



中央研究院

運用地理資訊處理技術在考古調查研究及數位典藏工作坊
2010. 10. 22

GPS在空間資訊收集與地圖測繪 之運用

張嘉強

清雲科技大學 應用空間資訊系



卡通世界-1

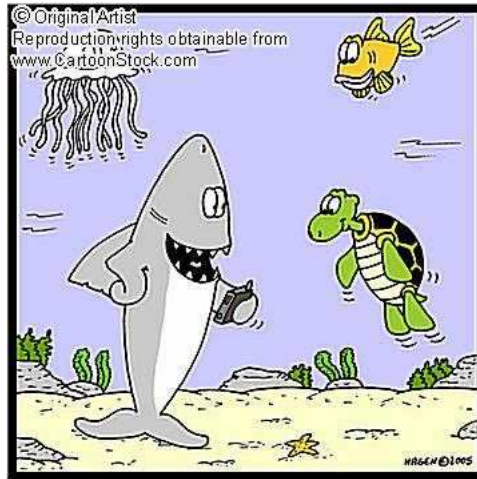


Sorry Charles, but according to my GPS-receiver,
I'm still in my own territory...





卡通世界-2



My Pilot-Fish is on holidays,
so I'm using a GPS System to find my way around...



卡通世界-3



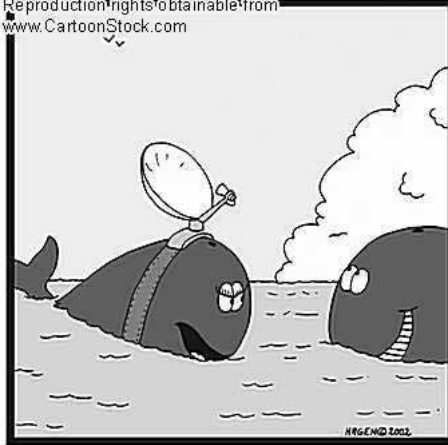
I blame it on the GPS-System myself:
Hardly anybody gets lost around here anymore...



卡通世界-4

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by HAGEN

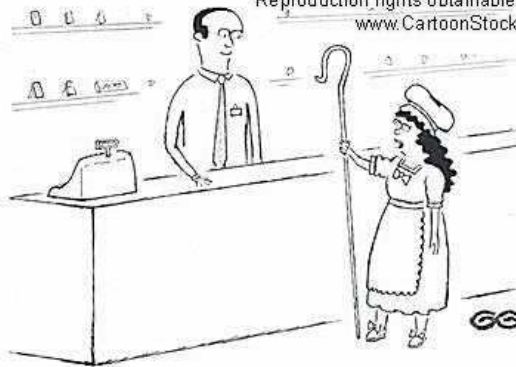


You can laugh all you want, but since I bought this "GPS" system, I haven't beached myself once!



卡通世界-5

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I'D LIKE TO BUY A GPS RECEIVER.

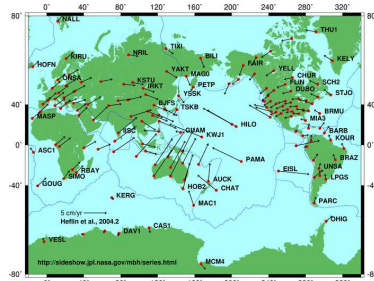


卡通世界內的需求為何？

- 我想知道我可活動的疆界在哪裡
- 我要規劃想去的地方該怎麼走
- 我想知道我現在身處何處
- 我要避免走錯路或迷路
- 我想記錄我的活動路徑
- 我要知道及管理特定目標的行蹤



導航衛星的兩大應用主軸



地球表面測繪及監測

行動載具導航及監控



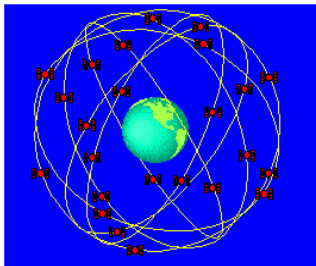


全球導航衛星系統(GNSS)

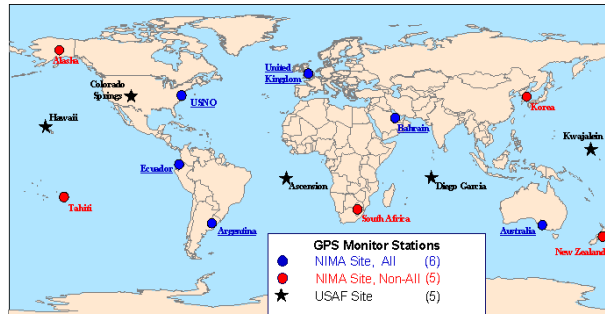
- Global Navigation Satellite Systems
 - Global Positioning System (GPS, USA)
 - GLObal Navigation Satellite System (GLONASS, Russia)
 - Galileo (EU)
 - Beidou/Compass (China)
- Regional Augmentation Systems
 - Quasi Zenith Satellite System (QZSS, Japan)
 - Indian Regional Navigation Satellite System (IRNSS, India)
 - Multi-Constellation Augmentation Service System (MASS, China)



美國-GPS系統



24+3



5+6+5





俄羅斯-GLONASS系統

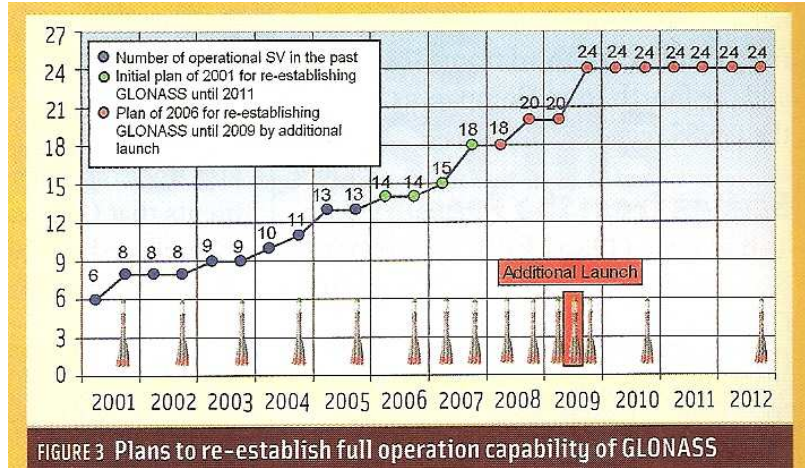
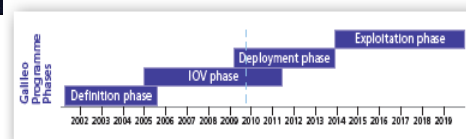
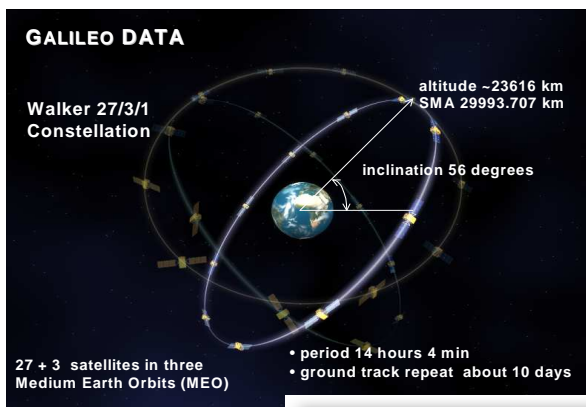


FIGURE 3 Plans to re-establish full operation capability of GLONASS



歐盟-Galileo系統



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中國-Compass系統




<http://www.beidou.gov.cn/>

5顆靜止軌道衛星
+ 30顆非靜止軌道衛星



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日本-QZSS/印度-IRNSS系統

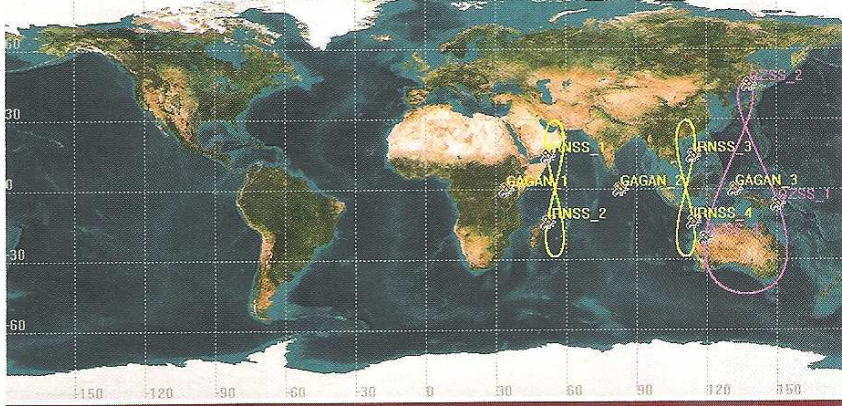


FIGURE 5 Ground Tracks of QZSS and IRNSS.

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that creeps

GPS = 國安 > 國防

Civil Use

“The nation’s reliance on GPS has become an issue of national security – national security in its broadest sense, that goes beyond merely national defense.” – Dr. James Schlesinger, March 1997

