

# Monitoring dynamical displacements of Tongji mansion A building using GNSS technology

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# Outline

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- \* Objectives
- \* Monitoring System
- \* Experiment
- \* Initial results
- \* Conclusion



# Objectives

- \* Monitoring deformation of structures of Tall buildings under natural and artificial loads, such as gust wind, earthquake, metro operation.....
- \* A real time monitoring system for evaluating structure health for emergency issues
- \* Database of deformation of structures under various loads, supporting structure life-cycle and safety research





# Tall buildings in Shanghai



# Tall building in Shanghai

- \* Park Hotel Shanghai(上海国际饭店) , 78m, 1934
- \* Hotel Shaianghai(上海宾馆),92m,1983
- \* Shanghai Telecom Building(电信大楼),131m,1987.
- \* Hilton Hotel(静安希尔顿宾馆),143m,1987.
- \* 新锦江宾馆, 154m,1989.
- \* 上海商城,165m,1990.
- \* 信息枢纽大厦202m,1995
- \* 国际航运大厦238m,1996
- \* 明天广场 283m
- \* 恒隆广场 288m
- \* 金茂大厦420.5m,1998
- \* Shanghai World Financial Center(上海环球金融中心),492m,2008.
- \* Shanghai Center(上海中心大厦),632m, in construction。





