Evolution of GPS

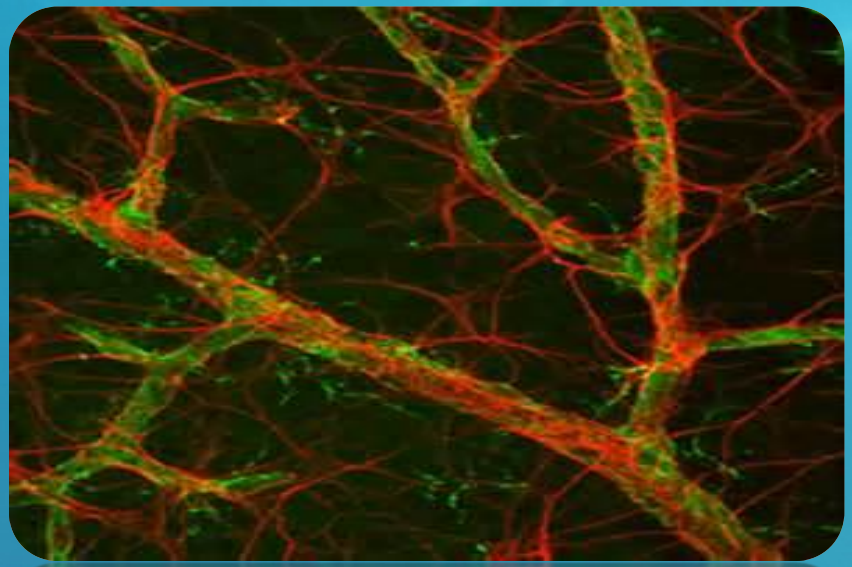
Applications in Highways Department

Contents

Introduction

‘The transport network in a city is like its blood vessels, a cohesive liaison and catalyst to promote social activities…’

(Ways to Urbanisation Post-War Road Development in Hong Kong, HO Pui-yin)



Blood vessels

Road network

Highways Department

Road and railway network

Carriageway	2,000 km
Footway	13,000 km
Roadside Slope	13,000 no.
Street Light	128,000 no.
Structure	2,200 no.