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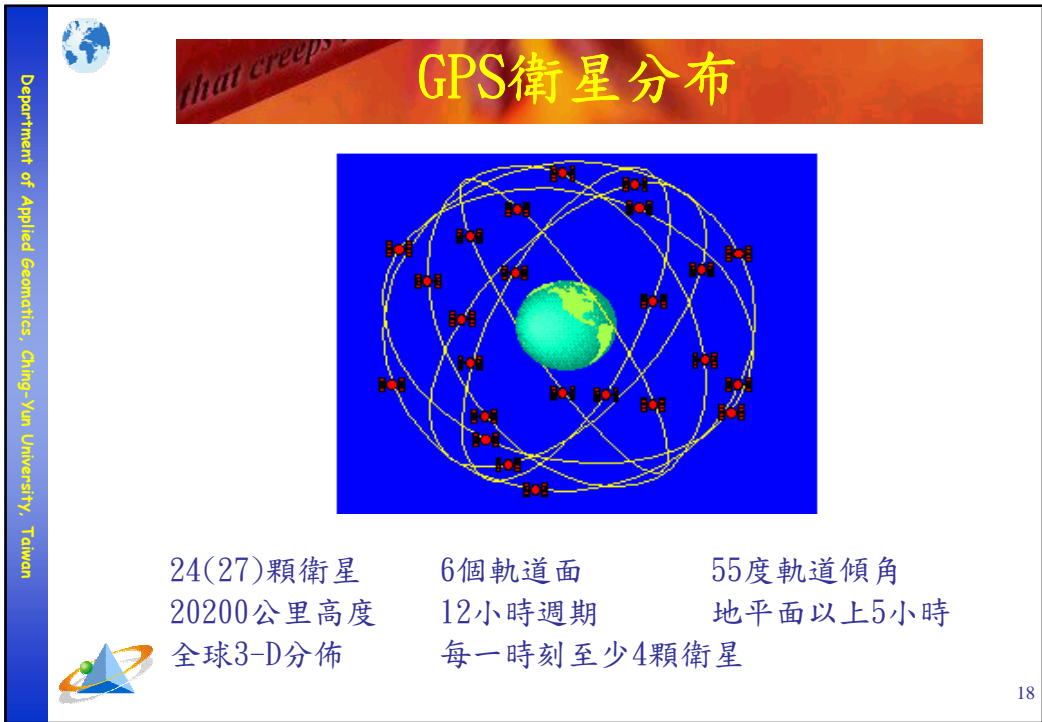
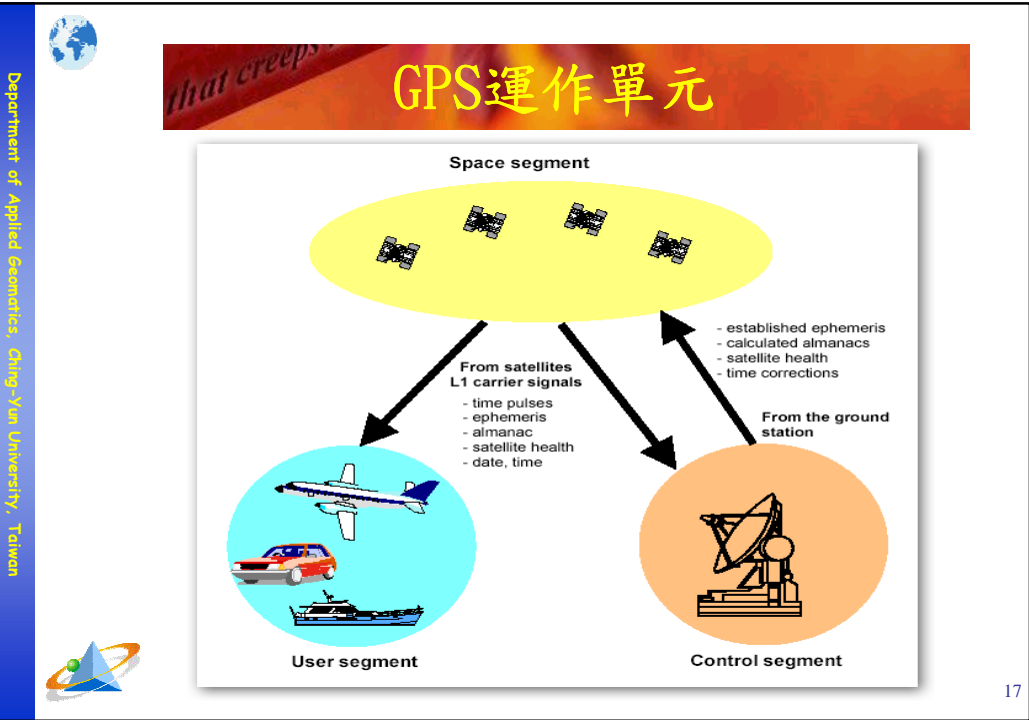
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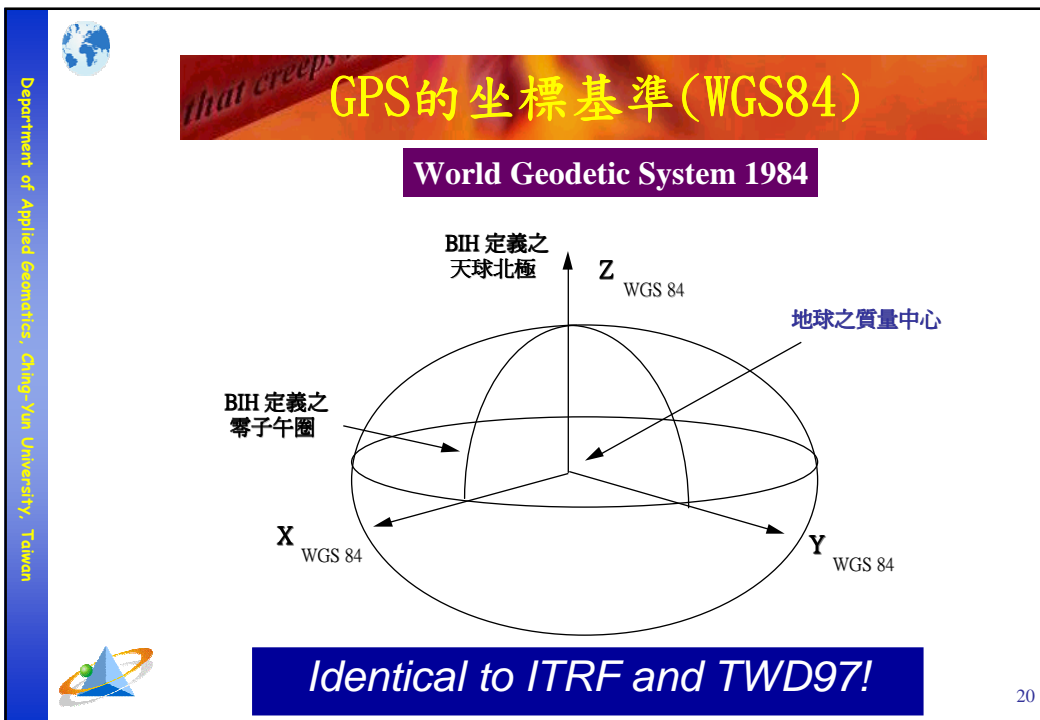
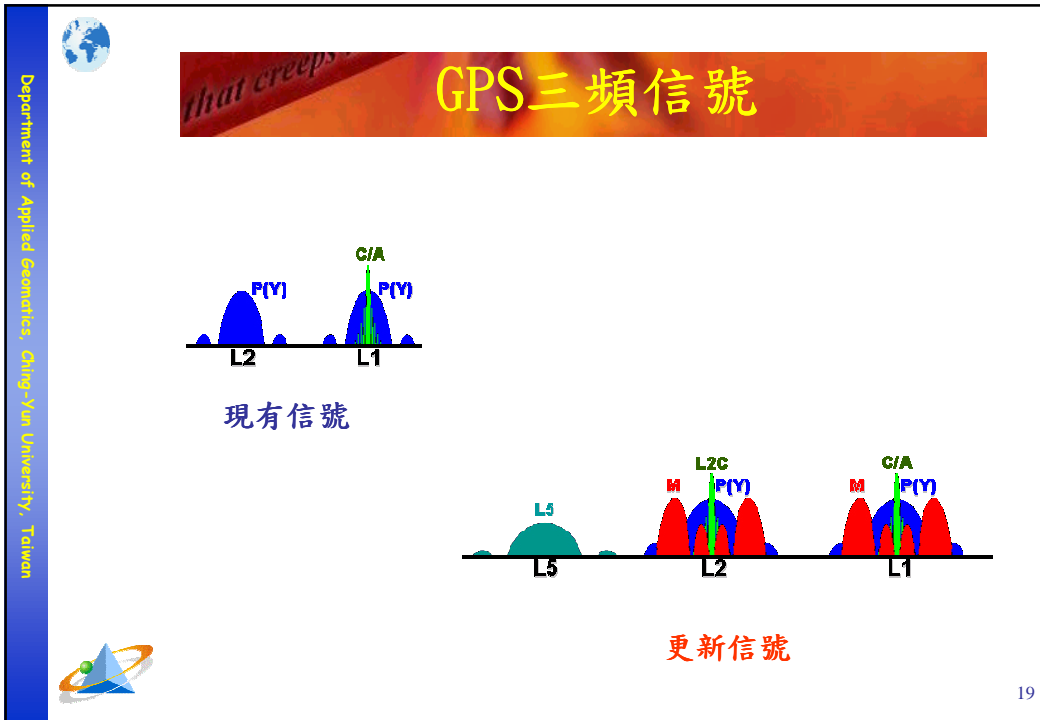
that creeps

GPS基本介紹

- 英文全名 NAVSTAR GPS (NAVigation Satellite with Time And Ranging Global Positioning System)
- 全球性、全天候、24小時運作之衛星導航定位系統
- 美國國防部為軍事目的所發展之系統
- 被動式接收衛星信號以決定使用者之三維坐標及其速度
- 依接收儀種類、使用者運動型態、觀測方法及計算處理技術之不同，其定位精度於1 cm至5 m不等

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地球形狀與大小的表示

Earth Macro image of the earth Geoid (exaggerated form)

物理性-大地水準面(平均海水面)

$$f = \frac{a-b}{a}$$

North pole Rotation South pole

Equatorial plane

Vertical deviation

Earth

Geoid

Ellipsoid

幾何性-橢球面

H (正高) = h (GPS高) - N (大地起伏)

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慣用的全球性坐標值

Ellipsoid North Pole Equatorial plane

Origin z P

x y a b

Greenwich Meridian Equator

三維直角/卡式坐標
(X, Y, Z)

橢球坐標(經/緯/高度)

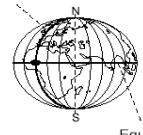
Ellipsoid North Pole Equatorial plane

h p

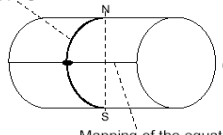
Greenwich Meridian Equator

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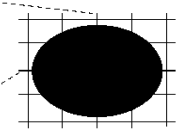
慣用的地區性坐標值



Local spheroid
(Bessel ellipsoid)

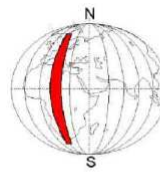


1st step:
projection
onto cylinder

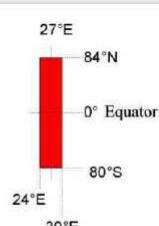


Processing the cylinder:
map with country
co-ordinates

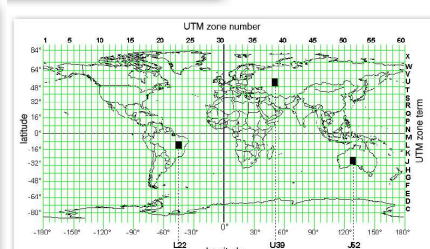
平面投影坐標
(x, y / N, E)



Ellipsoid
for ex. WGS 84



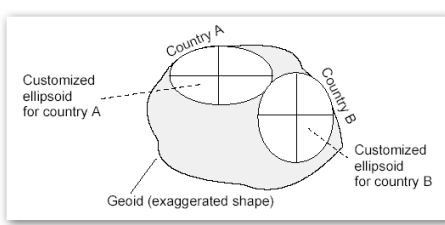
UTM projection



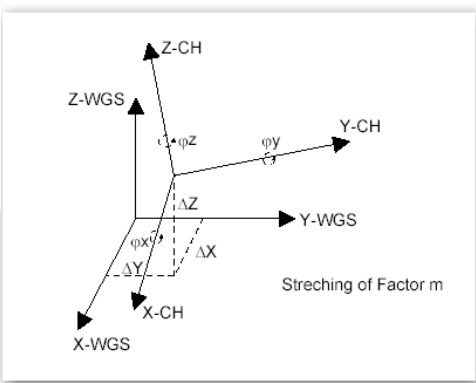
UTM zone number

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坐標基準的轉換(如TWD67/97)



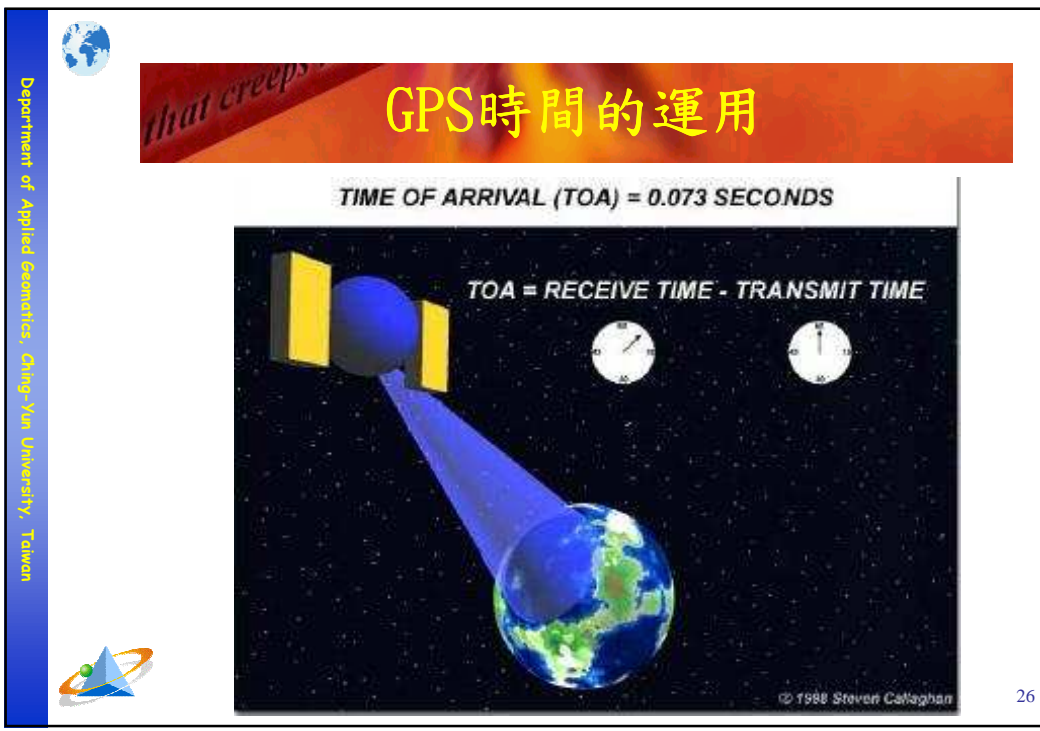
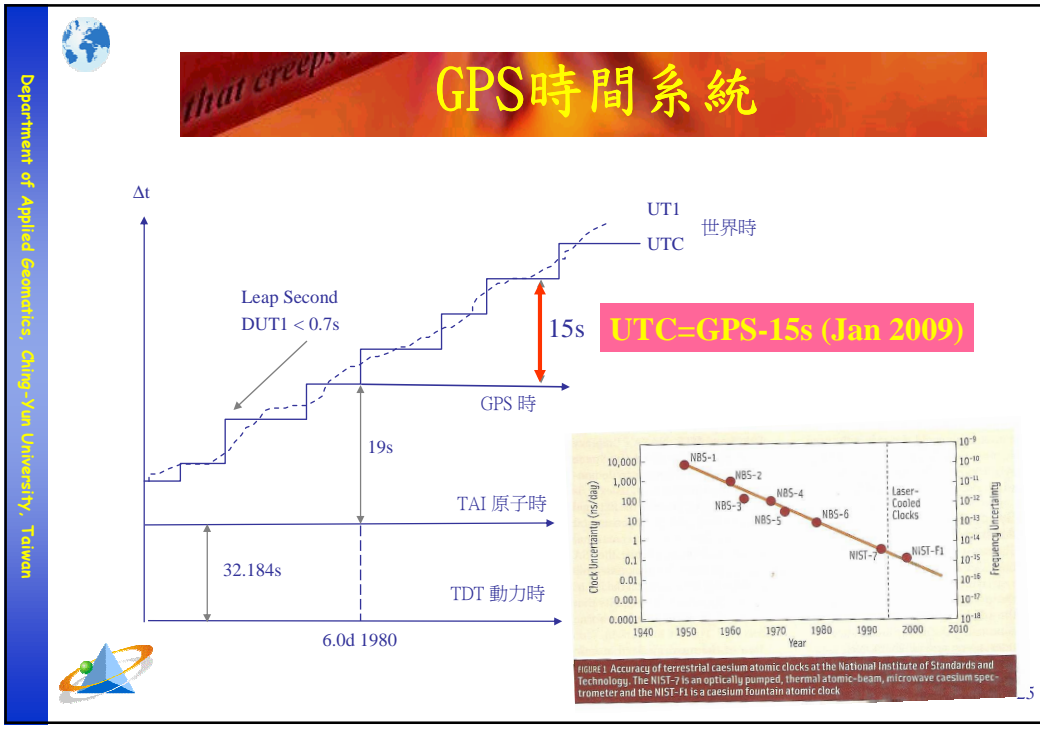
Geoid (exaggerated shape)



Stretching of Factor m

三個平移量
 三個旋轉角
 一個尺度比

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交會定位原理

Position

The Global Positioning System
Measurements of code phase and time from at least four satellites are used to estimate four quantities: position in three dimensions (X, Y, Z) and GPS time (T).