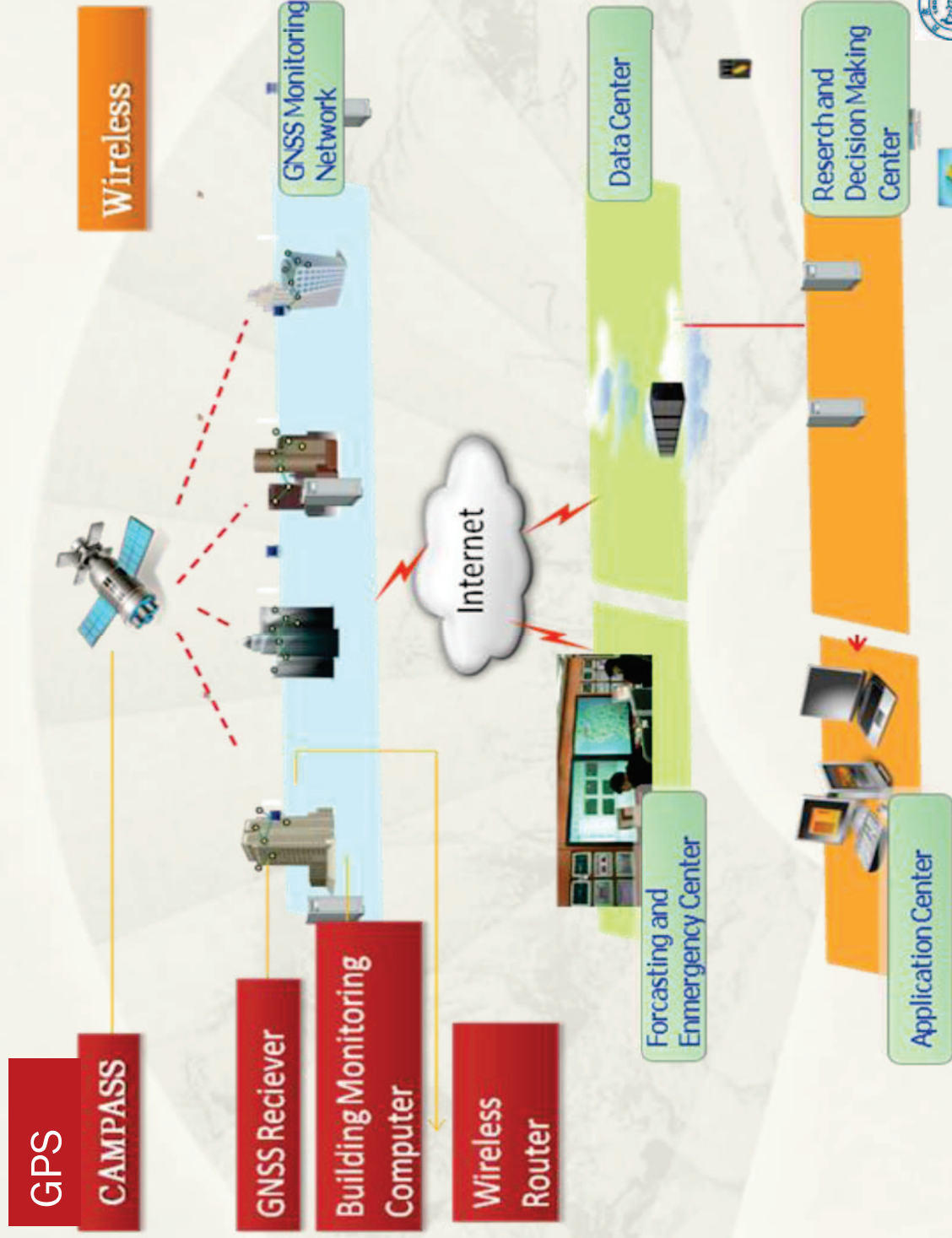
# Tall Buildings in Shanghai



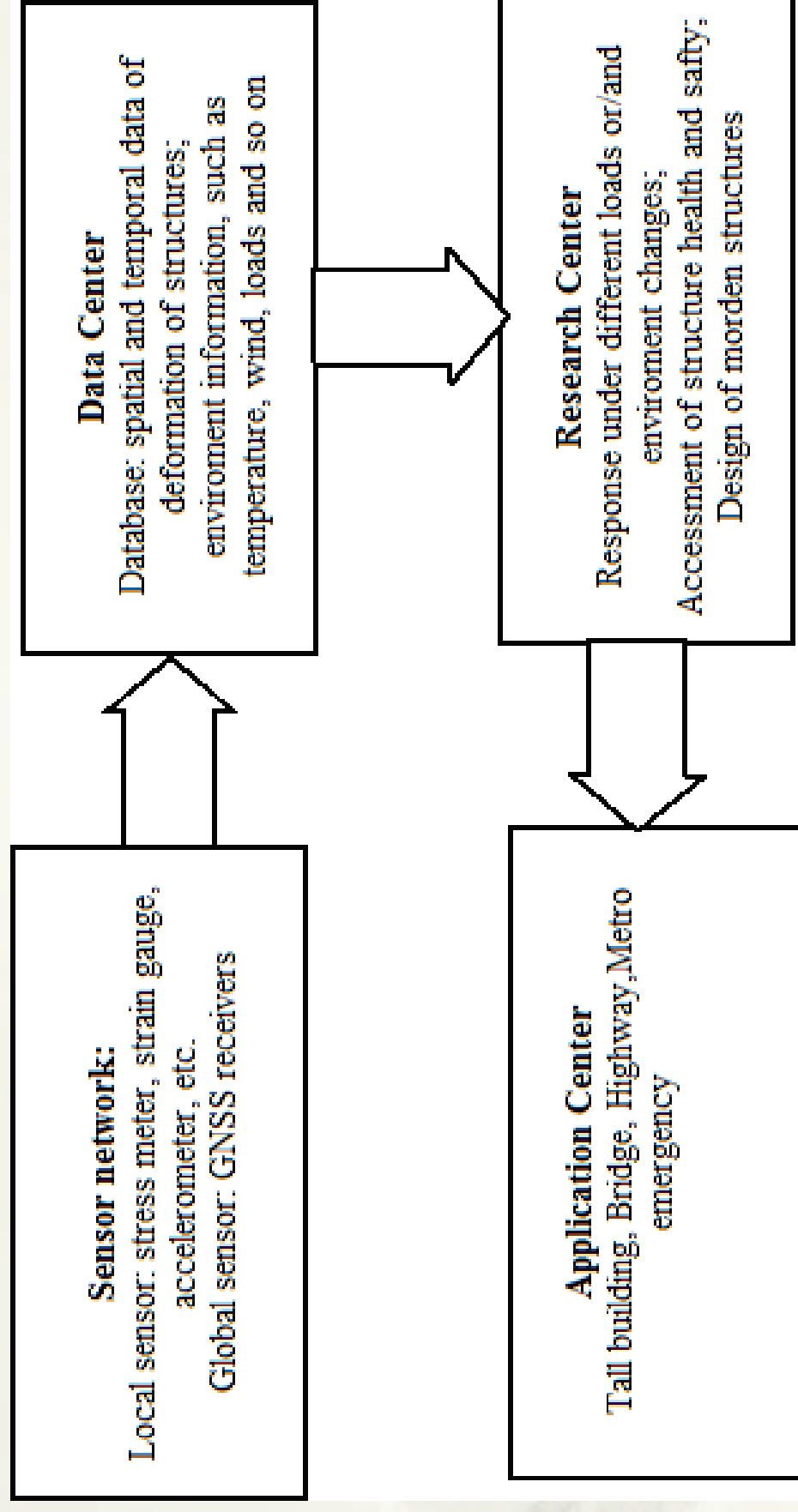
	Built	In Construction	Planned
Above 400m	2	1	3
300-400m	1	1	4
200-300m	26	8	26
100-200m	401	177	NA

