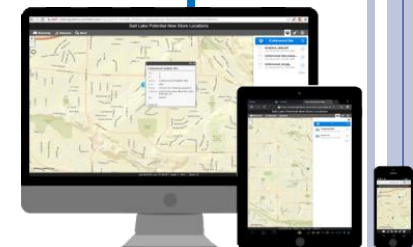
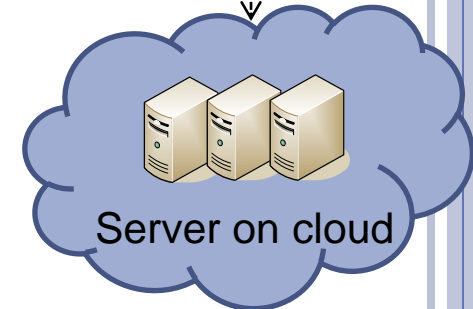


Landslide Detection Module on Rigid Barrier



- Level sensor (laser)
- Camera
- Infra-red lighting
- Control unit
- Solar panel + battery

4G + SMS

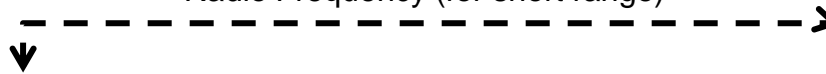


iOS App / GInfo

Return signal:

- Impact time
- Debris thickness
- Photos (regular, at request, when impacted)
- Regular heart beat
- Battery level

Radio Frequency (for short range)



- Tilt sensor
- Pull switch
- Transmission unit



Wire connecting
the pull switch

Landslide Detection Module on Flexible Barrier

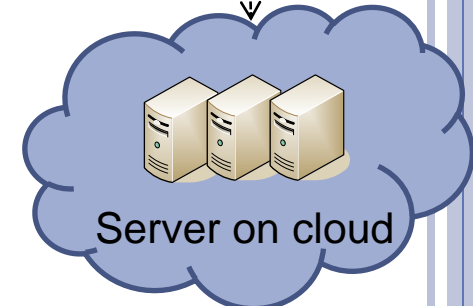
Return signal:

- Tilt angle
- Wire break time
- Pull switch triggering time
- Regular heart beat
- Battery level



Control unit on RB

4G



Server on cloud



iOS App / GInfo

Design Consideration

- Reliable Power Supply
 - Solar Panel
 - Low Energy power consumption on device
- Heavy Rain for outdoor Communication for remote sensor
 - 433Mhz which is good penetration
- Ease for installation
 - Wireless device is preferred
 - All sensor into one modules
- 4G /3G for internet connection



Base Station on Rigid Barrier

Communication Units:

- Mobile 4G(/3G) wireless transmission for Internet connection
- 433 MHz wireless transmission for local site connection

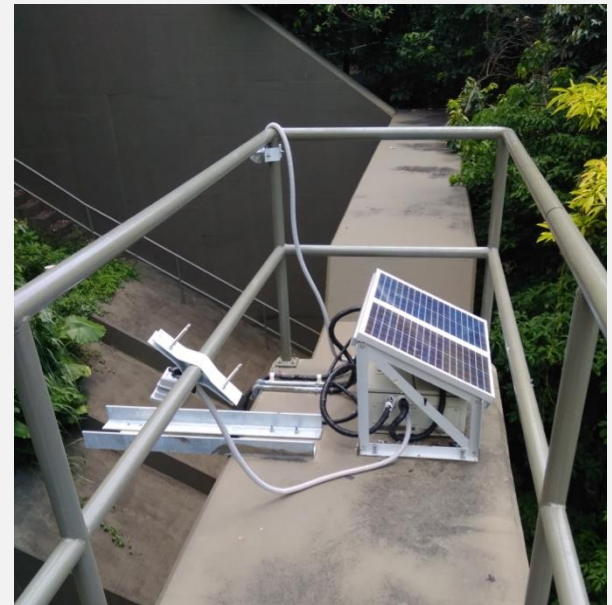
Control Unit /Storage:

- Support SD Card Storage

Sustainable Power Units:

- Rechargeable lithium battery
 - 15 days operation
- Solar panel (sustainable source)

Base Station (Terminal)



Sensors on Rigid Barrier

Distance Sensor

- high-performance optical distance measurement
- Accuracy: +/- 2.5cm

Camera

- Remote Taking
- Automatic 5 hours shooting
- Alert Auto shooting



Wireless Impact Switch

- Water Proof
- Heart beat
- About 3 battery life



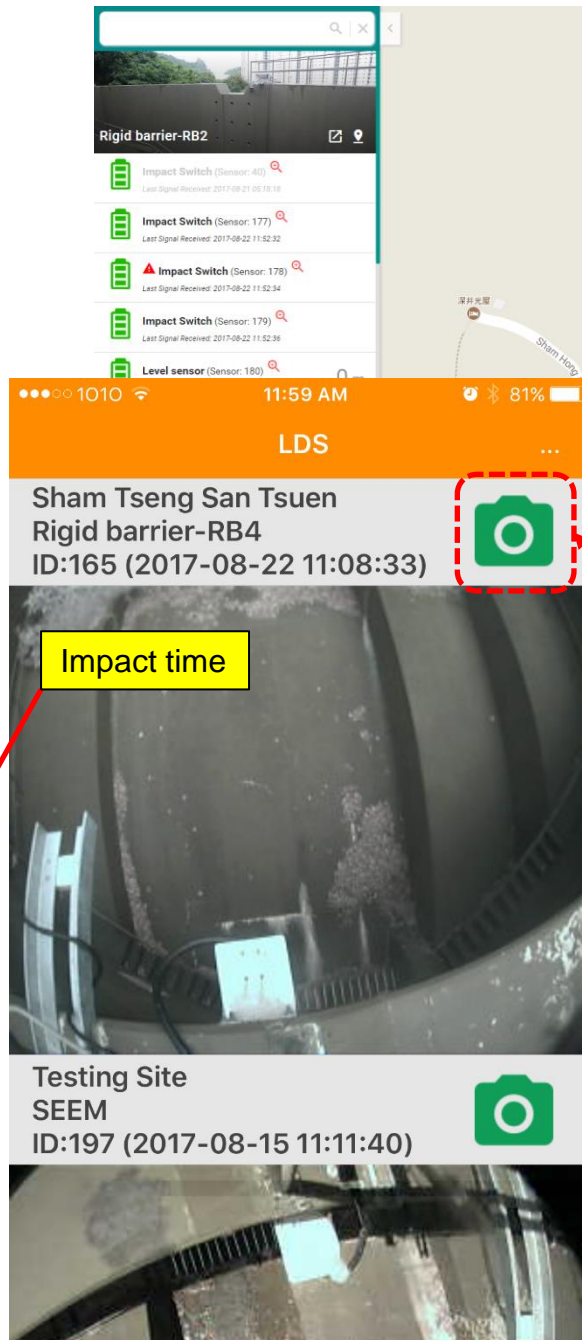
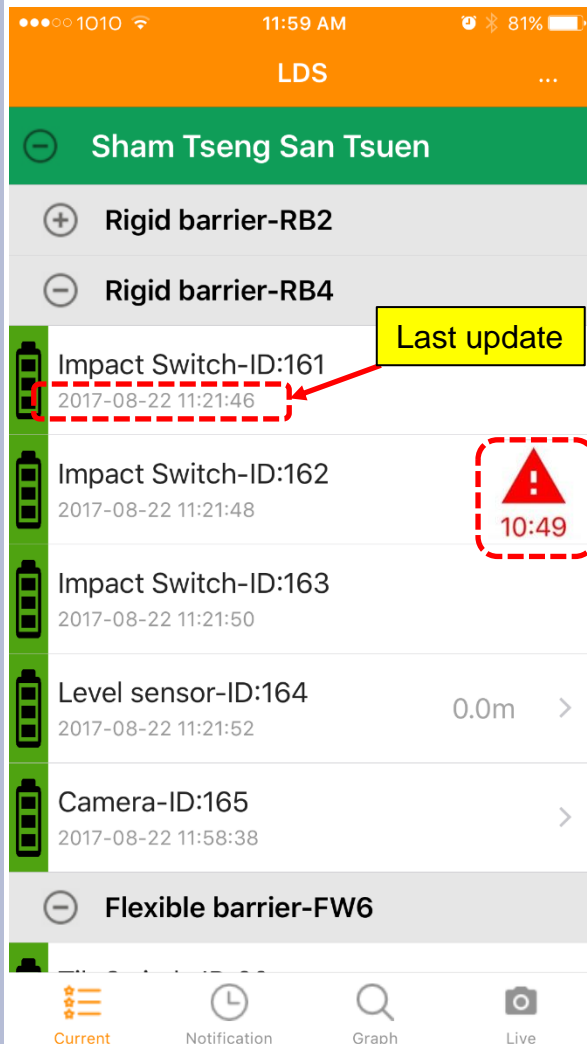
Flexible Barrier