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GPS誤差來源

SA效應

衛星軌道

衛星時錶

大氣效應
(電離層、對流層)

多路徑

接收儀時錶
天線相位中心

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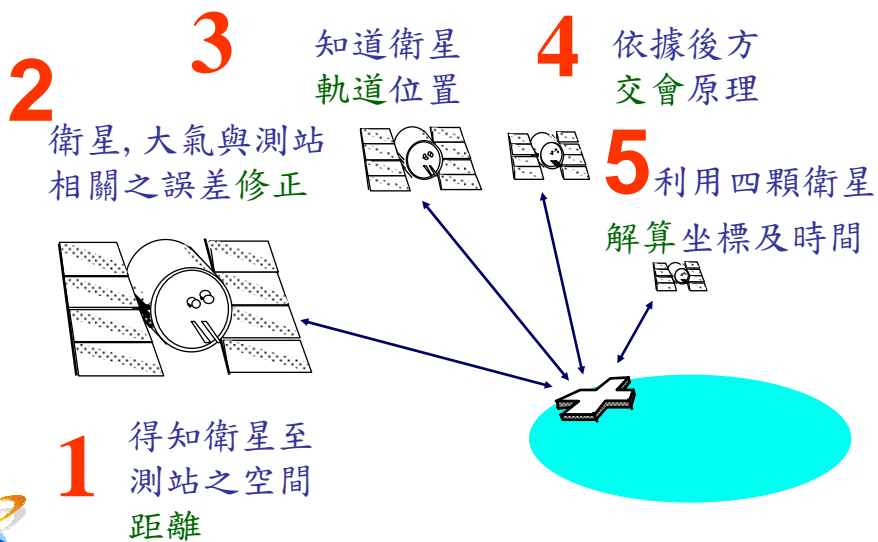
差分觀測誤差估值

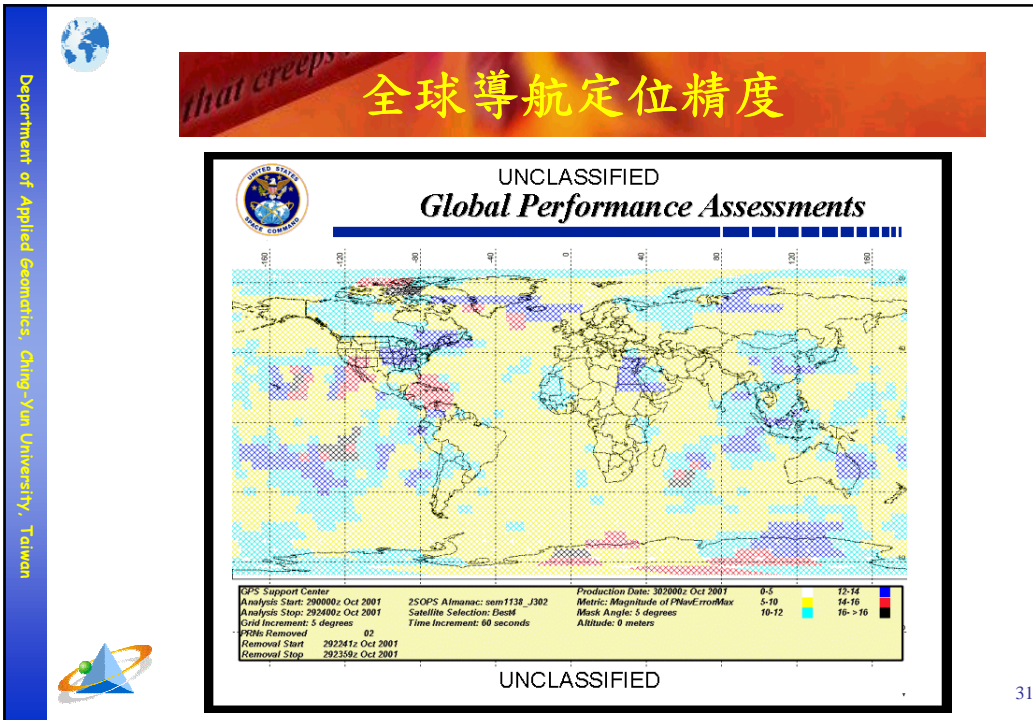
Error cause	Error without DGPS	Error with DGPS
Ephemeris data	2.1m	0.1m
Satellite clocks	2.1m	0.1m
Effect of the ionosphere	4.0m	0.2m
Effect of the troposphere	0.7m	0.2m
Multipath reception	1.4m	1.4m
Effect of the receiver	0.5m	0.5m
Total RMS value	5.3m	1.5m
Total RMS value (filtered, i.e. slightly averaged)	5.0m	1.3m

雙站共通性誤差可抵銷/降低



GPS定位基本要素





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that creeps... DGPS 差分定位

配置無線電發送裝備

DGPS 基站

差分改正量

L1 C/A 虛擬距離量

配置無線電接收裝備

< 2 m

用途：調查

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that creeps... RTK 即時動態定位

配置無線電發送裝備

RTK 基站

基站觀測量

L1 載波相位觀測量

配置無線電接收裝備

控制器配置OTF演算法

< 5 cm

用途：放樣/導線/戶地/複丈

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Static靜態相對定位

已知坐標點

待定坐標點

$dR(X,Y,Z)$

L1/L2相位觀測量

差分後處理

用途：控制/監測

< 2 cm

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GPS成果資料供應

<http://www.gps.moi.gov.tw/>

內政部地政司衛星測量中心
Satellite Survey Center, Department of Land Administration, MOI

基本控制測量成果資料查詢系統

查詢條件

單位種類：
 一等衛星控制點
 二等衛星控制點
 一等一等水準點
 第一等二等水準點
 第一等重力點
 更新範圍顯示

以行政區查詢
 以縣名稱查詢
 以縣稱名稱查詢
 以縣稱名稱查詢
 以縣稱名稱查詢
 以縣稱名稱查詢

圖主畫面
 操作說明
 手機上網操作說明

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that creeps PPP精密單點定位

A GPS Receiver
& Precise Orbit/
Clock Data

CACS
Central Control Site
NRC.ca, Ottawa

CSRS-PPP applies
Precise GPS Orbits
and Clocks

User submits Raw
GPS data (RINEX)

centimetres

Typically 2 hours of dual-frequency raw data (collected at 30 sec interval) can provide better than 10 cm positioning accuracy while 24 hours of data can provide 1 to 2 cm positioning accuracy

Separation (m)

Week 1318
WGS84(C) + Daves(C)

GPS Time (sec)

15:23:39 on 11/17/2008

— East — North — Up

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that creeps VRS虛擬參考站定位

Reference
Stations

Network
Processing
Centre

Rover
Station

Virtual Ref

Rover

A B C D

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VRS運作程序(I)

Network Sketch

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VRS運作程序(II)

Rover transmits NMEA message for VRS position to the network server

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VRS運作程序(III)

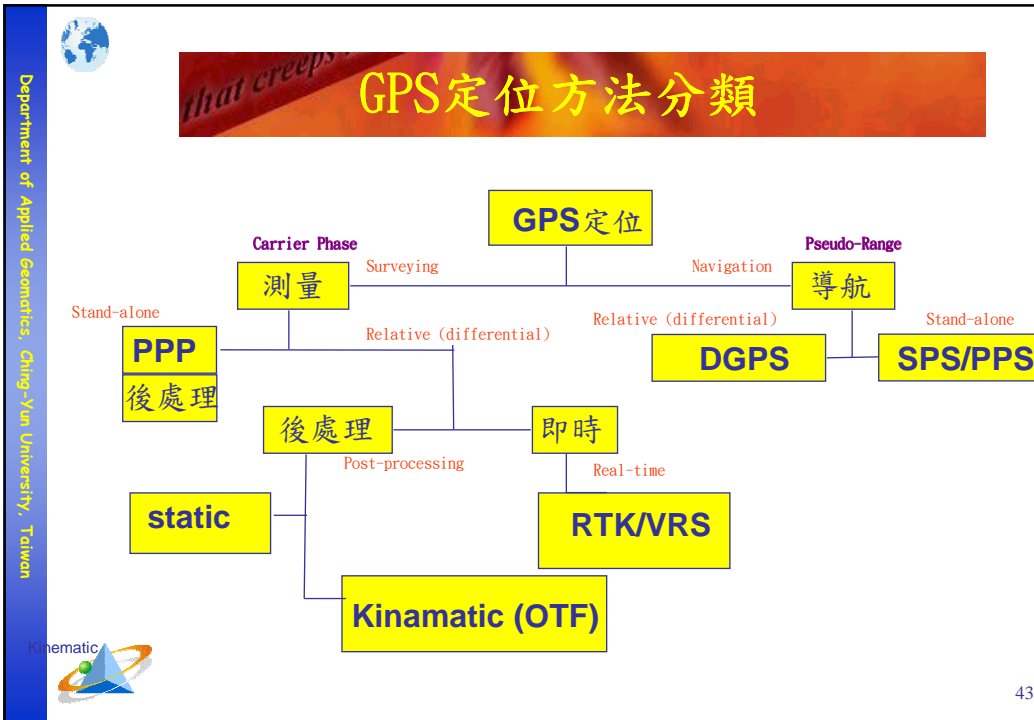
Network server transmits RTCM correction stream (virtual observables) for VRS position

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內政部eGPS服務網

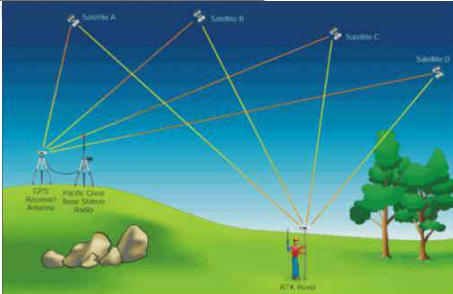
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差分定位裝備


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商業產品:GPS定位儀



Continuously Operating Reference Stations

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商業產品:GPS導航器



車用GPS導航系統



GPS手機



GPS+照相手機



車用GPS測速警示器



GPS接收器+電子羅盤



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商業產品:GPS手錶



GPS里程錶



GPS手錶



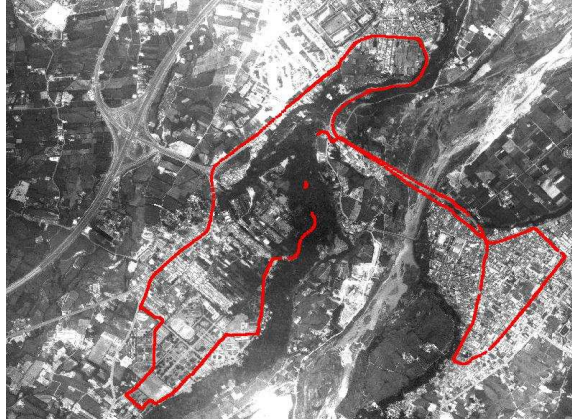
GPS時鐘



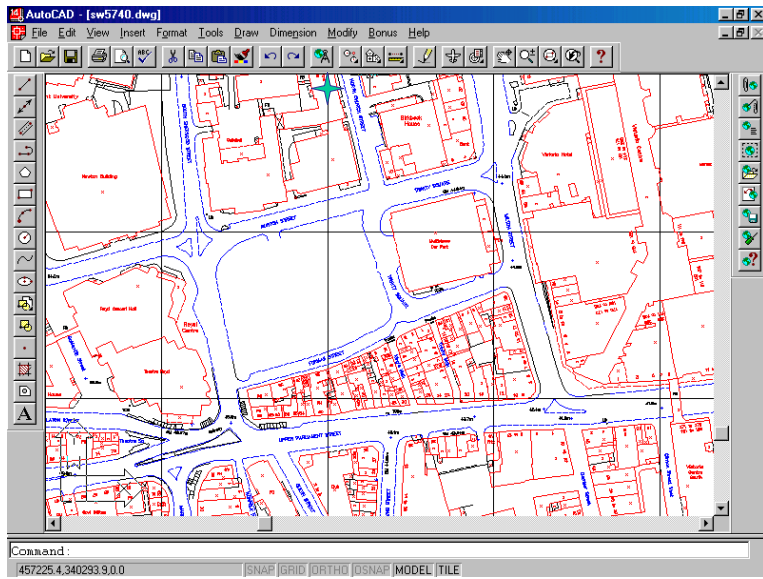
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that creeps 路徑監控顯示