*There are 51 tall buildings higher than 150m*

# Monitoring system of tall building

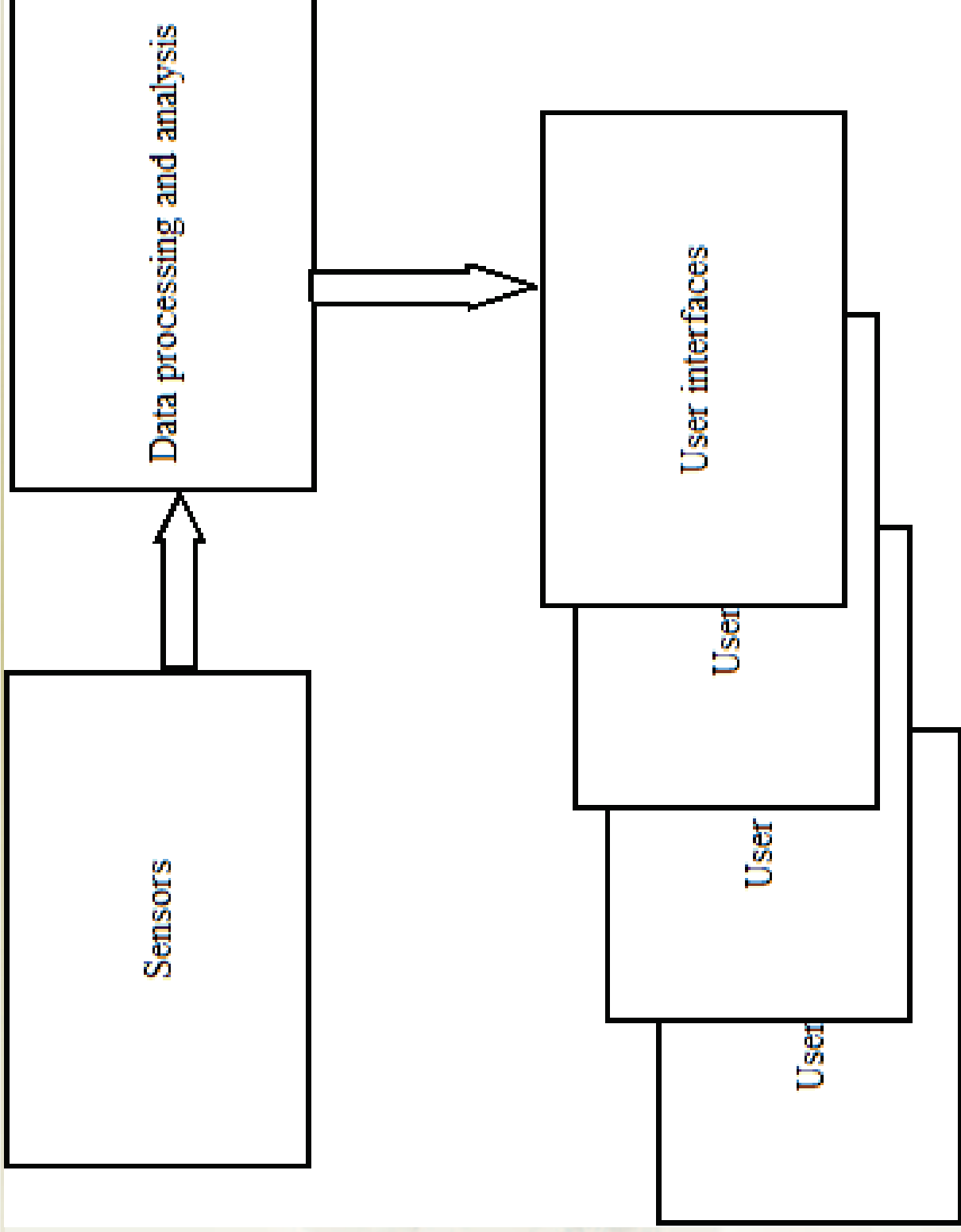


# Structure health monitoring system research





# Monitoring System



# Sensor Requirements

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- \* Low power
- \* Synchronous
- \* Expandable



# Wire or wireless communication

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- \* Among sensors
- \* Between sensor network and data center
- \* Emergency system





# SHM Applications

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- \* Huge Bridge
- \* Tall building
- \* Complex structure of important infrastructure
- \* Heritage building



# Experiment

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- \* Location
- \* Compass/GPS receivers
- \* Data communication
- \* Initial results



