

衛星定位基礎設施 – 新的服務和應用

Satellite Positioning Infrastructure New Services and Applications

郭志和 Simon Kwok

地政總署 Lands Department

20.2.2013



摘要

- 香港的衛星定位基礎設施
- 新的GPS + GLONASS數據服務
- 新應用

Summary

- The Hong Kong Satellite Positioning Infrastructure
- The new GPS + GLONASS Data Services
- New Applications



香港的衛星定位基礎設施由兩部份組成：

- 被動控制系統



The Hong Kong Satellite Positioning Infrastructure consists of two parts :

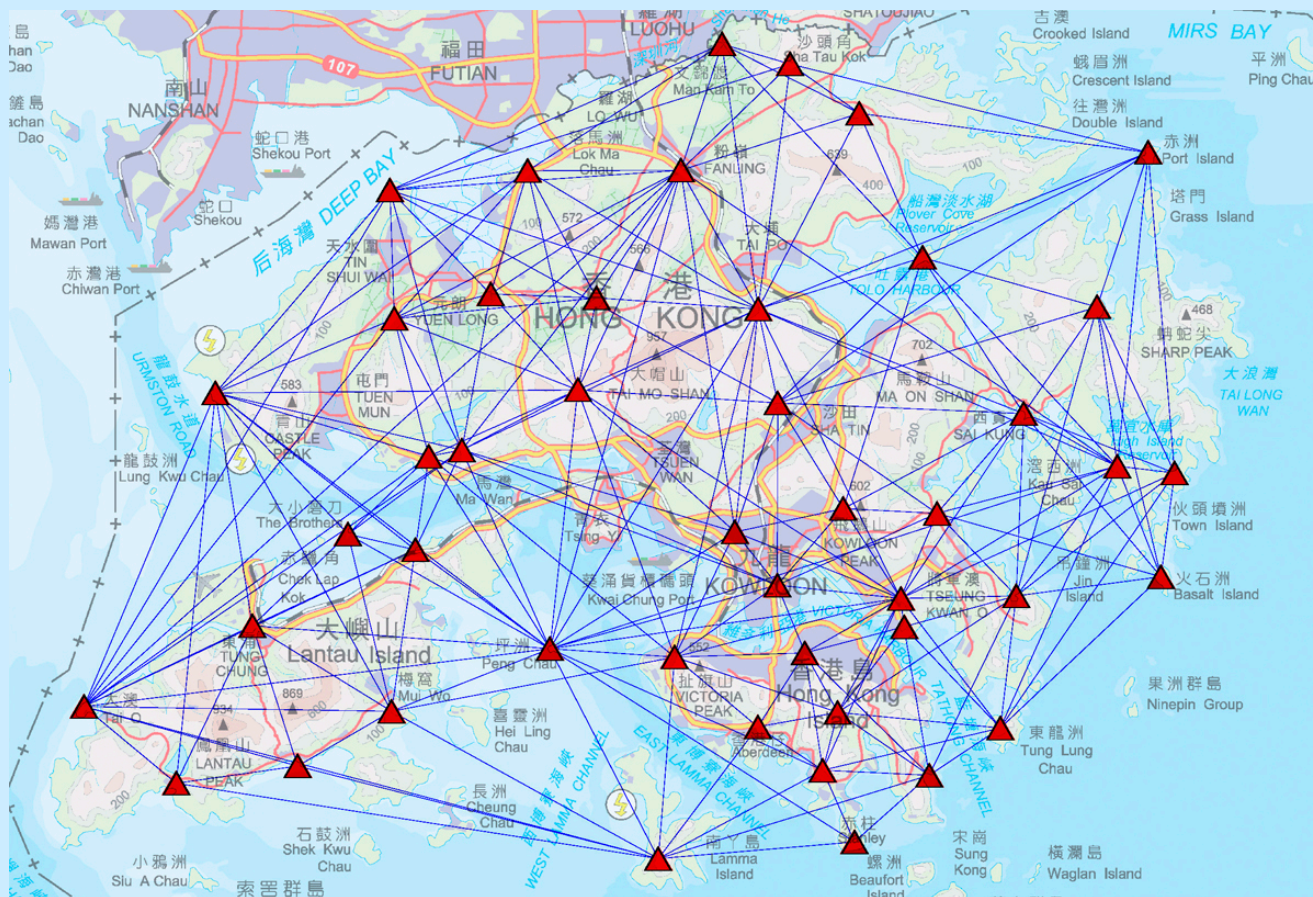
- Passive Control System

- 主動控制系統



- Active Control System

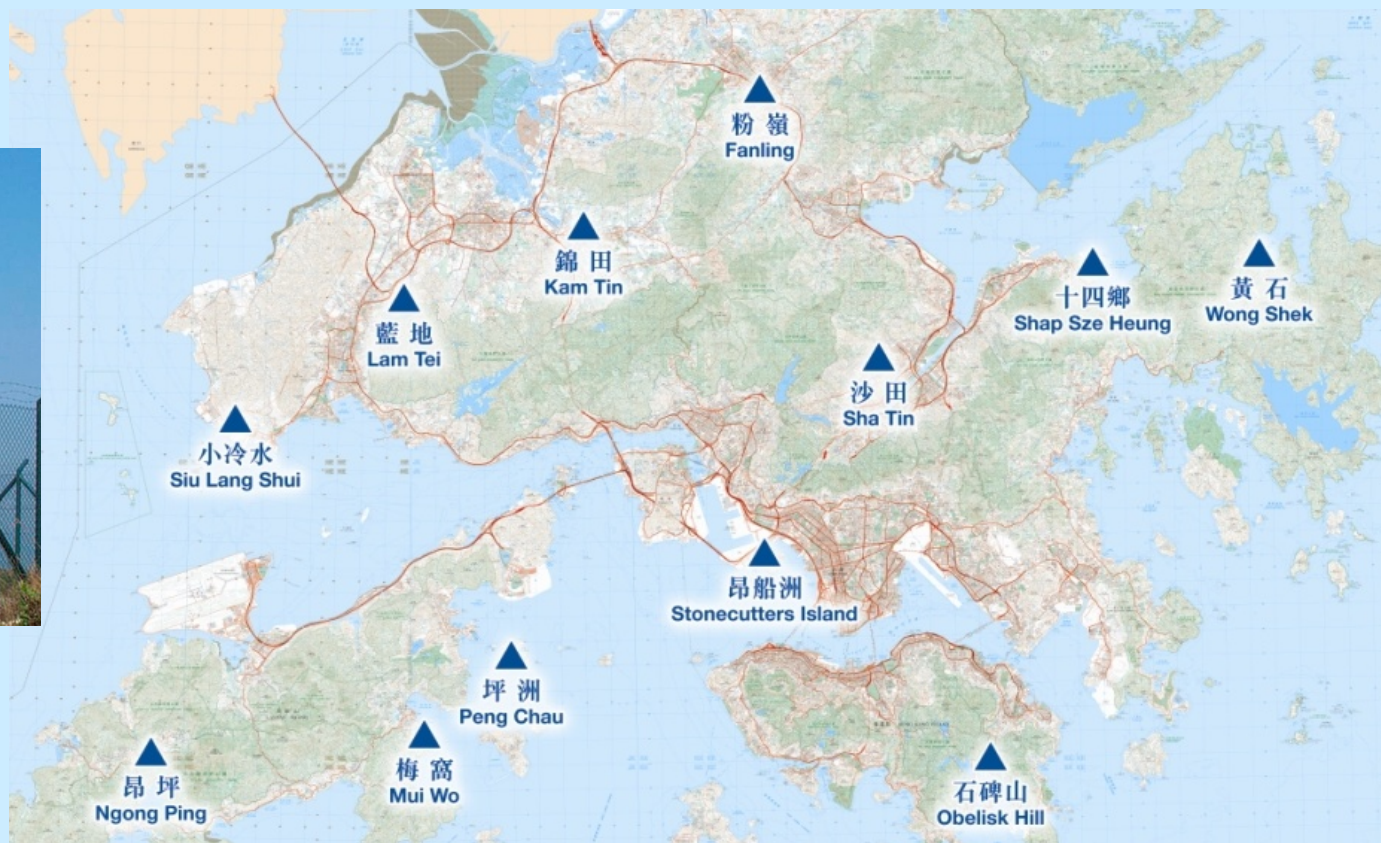
被動控制系統 Passive Control System



香港2000衛星定位控制網。 46 個控制點。

The Hong Kong 2000 satellite positioning control network. 46 stations.

主動控制系統 Active Control System



香港衛星定位參考站網。 12 個連續運作的參考站。

The Hong Kong Satellite Positioning Reference Station Network.
12 Continuously Operating Reference Stations.