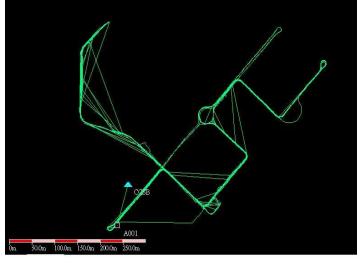


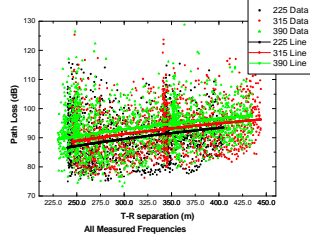
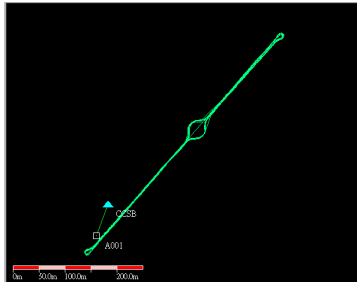
that creeps GPS及GIS運用於即時監控



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通訊路徑測試

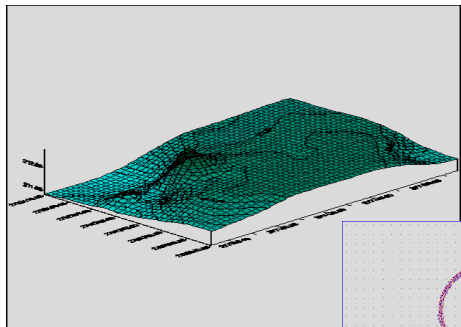
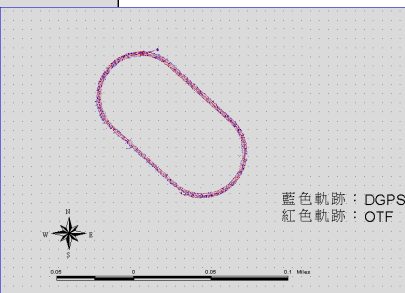



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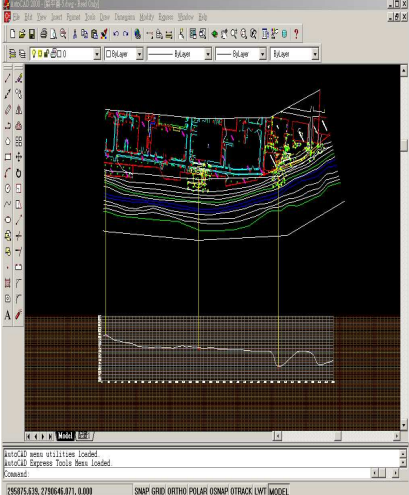
地形及軌跡快速測繪

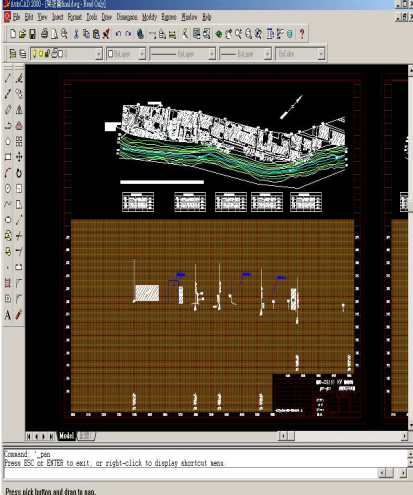
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that creeps 電力管線GIS測量



高壓線路剖面

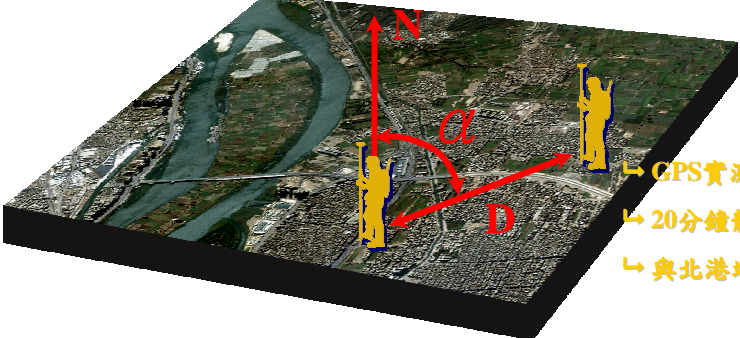


高壓電塔架空路線

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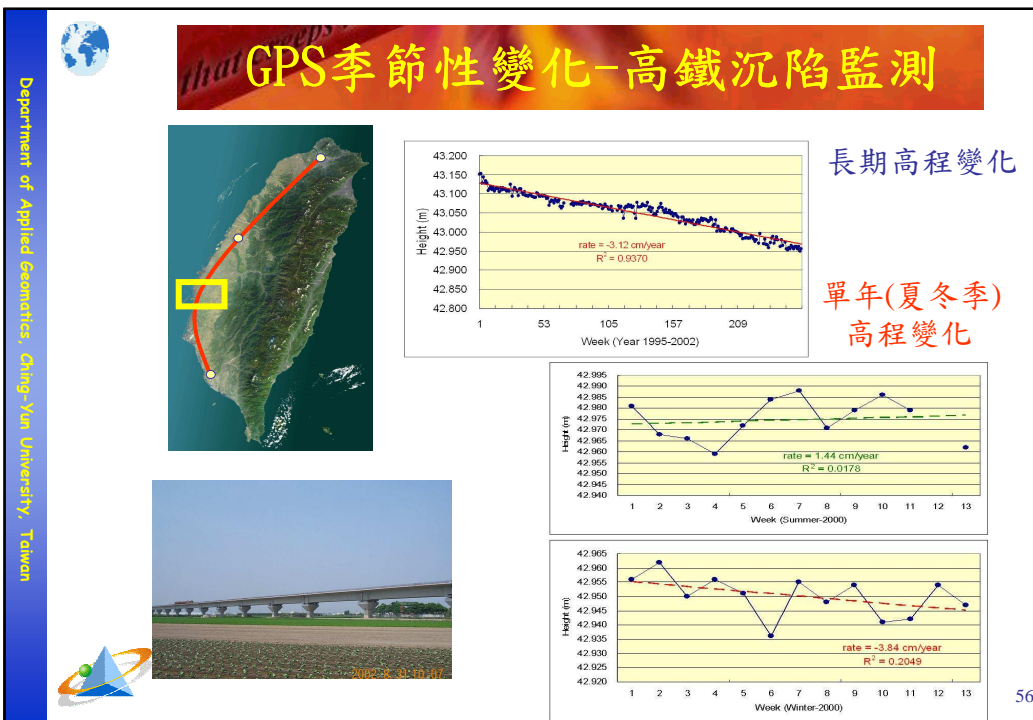
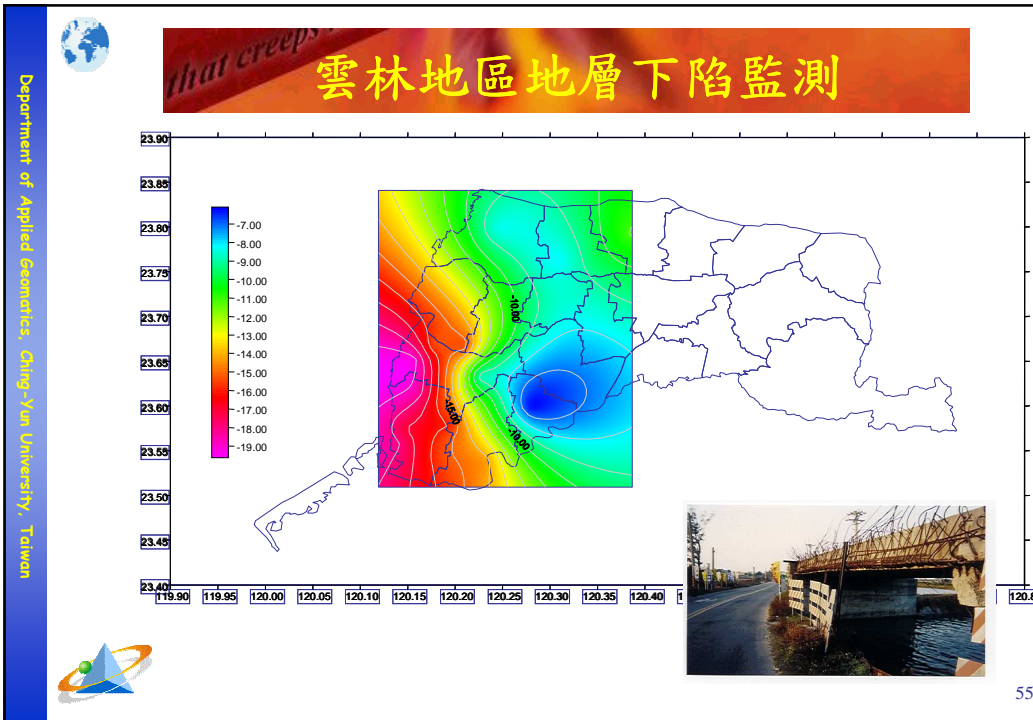
that creeps 衛星影像精度檢核



- ↳ GPS實測
- ↳ 20分鐘靜態觀測
- ↳ 與北港站連測

衛星影像點 誤差RMS值	絕對精度 (m) 太空圖像公司宣稱之精度為50m	相對精度	
		距離 (m)	方位角 (°)
三鶯幅	11.0	2.8	0.888
台中幅	56.0	6.3	0.988
社頭幅	92.6	17.9	0.756

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that creeps 林肯大郡坡地滑動監測

災變區





危險區



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that creeps 921大地震檢測控制點







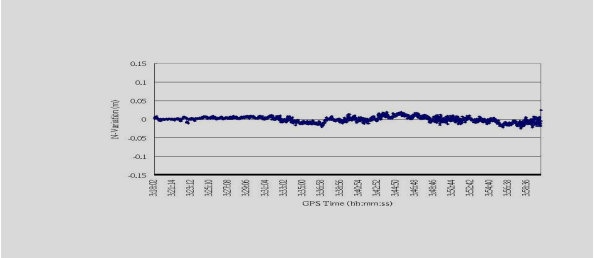
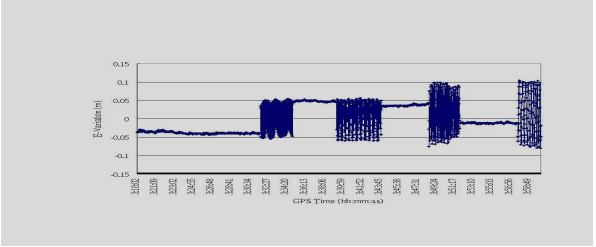

250 cm
Displacement Scale

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地震震動模擬偵測

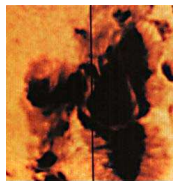
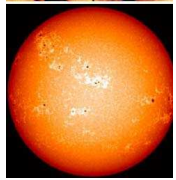