Photographed by Mr. G.B.TIO, SO(Eng)/HyD

Introduction

Services of Survey Division, Highways Department

- Engineering Survey Services
- Emerging Survey Technology Applications

Introduction

Traditional Engineering Surveys

GPS Applications
in Highways Department

Survey Work in Construction Sites

Mobile Mapping System (MMS) Project

Introduction

Traditional Engineering Surveys

Survey Work in Construction Sites

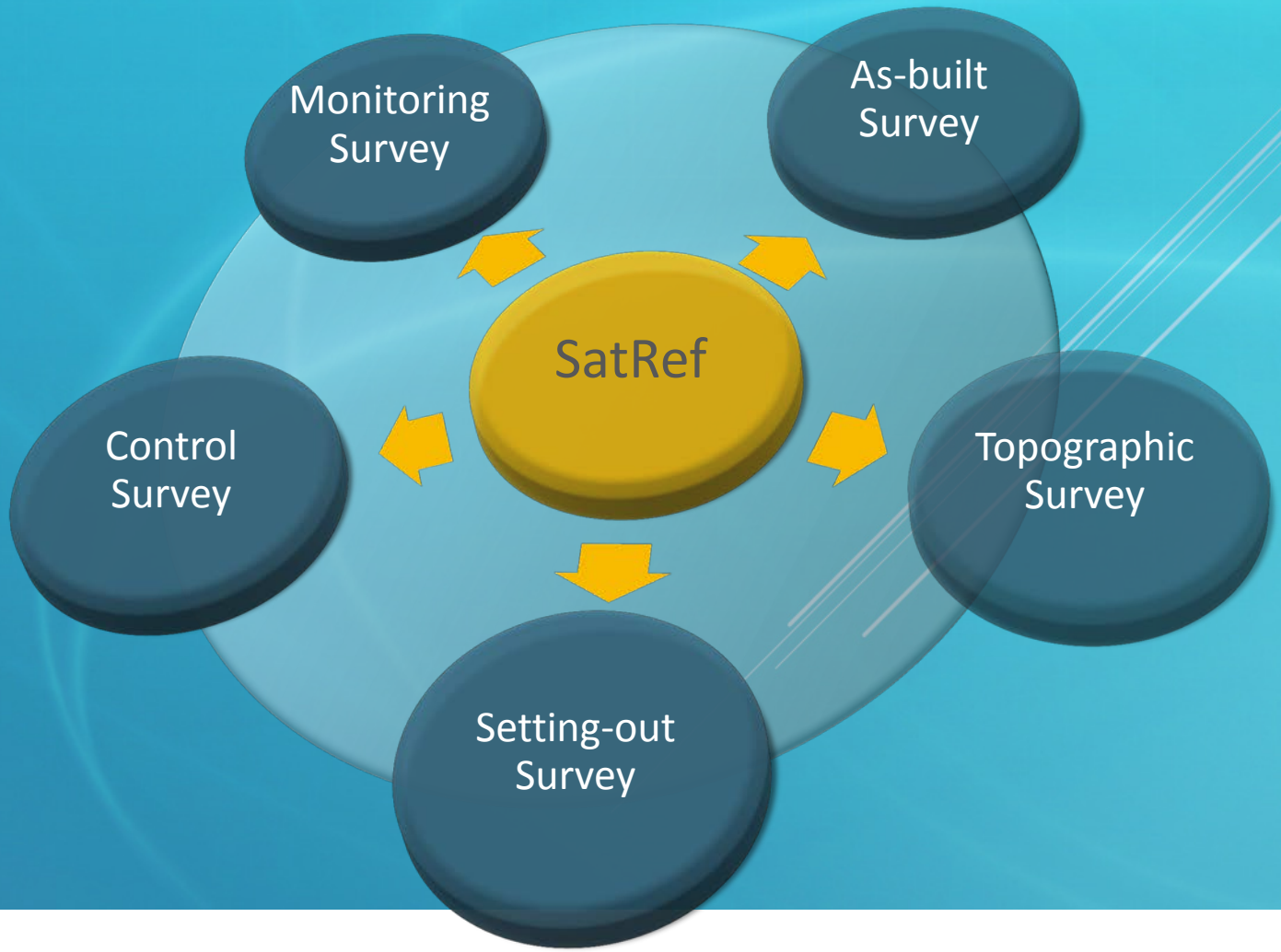
Mobile Mapping System (MMS) Project

Part 1 - Applications of GPS in Traditional engineering surveys

Part 1 - Traditional engineering surveys

- Control Survey
- Topographical Survey
- Setting-out Survey
- Monitoring Survey
- As-built Survey

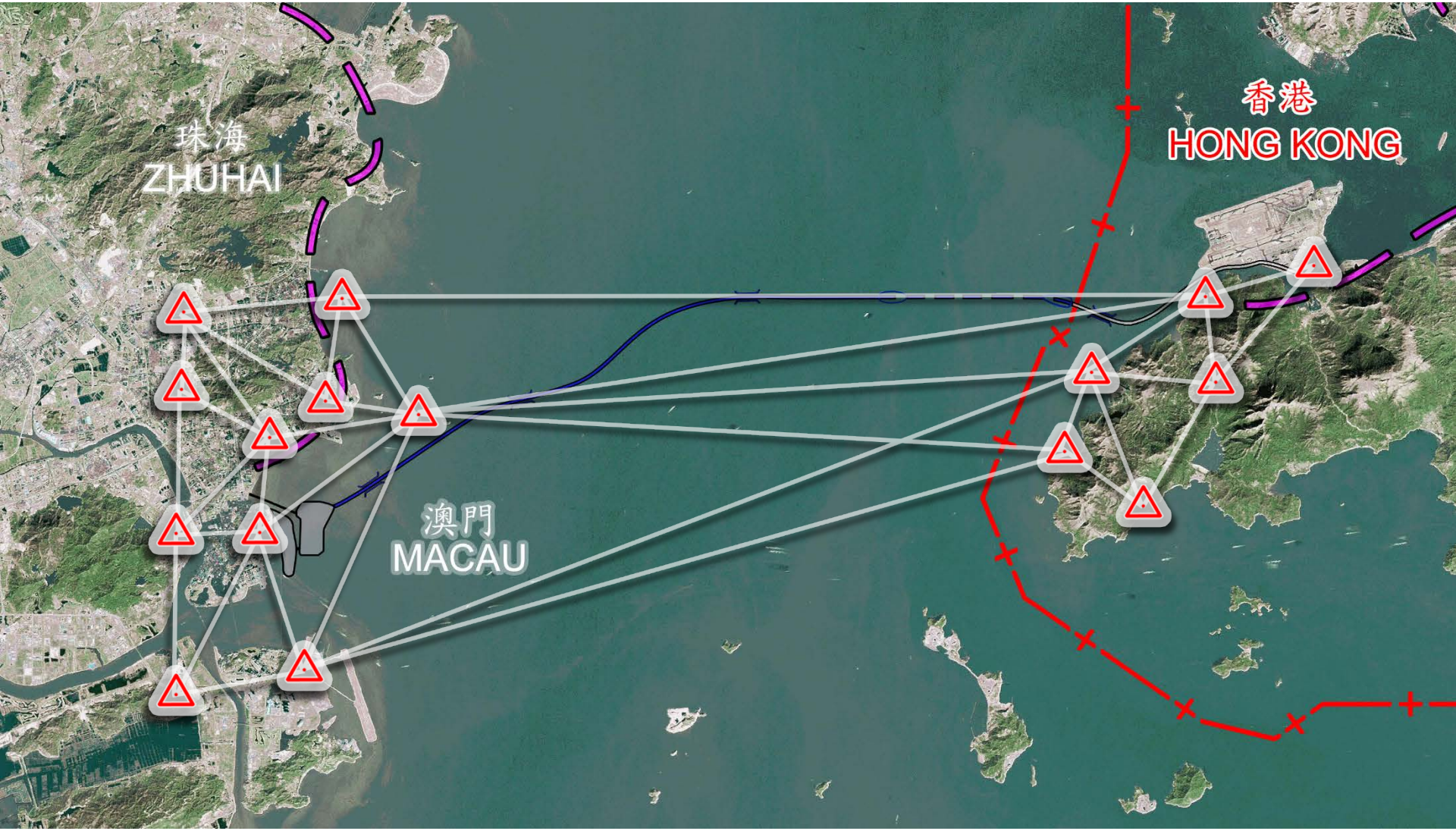
Part 1 - Traditional engineering surveys