主動控制系統 Active Control System

香港衛星定位參考站網
The Hong Kong Satellite Positioning
Reference Station Network



遙控
Remote
Control

控制中心
Control Centre



數據
Data

用戶
Users

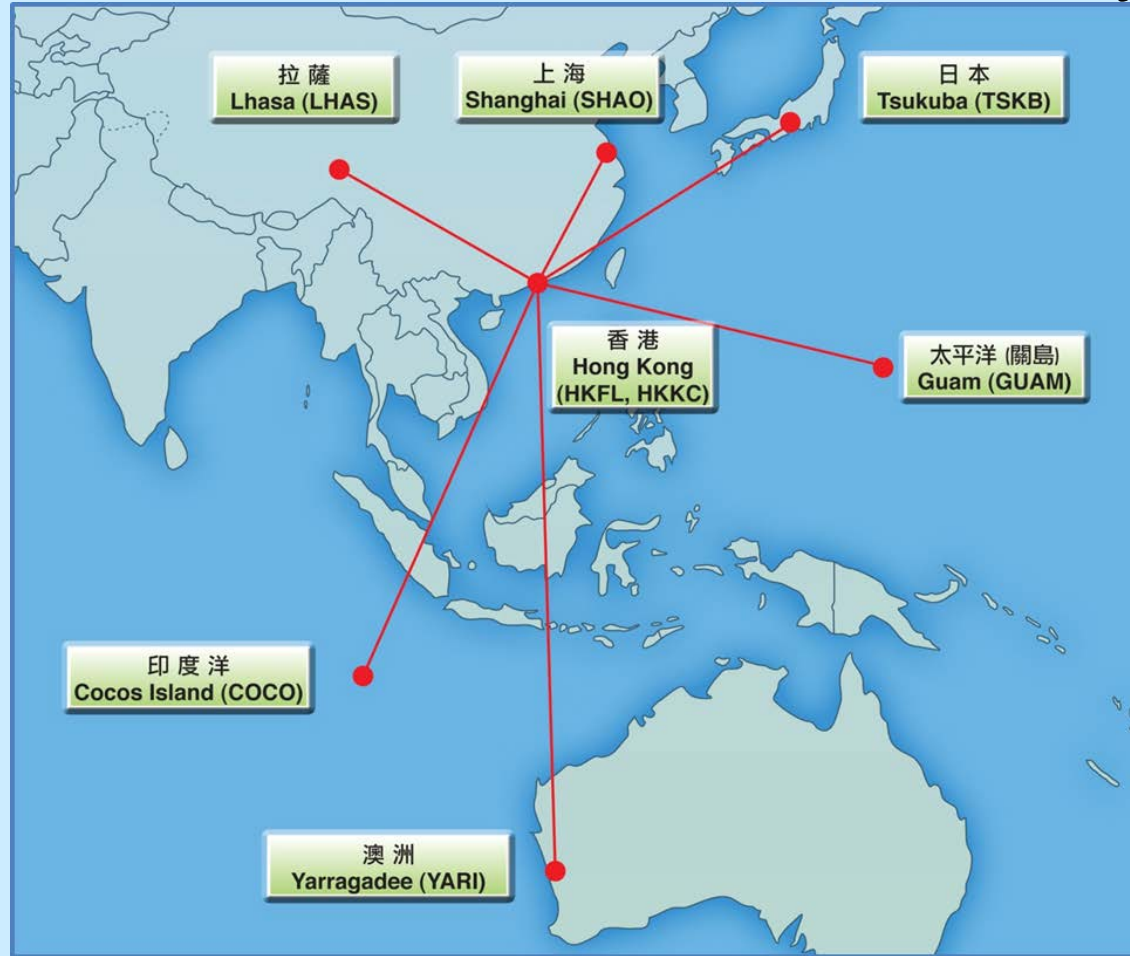
數據
Data



數據中心
Data Centre

遙控
Remote Control

主動控制系統 Active Control System

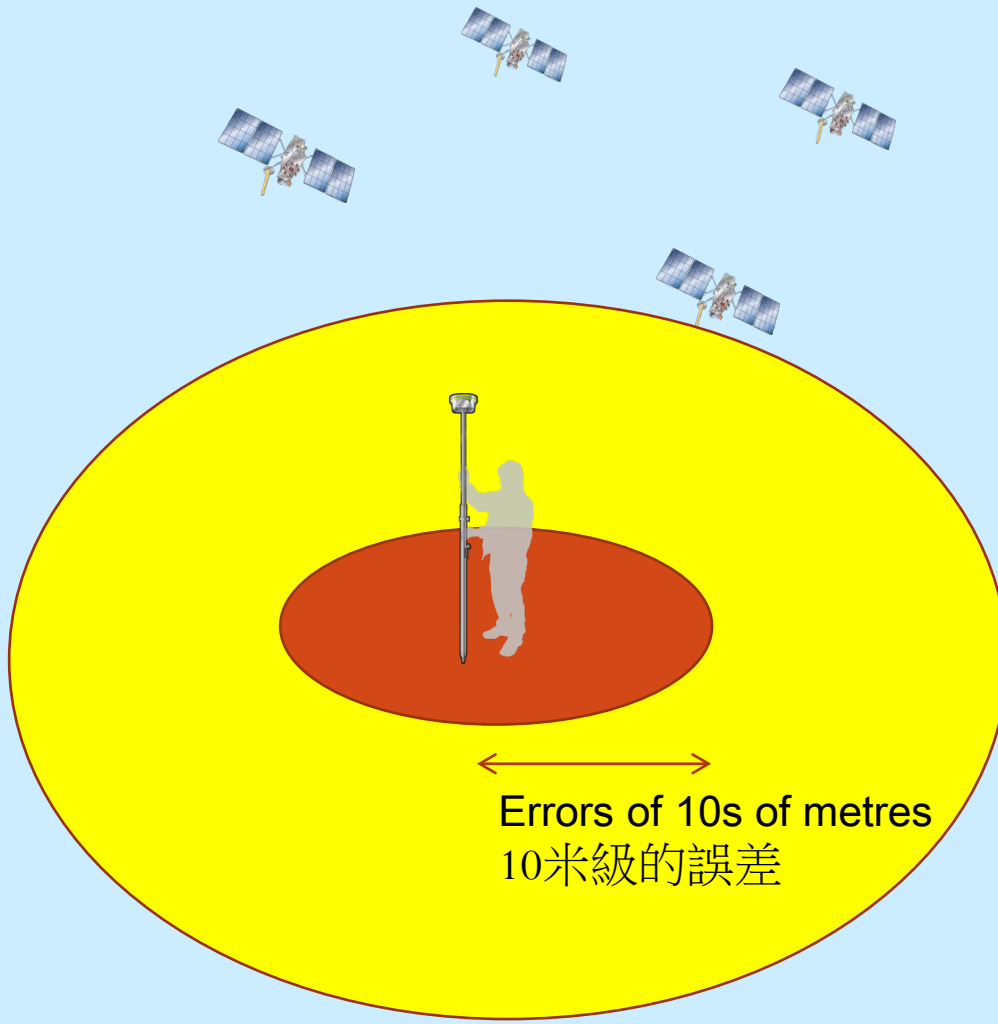


香港衛星定位參考站將香港的大地測量基準聯系到國際地球參考框架

The satellite positioning reference stations linked the Hong Kong Geodetic Datum to the International Terrestrial Reference Frame

單點定位的誤差量

The Magnitude of Error for Single Point Positioning



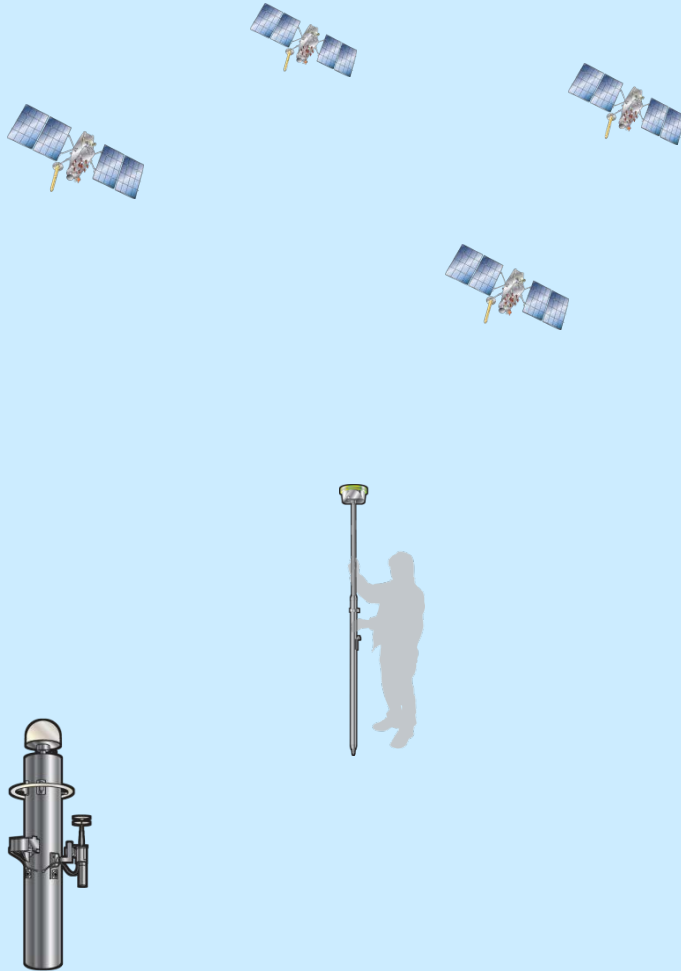
衛星鐘差
接收機鐘差
電離層誤差
對流層誤差
多路徑效應

Satellite Clock Bias
Receiver Clock Bias
Ionospheric Error
Tropospheric Error
Multipath Effect

Error due to difference in geodetic datum may up to 100s of metres
因不同的大地基準，可帶來百米級的誤差

利用參考站來提升定位的準確度

Improve Positional Accuracy with Reference Station



- **RINEX 數據** (用於高精度的後處理定位)
- **網路實時動態 (RTK) 數據** (用於厘米級精度的實時定位)
- **差分定位 (DGPS) 數據** (用於米級精度的實時定位)
- **RINEX Data Service** (For highly accurate applications using the data for post processing)
- **Network RTK Data Service** (For centimetre-level accuracy real time applications)
- **DGPS Data Service** (For metre-level accuracy real time applications)

數據服務的用戶

Users of the Data Services

Government Department Users

- Agriculture, Fisheries and Conservation Department
- Civil Engineering and Development Department
- Civil Aviation Department
- Drainage Services Department
- Environmental Protection Department
- Highways Department
- Hong Kong Observatory
- Housing Department
- Lands Department
- Marine Department
- Planning Department
- Water Supplies Department
- The Government of Macao SAR, Cartography and Cadastre Bureau

政府部門的用戶

- 漁農自然護理署
- 土木工程拓展署
- 民航處
- 渠務署
- 環境保護署
- 路政署
- 香港天文台
- 房屋署
- 地政總署
- 海事處
- 規劃署
- 水務署
- 澳門特別行政區政府地圖繪製暨地籍局

Private Companies - Construction, Surveying, Telecommunication, Logistic.