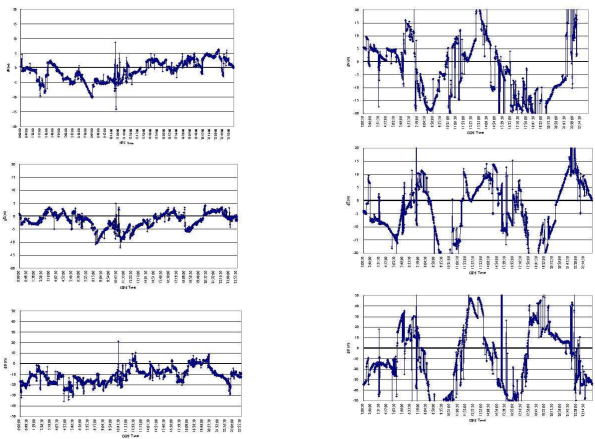




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太陽活動干擾導航精度

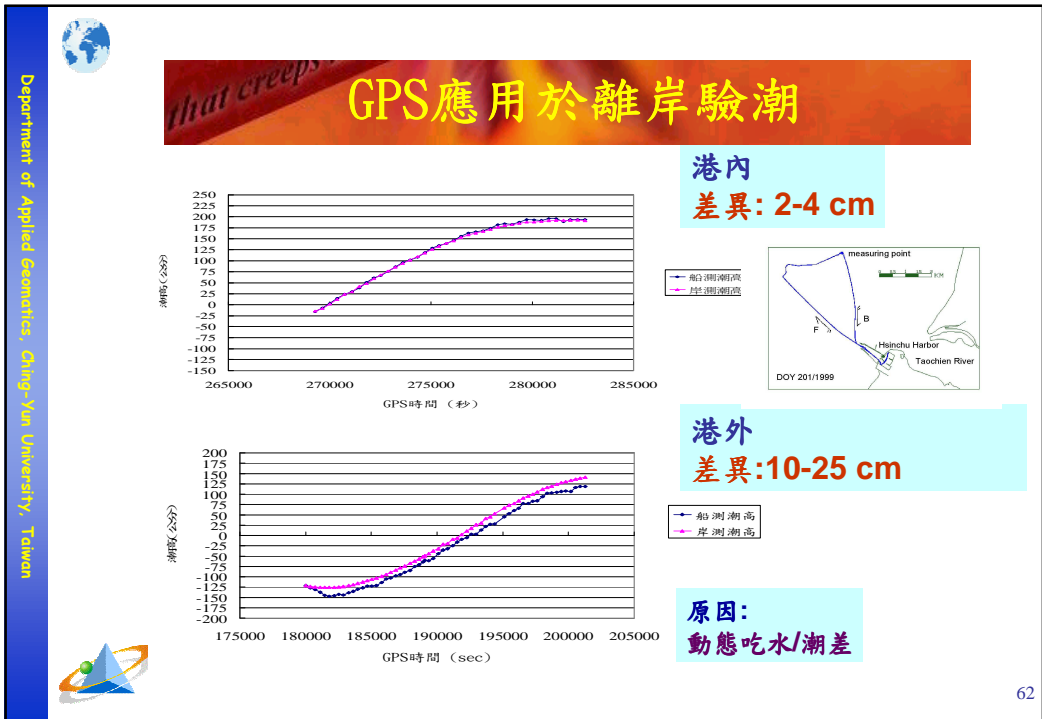
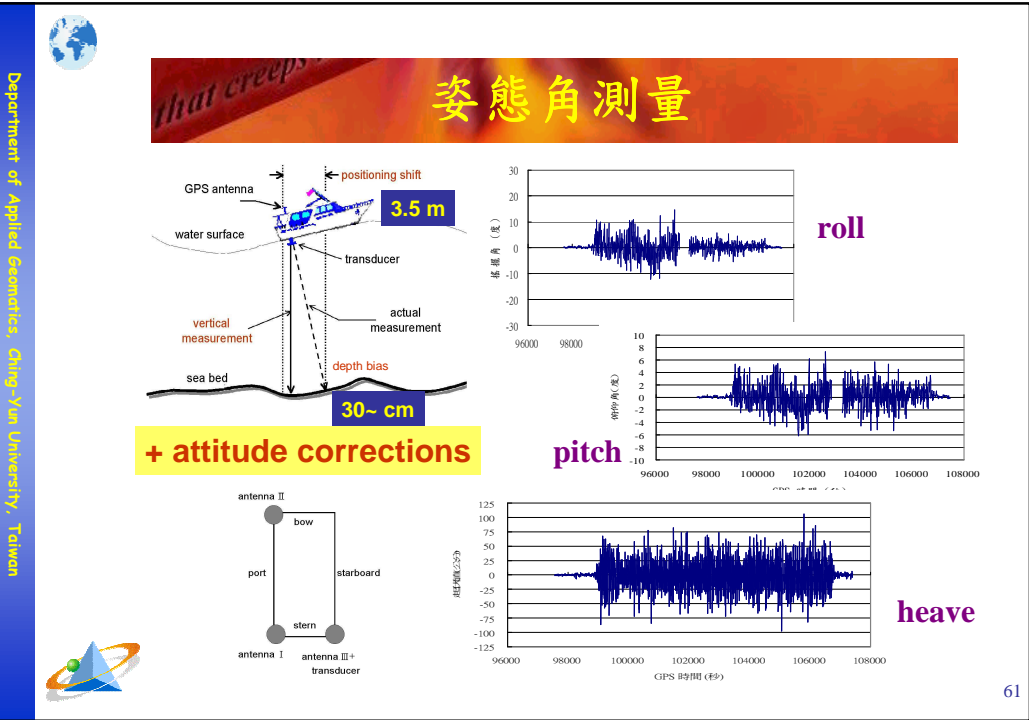







三天後

60



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GPS傳遞測深基準面

Method	Average Bias (cm)
Levelling Difference	22.6
Simultaneous Observation	19.5
Range Ratio	11.3
Least Squares Water Level	7.2
GPS-based	3

IHO specification : Special Order $\pm 5\text{ cm}$

63

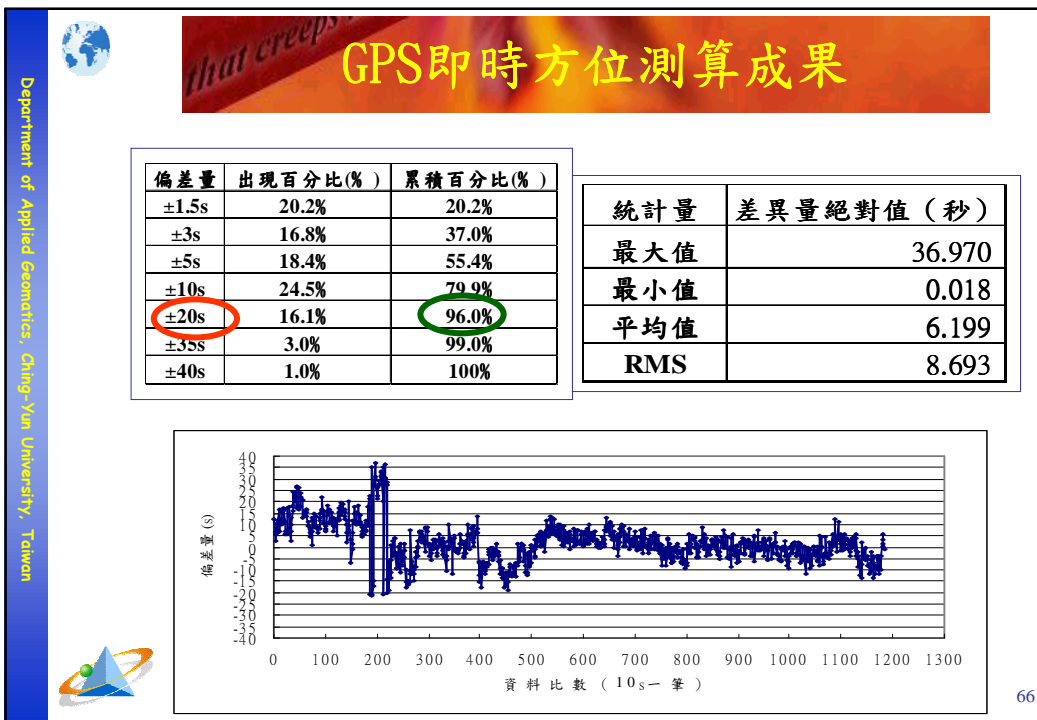
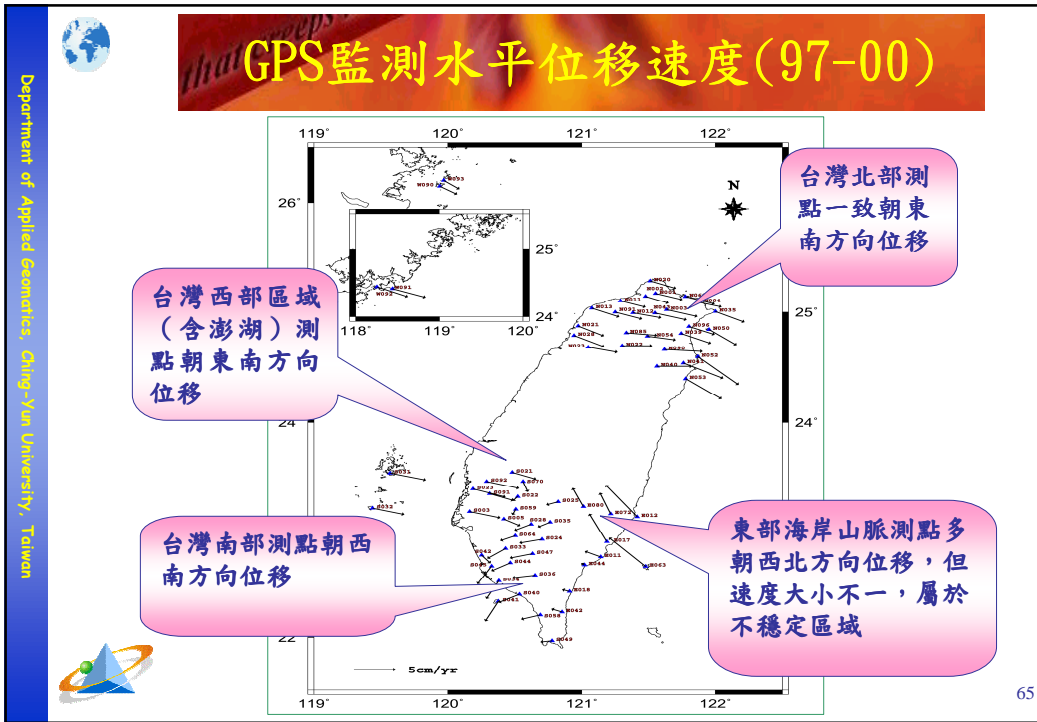
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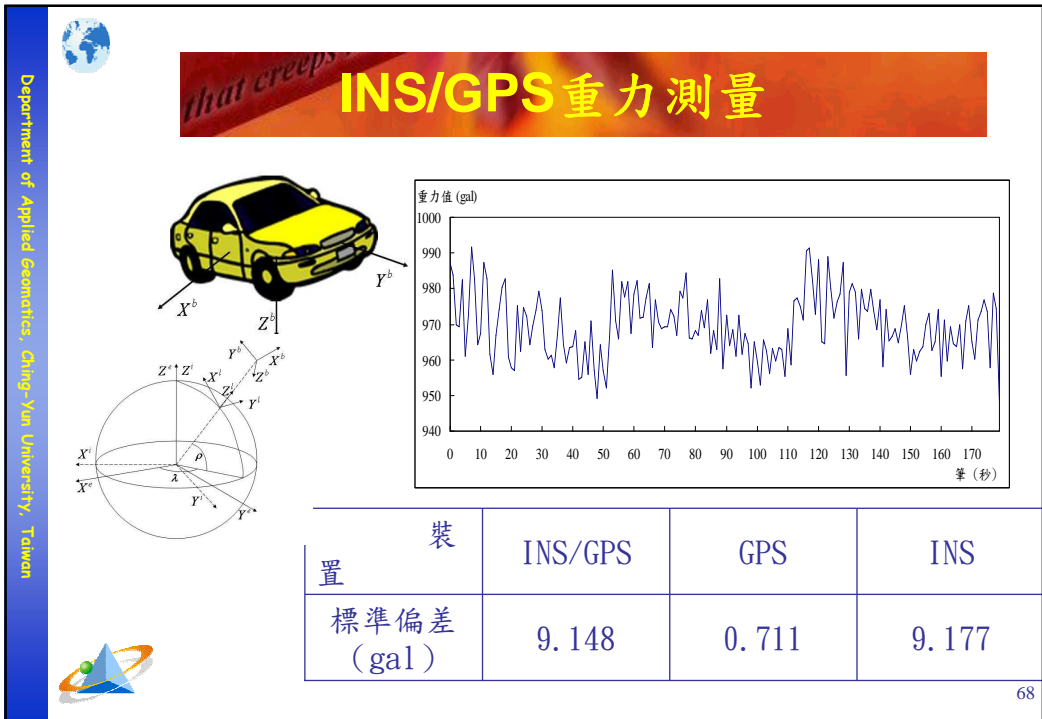
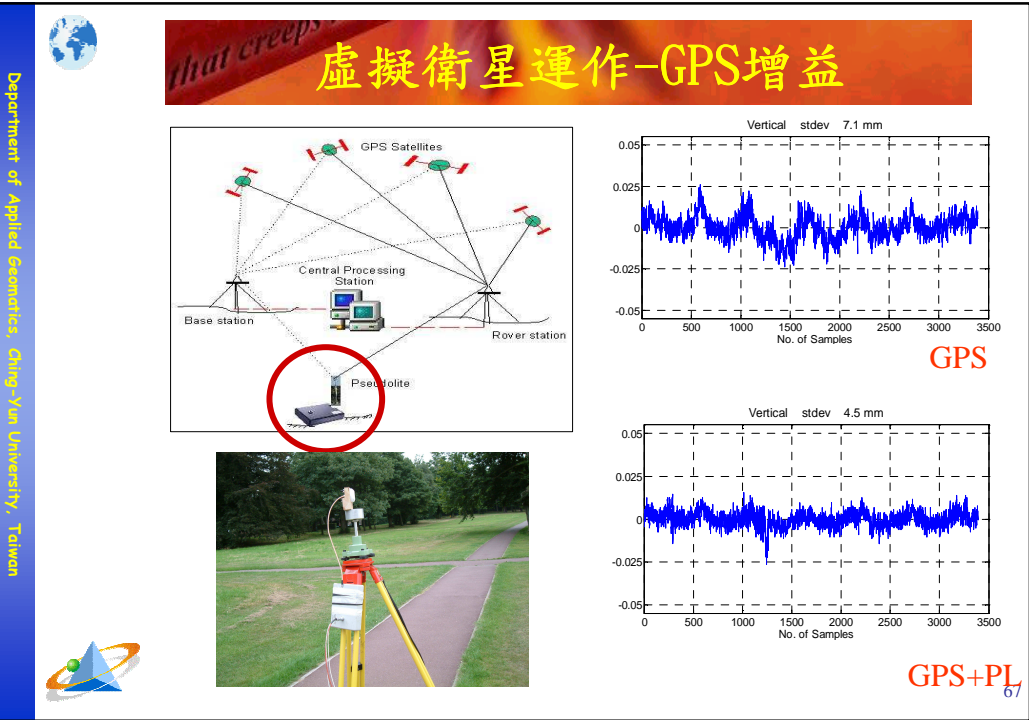
GPS遠距定位技術研發