Part 2: Applications of GPS in Survey work in construction sites

Part 2 - Survey work in construction sites

Part 2 - Survey work in construction sites



Hong Kong – Zhuhai – Macao Bridge

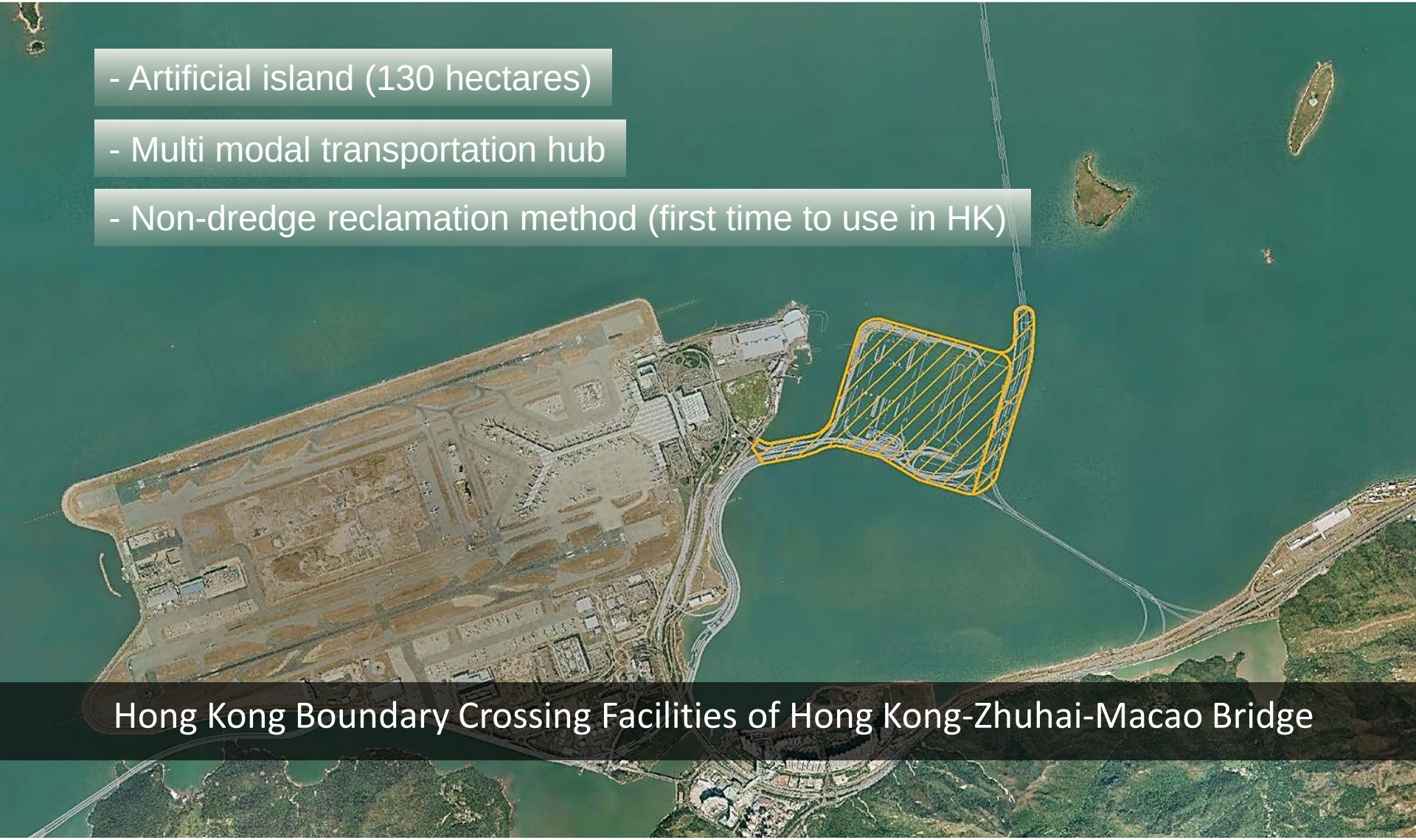
Hong Kong-Zhuhai-Macao Bridge

Continuously **O**perating **R**eference **S**tation *(CORS)*

Part 2 - Survey work in construction sites

Part 2 - Survey work in construction sites

- Artificial island (130 hectares)
- Multi modal transportation hub
- Non-dredge reclamation method (first time to use in HK)



Hong Kong Boundary Crossing Facilities of Hong Kong-Zhuhai-Macao Bridge

Part 2 - Survey work in construction sites

Part 2 - Survey work in construction sites

Setting out the position of stone columns by using network RTK survey

Real-time position monitoring of the stone columns by using network RTK survey during installation

Setting out and As-built survey record of the installed cellular structures by using network RTK survey