- **Sensor**
 - Tilt Switch
 - Measure in Angle
 - Pull Switch
- **Communication**
 - 433Mhz
- **Functions**
 - Battery Level
 - Heart Beat
- **Battery life**
 - About 3 years



Software

Mobile Apps (iOS)



Desktop website

- Click to capture image
- 5 hours peer shoot
- Capture image if impact switch triggered



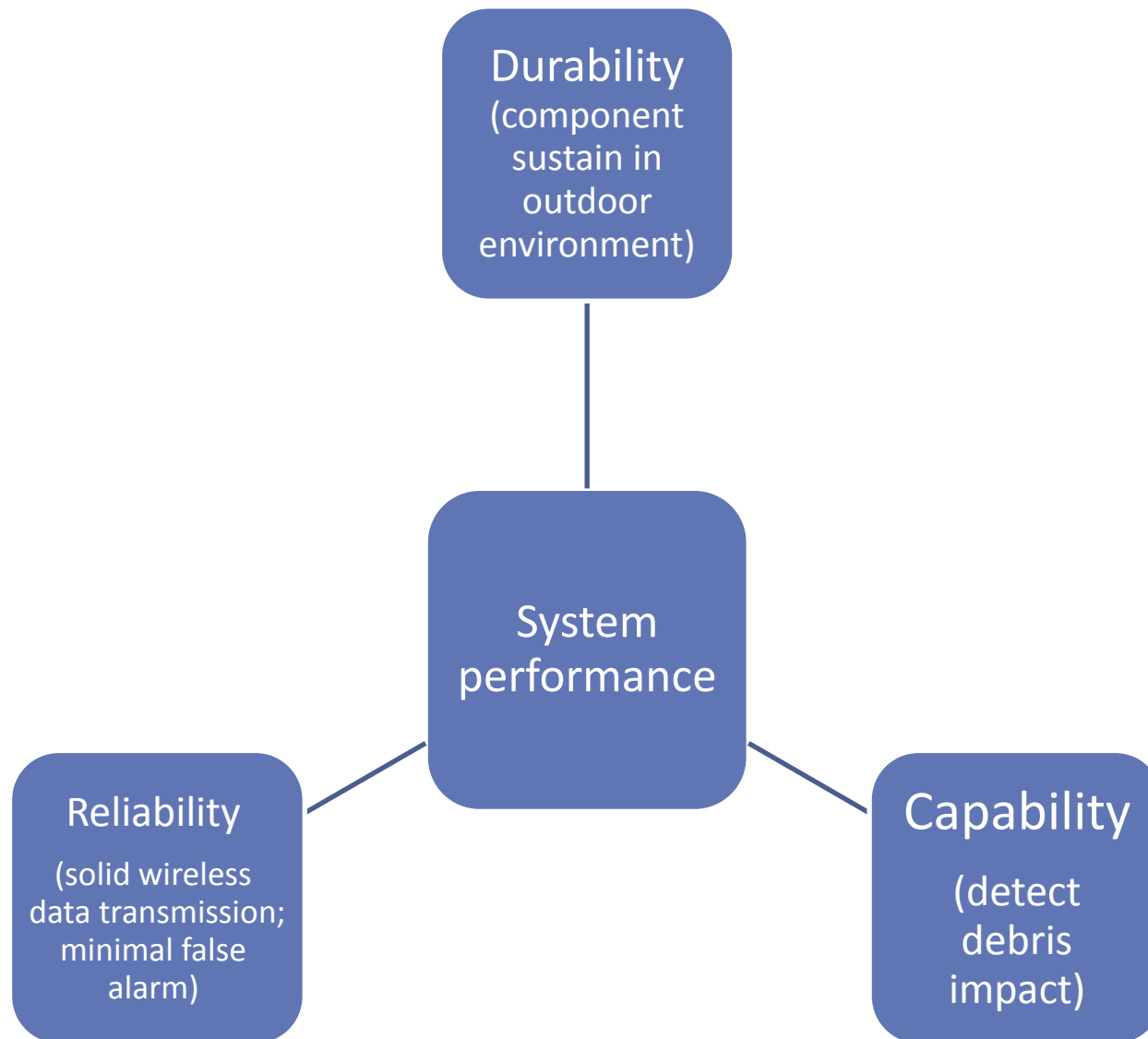
Rainfall in 24 May 2017

Built on past experience

Previous instrumentation projects	LDS Pilot Project
Off-the-shelf products	Customised components
Large power consumption, unstable solar power	Tiny power consumption
Unstable IT system and communication	IT system and wireless communication jointly developed by GEO and CUHK (no longer a “black box” !!)
Damage of wiring by rodents	Strong armour cable Wireless if possible