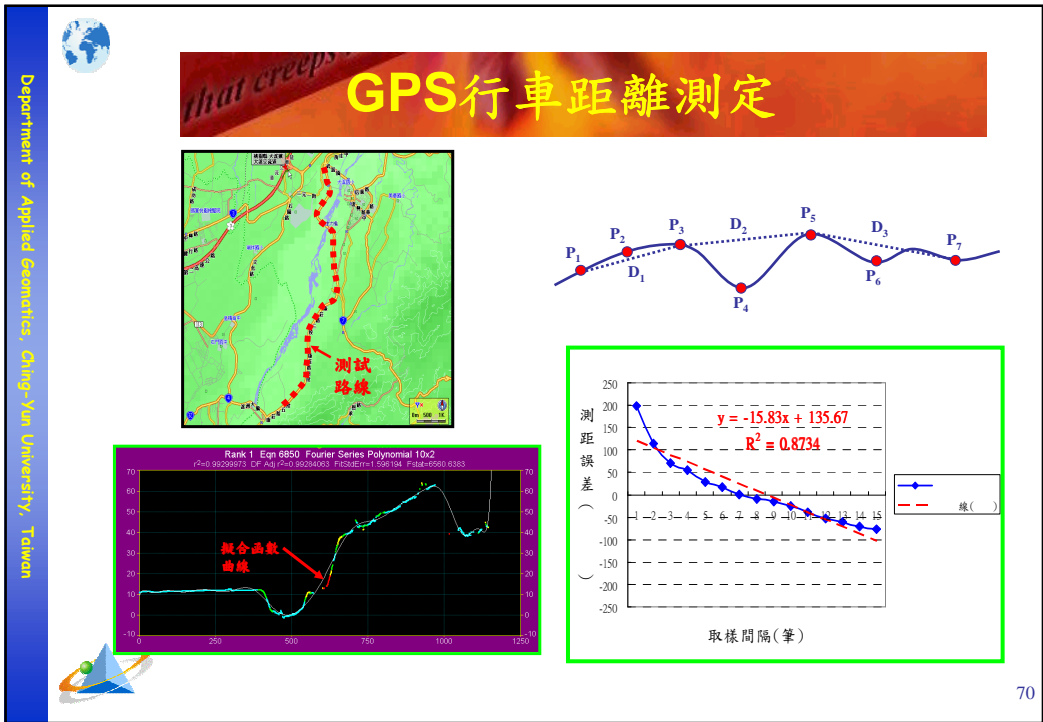
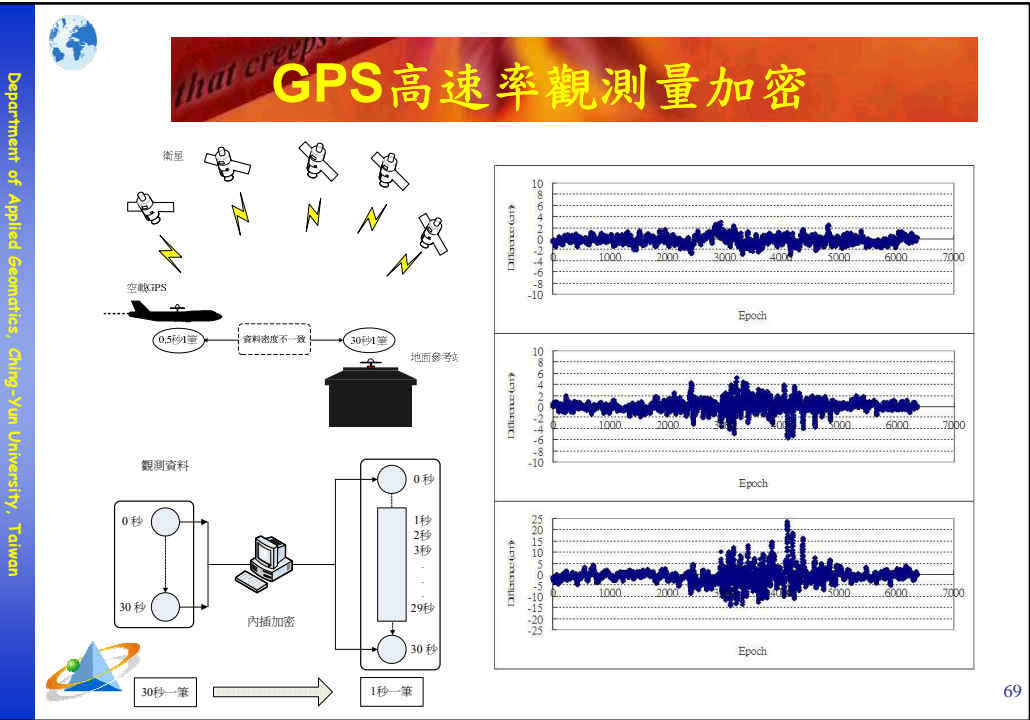
Distance (m)	Standard Method Error (m)	Improved Method Error (m)
1000	~20	~10
2000	~22	~12
3000	~25	~10
4000	~28	~12
5000	~32	~15
6000	~35	~18
7000	~38	~20
8000	~40	~22

最遠 20 km
精度 5 m

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GPS行車資訊管理系統

GPS行車資訊管理系統

總里程 **59.727 Km** 總費用 **\$ 56** 異常里程 **21.862 Km**
 停車時數總計 **17.8 分鐘** 停車計費 **\$6** 壅塞里程 **2.733 Km**
 超速里程 **5.818 Km**
 平均速度 **102.705 Km / h**
 當前速度 **121.1269712 | 24.8939266**

Evaluation Version

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GPS高爾夫球車管理系統

GPS訊號
 GPS衛星定位
 通報服務 (離線模擬)
 定位座標傳輸 (離線模擬)
 球場GIS
 高爾夫球道 管控系統

紀錄日期	球車編號	球道警示訊息
2007/5/20 下午 09:51	4	第4車打球太慢,請加快速度,管控時間
2007/5/20 下午 09:50	2	第五洞壘塞,第2車請前往第六洞開球
2007/5/20 下午 09:47	3	第五洞壘塞,第3車請前往第六洞開球
2007/5/20 下午 09:47	4	第五洞壘塞,第4車請前往第六洞開球
2007/5/20 下午 09:45	2	第一洞壘塞,第2車請前往第二洞開球
2007/5/20 下午 08:43	3	第一洞壘塞,第3車請前往第二洞開球
2007/5/20 下午 08:32	14	第一洞壘塞,第4車請前往第二洞開球

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GPS圖像導航顯示

序	緯度	經度	高度	速度	方位角	時間
1	22.98486	121.1711	1.00	0.00	0.00	11:00
2	22.98486	121.1711	1.00	0.00	0.00	11:00
3	22.98486	121.1711	1.00	0.00	0.00	11:00
4	22.98486	121.1711	1.00	0.00	0.00	11:00
5	22.98486	121.1711	1.00	0.00	0.00	11:00
6	22.98486	121.1711	1.00	0.00	0.00	11:00
7	22.98486	121.1711	1.00	0.00	0.00	11:00
8	22.98486	121.1711	1.00	0.00	0.00	11:00
9	22.98486	121.1711	1.00	0.00	0.00	11:00
10	22.98486	121.1711	1.00	0.00	0.00	11:00
11	22.98486	121.1711	1.00	0.00	0.00	11:00
12	22.98486	121.1711	1.00	0.00	0.00	11:00
13	22.98486	121.1711	1.00	0.00	0.00	11:00
14	22.98486	121.1711	1.00	0.00	0.00	11:00
15	22.98486	121.1711	1.00	0.00	0.00	11:00
16	22.98486	121.1711	1.00	0.00	0.00	11:00
17	22.98486	121.1711	1.00	0.00	0.00	11:00
18	22.98486	121.1711	1.00	0.00	0.00	11:00
19	22.98486	121.1711	1.00	0.00	0.00	11:00
20	22.98486	121.1711	1.00	0.00	0.00	11:00
21	22.98486	121.1711	1.00	0.00	0.00	11:00
22	22.98486	121.1711	1.00	0.00	0.00	11:00
23	22.98486	121.1711	1.00	0.00	0.00	11:00
24	22.98486	121.1711	1.00	0.00	0.00	11:00
25	22.98486	121.1711	1.00	0.00	0.00	11:00
26	22.98486	121.1711	1.00	0.00	0.00	11:00
27	22.98486	121.1711	1.00	0.00	0.00	11:00
28	22.98486	121.1711	1.00	0.00	0.00	11:00
29	22.98486	121.1711	1.00	0.00	0.00	11:00
30	22.98486	121.1711	1.00	0.00	0.00	11:00

73

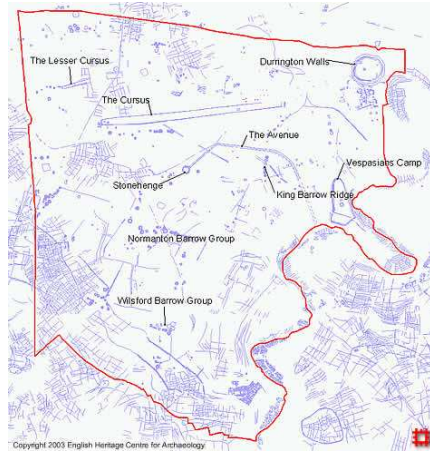
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GPS與考古

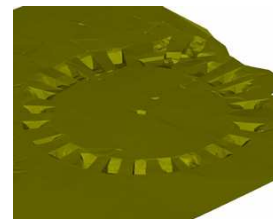
74



GPS與考古

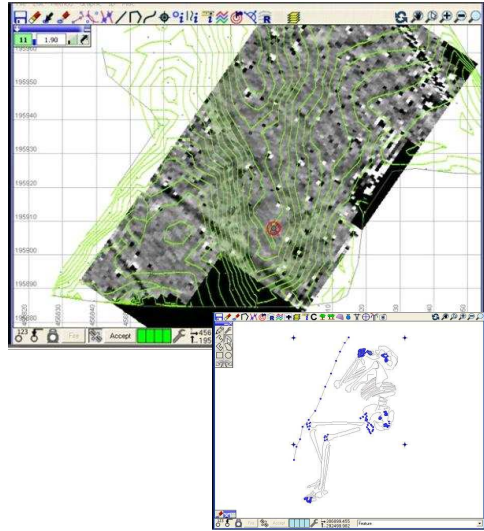


GPS與考古





GPS與考古



GPS與考古





空間資訊系統與考古應用

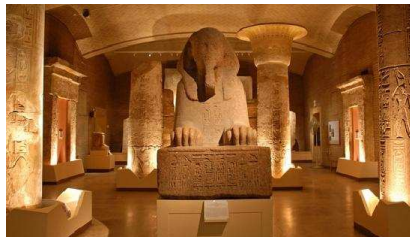
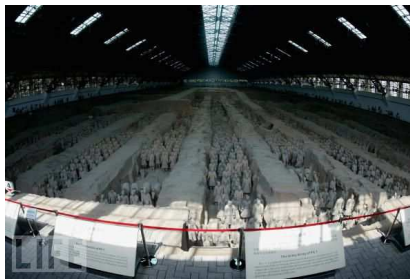
- 全測站經偉儀/GPS：測定位址、地物及地貌
- GPS：紀錄軌跡、路徑及範圍
- 地面雷射：掃瞄3D點雲及立體建模
- 航、遙測影像：建置背景圖資
- GIS/Google Maps/Earth：進行資料顯示、管理及分析



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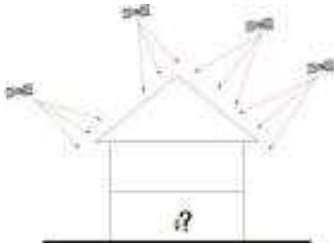

室內考古



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沒有GPS信號時怎麼辦

GPS信號遮蔽 或 強度過弱 無法接收...