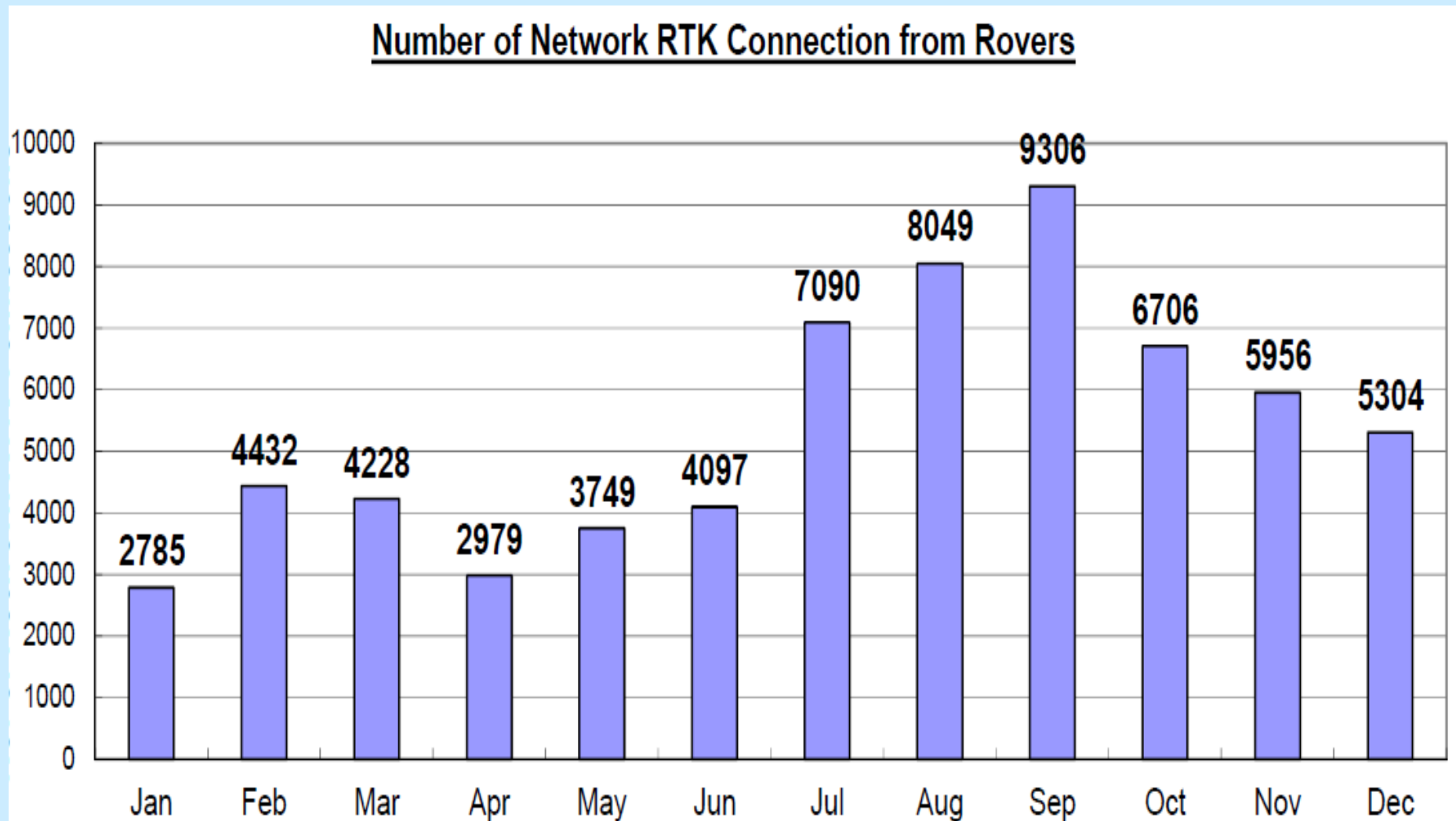
私人機構的用戶主要是與工程建造、測量、電訊、物流有關的公司

Academic and Research Institutes

大專院校和究研中心亦是重要用戶

RTK 數據使用率 (2012年1月至12月)

RTK Data Utilization Statistics (Jan to Dec 2012)



新服務 New Services

GPS + GLONASS
參考站數據 Reference Station Data



全球衛星導航系統

Global Navigation Satellite Systems

(GPS) Global Positioning System

- USA
- Global Coverage
- Fully operational

GPS 全球定位系統

- 美國
- 全球覆蓋
- 全面運作

(GLONASS) Global Navigation Satellite System

- Russia
- Global Coverage
- Fully Operational

GLONASS 全球衛星導航系統

- 俄羅斯
- 全球覆蓋
- 全面運作

(BDS) BeiDou Navigation Satellite System

- China
- Asia Pacific Region (offering services to customers since December 2102)
- System with Global Coverage (under construction)

BDS 北斗衛星導航系統

- 中國
- 於2012年12月開始向亞太區用戶提供服務
- 全球系統正在構建

Galileo

- European Union
- Global Coverage (system under construction)

Galileo 伽利略定位系統

- 歐盟
- 全球覆蓋 (系統正在構建)



全球定位系統

Global Positioning System (GPS)

The Global Positioning System (GPS) consists of 31 satellites with altitude of 20,200 km above the Earth. The satellites are flying in 6 orbital planes with 55 degrees inclination.

GPS was developed and managed by the Department of Defense for US Government since 1973. The early generation of satellites was Block I which was then developed into Block II and Block III. The latest operational satellite, GPS IIF-3, was launched on 4 October 2012.

The new civilian signal L5 is now available in addition to L1 C/A and L2C. The fourth civilian signal L1C will be available in 2015.

美國的全球定位系統(GPS)由31顆衛星組成，飛行高度離地球20,200公里，在6個軌道平面上運行，軌道的傾斜角為55度。

整個系統由美國政府國防部於 1973 年開發和管理。早期的衛星為 Block I 型號，其後發展成 Block II 和 Block III。最新已運行的衛星 GPS IIF-3 在 2012 年 10 月 4 日發射升空。

現在除 L1 C/A 和 L2C 兩個民用訊號外，新的民用訊號 L5 也可供使用。而第四個民用訊號 L1C 將在 2015 年提供服務。



全球衛星定位導航系統

Global Navigation Satellite System (GLONASS)

Global Navigation Satellite System (GLONASS) consists of 23 operational satellites with altitude of 19,100 km above the Earth. The satellites are flying in 3 orbital planes with 65 degrees inclination.

GLONASS was developed by the former Soviet Union since 1982 and managed by the Russian Aerospace Defence Forces for the Russian Government. The early generation of satellites was GLONASS which was then developed into GLONASS-M and GLONASS-K. The latest GLONASS-M satellite, 746, was launched on 28 November 2011.

The new satellite signal L3 is now available in addition to L1 and L2.

俄羅斯全球衛星定位導航系統由23顆已運行的衛星組成，飛行高度離地球19,100公里，在3個軌道平面上運行，軌道的傾斜角為65度。

系統自1982年由前蘇聯開發後，現由俄羅斯政府航空航天防衛部隊管理。衛星的發展，由最早期的GLONASS衛星，已發展成GLONASS-M衛星和GLONASS-K衛星。而最新的GLONASS-M衛星746號，在2011年11月28日發射升空。

現在除L1和L2兩個衛星訊號外，新的衛星訊號L3也可供使用。

GPS + GLONASS

提升定位能力 Improve Positioning Capability

In February 2013, the Lands Department launches the new GPS + GLONASS Reference Station Data Services to improve the capability of the positioning infrastructure.

The system is upgraded to receive signals from the Russian Global Navigation Satellite System (GLONASS) in addition to the American Global Positioning System (GPS) satellite.

With more satellites available, accurate positioning results can be obtained even with limited sky window. Hence the cost efficiency and productivity can be improved.