Making use of SatRef

Part 2 - Survey work in construction sites

Barge for the installation of stone columns

Part 2 - Survey work in construction sites

Guide frames for installation of cellular structures

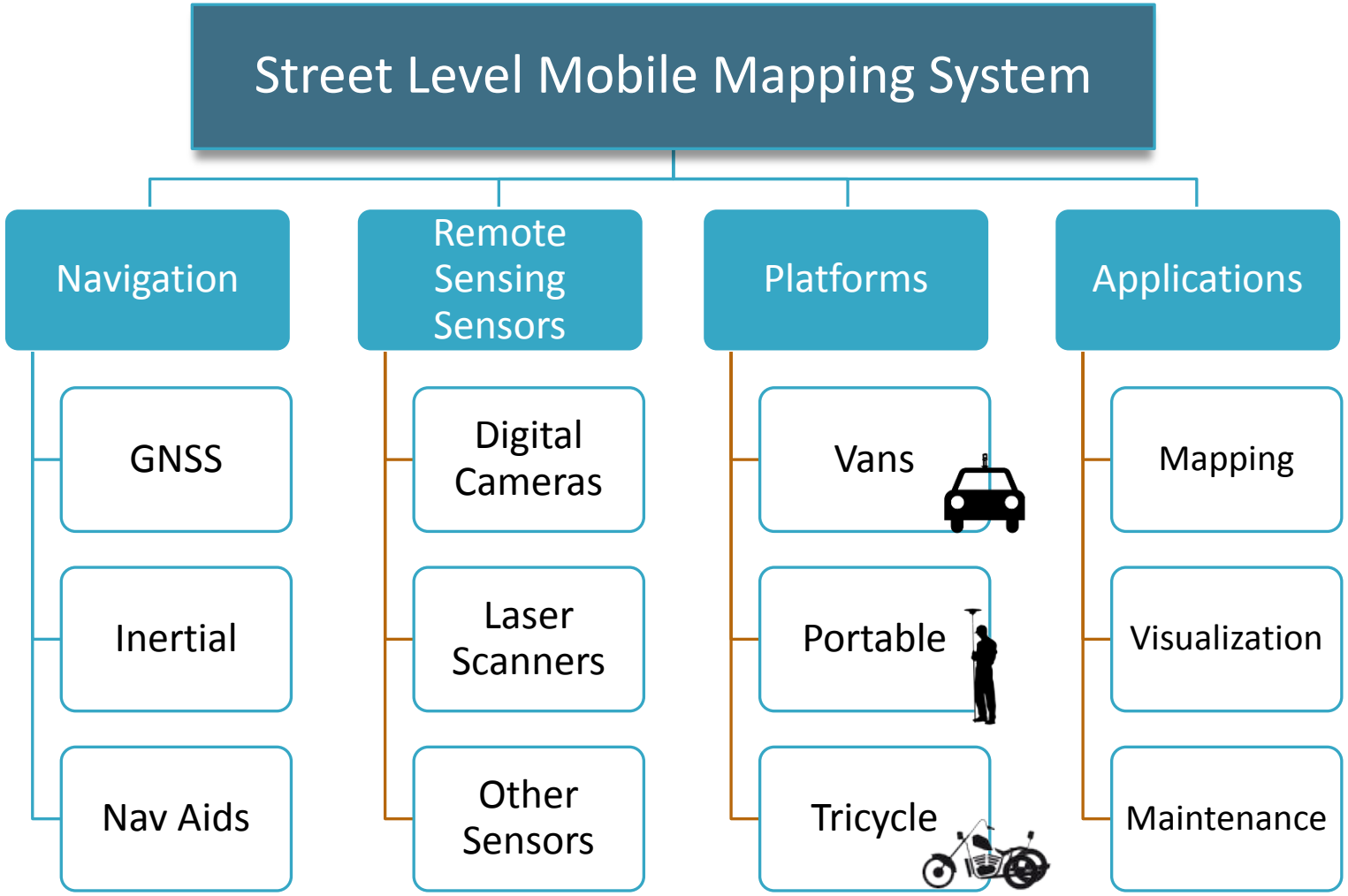
Cellular structure that formed the perimeter of the reclamation works site of the artificial island

Installed cellular structure

As-built survey of cellular structure

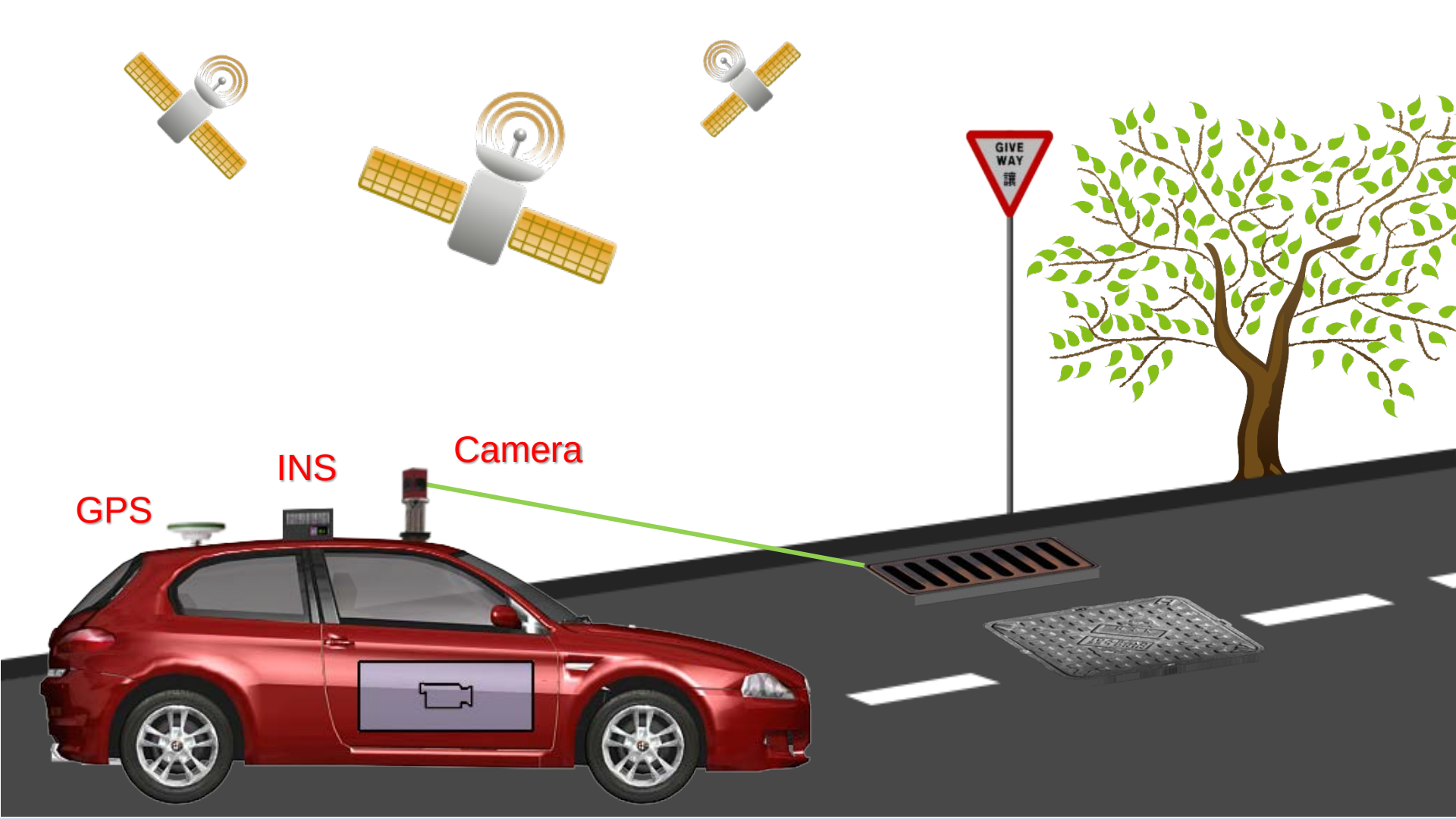
Part 3: Applications of GPS in Mobile Mapping System (MMS) Project