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室內定位的用途



emergency services



PND locating



tunnel transportation



vehicle navigation



asset tracking



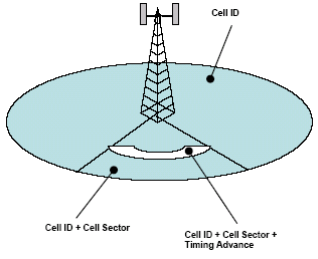
exhibition guidance

仍有許多...待開發

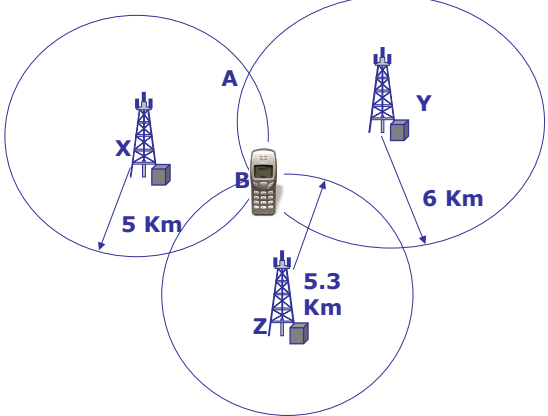
82

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手機定位(被動式)



Cell-ID



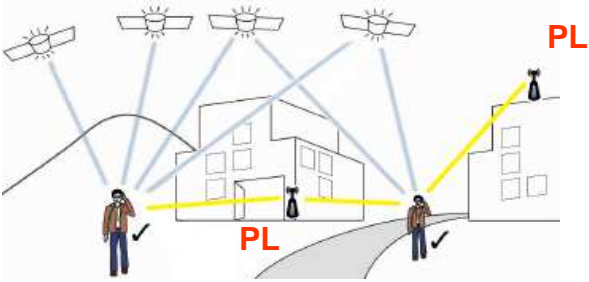
TOA (time of arrival) / signal strength

83

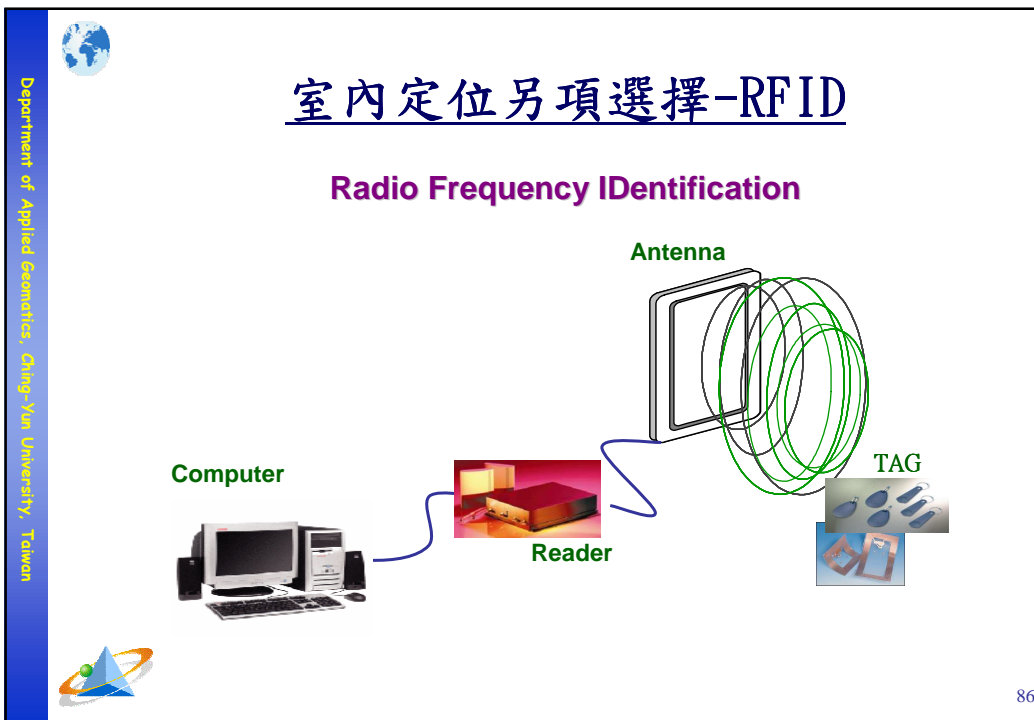
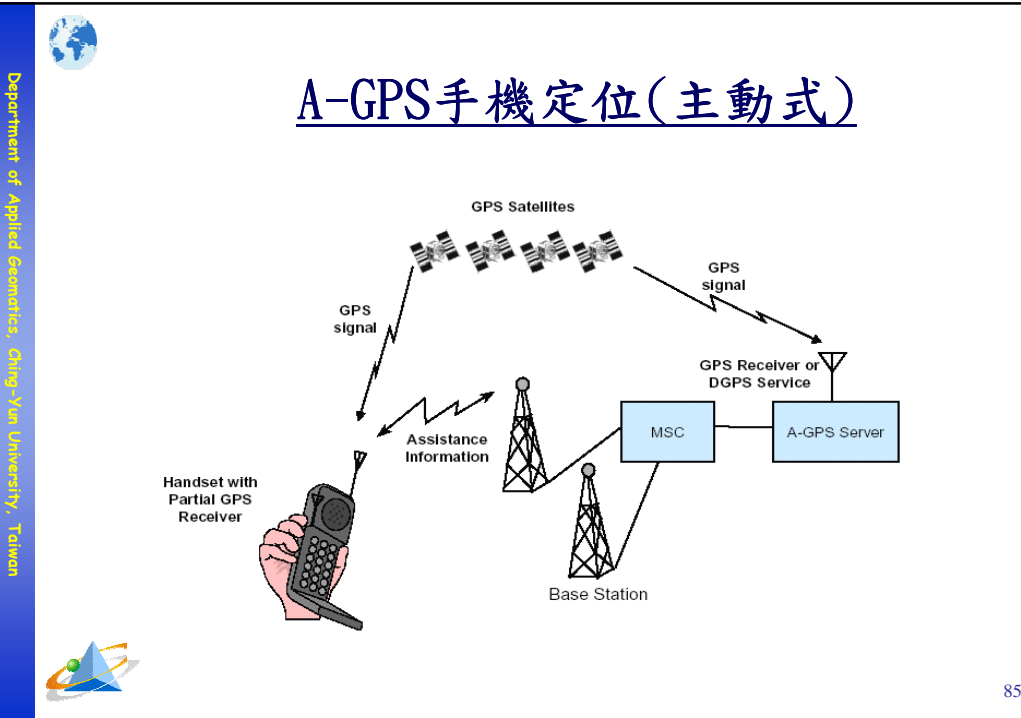
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GPS虛擬衛星(Pseudolite)

- 提供額外的近地觀測量
- 提升垂直向定位精度
- 延伸定位服務範圍



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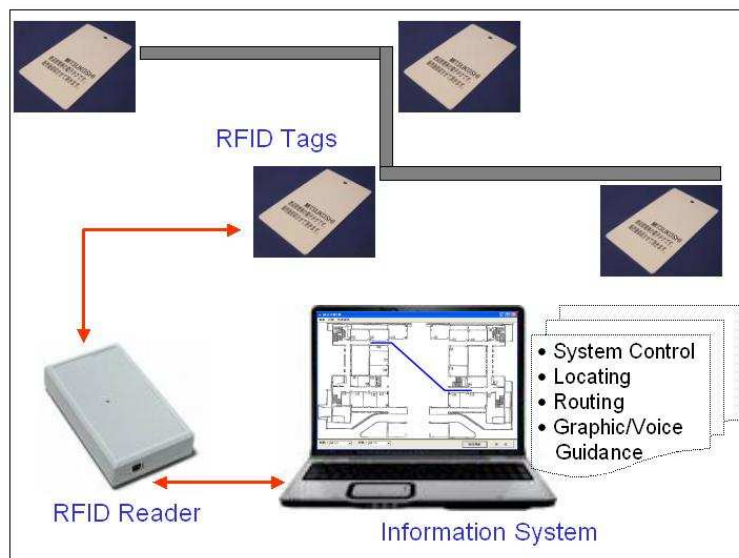
資料設計格式

	A	B	C	D
0	廠商識別碼	擴充區	擴充區	
1	坐標區	坐標區	節點名稱	
2				
3				
4	位		置	
5				
6				鍵
7				
8				值
9				
10				
11	關	係	區	
12				
13				
14				
15				

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RFID導引系統架構

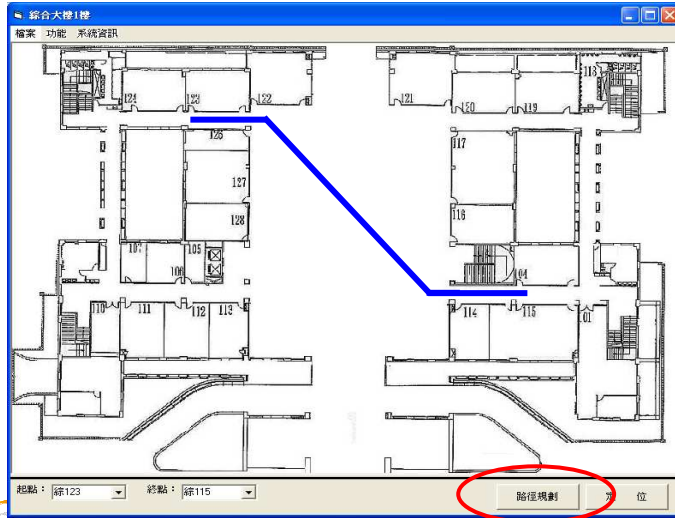


88

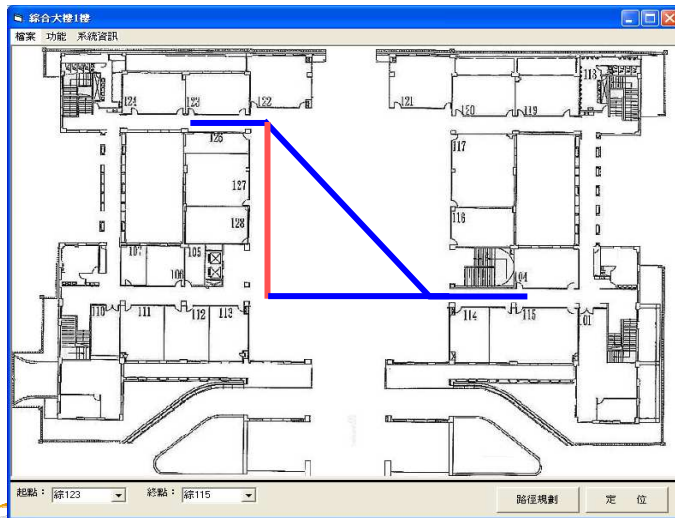




路徑導引



路徑修正



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RFID路徑監控系統

軌跡顯示

System
秒數欄位設定: abcd

儲藏室

資源系
研究生研究室

清除物件軌跡 清除資料庫 清除軌跡 設定

Tag ID	Tag ID	Tag ID	Tag ID	Tag ID	Tag ID	Tag ID	Tag ID	Tag ID	Tag ID
1	16	19	20	21	22	23	24	25	26
2700	2701	2702	2703	2704	2705	2706	2707	2708	2709
2710	2711	2712	2713	2714	2715	2716	2717	2718	2719
2720	2721	2722	2723	2724	2725	2726	2727	2728	2729
2730	2731	2732	2733	2734	2735	2736	2737	2738	2739
2740	2741	2742	2743	2744	2745	2746	2747	2748	2749
2750	2751	2752	2753	2754	2755	2756	2757	2758	2759
2760	2761	2762	2763	2764	2765	2766	2767	2768	2769
2770	2771	2772	2773	2774	2775	2776	2777	2778	2779
2780	2781	2782	2783	2784	2785	2786	2787	2788	2789
2790	2791	2792	2793	2794	2795	2796	2797	2798	2799

Legend:
■ 本樓物件
■ 已讀物件
■ 已讀物件
■ 已讀物件

警告顯示

Project!

注意!! 物件軌跡輸入異常!!

確定

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RFID雷達系統

收發天線

讀取器

電子標籤

RFID-radar(tm)

60° 40m

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系統偵測物件

Department of Applied Geomatics, Cheng-Yun University, Taiwan

雷達式RFID儲存資訊系統

雷達式RFID位置

儲存物件狀況查詢一覽表

標籤編號	距離 (公尺)	角度 (度)	X坐標 (公尺)	Y坐標 (公尺)
BCBB4774	2.44	16.6	0.70	2.34
BCBB4775	0.33	-9.4	-0.05	0.33
BCBB4776	1.81	0.8	0.03	1.81
BCBB4777	5.34	0.8	0.07	5.34
BCBB4778	1.77	-16.2	-0.49	1.70

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系統偵測物件移位

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雷達式RFID儲存資訊系統

雷達式RFID位置

物件比對作業-請選擇兩筆時間-日期、進行比對

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主動式RFID室內定位裝置

Ethernet Active RFID

PUK CODE	TAG CLASS TYPE	TAG ID	SITE CODE	READ COUNT	TAG STATUS	RSSI	REPEAT RATE	Polling
110411	ClassType05	69203	9211015	1	EXISTING	73	15 SEC	None011
110418	ClassType02	1819284840		1	ADDRESS	94	15 SEC	None011
110488	ClassType01	9292058		1	EXISTING	77	15 SEC	None011
110485	ClassType01	69203		1	ADDRESS	77	15 SEC	None011
110400	ClassType04			1	ADDRESS	87	15 SEC	None011