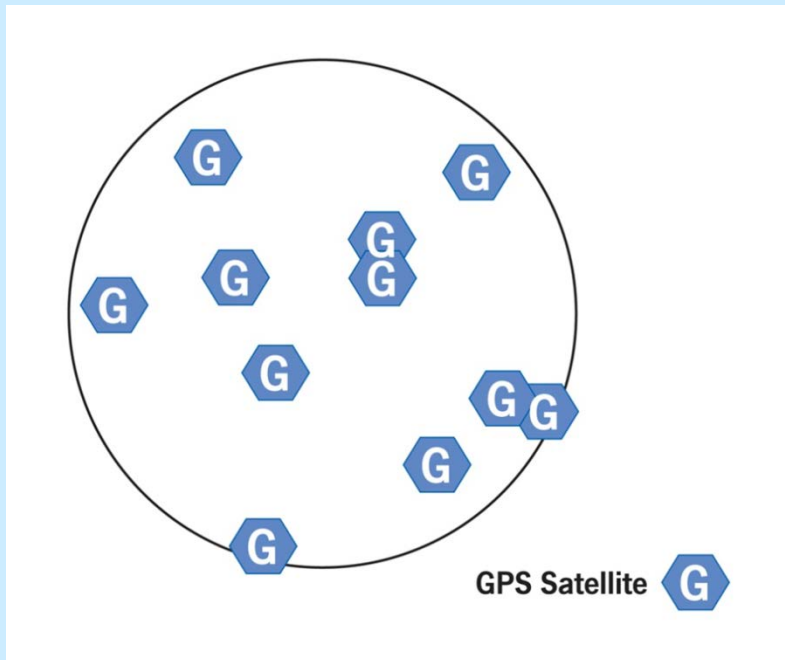
地政總署在2013年2月推出新的GPS+GLONASS參考站數據服務，提升衛星定位基礎設施的功能。

系統除可接收美國全球定位系統 (GPS) 的衛星訊號外，還可接收由俄羅斯全球衛星定位導航系統 (GLONASS) 發出的訊號。

隨著更多衛星可供使用，即使在狹窄的天窗下，仍可獲得準確的衛星定位成果。因而提升生產力及減低運作成本。

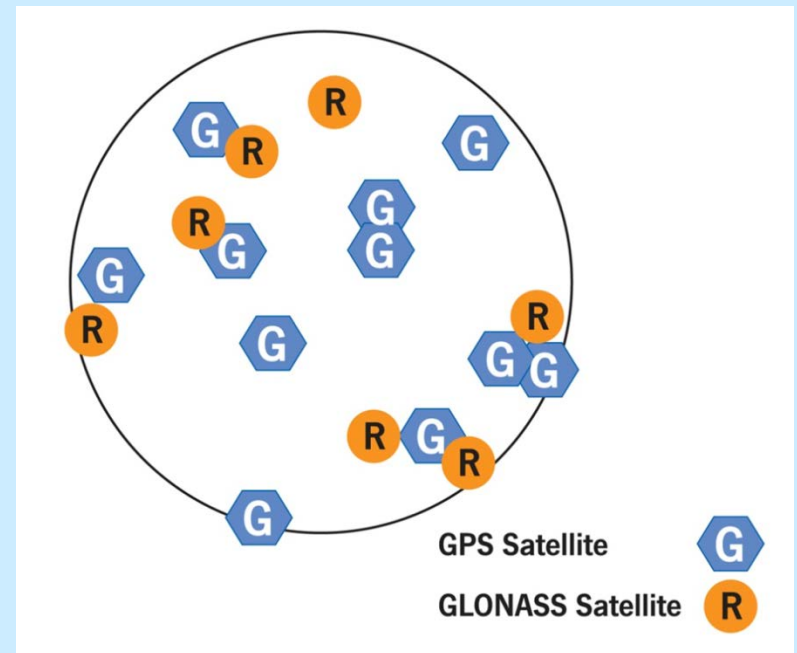
星空圖例子

Example of Sky Plot



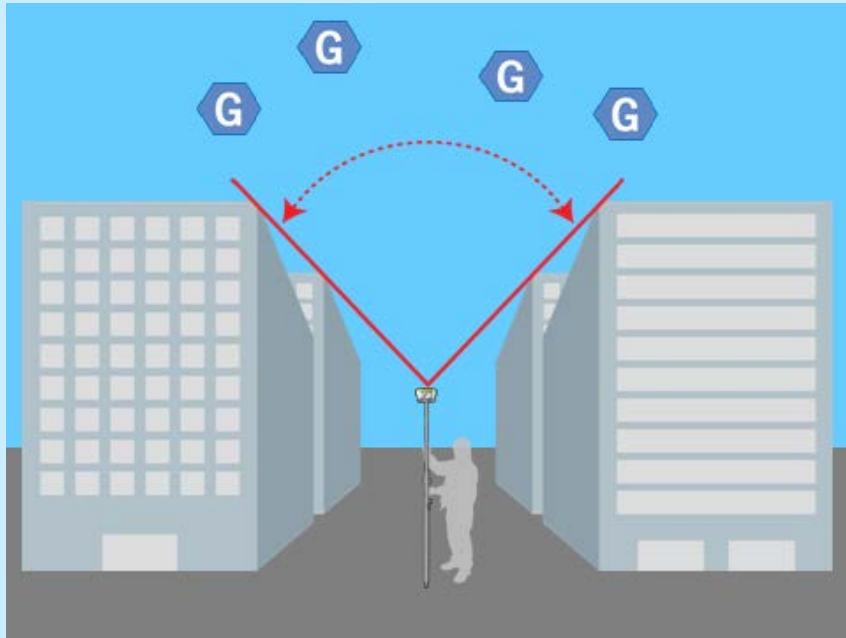
GPS 接收機能跟蹤 11顆衛星

11 satellites were tracked by
GPS receiver

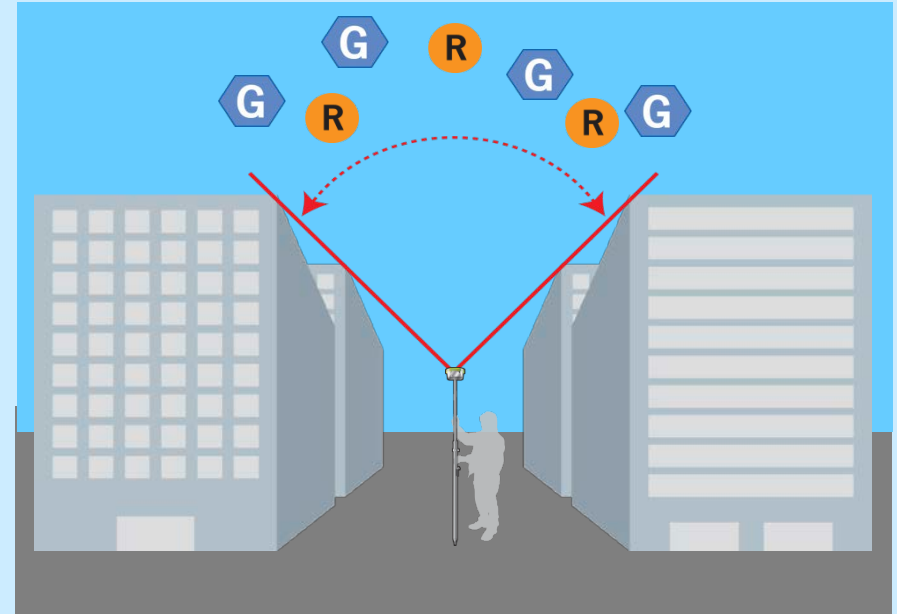


GPS + GLONASS接收機能跟蹤 18顆
衛星（約增加 60% 的衛星數量）

18 satellites were tracked by GPS
+ GLONASS receiver
(about 60% more satellites)



GPS
G

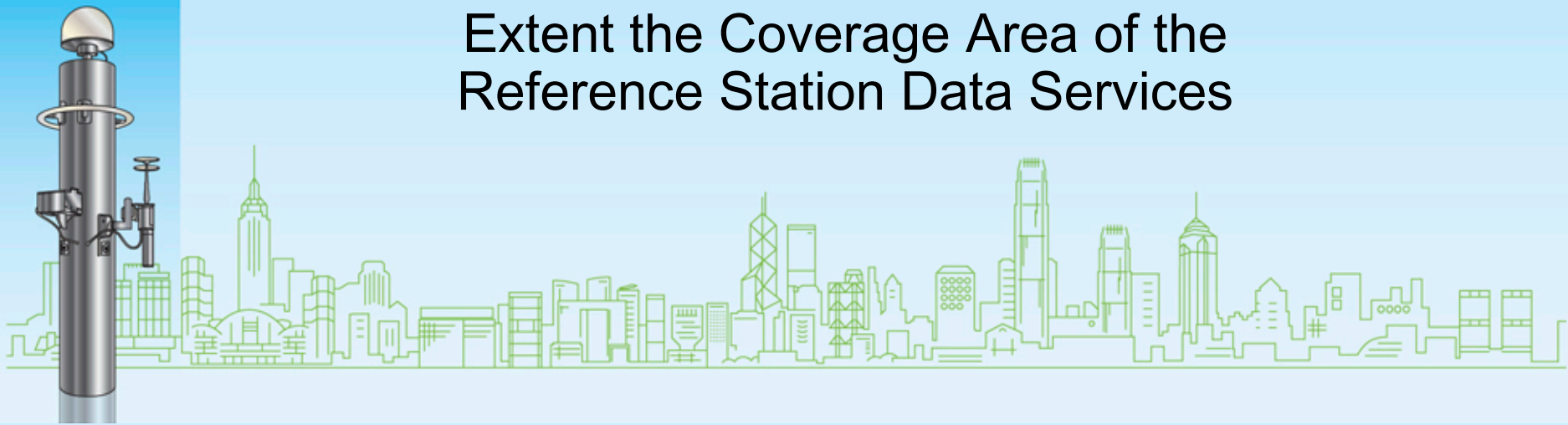


GPS + GLONASS
G R

新服務 New Services

擴大參考站數據服務的覆蓋範圍

Extent the Coverage Area of the
Reference Station Data Services



香港與澳門衛星定位參考站數據共享

Sharing of the Satellite Positioning Reference Station Data of Hong Kong and Macao

Hong Kong and Macao has a long tradition of cooperation in survey and mapping activities.

