Application of Multi-Antenna GPS Technology in Monitoring Stability of Slopes

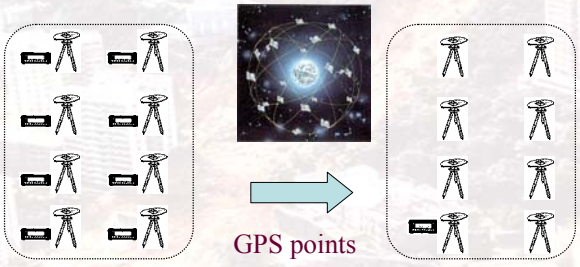
XL Ding, WJ Dai, WT Yang, XW Zhou, J Lam,
The Kong Hong Polytechnic University

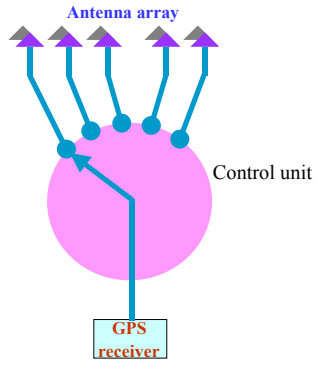
Q Zhang, L Wang
Chang'An University

GPS and Slope Monitoring

- There are many unstable slopes
- Monitoring the progressive movement of slopes is important for preventing unexpected slope failures
- Conventional GPS technology is considered too expensive for monitoring slopes
- Multi-antenna GPS provides a solution to the problem

Multi-Antenna GPS: Basic Concept





Multi-Antenna GPS: System Components

1) GPS receivers and antennas
2) Control unit
3) Communication system
4) Software
5) Power supply

Multi-Antenna GPS: System Components

1) GPS receivers and antennas
   - Any standard receivers and antennas can be used with the system
   - One or more receivers as reference station(s)
   - One receiver as rover station that is linked to the antenna array

Multi-Antenna GPS: System Components

2) Control unit

- Automatically connects to the rover receiver to different antennas

Multi-Antenna GPS: System Components

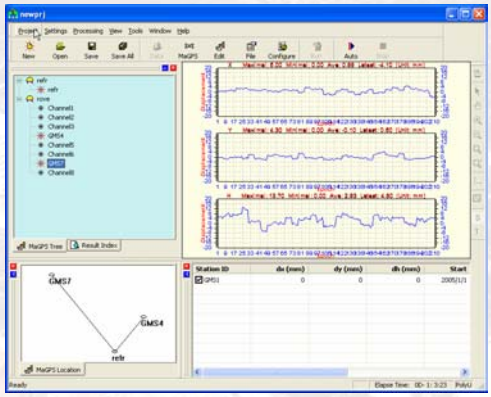
3) Communication system

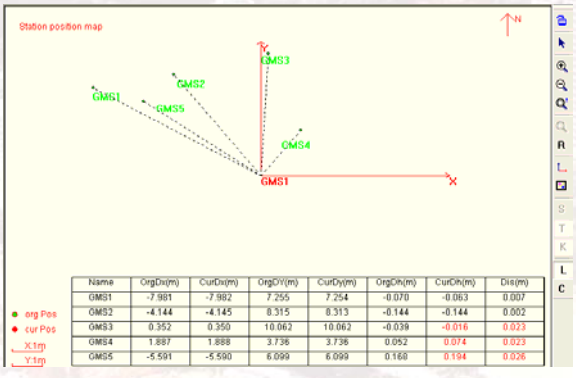
- Functions as data link between a slope site and the office
- Controls the operation of the system and transmits data from site to office
- Any standard systems can be used, e.g., GPRS, GSM, fixed line or wireless internet

Multi-Antenna GPS: System Components

4) Software for system control, data management and processing

- Controls system operation
- Data management
- Data processing
- Visualisation of results





Name	OrgDx(m)	CurDx(m)	OrgDY(m)	CurDy(m)	OrgDh(m)	CurDh(m)	Dis(m)
GMS1	-7.981	-7.982	7.255	7.254	-0.070	-0.063	0.007
GMS2	-4.144	-4.145	8.315	8.313	-0.144	-0.144	0.002
GMS3	0.352	0.350	10.062	10.062	-0.039	-0.016	0.023
GMS4	1.887	1.888	3.736	3.736	0.052	0.074	0.023
GMS5	-5.591	-5.590	6.099	6.099	0.168	0.194	0.026

Overview of System Structure

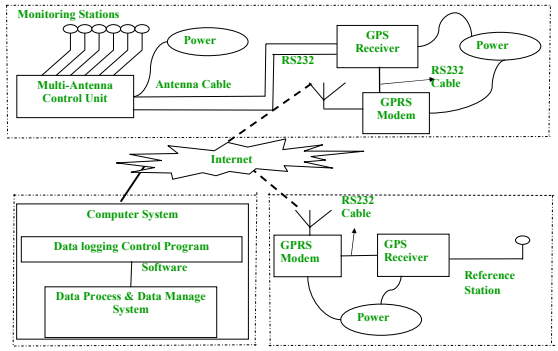


Illustration of a Reference Station

Illustration of a Monitoring Station

Advantages of Multi-Antenna GPS

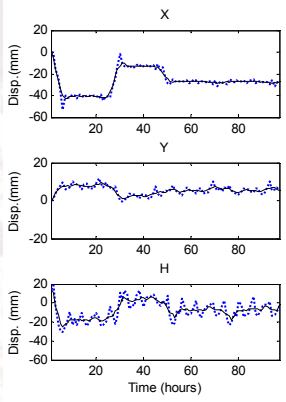
- A much more economical multi-point monitoring system
  - Two receivers for monitoring many points
  - Savings in power supply
  - Savings in data communication
  - Savings in site formation and installation
- When a landslide occurs, only antennas are lost, not the receivers