# Location of Tongji A building





# Tongji A building

- \* Height 99.5m
- \* 25 storey, 2010
- \* Steel
- \* concrete cylinder core



# Surveying&Mapping Building

- \* Height, 18m
- \* 5 storey, 1988





# Compass/GPS receivers

## UR240-RTK BD2/GPS 双系统四频高精度接收机

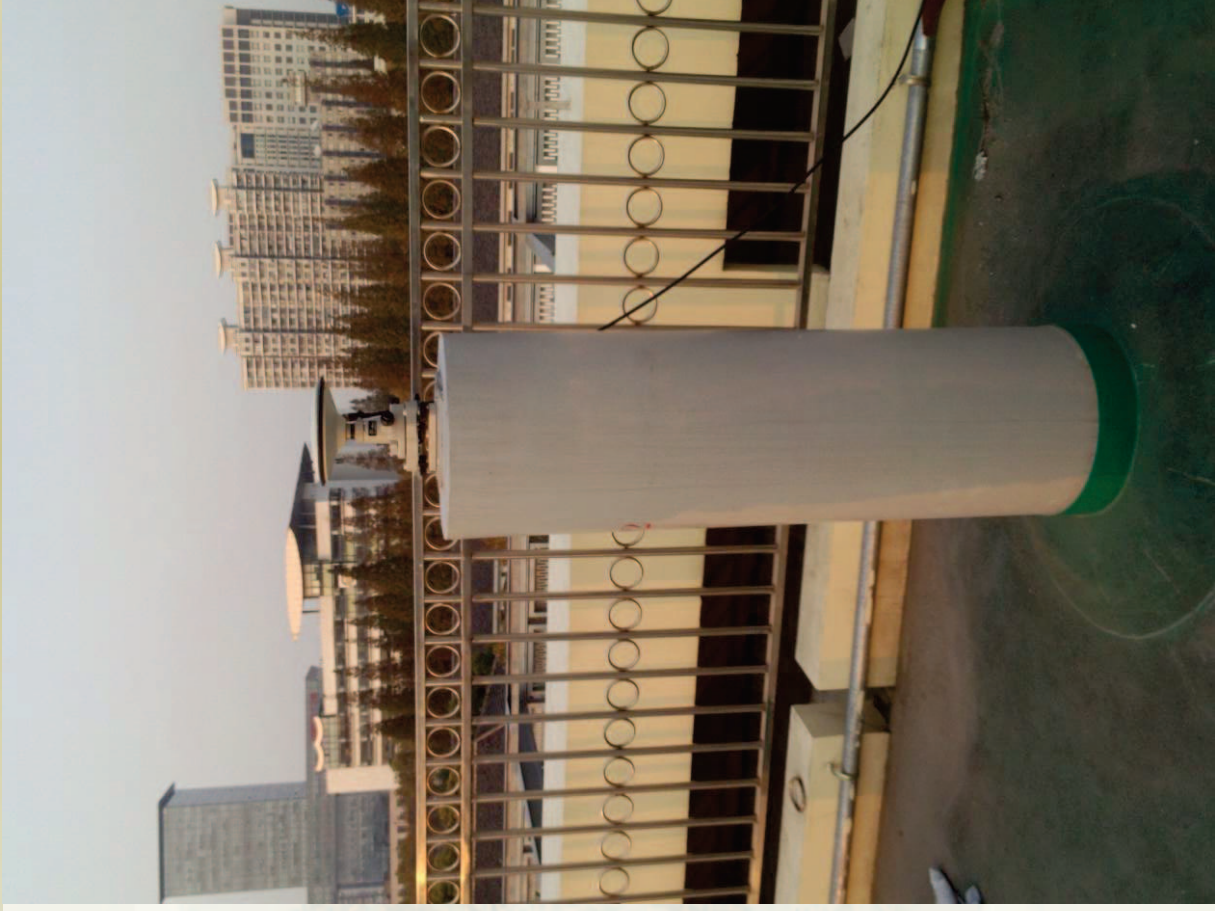


通道 Channels	基于I92 通道Nebulas 芯片 支持BD2 B1/B2 + GPS L1/L2	
单点定位 PPP	1.5m (水平)	
RTK	Horizontal 水平: 1cm+ 1ppm Vertical 垂直: 2cm + 1ppm	
观测精度 Precision	北斗	GPS
	B1/L1 C/A 码	10cm
	B1/L1 载波相位	0.5mm
	B2/L2P(Y) 码	10cm
B2/L2 载波相位	0.5mm	
冷启动时间 Cold start	50s	
差分数据 Data format	RTCMV3.0	
数据格式 Data format	NMEA-0183 (可定制), RINEX	
原始观测量更新率 Frequency	最高可达 10Hz	
时间精度 (RMS) Time accuracy	20ns	
速度精度 (RMS) Velocity accuracy	0.03m/s	



# Compass receiver at S&M building

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# Compass receiver at Tongji A building

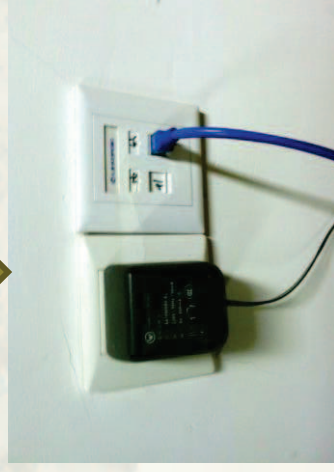




COMPASS/GPS天线

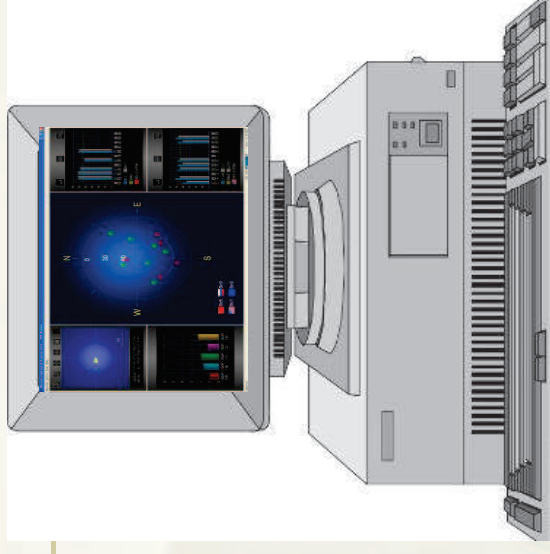


COMPASS/GPS接收机模块



网络端口

# Data Communication





# S&M Building Station

Unicore Control & Display Tool - Logging Control Window  
Receiver Option View Help