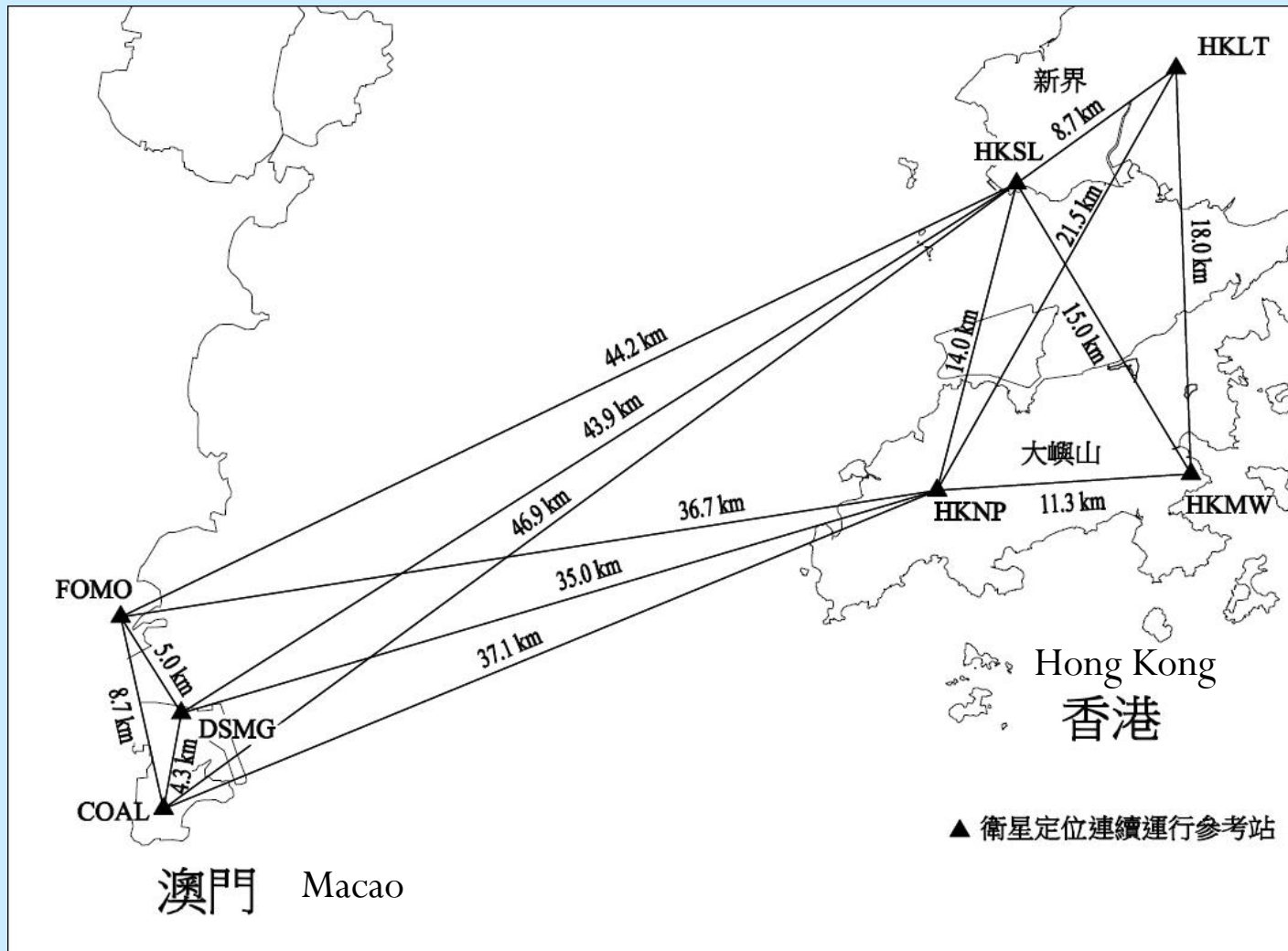
In August of 2012, the Lands Department of HKSAR and the Cartography and Cadastre Bureau of Macao SAR has completed a joint survey to establish the transformation relationship between the Hong Kong Geodetic Coordinate System and the Macao Geodetic Coordinate System.

香港與澳門在測繪方面有悠久的合作傳統。

近期於2012年8月香港地政總署與澳門地圖繪製暨地籍局合作完成了香港澳門測量控制網聯測項目，成功建立了「香港大地座標系」與「澳門大地座標系」的轉換關係。

香港澳門測量控制網聯測

Joint survey of the geodetic network of
of Hong Kong and Macao



建立了「香港大地座標系」與「澳門大地座標系」的轉換關係
Established the transformation relationship between the Hong Kong Geodetic
Coordinate System and the Macao Geodetic Coordinate System

$$\begin{bmatrix} X_2 \\ Y_2 \\ Z_2 \end{bmatrix} = \begin{bmatrix} dX \\ dY \\ dZ \end{bmatrix} + \begin{bmatrix} 1+dS & R_Z & -R_Y \\ -R_Z & 1+dS & R_X \\ R_Y & -R_X & 1+dS \end{bmatrix} \begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix}$$

Macao
澳門

Hong Kong
香港

香港與澳門衛星定位參考站數據共享

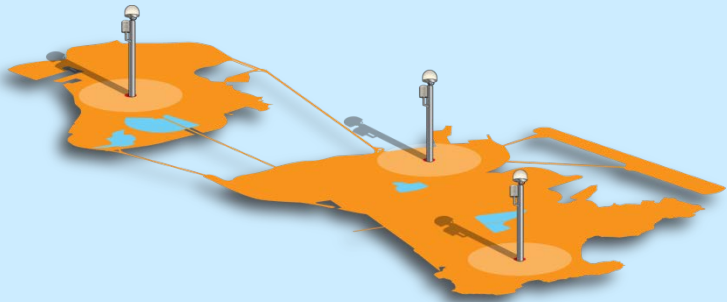
Sharing of the Satellite Positioning Reference Station Data of Hong Kong and Macao

To further the gain from the cooperation, the Lands Department of HKSAR and the Cartography and Cadastre Bureau of Macao SAR will study the feasibility of sharing the reference station data so as to extent the coverage area of the services of each other.

為進一步利用合作的成果，香港地政總署與澳門地圖繪製暨地籍局將會研究共享香港與澳門的衛星定位參考站數據的可行性，以擴大雙方各自參考站數據服務的覆蓋範圍。

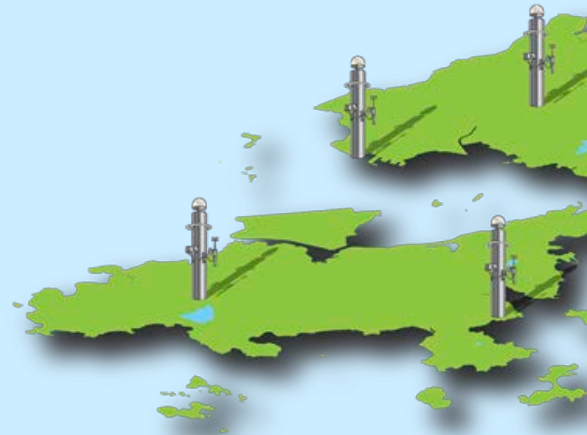
香港與澳門衛星定位參考站數據共享

Sharing of the Satellite Positioning Reference Station Data of Hong Kong and Macao



澳門計劃向香港提供大炮台站、大潭山站、路環最高站的數據。

Macao planned to provide Hong Kong the data of Fortaleza do Monte, Taipa Grande and Coloane Alto.



香港計劃向澳門提供昂坪站、梅窩站、小冷水站、藍地站的數據。

Hong Kong planned to provide Macao the data of Ngong Ping, Mui Wo, Siu Lang Shui and Lam Tei.

新應用 New Applications

香港衛星定位參考站

支援快速移動的數據採集平台

Hong Kong Satellite Positioning Reference
Station Supports Fast Moving Platform for Data Acquisition



衛星定位 配合 慣性導航系統

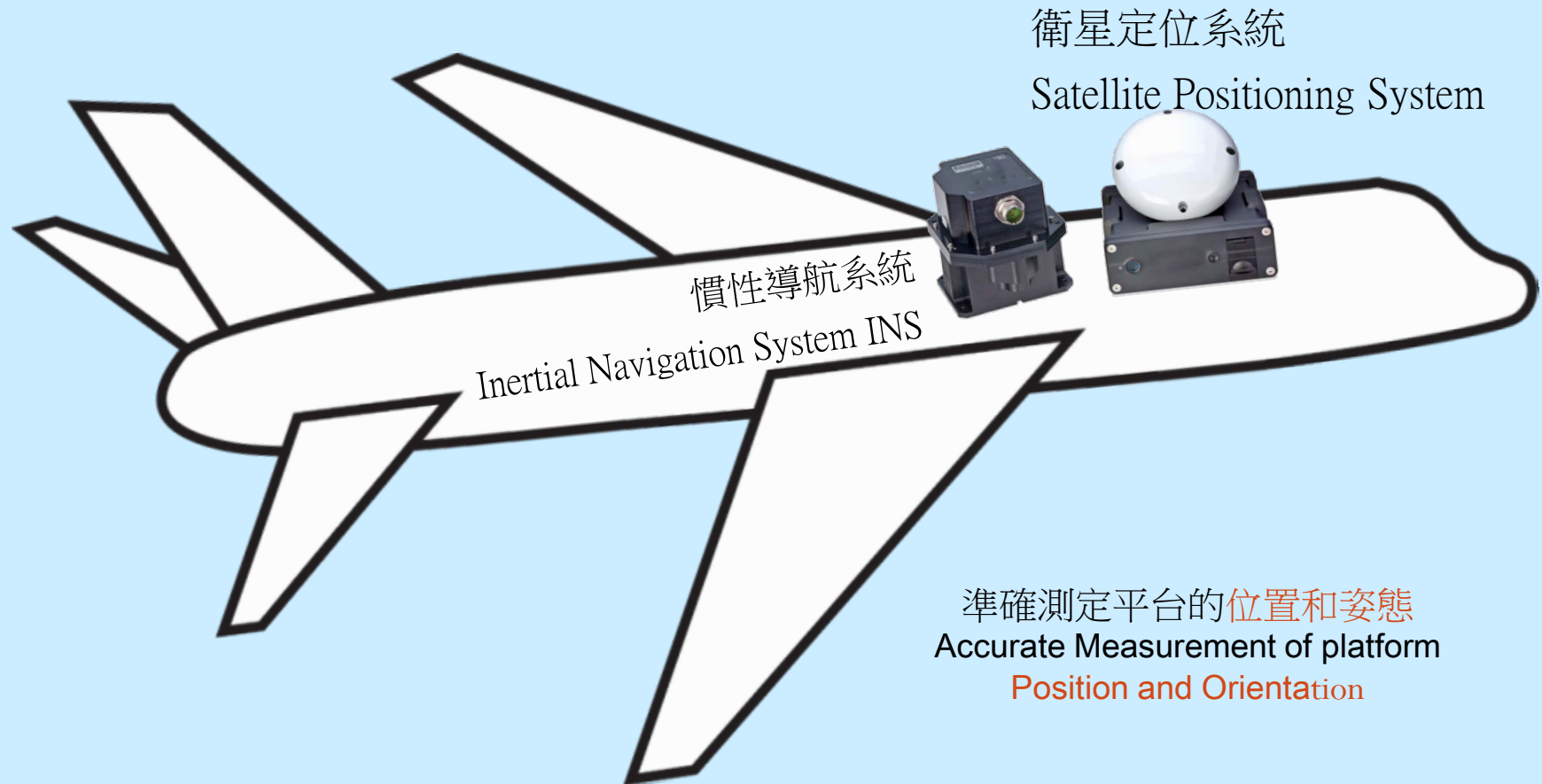
Combine satellite positioning with Inertial Navigation System (INS)

