GPS Data formats
An Introduction
NMEA format

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Topics

- Background

- Message Format and Sentence structures

- Common NMEA sentence

- Other GPS-related NMEA sentence

- References

Common GPS Data Format

- **RINEX**
  - Combine data from different manufacturer's GPS receivers
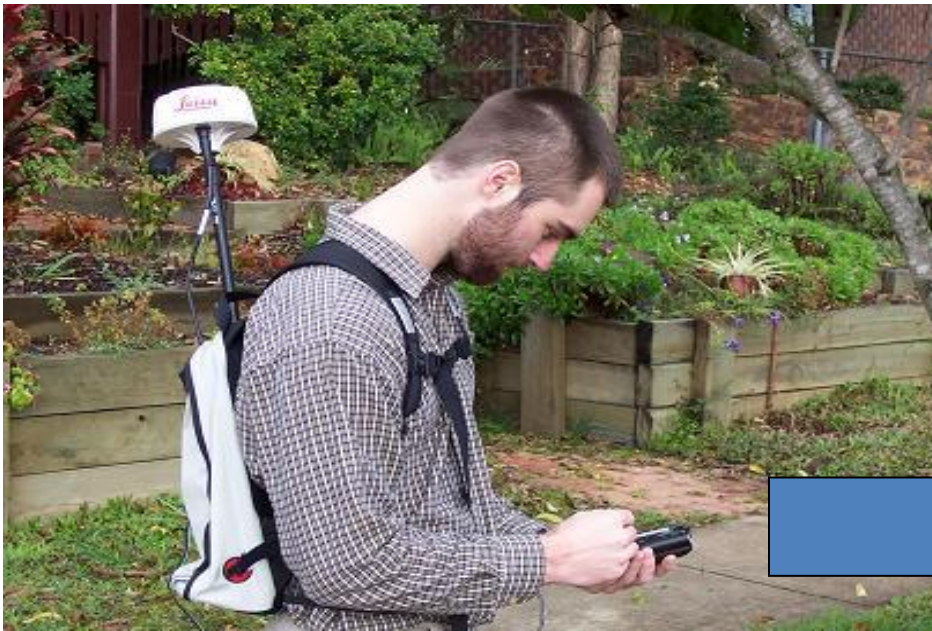 - For static data processing and archive

- **NMEA**
  - Transmission of data between GPS receiver and other devices (e.g. GPS →PDA with ArcPad software)
  - For real time positioning
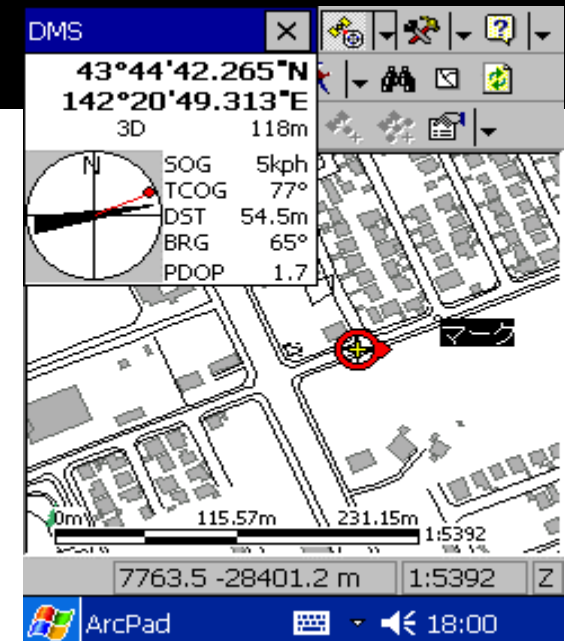
- **RTCM**
  - Transmission of data between GPS receivers (e.g Base → Rover)
  - Binary file (more compact but difficult to understand)
  - For real time DGPS/RTK corrections