Longitude : 121.497991080°E ±1.44m  
Latitude : 31.284794760°N ±1.78m

HOOP	0.70
VDOP	1.28
PDOP	1.46
TDOP	0.83
GDOP	1.68

Port: 19.01 KB/S  
9:02  
2012/11/14

# Tongji A Building Station

Unicore Control & Display Tool - Logging Control Window

Receiver Option View Help

Longitude : 121.502853538°E ±1.47m  
Latitude : 31.284697847°N ±1.79m

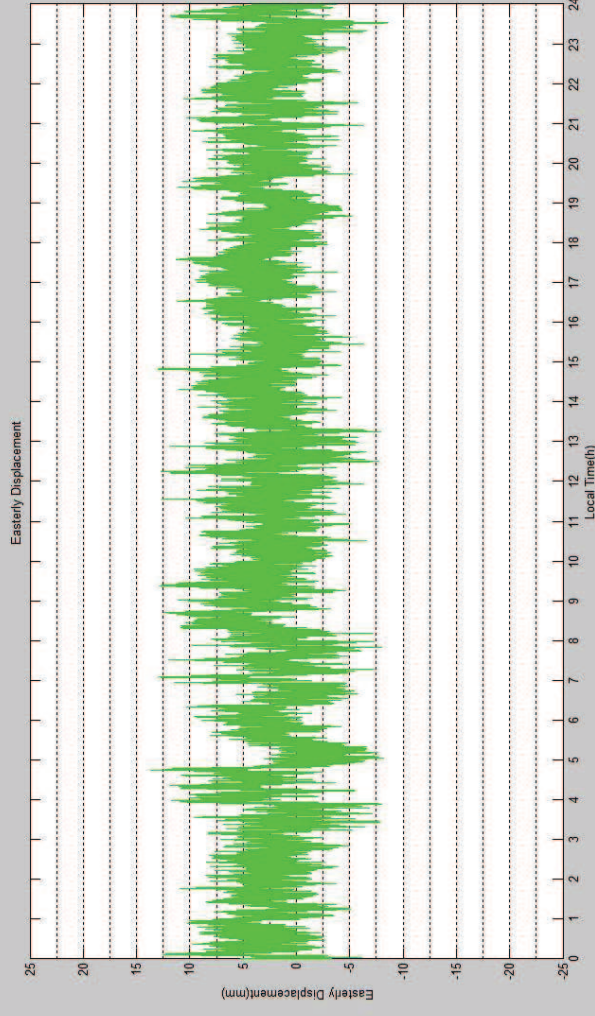
HDOP	VDOP	PDOP	TDOP	GDOP
0.70	1.27	1.45	0.82	1.67