The latest positioning method is to combine satellite positioning with Inertial Navigation System (INS) to determine the position and attitude of the data acquisition platform.

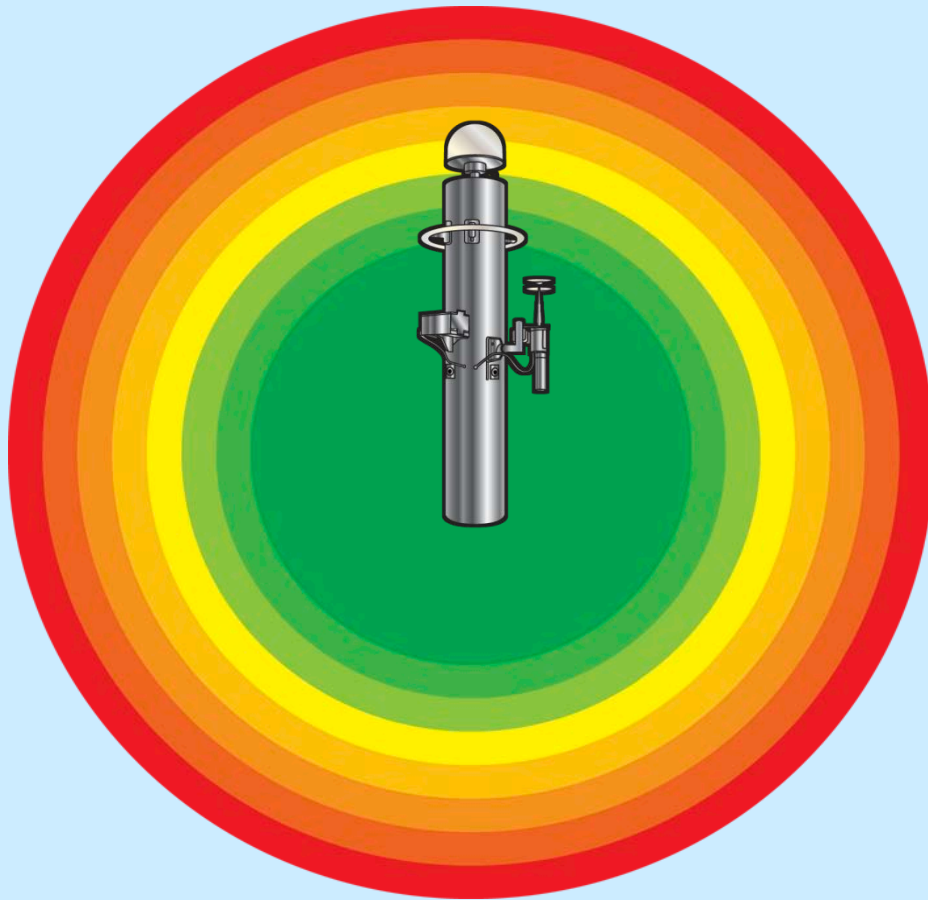
最新的定位方法是以衛星定位配合慣性導航系統（INS）直接測定數據採集平台的位置和姿態。

衛星定位 配合 慣性導航系統

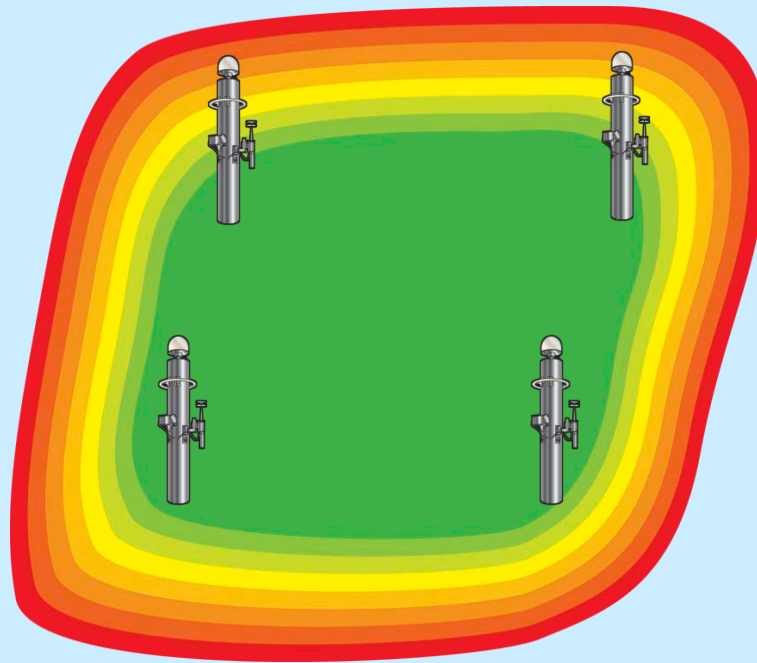
Combine satellite positioning with Inertial Navigation System (INS)
Accurate Measurement of Vehicle Position and Orientation



定位誤差隨基站的距離而增加
Positioning error increases with the distance from the base station

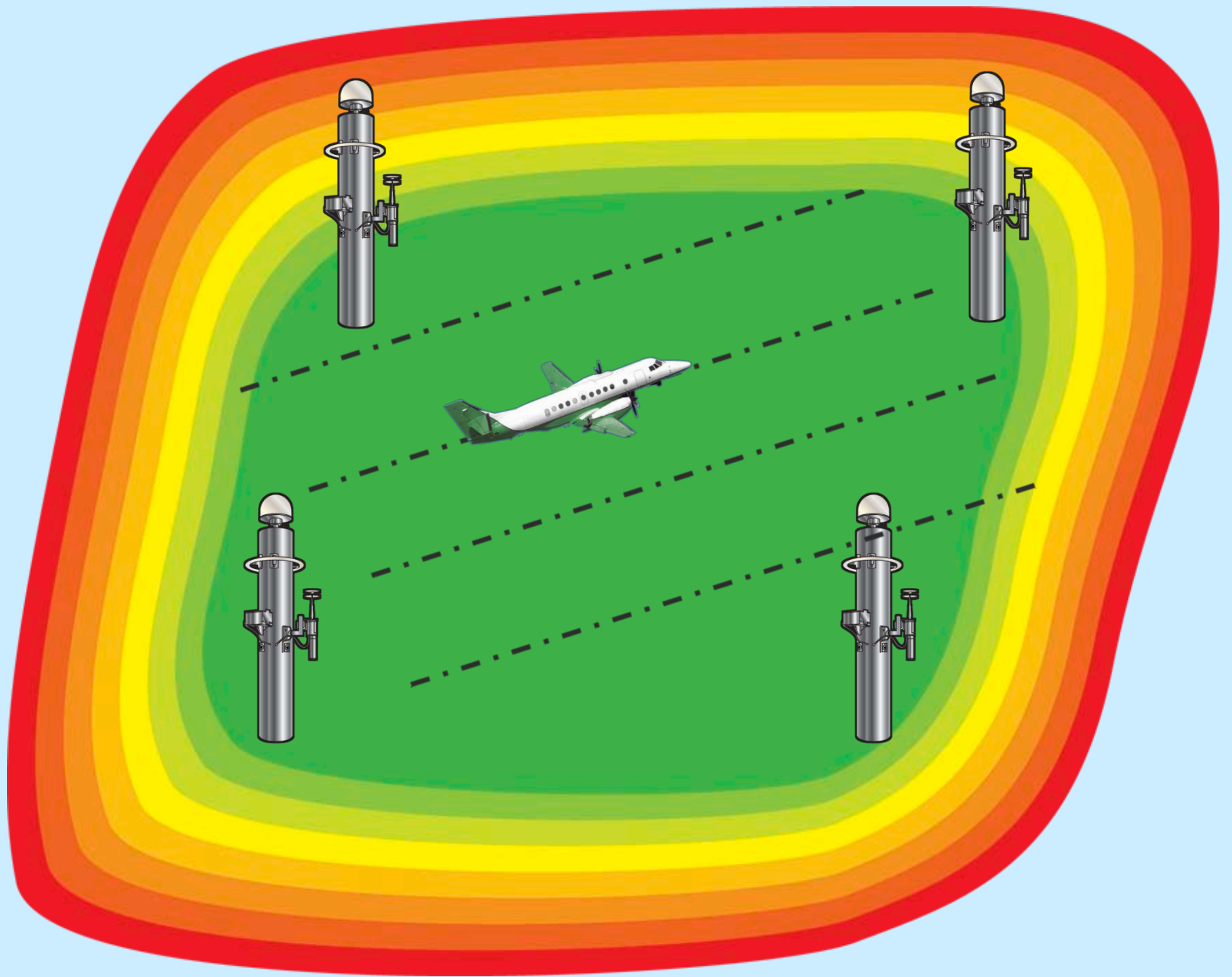


後處理 網絡動態定位 Post-Processed Network Kinematic Solution (Virtual Reference Station)