Performance of LDS

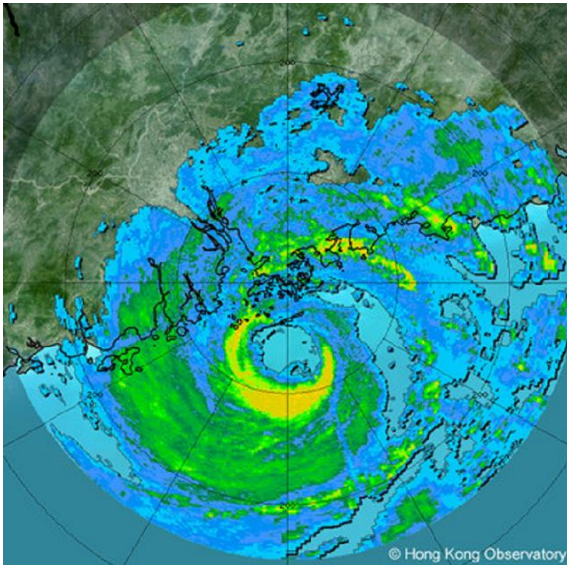


Outdoor durability performance

- Very stable solar power supply, even under prolonged adverse weather
 - Tiny power consumption
 - Within 5 days two Tropical Cyclone Warning Signals
 - All system up and running
 - Battery level shown on mobile app
 - All Battery full
- Very stable data logging
 - Statuses of sensors monitored regularly and automatically



Outdoor durability performance

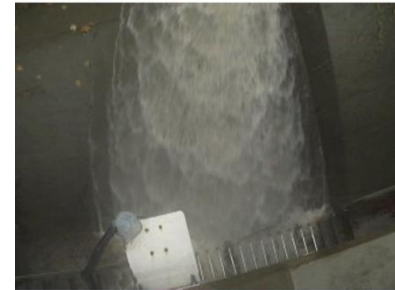


Warnings and Signals issued in August 2017

Table 1.1 Tropical Cyclone Warning Signals

Name of Tropical Cyclone	Signal Number	Beginning Time		Ending Time	
		Day/Month	HKT	Day/Month	HKT
HATO	1	22 / 8	0840	22 / 8	1820
	3	22 / 8	1820	23 / 8	0520
	8 NE	23 / 8	0520	23 / 8	0810
	9	23 / 8	0810	23 / 8	0910
	10	23 / 8	0910	23 / 8	1410
	8 SE	23 / 8	1410	23 / 8	1710
	3	23 / 8	1710	23 / 8	1820
	1	23 / 8	1820	23 / 8	2040
PAKHAR	1	26 / 8	0940	26 / 8	2040
	3	26 / 8	2040	27 / 8	0510
	8 SE	27 / 8	0510	27 / 8	1340
	3	27 / 8	1340	27 / 8	1740
	1	27 / 8	1740	27 / 8	2210

Wi-Fi Call 11:01 61%
 < Sham Tseng San Tsuen Rigid barrier-RB2



1:01 PM 100%
 < LDS Rigid barrier-RB4
 2017-08-23 11:39:41

1:01 PM 100%
 < LDS Rigid barrier-RB4
 2017-08-23 12:08:51

1:01 PM 100%
 < LDS Rigid barrier-RB4
 2017-08-23 17:08:13

2017-05-24 11:00:07




Reliability

- Stable data transmission
 - Good 3G/4G coverage required
- False alarm
 - Sources of false alarm:
 - Wiring of impact switches
 - Solutions:
 - Wireless impact switches



Capability

- No landslide detected in the last 4 months
 - Uncertainties:
 - Premature damage of impact switch by impacting debris
 - Radio signal blocked by debris that bury the impact switch
 - Premature/late activation of pull switch
 - Progressive deposition which may not induce post tilting
 - Verification:
 - Landslide occurring in the coming 8 months!
 - Field-scale impact test of LDS
 - Other measures to reduce uncertainties:
 - Redundant deployment of impact switch
 - Cross checking of measurements (e.g. level sensors v.s. impact switch; pull switch v.s. tilt switch)
 - Validation by digital camera
- 

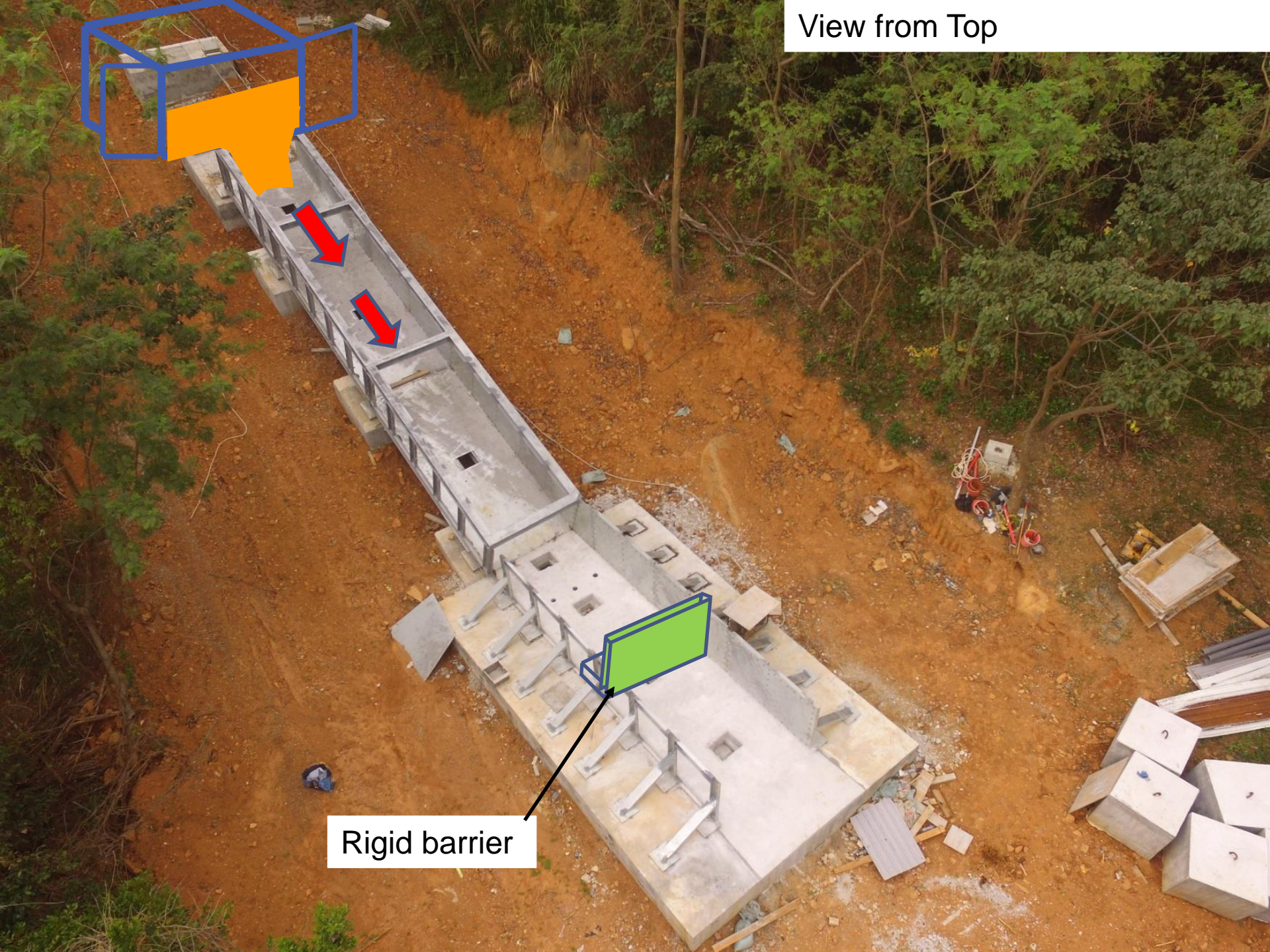
Testing Site (in Shek Mun, Shatin) for Pull Switch at Flexible Barrier