Connected. Port: 19.48 Kb/S 9:00 2012/11/14

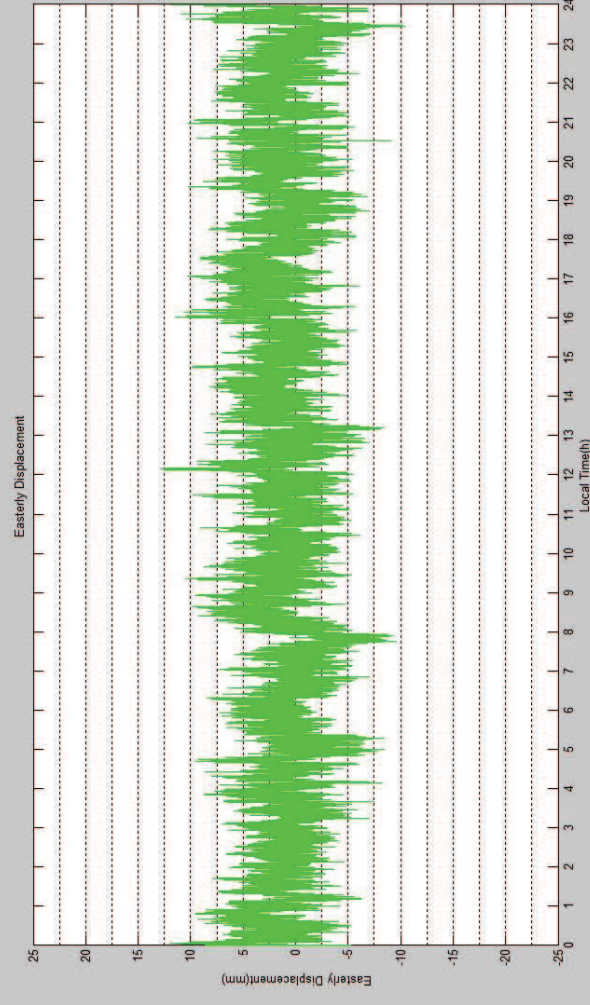


# East components

Nov.8, 2012



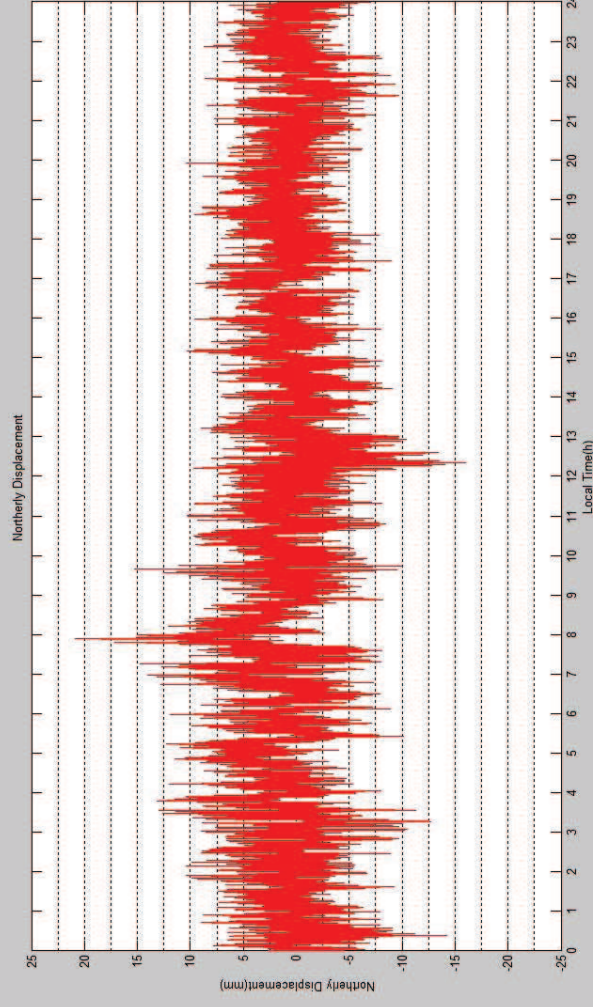
Nov.9, 2012