Disadvantages of Multi-Antenna GPS

- Not real-time measurements for all the monitored points
- Antenna cable lengths are limited

Test and Application Examples (1)

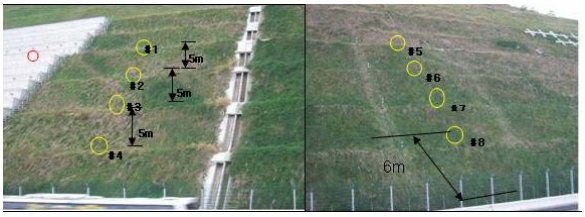
1) Controlled test

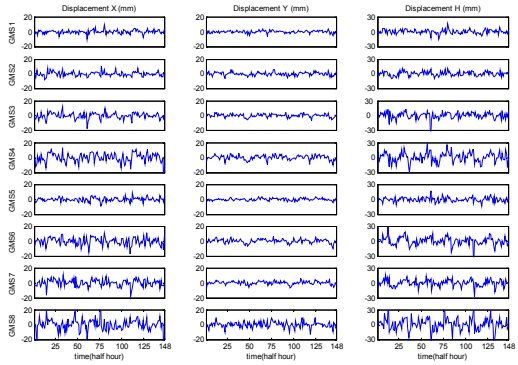


- Four days of data
- Data sampling rate: once every 5 s
- One solution every hour

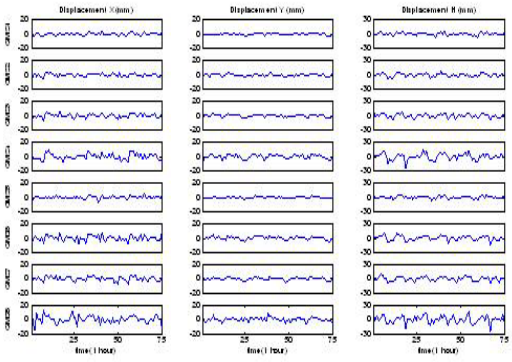
Test and Application Examples (2)

2) Results from a roadside slope

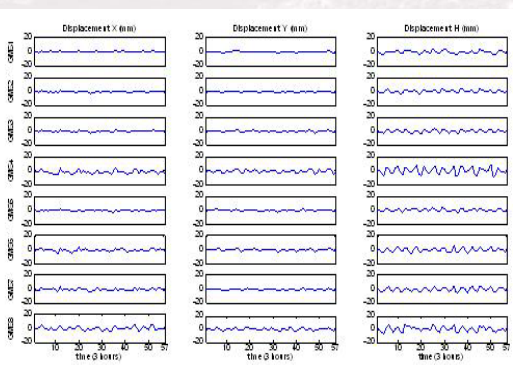




30-minute measurement series



One-hour measurement series



Three-hour measurement series

Table2. RMS values of the coordinate series (interval=30min) (unit: mm)

RMS value	GMS1	GMS2	GMS3	GMS4	GMS5	GMS6	GMS7	GMS8	Average
X	2.5	3.0	4.0	5.9	2.7	5.1	4.6	7.4	4.4
Y	1.7	2.2	2.2	3.0	1.6	2.7	2.3	3.7	2.4
H	4.2	4.5	6.8	9.8	4.4	8.1	6.7	12.5	7.1

Table3. RMS value of the coordinate series (interval=1hour) (unit: mm)

RMS value	GMS1	GMS2	GMS3	GMS4	GMS5	GMS6	GMS7	GMS8	Average
X	1.8	2.2	2.8	4.2	2.0	4.0	3.3	5.1	3.2
Y	1.2	1.7	1.7	2.7	1.3	2.2	1.8	2.9	1.9
H	2.8	3.4	4.1	6.6	2.8	5.0	4.5	7.7	4.6

Table4. RMS value of the coordinate series (interval=3hour) (unit: mm)

RMS value	GMS1	GMS2	GMS3	GMS4	GMS5	GMS6	GMS7	GMS8	Average
X	0.9	1.2	1.3	3.2	1.2	2.1	1.9	2.4	1.8
Y	0.9	1.0	1.2	2.3	1.1	1.4	1.2	1.9	1.4
H	2.1	2.0	2.1	4.7	1.9	2.9	2.7	3.8	2.8

Conclusions

- Multi-antenna GPS is an economical and effective solution for applications such as landslide monitoring
- Results from controlled tests and applications of the technology have shown that millimeter level of measurement accuracy can be routinely achieved

Acknowledgements

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