A flume under construction at Kadoorie Farm and Botanic Garden (Lam Tsuen, Tai Po)



View from Top



Rigid barrier

智能感應泥石壩保民居 即時警報如「平安鐘」

發佈日期: 2017-09-04



颶風襲港或帶來大量雨水，沖刷山上泥土，一旦泥石滾下，隨時威脅山坡下的居民安危，土力工程拓展處在全港約200個天然山坡加建了混凝土泥石壩和柔性防護網，以阻擋泥石滾至民居，為了全天候監察山泥傾瀉情況，該處正進行試驗計劃，率先在深井新村安裝智能系統作為試點，包括設置感應器及攝錄機，一旦發覺石塊即將填滿石壩等，便可以即時知道，隨即發出警報，通知村民暫時疏散，以策安全。每套儀器成本數千元，明年第二季完成試驗工作，屆時便會決定如何全面應用。土力處形容此系統儼如專為長者而設的「平安鐘」，發揮救命作用。

本報港聞部報道

截至本年8月1日為止，共有43個天然山坡正在進行或已計劃進行防治山泥傾瀉工程，在天然山坡通常會採取風險緩減措施（例如外圍常用的泥石壩和防護屏障），例如東涌裕康路天然山坡山泥傾瀉風險緩減工程，已斥資逾6,000萬元加建四個混凝土泥石壩和一張柔性防護網，降低山泥傾瀉造成的影響，並在泥石壩和防護網周邊栽種花卉和樹木，使斜坡外觀與四周環境融合。

預計明年第二季完成測試

這類緩減設施通常置於山間叢林，如何全面監控是另一課題，土木工程拓展署轄下的土力工程處處長潘偉強接受本報訪問時解釋，隨著科技發展漸趨成熟，他們計劃制定一套山泥傾瀉偵察儀器的規格，以便將來應用於其他山泥傾瀉風險緩減措施，目前正與中文大學系統工程與工程管理學系教授鄭進雄合作，現時正進行實地的測試工序，測試時段由本年6月至明年5月為止，期間會繼續優化此系統，預計明年第二季完成。

您可能有興趣:

3



學者：朗迫美承認其擁核地位

4



金磚峰會廈門商合作 習近平提4點希望 冀再創金色十年

5



「金磚+」模式廣吸納其他發展中國家

6



山泥傾瀉偵察系統試點在深井新村，該村設有兩個混凝土泥石壩，其設計可阻截750至1,860立方米的泥石碎屑，以及兩個柔性防護網，設計以承受高達3,000千焦耳動能的泥傾瀉，該處分別在泥石壩及防護網安裝偵察部件，前者包括有衝擊感應開關、高度感應器以及相機；後者包括傾斜度和拉力感應開關，及安裝在制動鋼繩上的感應開關器，然後再於網上和ISO流動應用程式上瀏覽及控制，便可一目了然掌控設施的狀況。

潘偉強補充此儀器的優點是可以即時作出山泥傾瀉通報，加快部門的應變時間。當他們透過偵察器知悉有任何異樣，便可迅速作出決定，例如可以即時通報，以便即時疏散影響市民，「情況如平安鐘，救命鐘發揮的效果」。其實過去土力工程處亦曾測試一些智能系統監察儀器，但其效果均不理想，例如耗電量很大、儀器很昂貴、不耐用以及維修困難，而今次測試的儀器約數千元（每套計），電芯便宜，目前仍測試其耐用程度及維修情況，為他們拓展「智能泥石壩」帶來契機。

Source: <https://www.singpao.com.hk/index.php?fi=news1&lang=1&id=44647>

Video Analytics for Resource Tracking & Management

Camera/CCTV Infrastructure

Turning Videos into Tracking Data & Actionable Intelligence

Scalable Hybrid Networking

Enabling Technologies

Real-time Notifications

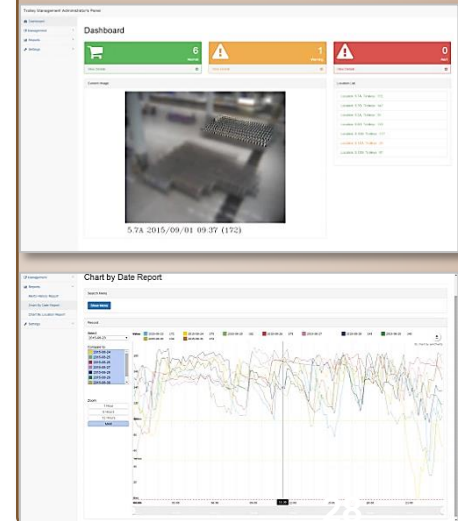
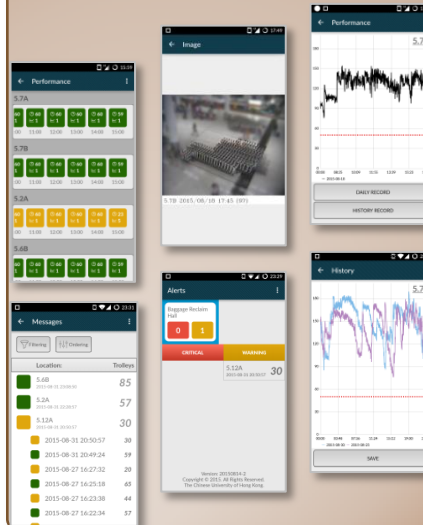
Resource Analytics

Real-time Detection & Machine Learning

Frontline Operation & Responses

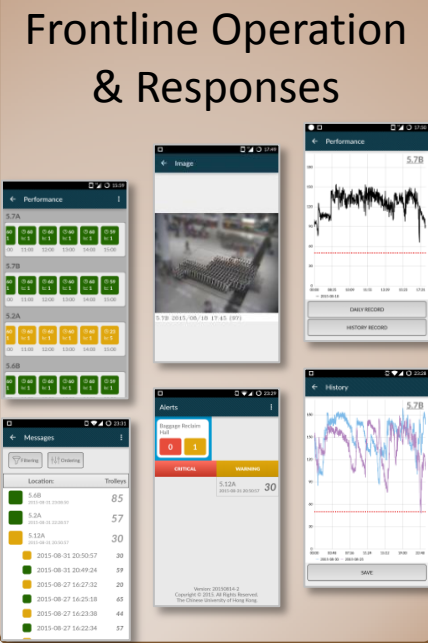
Management Dashboard

Trolleys Available in Rack



Funding

- Video analytics for resource management, Innovation & Technology Commission – Innovation and Technology Support Programme, HK\$5,256,999
 - A company sponsorship of HK\$450,000
 - An inkind sponsorship of HK\$1,100,000 (for high-end blade server)



Video Stream & Image Data

Replenishing trolleys in timely manner?

Looking for trolleys?