Part 3 - Mobile Mapping System (MMS) Project



Courtesy of Prof. Naser El-sheimy
Department of Geomatics Engineering,
University of Calgary, Canada

Part 3 - Mobile Mapping System (MMS) Project



Part 3 - Mobile Mapping System (MMS) Project

The Acquisition of Road Inventory Data By Using The Technology of Mobile Mapping System For Hong Kong *(Under Tender Evaluation)*

- Commence in the **1st quarter of 2013** (tentative)
- **5 years** contract period (2013-2018)
- Complete data capture work with 3D Geo-Referenced images of **existing roads** in the **first two years**
- Complete **data integration** with the departmental GIS system data in the **third year**
- Complete data capture work with 3D Geo-Referenced images of **new and improved roads on request** during the contract period.

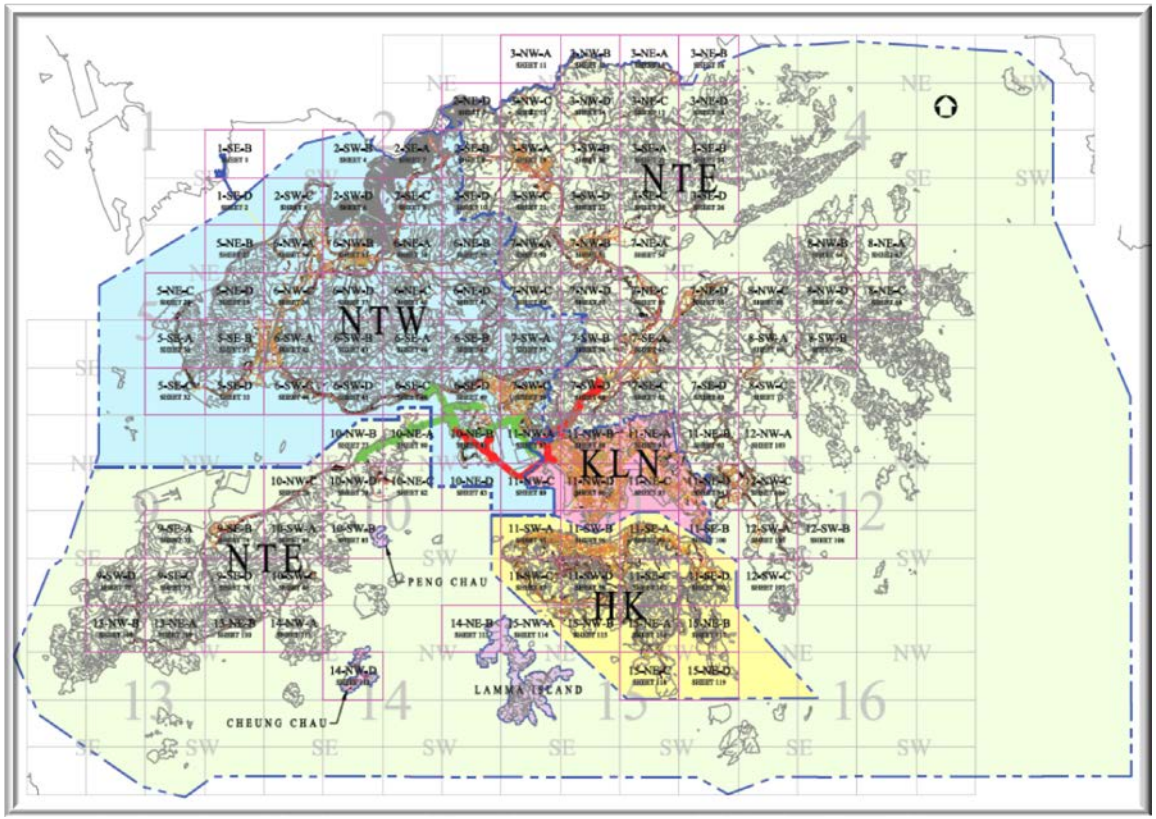
Project Zones

Hong Kong Island

Kowloon

New Territories West

New Territories East
and outlying Islands



Scope of Work

Highways Department maintains

- Carriageways
- Footways
- Roadside slopes

Applications of GPS in Direct Geo-referencing

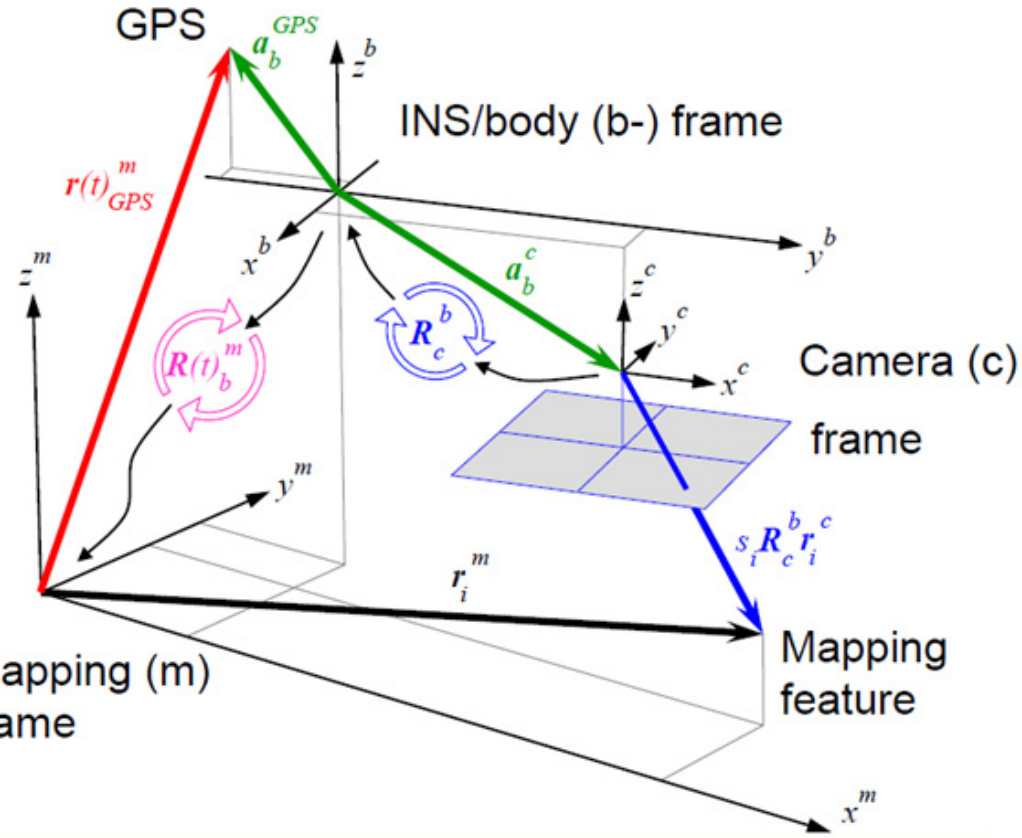
- Integration of GPS with INS / other sensors
- Less ground point (100 m intervals for Pilot MMS project)

- Reduce the labor cost for ground survey
- Speed up the project work