Flow of NMEA data between devices

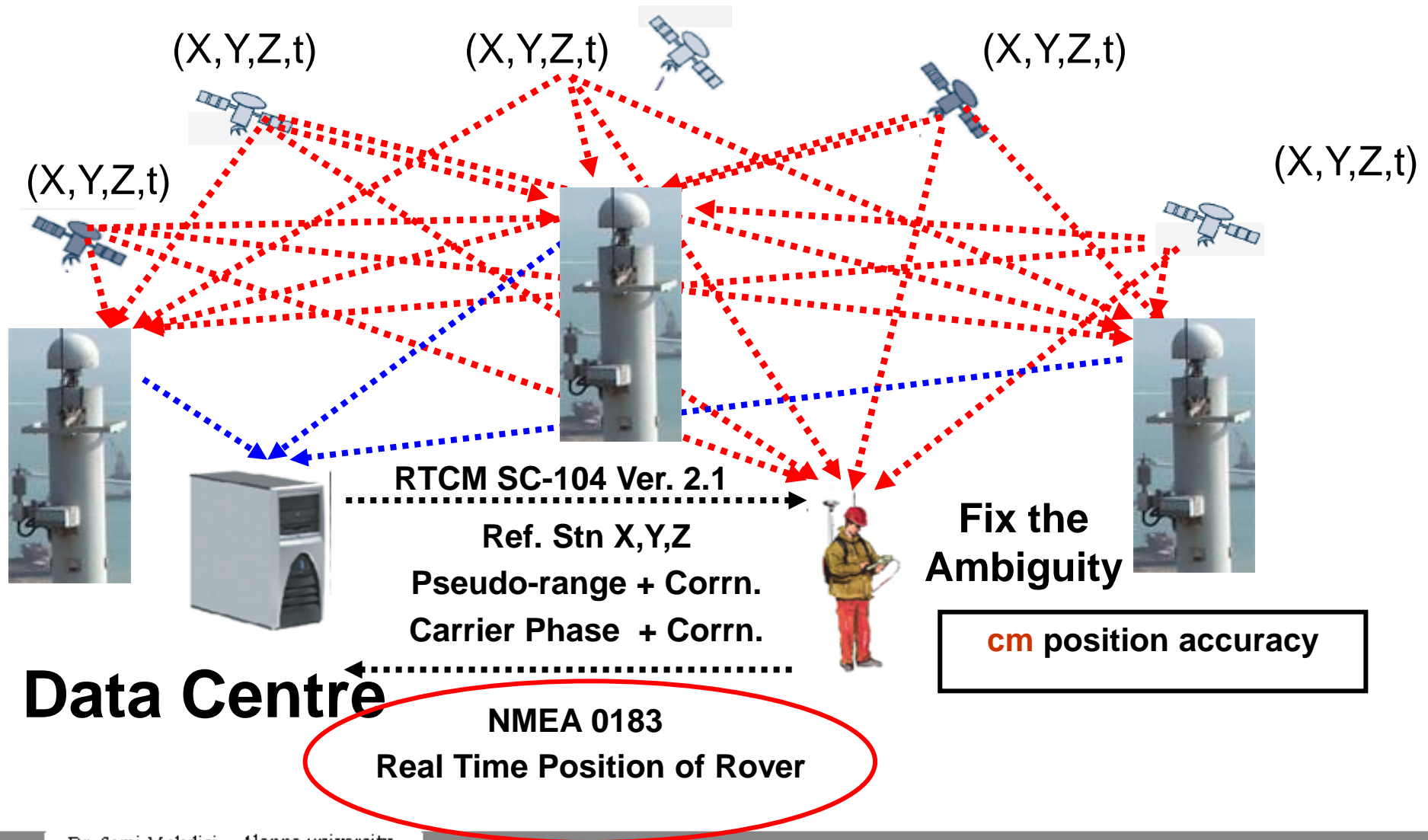
NMEA data transfer from GPS antenna to PDA
with ArcPAD software

Real-time
positioning using

NMEA data used in Network RTK

(X,Y,Z,t)   (X,Y,Z,t)   (X,Y,Z,t)

(X,Y,Z,t)   (X,Y,Z,t)

RTCM SC-104 Ver. 2.1

Ref. Stn X,Y,Z
Pseudo-range + Corrn.
Carrier Phase + Corrn.

Fix the Ambiguity

cm position accuracy

Data Centre

NMEA 0183
Real Time Position of Rover

What is NMEA data?

- Developed by **N**ational **M**arine **E**lectronics **A**ssociation

- Standard for interfacing marine electronic devices (GPS, , Compass, Echosounder…)

- Standard specifies the electrical signal requirements, data transmission protocol (i.e. agreed format for transmitting data between two devices), message formats

- Most GPS receivers understand the most popular NMEA format → NMEA 0183

What is NMEA data?