5.7B 4/5/2015 4:17:27 PM 31

5.7A 3/31/2015 9:48:02 PM 1

Video Sensing Analytics Architecture Framework

Video Sensing Analytics Architecture Framework

Video & Sensor Input Sources

Video Stream

Image

Sensing Data

Communication Data

Content Analysis

Feature Extraction

Object Detection

Object
Component
Detection

Feature
Identification for
Similarity Matching

Machine
Learning
Module

Monitoring & Management Platform

Management Module

Object
Tracking

Event
Monitoring

Event Detection for
Alert Notification

Comprehensive
Resource Monitoring

Analytics Module

Resource Allocation
& Deployment

Utilization
Analysis

Data-driven
Forecasting

Resource
Planning

External Factor
Correlation Analysis

Operation
Efficiency

Application & Presentation

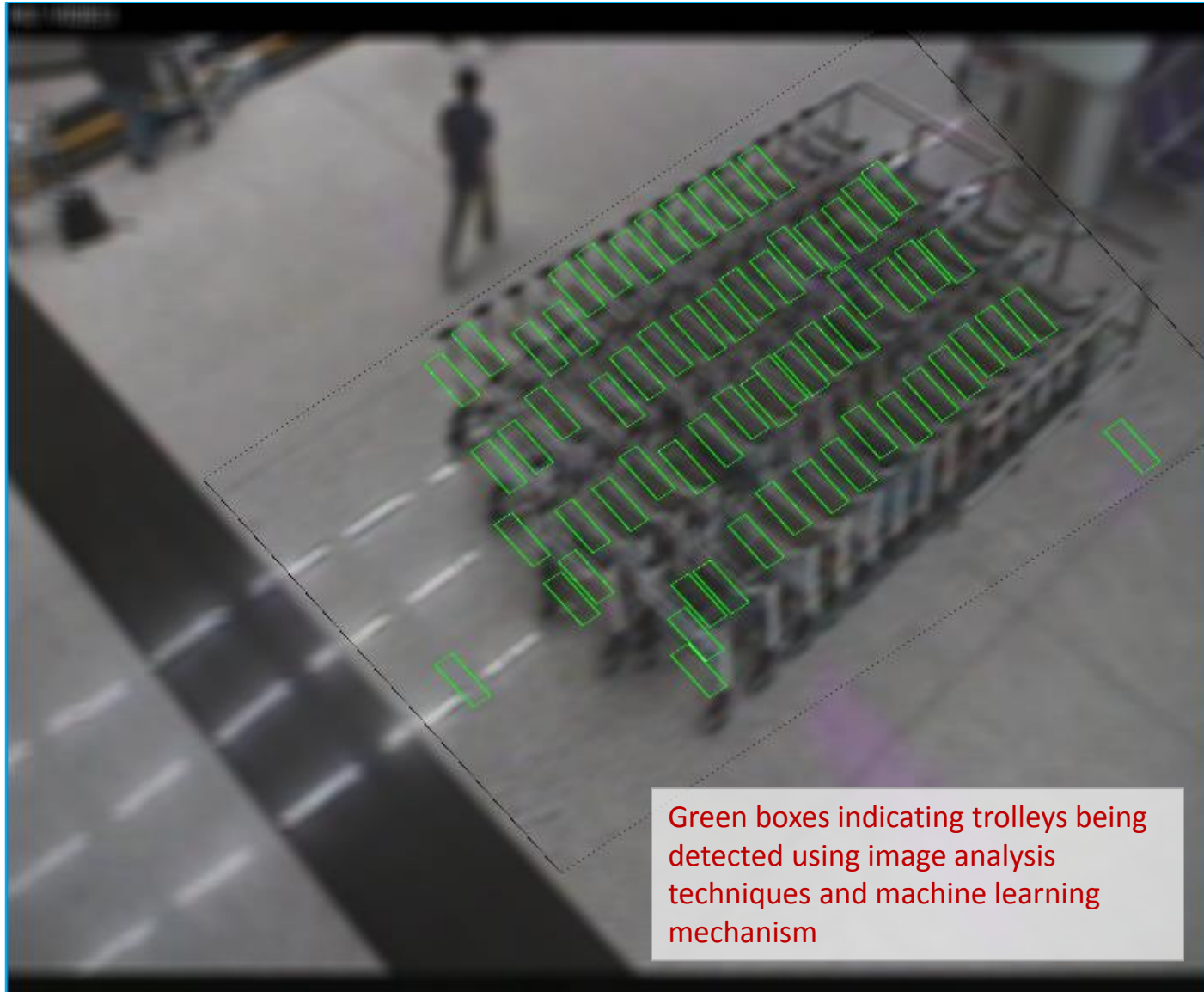
Real-time Resource
Availability Awareness