$$\boldsymbol{r}_i^m = \boldsymbol{r}(t)_{GPS}^m + \boldsymbol{R}(t)_b^m \left(s_i \boldsymbol{R}_c^b \boldsymbol{r}_i^c + \boldsymbol{a}_b^c - \boldsymbol{a}_b^{GPS} \right)$$

Georeferencing

– Coordinate Frames



Part 3 - Mobile Mapping System (MMS) Project

$$r_i^e(t) = r_c^e(t) + R_b^e(t)\Delta r^b$$

Synchronization

- Synchronization is performed using the PPS from the GPS receiver
- The PPS interrupts the computer every second through either LPT ports or the COM ports of the host PC
- The synchronization accuracy depends on the applications (e.g. for land applications: 0.1 s is equivalent to 1.6 m position error at a velocity of 60km/h).

Example:

$$T_{INS}^{GPS} = T_{INS}^{c} + (T_{pps}^{GPS} - T_{pps}^{c})$$

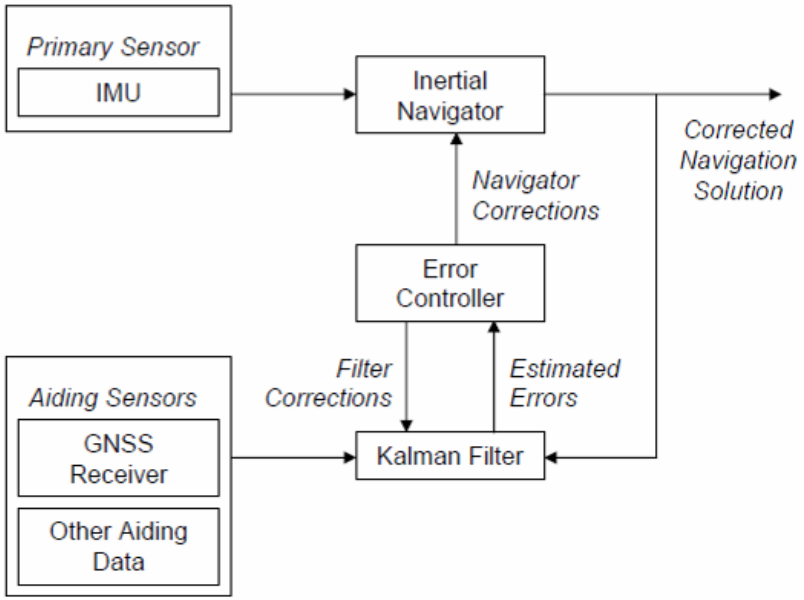
The computer time of the INS pulse interrupt

The GPS time defined By the PPS

The computer time at the PPS interrupt

Combining GPS and INS data IN-Fusion ™ technology (Loosely Coupled)

- Require 5 or more satellites to aid the solution
- Compare GNSS solution with inertial solution
- Aiding sensor (e.g. DMI) data assists in the error estimation
- Estimate errors using a Kalman filter
- Correct errors in the Inertial Navigator solution



Combining GPS and INS data IN-Fusion ™ technology (Tightly Coupled)