- ASCII file
  - Easily readable (even by people)
  - Less compact than binary

- Numerous sentence types
  - Not all related GPS application
  - Some popular GPS-related sentences are described in this presentation

NMEA settings

- Baud rate: 4800 (4800 characters in one second)
- Data bits: 8 (Bit 7 set to 0)
- Stop bits: 1 or 2
- Parity: none

- The "send" device and "receive" device should have same setting so as to transfer the NMEA data

Standard Message Format

- $aaaaa, df1,df2……… [Carriage Return][Line Feed]

  – Each message start with $

  – Five characters after $ are address field

  – Multiple data fields delimited by commas

  – Check sum (optional): a 2-character field (0-9,A-F) to increase data integrity

  – (*) character placed after the last data field

  $GPGSV,3,1,10,20,78,331,45,01,59,235,47,22,41,069,,13,32,252,45*70

Sentence structure

- There are three sentence structures

  - Talker: output from talker (e.g. GPS receiver) to other devices (PAD)

  - Query: means for listener (e.g. notebook) to request specified talker sentence from talker (GPS receiver)

  - Proprietary: means for manufactures to use non-standard sentences for special purpose

Talker sentence

- Format: $ttsss, df1, df2…[CR][LF]
  - tt: defines device (for gps receivers the prefix is GP)
  - sss: sentence type

Example

$GPGGA,031956,2218.2035,N,11410.7595,E,1,04,3,9,005.9,M,-001.3,M,,*51

- The talker sends the GPS data in GGA sentence format.

Query sentence

- Format: $ttllQ, sss, [CR][LF]

Example

CCGPQ,GGA, [CR][LF]

- A computer (CC) is requesting from GPS device (GP) the GGA sentence

Proprietary sentence

- Format: $PmmmA,df1,df2,….[CR][LF]
  - "P" indictes it is a proprietary message
  - "mmm" define as the manufacture
  - The fifth character is a letter (A-Z) defines the specific message type

Example

$PLEIS,AHT,0,1.90,0*34

- "LEI" is Leica manufacturer
- "S" for set command

The message set the antenna height at 1.9m in the configuration of the internal sensor setting.

Common NMEA-0183 Sentence

Sentence   **Description**

$GPGGA: Global positioning system fixed data

$GPGLL: Geographic position - latitude / longitude

$GPGSA: GNSS DOP and active satellites

$GPGSV: GNSS satellites in view

$GPRMC: Recommended minimum specific GPS data

$GPVTG: Course over ground and ground speed

To extract information related to surveyed position→

Record at least one of the 3 sentences: $GPGGA, $GPGLL, $GPRMC

GGA Sentence Format (fixed data)

$GPGGA,092204.999,4250.5589,S,14718.5084,E,1,04,24.4,19.7,M,,,,0000*1F

Field	Example	Comments
Sentence ID	$GPGGA	
UTC Time	092204.999	hhmmss.sss
Latitude	4250.5589	ddmm.mmmm
N/S Indicator	S	N = North, S = South
Longitude	14718.5084	dddmm.mmmm
E/W Indicator	E	E = East, W = West
Position Fix	1	0 = Invalid, 1 = Valid SPS, 2 = Valid DGPS, 3 = Valid PPS
Satellites Used	04	Satellites being used (0-12)
HDOP	24.4	Horizontal dilution of precision
Altitude	19.7	Altitude (WGS-84 ellipsoid)
Altitude Units	M	M= Meters
Geoid Separation		Geoid separation (WGS-84 ellipsoid)
Seperation Units	M	Meters
Time since DGPS		In seconds
DGPS Station ID		
Checksum	*1F	always begin with *

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$GPGGA,092204.999,4250.5589,S,14718.5084,E,**1**,04,24.4,19.7,M,,,,0000*1F

- Fix quality:
  - 0 = invalid
  - 1 = GPS fix (SPS)
  - 2 = DGPS fix
  - 3 = PPS fix
  - 4 = Real Time Kinematic
  - 5 = Float RTK

GLL Sentence Format
Geographic position

$GPGLL,4250.5589,S,14718.5084,E,092204.999,A*2D

Field	Example	Comments
ID	$GPGLL	
Latitude	4250.5589	ddmm.mmmm
N/S Indicator	S	N = North, S = South
Longitude	14718.5084	dddmm.mmmm
E/W Indicator	E	E = East, W = West
UTC Time	092204.999	hhmmss.sss
Status	A	A = Valid, V = Invalid
Checksum	*2D	

GSA Sentence Format
GNSS DOP and active satellites

$GPGSA,A,3,01,20,19,13,,,,,,,,,40.4,24.4,32.2*0A

Field	Example	Comments
Sentence ID	$GPGSA	
Mode 1	A	A = Auto 2D/3D
		M = Forced 2D/3D
Mode 1	3	1 = No fix, 2 = 2D, 3 = 3D
Satellite used 1	01	Satellite used on channel 1
.		
.		
.		
Satellite used 12	24	Satellite used on channel 12
PDOP	2.5	Position dilution of precision
HDOP	1.3	Horizontal dilution of precision
VDOP	2.1	Vertical dilution of precision
Checksum	*0A	