Alert
Handling

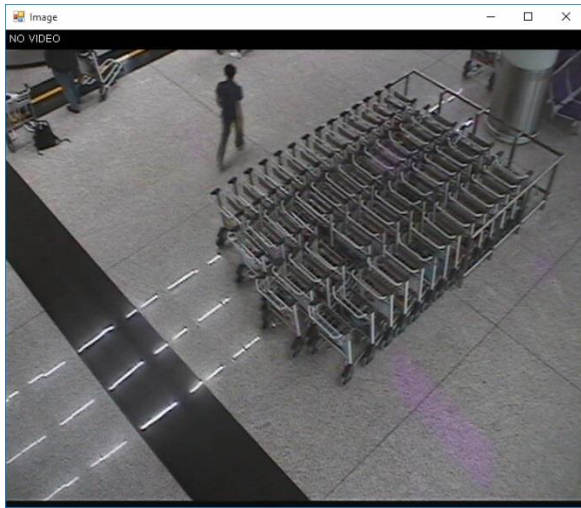
Monitoring
Visualization

Resource
Visualization

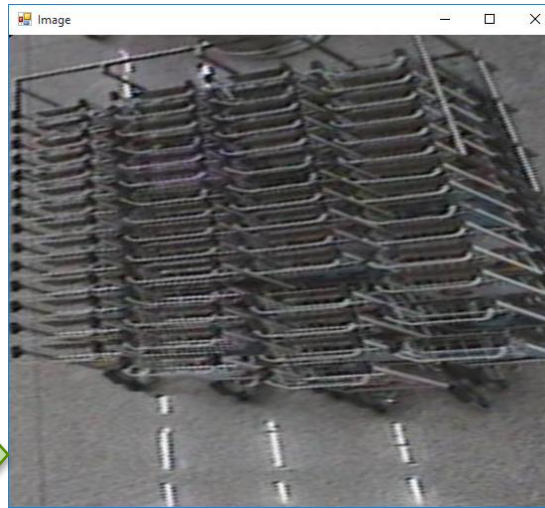
Trolley Object Detection



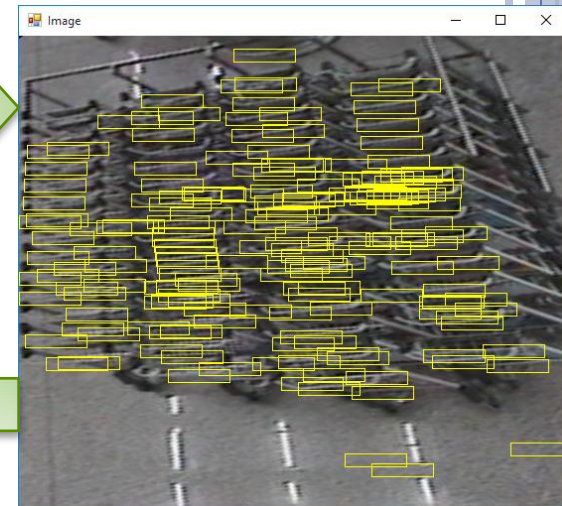
Trolley Detection



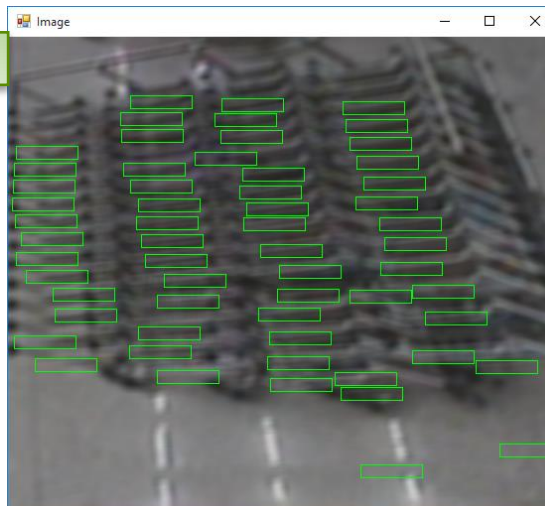
Input



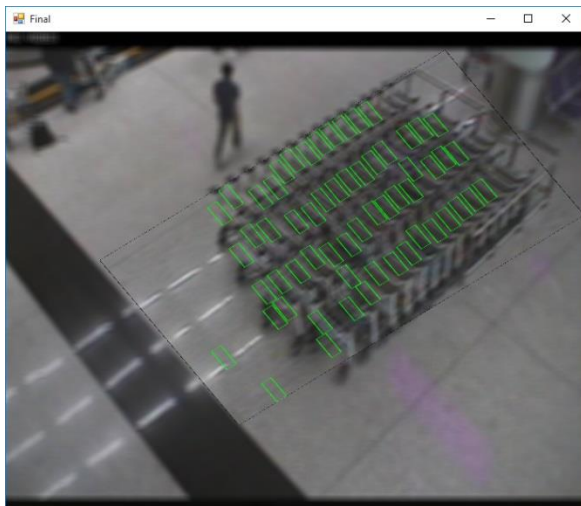
Transform



Detect



Filter



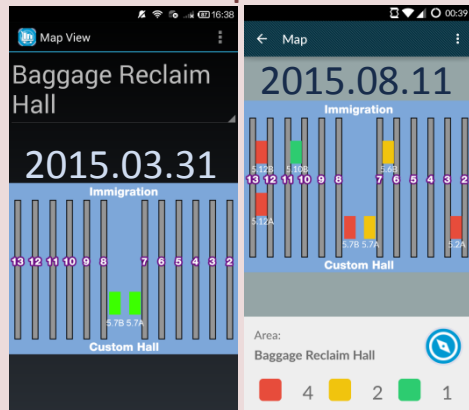
Transform

5.2A 2015/10/09 10:52 (59)

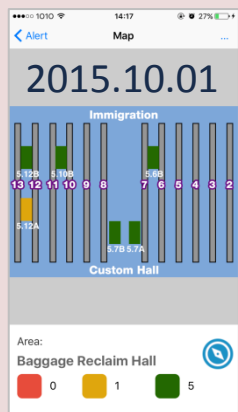
2014.10 – 2016.10 POC Prototype with Shared CCTVs

HKIA Baggage Reclaim Hall (BRH)

2015.03 Deployment with Android Trolleys App
Up to 7 Racks with 5 Shared CCTVs



2015.10 Available with iOS Trolleys App

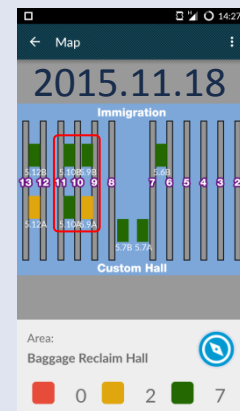


Research & Development Process
From 2 Prototype Trial Runs
To Full-scale BRH Deployment