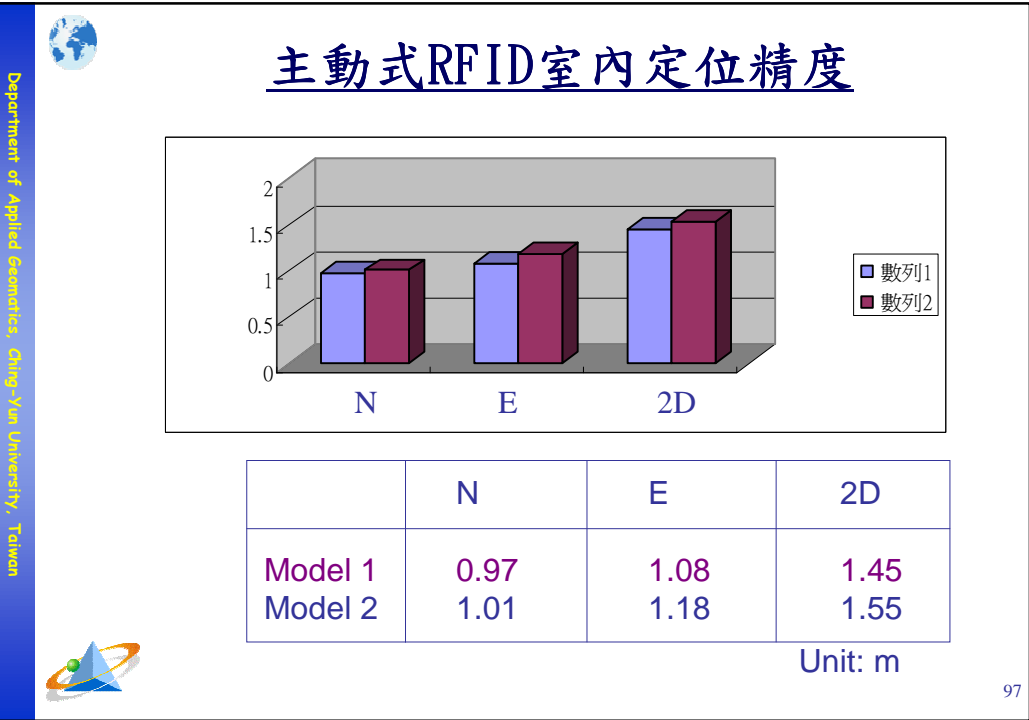
Total Tags : 5 Existing Tags : 3 Added Tags : 2 Removed Tags : 0 12/14/2006 12:52:47 PM

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主動式RFID室內定位測試

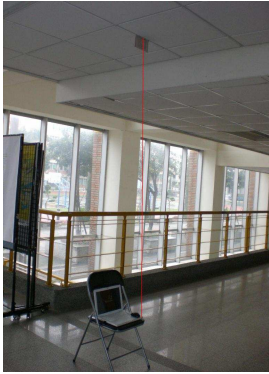
96



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室內定位另項選擇-WiFi

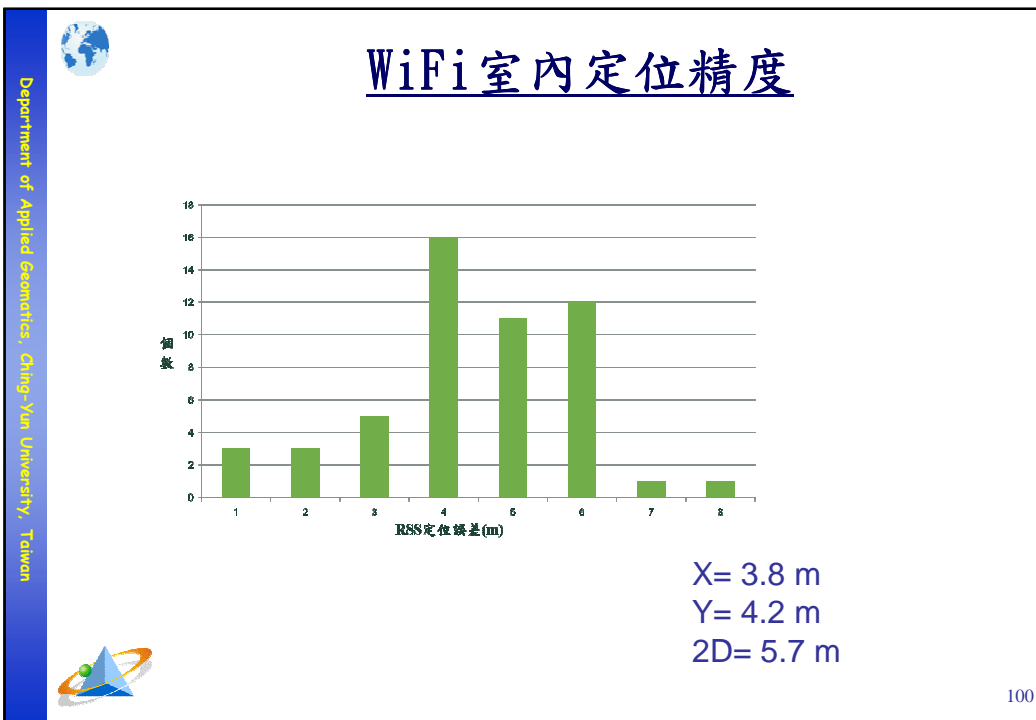
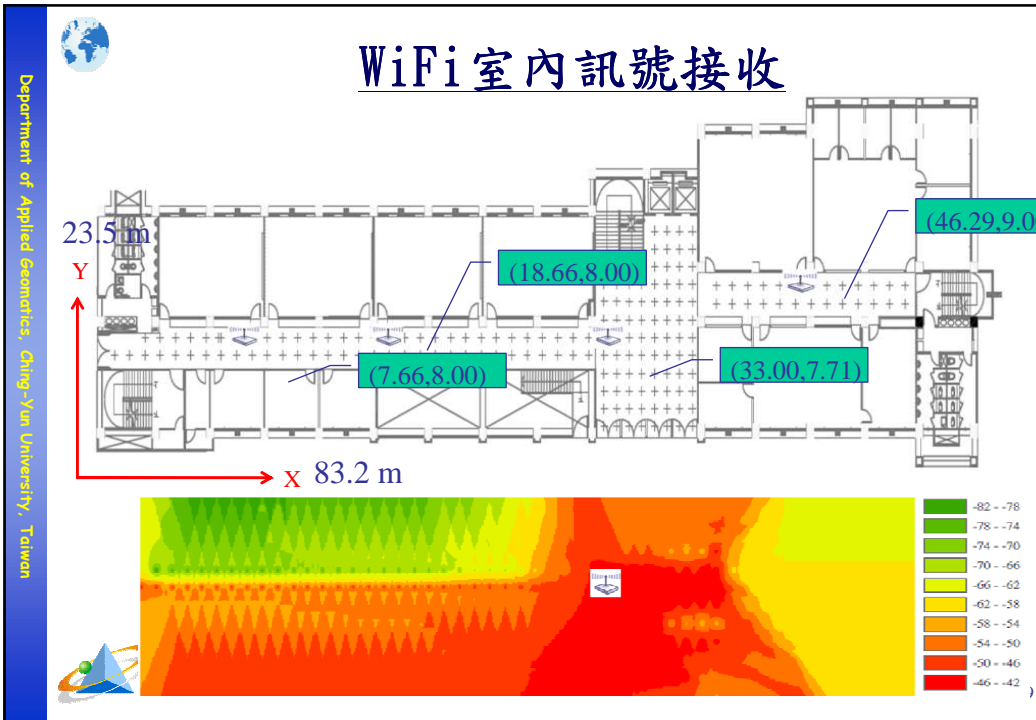
WiFi存取裝置(AP)



MAC	SSID	Name	Chan	Speed	Vendor	Type	Encryption	SNR	Signal	Noise	SNR+I	IPAddr
00112688C799	WiFiB		11	54 Mbps	(False)	AP	WEP	-92	-100	8		
0011501844E3	01101044AE2		11	54 Mbps	(False)	AP	WEP	27	-71	-100	29	
000C8688CE01	zzzzzzzzzz		8	54 Mbps	(False)	AP	WEP	23	-77	-100	28	
000D8688A0C5	kuan		2	54 Mbps	(False)	AP	WEP	7	-91	-100	9	
00240145A42A	ink		2*	54 Mbps	(False)	AP	WEP	34	-55	-100	35	192.1

**WiFi訊號感測軟體
Network Stumbler**

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WiFi室內定位成功率

測試點：25
成功點：14
成功比例：56%

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A-GPS定位測試裝置

HSGPS+AGPS USB Dongle

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Department of Applied Geomatics, Cheng-Yun University, Taiwan

A-GPS定位測試環境

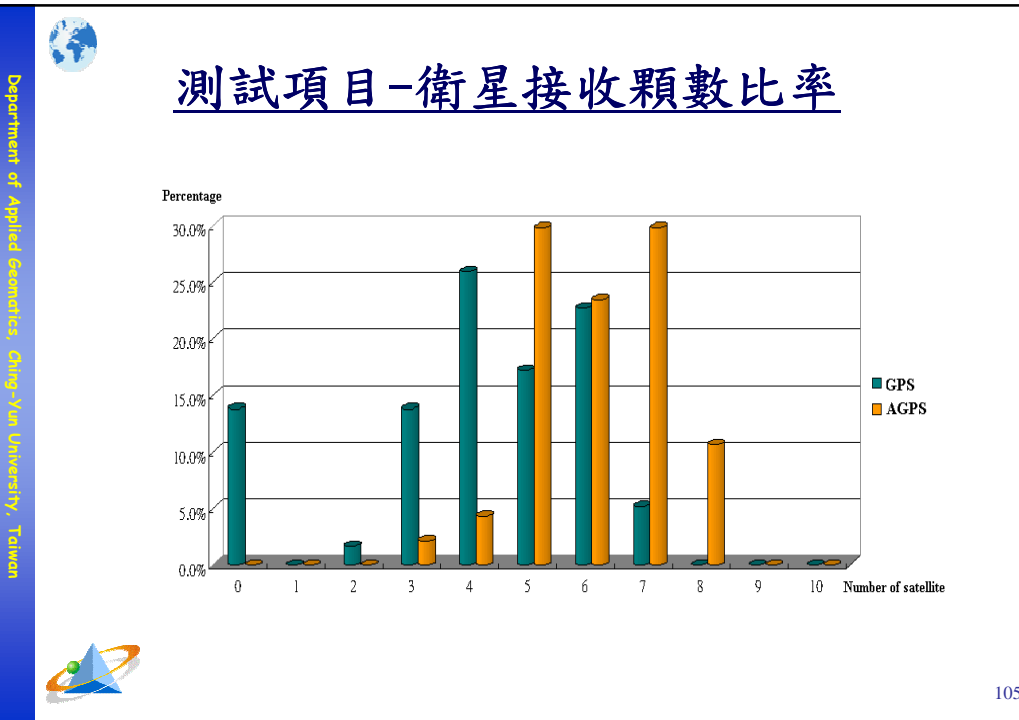
103

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測試項目-每小時接收衛星顆數

Time	GPS	A-GPS
1	7	7
2	6	7
3	6	7
4	3	7
5	5	8
6	5	8
7	6	7
8	7	8
9	4	6
10	5	5
11	5	7
12	6	6

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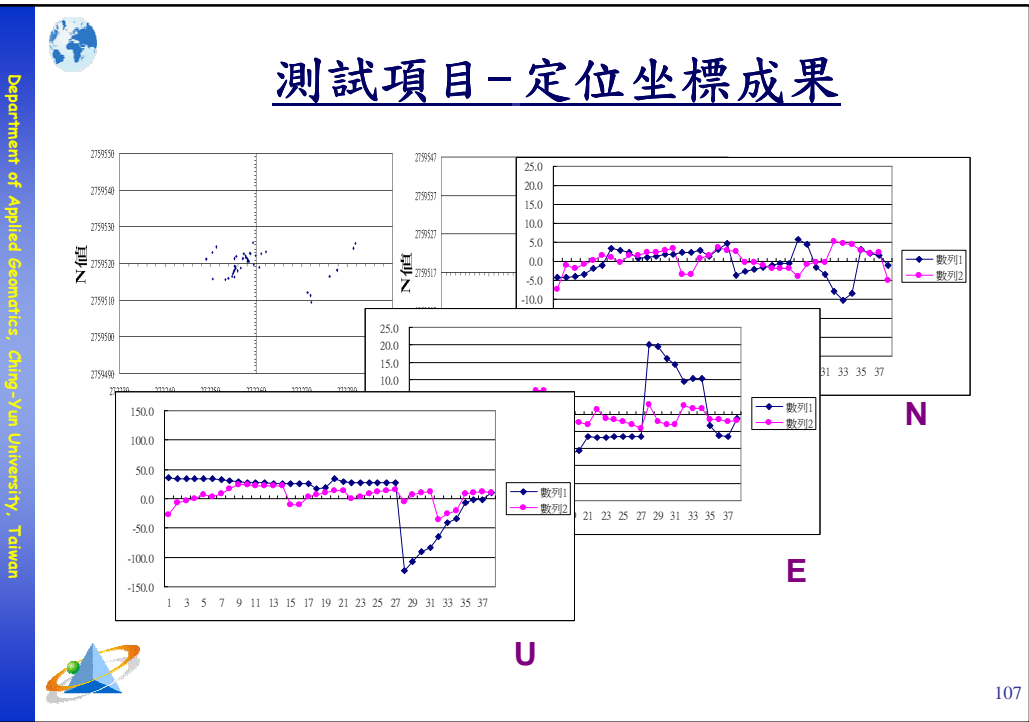
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測試項目-Time To First Fixed (TTFF)

時段	定位模式		耗時 減少量
	GPS	A-GPS	
1	512	484	28
2	816	54	762
3	865	387	478
平均	731	308	423

unit: second

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測試項目-定位坐標精度

比較表	N		E		h	
	GPS	AGPS	GPS	AGPS	GPS	AGPS
標準差	3.6	2.8	8.0	2.8	41.0	14.5
精度提升	N/A	0.8	N/A	5.3	N/A	19.6
提升百分比	23.1%		65.6%		64.6%	

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當這些人都使用GPS的時候?



MAX,
with your
features so bright,
won't you guide my
sled tonight?



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Department of Applied Geomatics, Chung-Yuan University, Taiwan



*Thanks for your
attention!*

敬請指教



ccchang50@cyu.edu.tw

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