GSV Sentence Format
GNSS satellites in view

$GPGSV,3,1,10,20,78,331,45,01,59,235,47,22,41,069,,13,32,252,45*70

Field	Example	Comments
Sentence ID	$GPGSV	
No. of messages	3	No. of messages in complete (1-3)
Sequence no.	1	Sequence no. of this entry (1-3)
Satellites in view	10	
Satellite ID 1	20	Range is 1-32
Elevation 1	78	Elevation in degrees
Azimuth 1	331	Azimuth in degrees
SNR 1	45	Signal to noise ratio dBHZ (0-99)
Satellite ID 2	01	Range is 1-32
Elevation 2	59	Elevation in degrees
Azimuth 2	235	Azimuth in degrees
.		
.		
Checksum	*70	

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RMC Sentence Format

Recommended minimum specific GPS data

$GPRMC,092204.999,A,4250.5589,S,14718.5084,E,0.00,89.68,211200,,*25

Field	Example	Comments
Sentence ID	$GPRMC	
UTC Time	092204.999	hhmmss.sss
Status	A	A = Valid, V = Invalid
Latitude	4250.5589	ddmm.mmmm
N/S Indicator	S	N = North, S = South
Longitude	14718.5084	dddmm.mmmm
E/W Indicator	E	E = East, W = West
Speed over ground	0.00	Knots
Course over ground	0.00	Degrees
UTC Date	211200	DDMMYY
Magnetic variation		Degrees
Magnetic variation		E = East, W = West
Checksum	*25	

VTG Sentence Format
Course over ground and ground speed

$GPVTG,89.68,T,,M,0.00,N,0.0,K*5F

Field	Example	Comments
Sentence ID	$GPVTG	
Course	89.68	Course in degrees
Reference	T	T = True heading
Course		Course in degrees
Reference	M	M = Magnetic heading
Speed	0.00	Horizontal speed
Units	N	N = Knots
Speed	0.00	Horizontal speed
Units	K	K = KM/h
Checksum	*5F	

NMEA-0183 data file

```
$GPRMC,104426.591,A,5920.7019,N,01803.2893,E,0.117980,320.93,141204,,*0F
$GPGGA,104427.591,5920.7009,N,01803.2938,E,1,05,3.3,78.2,M,23.2,M,0.0,0000*4A
$GPGSA,A,3,05,24,17,30,02,,,,,,,,,5.6,3.3,4.5*34
$GPGSV,3,1,12,30,72,254,30,05,70,125,39,24,37,083,43,02,36,113,45*7B
$GPGSV,3,2,12,04,32,059,34,01,27,307,00,14,26,256,00,06,24,219,00*7F
$GPGSV,3,3,12,17,22,135,40,25,20,311,31,09,19,159,25,20,08,346,34*7C
$GPRMC,104427.591,A,5920.7009,N,01803.2938,E,0.146345,320.93,141204,,*08
$GPGGA,104428.591,5920.7008,N,01803.2943,E,1,05,3.3,78.9,M,23.2,M,0.0,0000*43
$GPGSA,A,3,05,24,17,30,02,,,,,,,,,5.6,3.3,4.5*34
$GPGSV,3,1,12,30,72,254,31,05,70,125,41,24,37,083,44,02,36,113,46*71
$GPGSV,3,2,12,04,32,059,34,01,27,307,00,14,26,256,00,06,24,219,00*7F
$GPGSV,3,3,12,17,22,135,40,25,20,311,30,09,19,159,25,20,08,346,35*7C
$GPRMC,104428.591,A,5920.7008,N,01803.2943,E,0.164145,320.93,141204,,*08
$GPGGA,104429.591,5920.7012,N,01803.2931,E,1,05,3.3,77.1,M,23.2,M,0.0,0000*4B
$GPGSA,A,3,05,24,17,30,02,,,,,,,,,5.6,3.3,4.5*34
$GPGSV,3,1,12,30,72,254,31,05,70,125,40,24,37,083,43,02,36,113,46*77
$GPGSV,3,2,12,04,32,059,34,01,27,307,00,14,26,256,00,06,24,219,00*7F
$GPGSV,3,3,12,17,22,135,40,25,20,311,30,09,19,159,25,20,08,346,37*7F
```

Other GPS NMEA sentences

Sentence   **Description**

$GPALM: GPS almanac data

$GPGRS: GPS range residuals

$GPGST: GPS pseudorange noise statistics

$GPMSS: Beacon receiver status

$GPZDA: UTC and local date/time data

References

- Common NMEA Setence types
  - http://www.commlinx.com.au/NMEA_sentences.htm

- NMEA data
  - http://www.gpsinformation.org/dale/nmea.htm

- The National Marine Electronics Association
  - http://www.nmea.org/