2015.07 Counting Accuracy (N=172)

- Background subtraction: 75.58%
- Detection, Version 1: 76.51%

2015.05 – 2016.09 Prototype with Dedicated IP Cameras



2015.11 Deployment:
9 Racks,
4 Dedicated
+ 3 Shared
Cameras

2016.06 Counting Accuracy (N=571)

- Detection, Version 2: 83.23%

2015.12 – Current Full-scale BRH Deployment

2016.11 Counting Accuracy (N=200)

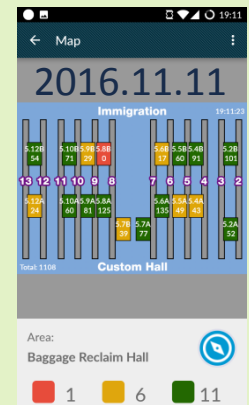
- Detection, Version 3.0: 87.52%

2016.12 Counting Accuracy (N=200)

- Detection, Version 3.1: 91.85%

2016.09 Camera & IT Infrastructure
Installation (6 weeks)

2016.11 Full-scale BRH Deployment
with updated iOS & Android
Trolleys App



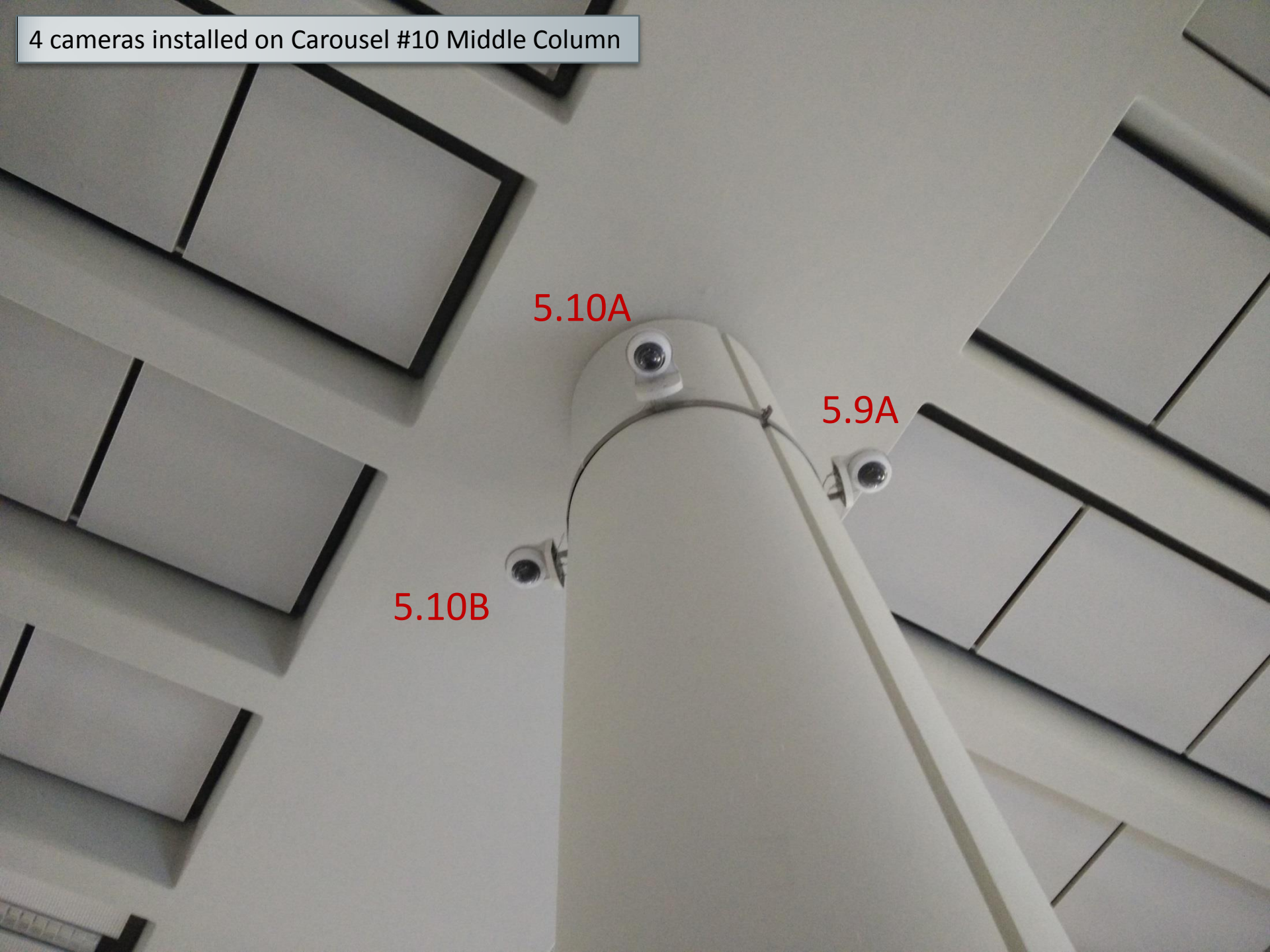


4 cameras installed on Carousel #10 Middle Column

5.10A

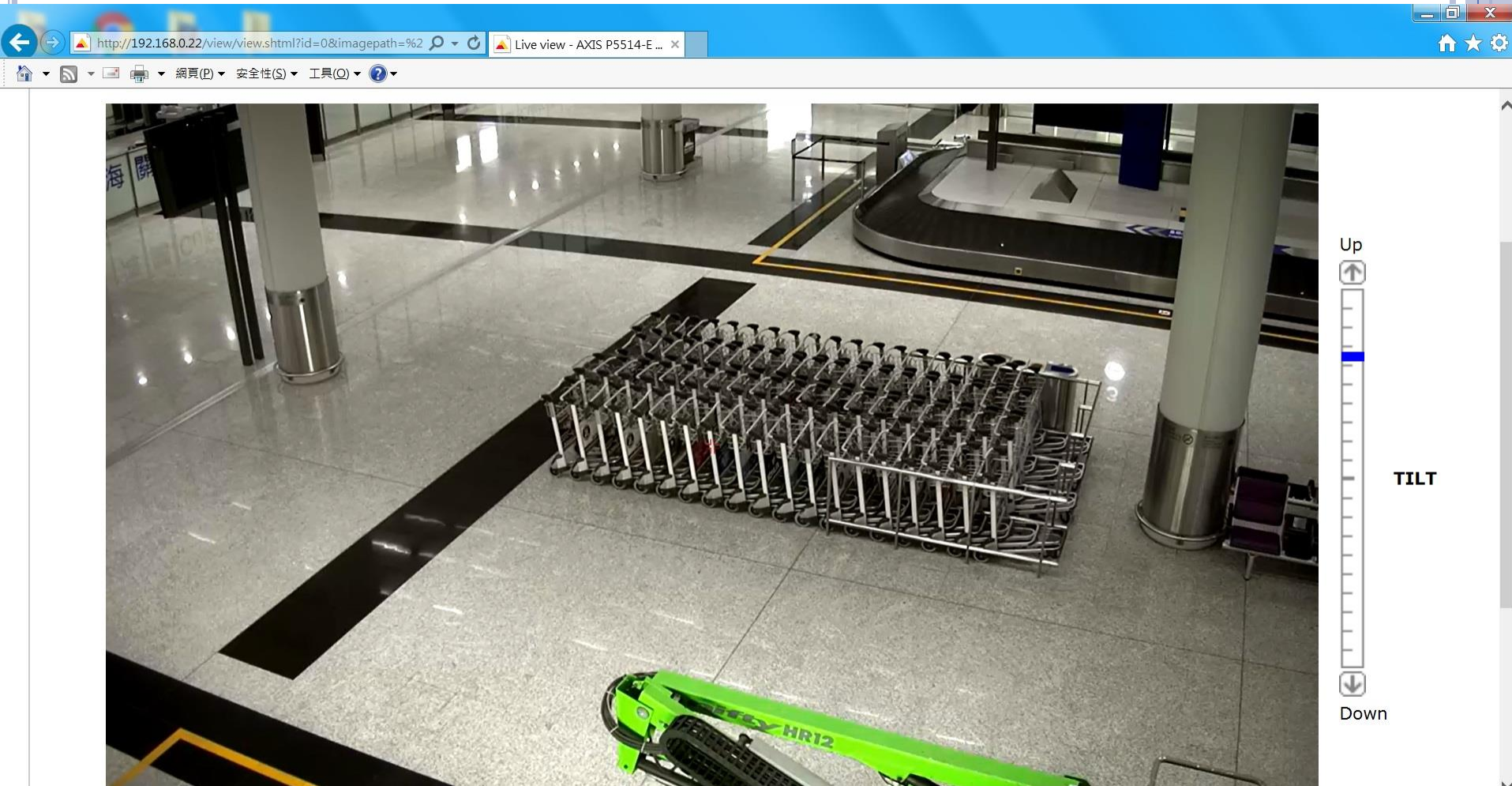
5.9A

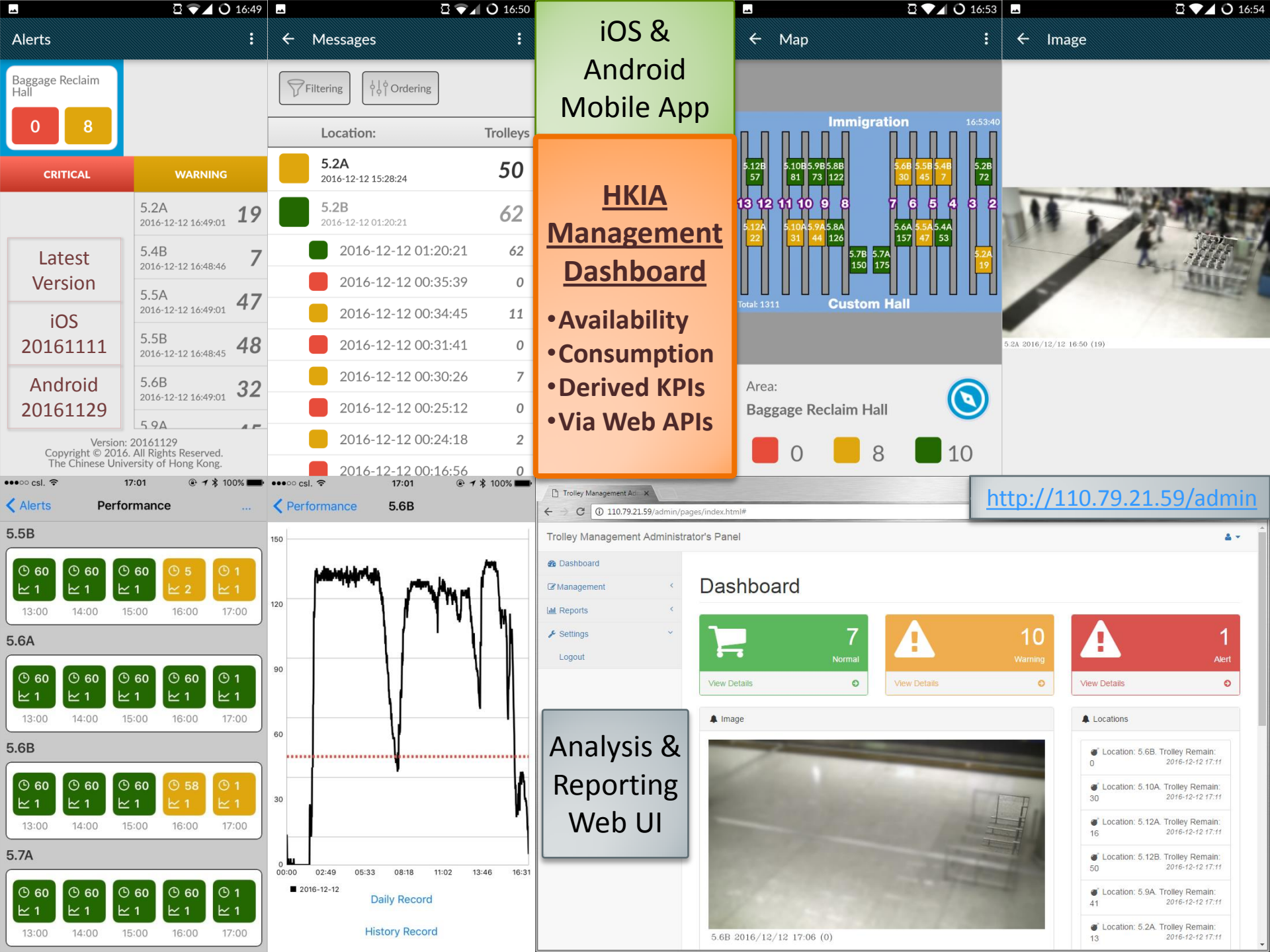
5.10B



Viewing 5.2A

Cam 2 – Carousel 2 Far Cam – 192.168.0.22







Trolleys Warning

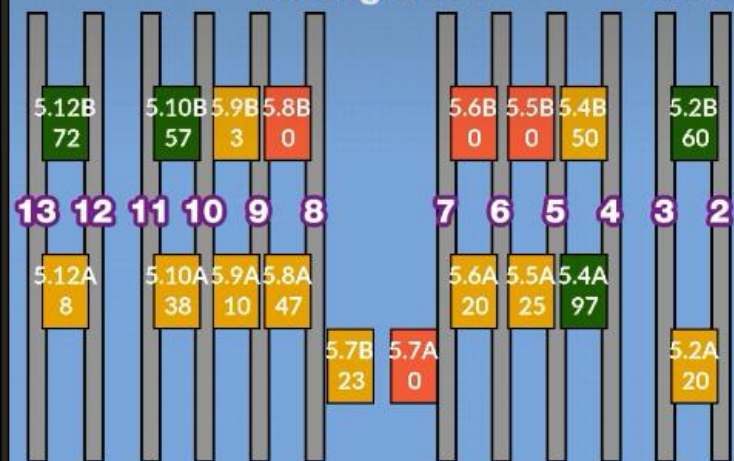
22:09

Location :5.4B Trolleys : 50 Date : 2016-11-2..



Immigration

22:09:22



Total: 530

Custom Hall

Monday 2016.11.28 22:09:22

Total: 530 [fairly low]

Area:

Baggage Reclaim Hall



4



10



4

Recorded by Mobizen

2 Snapshots at
22:09:22 &
22:34:43 on
Monday
2016.11.28



22:34

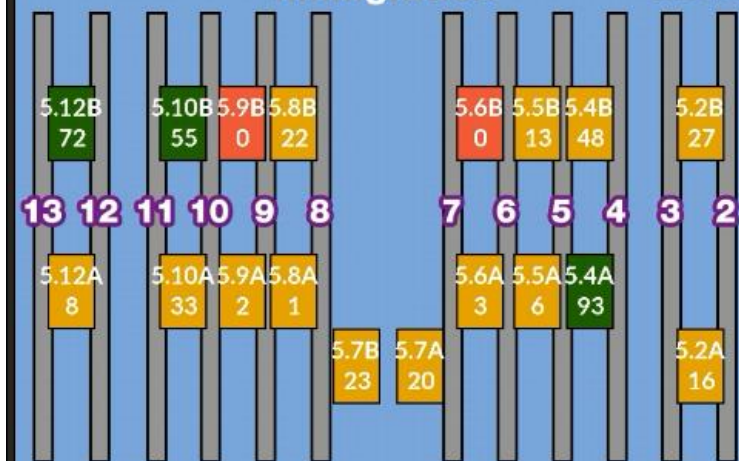