- Uses a network of reference stations
- Performs ambiguity fixed solution and models Ionospheric error

- 利用參考站網
- 計算模糊度固定解 和 電離層誤差



衛星定位 配合 慣性導航系統

Combine satellite positioning with Inertial Navigation System (INS)

The Hong Kong Satellite Positioning Reference Station Data Services supports fast moving platforms, for example:

- aircraft (Airborne Light Detection and Ranging, LiDAR and Aerial Photography)
- vehicle (Mobile Mapping System, MMS)
- vessel (Vessel-Based Mobile Mapping System, VMMS).

These systems collect accurate and high density geospatial data covering a large area quickly.

香港衛星定位參考站可以支援高速移動的數據採集平台，例如：

- 飛機（機載激光雷達測量 LiDAR、航空攝影）
- 車輛（車載流動測圖系統 MMS）
- 船隻（船載流動測圖系統 VMMS）。

這些系統可在短時間內獲取大範圍、高密度和精確的地理空間信息。

快速移動平台：飛機

Fast Moving Platform: Aircraft

Aircraft, equipped with satellite positioning receiver, Inertial Navigation System (INS), Airborne Light Detection and Ranging (LiDAR), Digital Aerial Camera, scans the ground surface and capture photographic images.

The acquired digital terrain model and images can be used to form 3D city model for land management, planning and construction works.

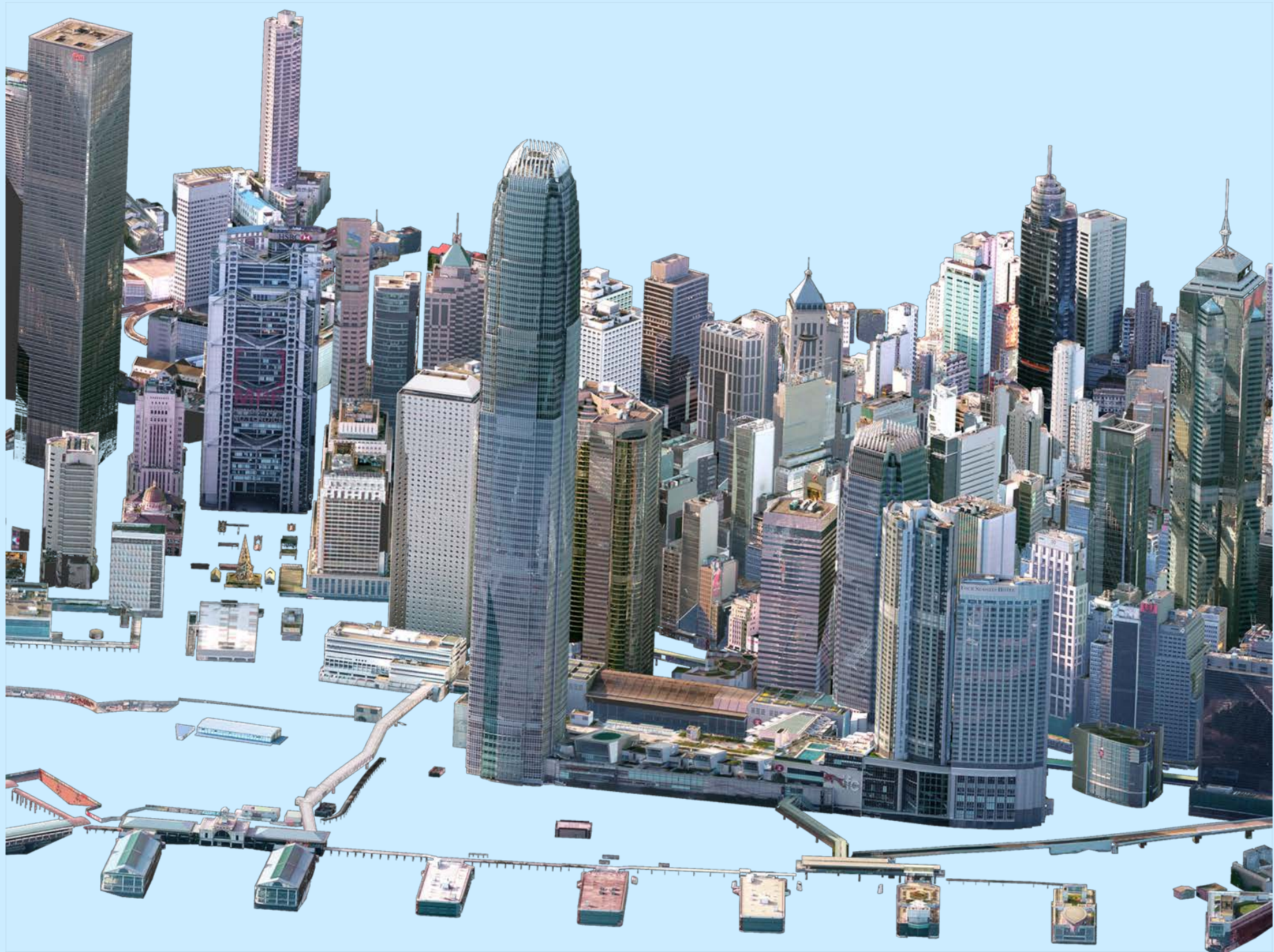
飛機上裝設衛星定位接收機、慣性導航系統（INS）、機載激光雷達（LiDAR）、數碼航空攝影機，從空中掃描地面和拍攝影像。