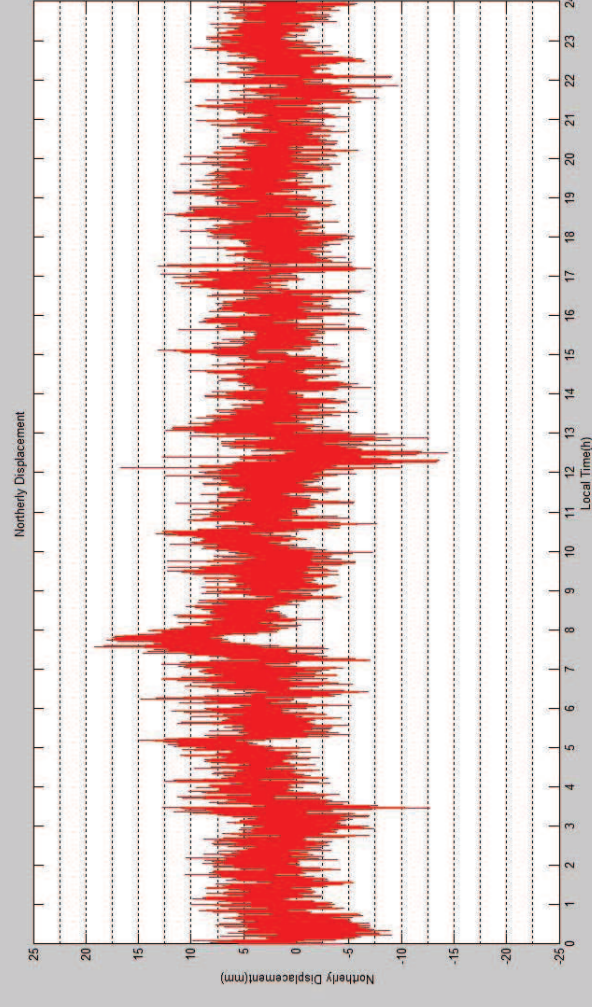


# North components

Nov.8, 2012



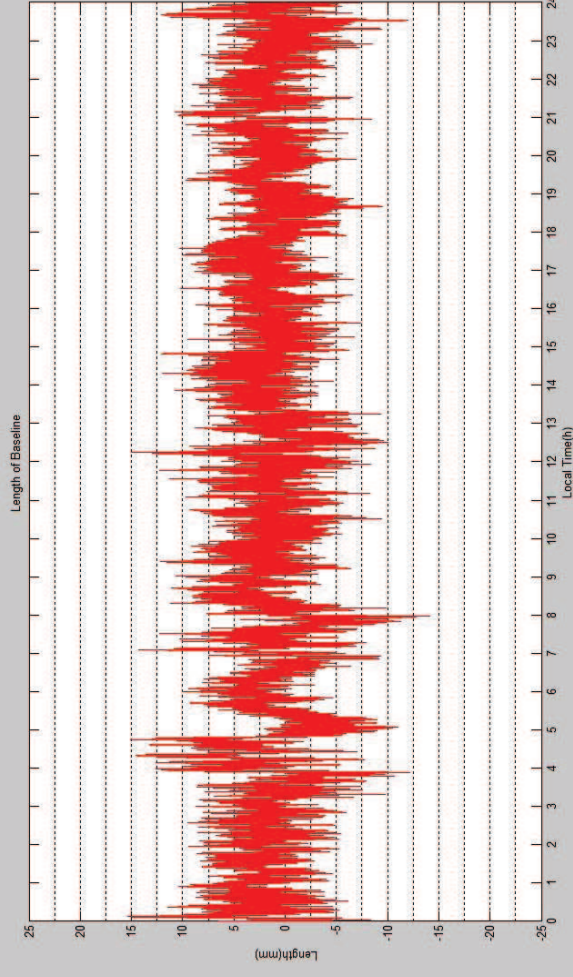
Nov.9, 2012



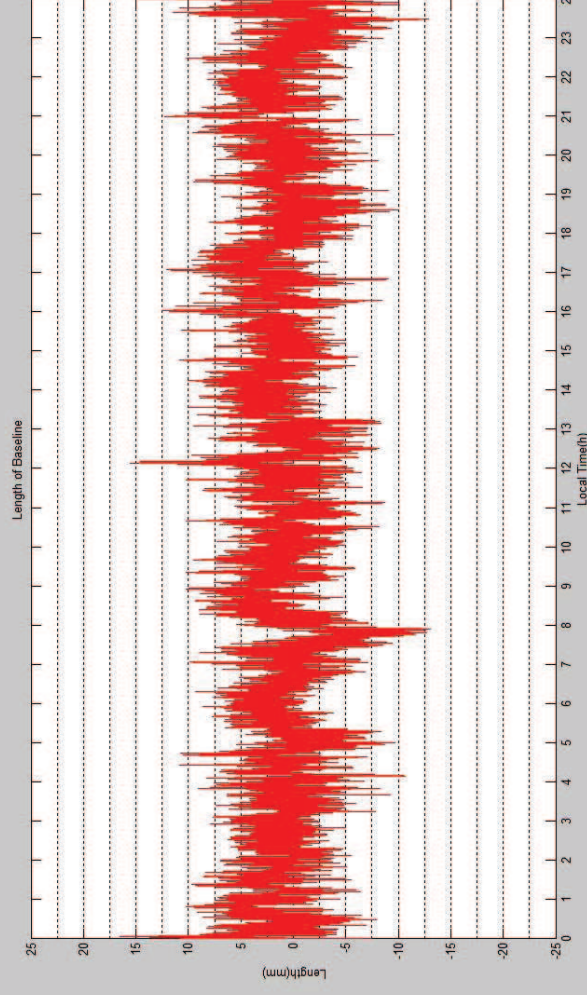