Map



Immigration

22:34:43



Total: 442

Custom Hall

Monday 2016.11.28 22:34:43

Total: 442 [seemingly low]

Area:

Baggage Reclaim Hall



2



13



3

Recorded by Mobizen



Google Cloud Platform.

Google Cloud Platform

Start your first VM for free with Google Compute Engine.



News / Hong Kong / Economy

Hong Kong International Airport

Trolley dash at Hong Kong airport as new monitoring system ensures passengers never left holding their bags

Engineers at Chinese University have developed a real-time artificial intelligence-based monitoring system that sends an alert to managers when the number of trolleys drops below 50

PUBLISHED : Monday, 11 September, 2017, 8:03pm

UPDATED : Monday, 11 September, 2017, 11:34pm

COMMENTS: 6

與摯愛投保
保費低至4折Cigna
信諾環球

立即報價

We recommend for you

BUSINESS

In Switzerland, local management
often holds the key to post-
takeover...

30 Sep 2017

STYLE

Five Miss Hong Kong winners who
made news, but not for reasons
you...

04 Sep 2017



BUSINESS

Hong Kong fast
developing as a
cryptocurrency
centre

30 Sep 2017



NEWS

Airline licence body
warns Hong Kong
Express of possible
action over...

01 Oct 2017



NEWS

'New internet' looks
to keep user data
away from tech
giants and...

01 Oct 2017

Thank you