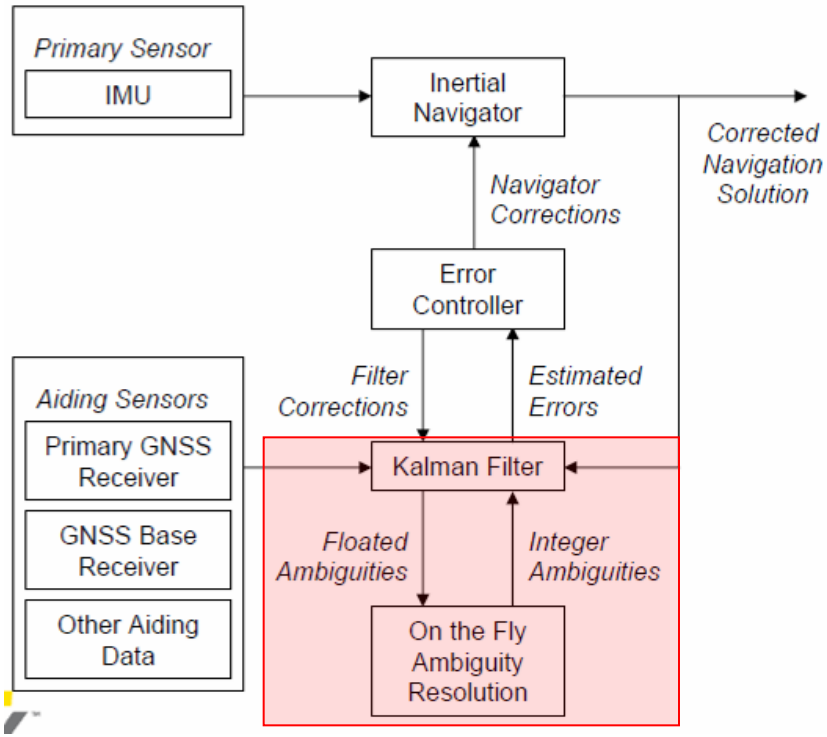
Inertailly-Aided Kinematic Ambiguity Resolution algorithm

Estimate errors in the inertial solution using a single Kalman filter with GNSS solution

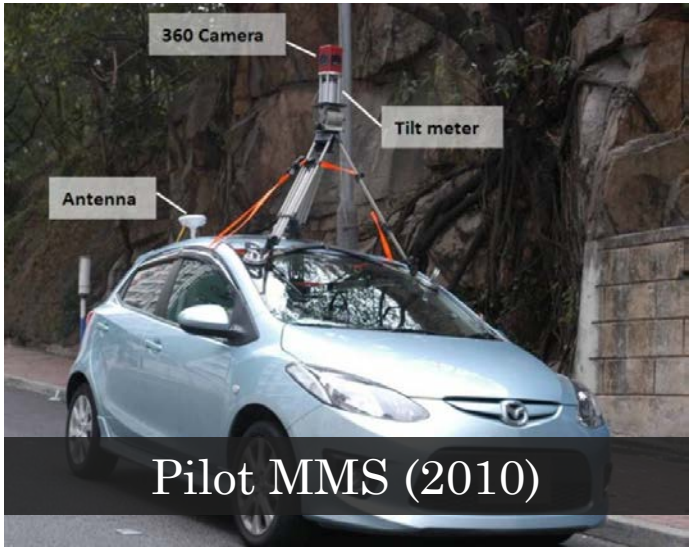
One or more satellites will aid the solution

Corrections are sent to the Inertial Navigator

Aiding sensor data (e.g. DMI) assists in (GNSS) ambiguity resolution and error estimation