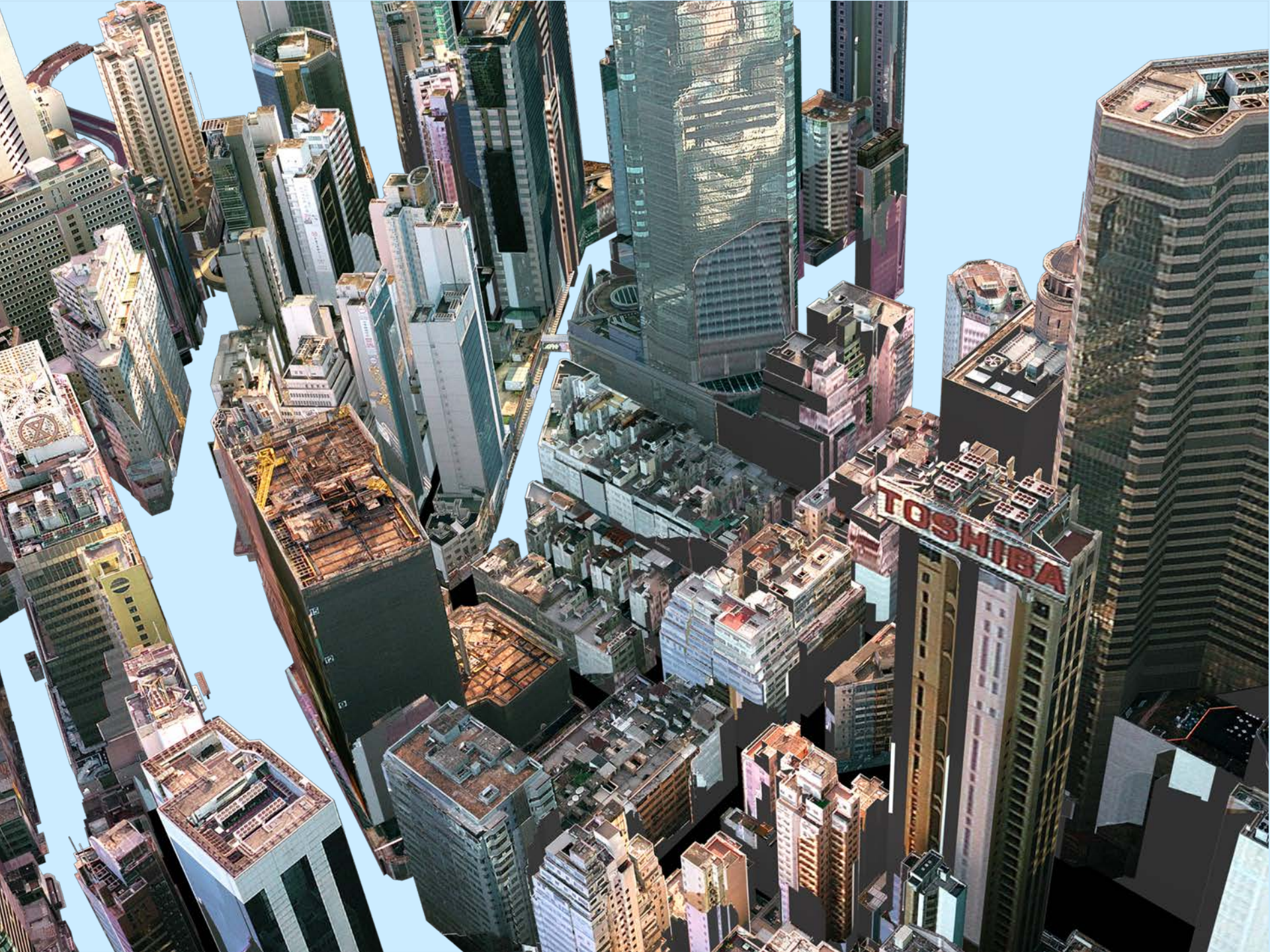
所得到的地表模型可建立三維城市模型，用作土地管理、規劃及建設。

航空攝影
Aerial Photography



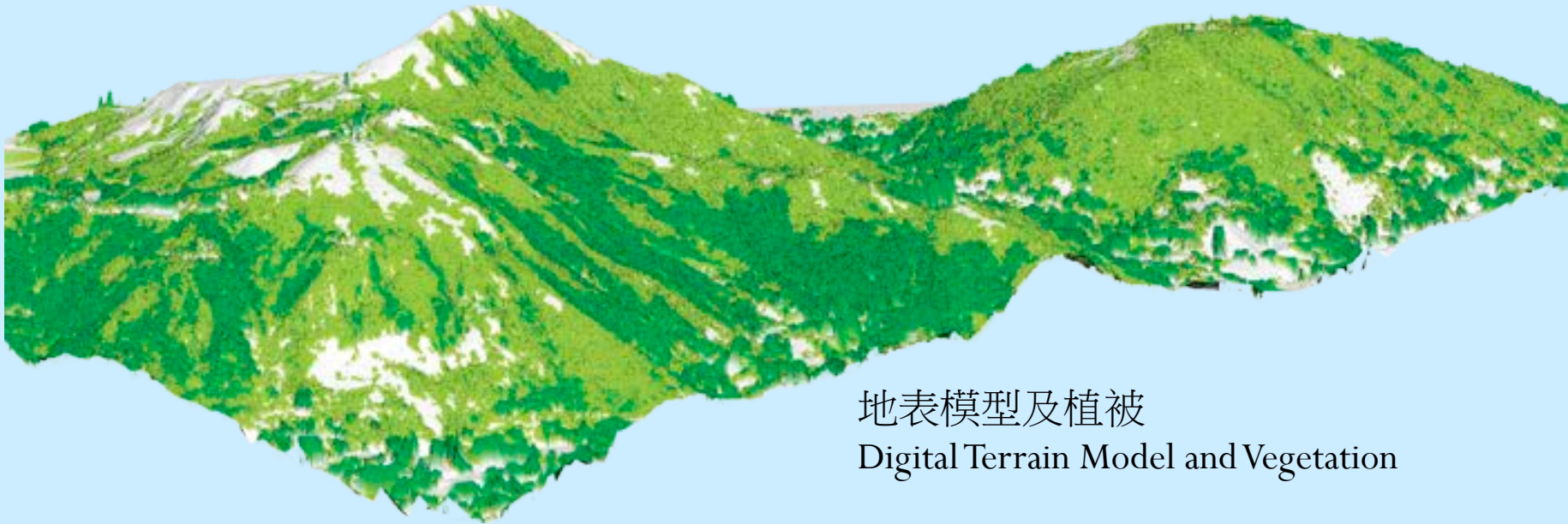
城市三維模型
3D City Model





機載激光雷達測量

Airborne Light Detection and Ranging, LiDAR



地表模型及植被

Digital Terrain Model and Vegetation

快速移動平台：船隻

Fast Moving Platform : Vessel

The satellite positioning system and Inertial Navigation System (INS) determine the position of the vessel.

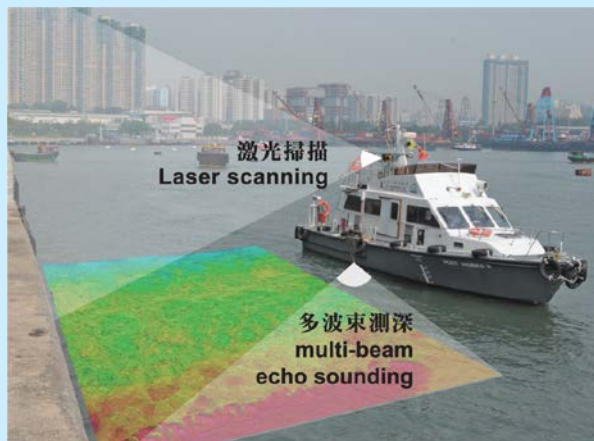
A laser scanner installed in the vessel scans the features above water and the multi-beam echo sounder scans the sub-aqua features.

The collected data are merged together to form a model of the features above and under the water.

船上的衛星定位系統和慣性導航系統（INS）測定船的位置。

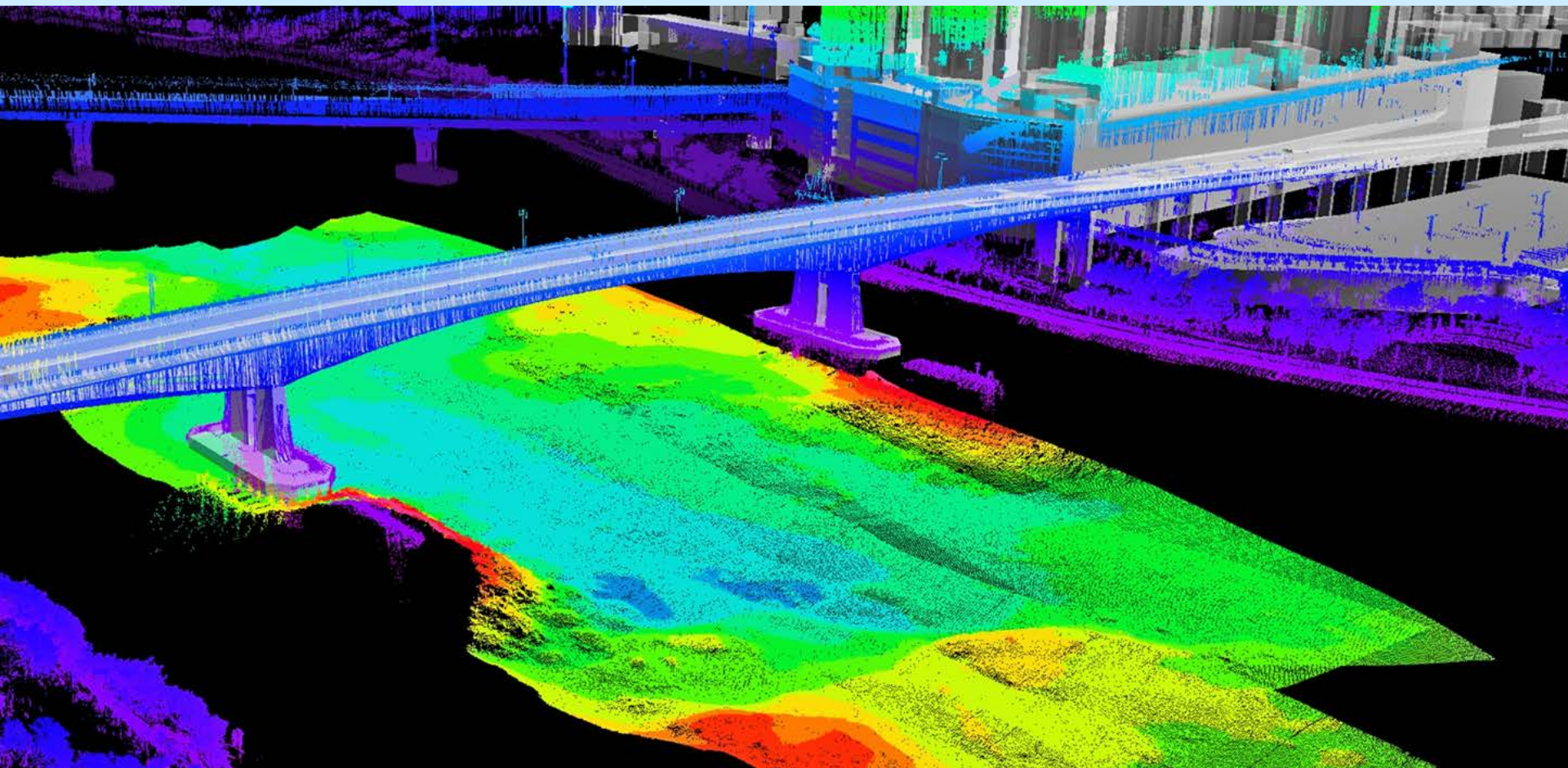
安裝在船上的激光掃描器，掃描岸上的景物。再配合多波束測深儀掃描水底景物。

收集得來的數據，可以繪畫出一個水面和水底景物的影像。



船載流動測圖系統□
Vessel-Based Mobile Mapping System

海底及陸上地貌模型
Model of the features above
and under the water surface



快速移動平台：車輛

Fast Moving Platform : Vehicle

Mobile Mapping System (MMS) technology uses a laser scanner and camera fitted on the vehicle to scan and take photographs of the features along the street.

After processing, the acquired data form a seamlessly 3D geo-referenced .

流動測圖系統(MMS) 是利用安裝在車上的激光掃描器和攝影機，在街道上進行掃描和拍攝。

所得的數據，可以組合出一個立體無縫的街道圖像。



流動測圖系統 □
Mobile Mapping System



街道影像圖
Street View Image



360度街道影像圖
360° Street View Image

謝謝

Thank You