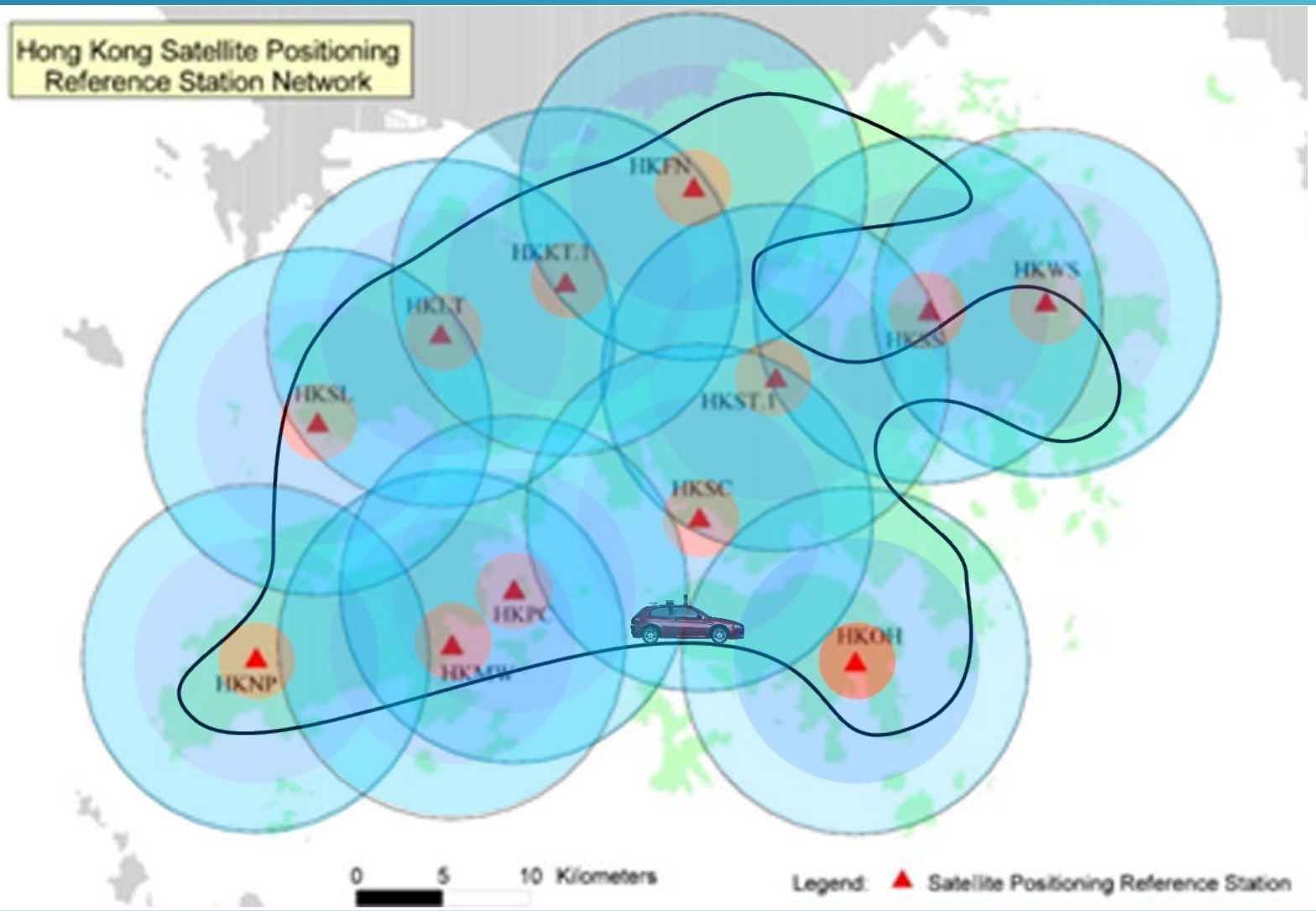


Pilot MMS vs Full Scale MMS in Direct Geo-referencing



	Pilot MMS	Full Scale MMS
GPS Antenna	✓	✓
Tilting Sensor	✓	✗
INS	✗	✓
Second GPS Antenna	✗	✓ (Optional)
Distance Measurement Indicator (DMI)	✗	✓ (Optional)

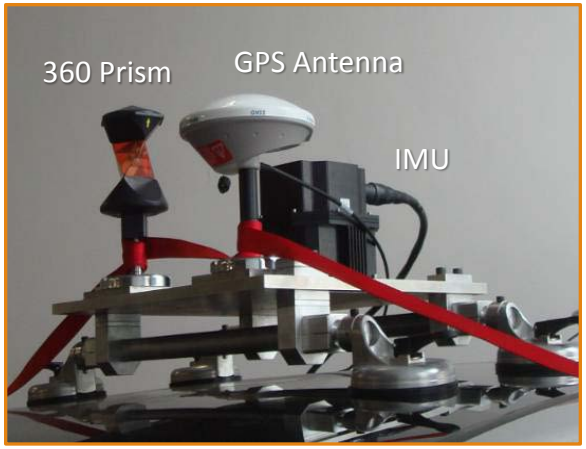
Part 3 - Mobile Mapping System (MMS) Project



Courtesy of Lands Department

Part 3 - Mobile Mapping System (MMS) Project

Trial Test on GPS / INS Integration



Part 3 - Mobile Mapping System (MMS) Project

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Trial Results

Distance between D and H ~ 1500m

Accuracy improved with a maximum of 0.3m by inputting ground control points

Require less ground control points vs pilot MMS project

Future work

Point	Cumulated GPS outage before GPS fixed	Without ground control point				With ground control point				Remark
		dN	dE	dHeight	Linear_NE	dN	dE	dHeight	Linear_NE	
B	N/A	-0.011	-0.014	0.088	0.018	0.000	-0.016	0.035	0.016	
D	80s	0.162	-0.084	-0.179	0.182	-0.009	0.009	-0.010	0.013	Fixed
F	N/A	-0.003	-0.011	0.128	0.011	-0.024	-0.012	0.099	0.027	
G	187s	-0.509	-0.301	-0.060	0.591	-0.252	0.036	0.196	0.255	Improved
H	346s	0.070	-0.682	-0.361	0.686	-0.019	0.030	0.003	0.036	Fixed

Part 3 - Mobile Mapping System (MMS) Project

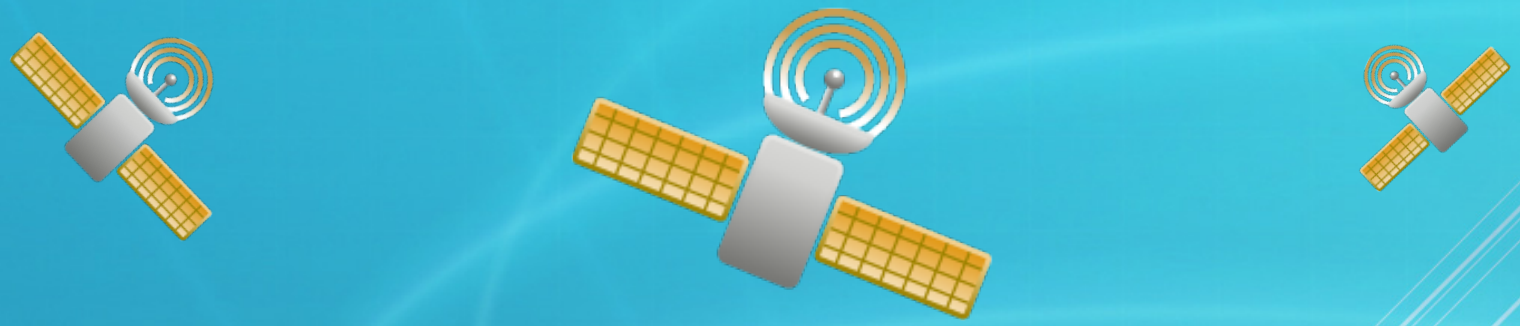
Conclusion and Future work

A little start of experiencing the integration of GPS/INS

More in-depth study on the technology

Derive the survey methodology for direct Geo-Referencing by using GPS+INS

Part 3 - Mobile Mapping System (MMS) Project



Thank you