# Initial results

## Baseline length change

Nov.8, 2012

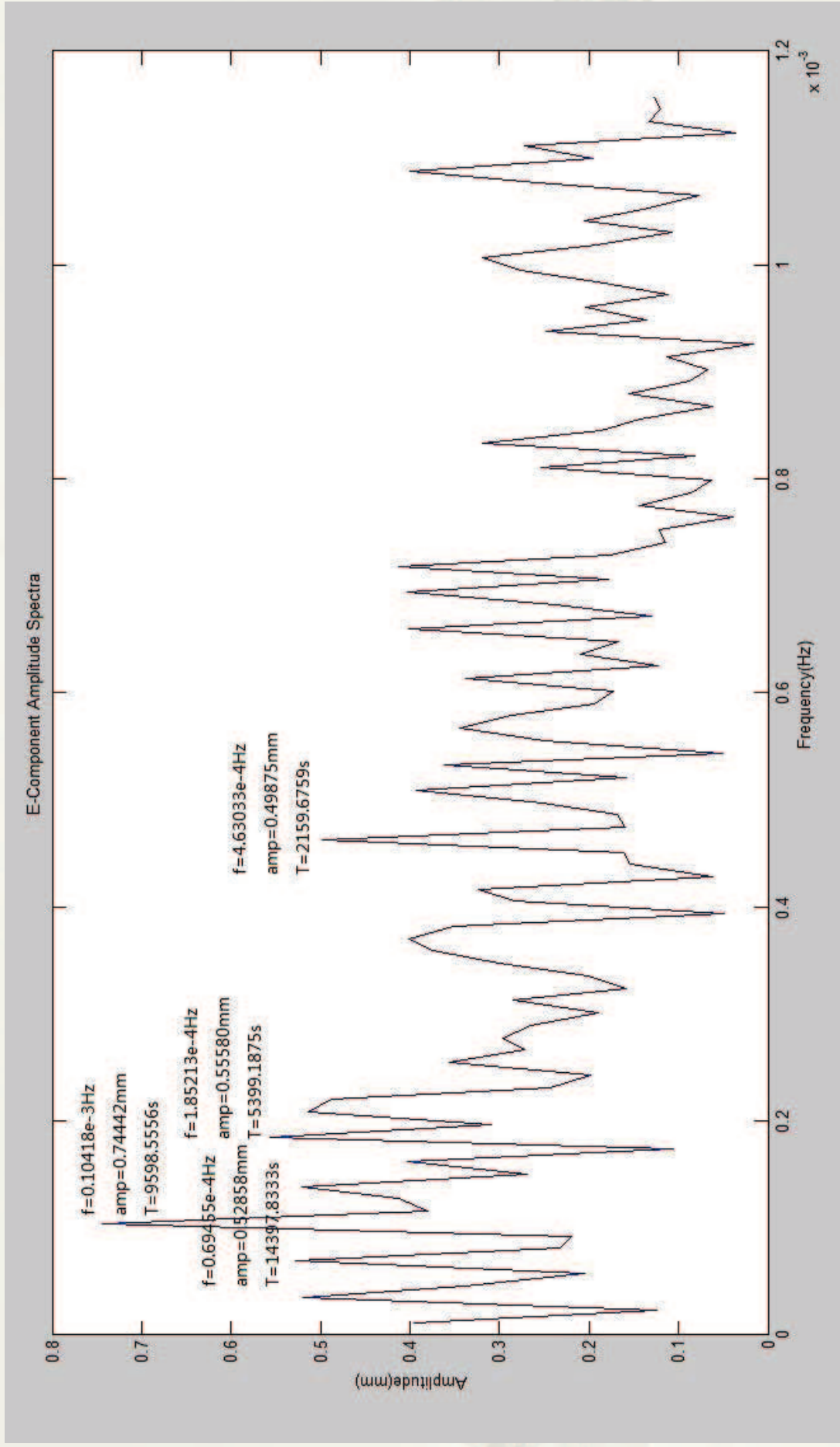


Nov.9, 2012



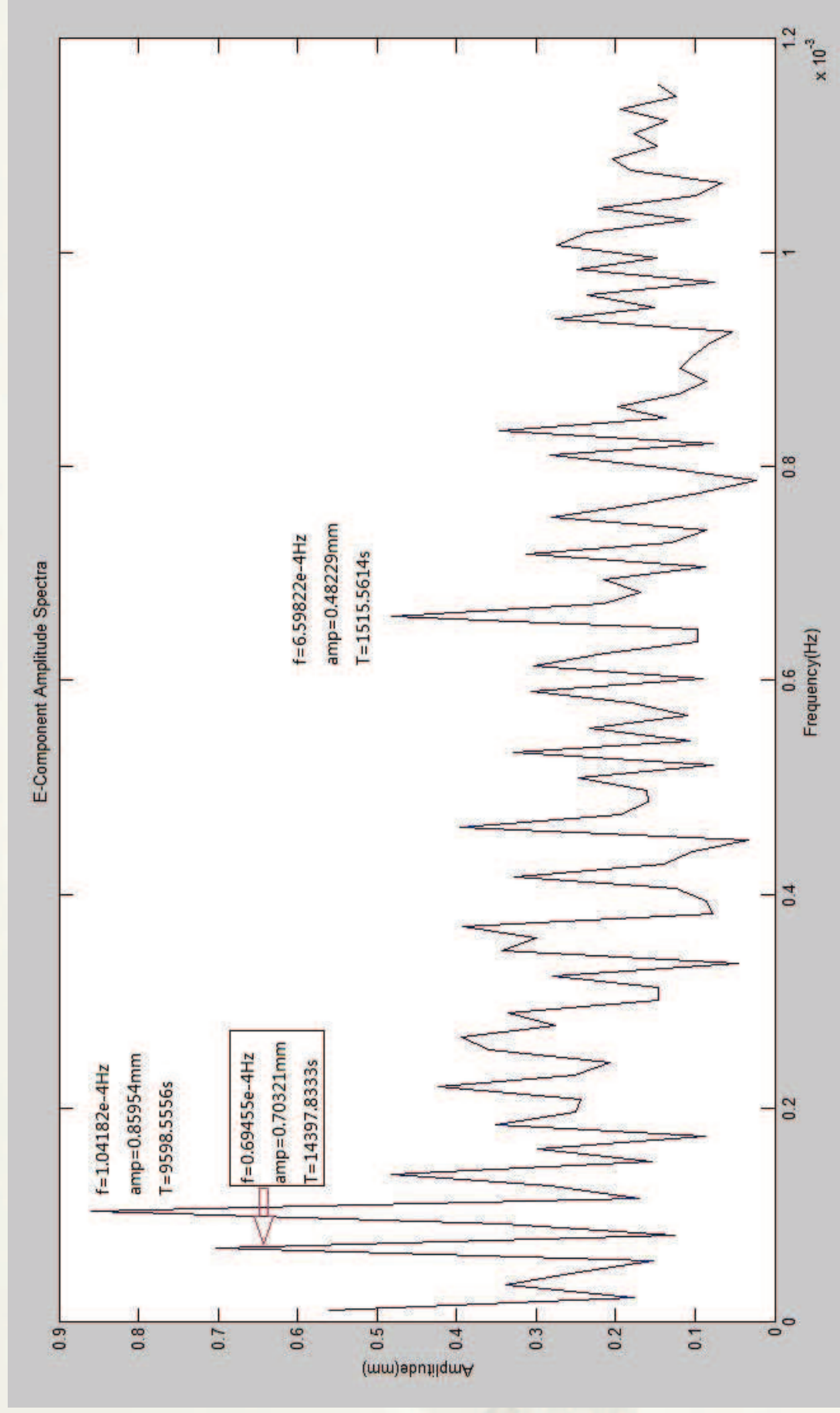


# Spectral Analysis

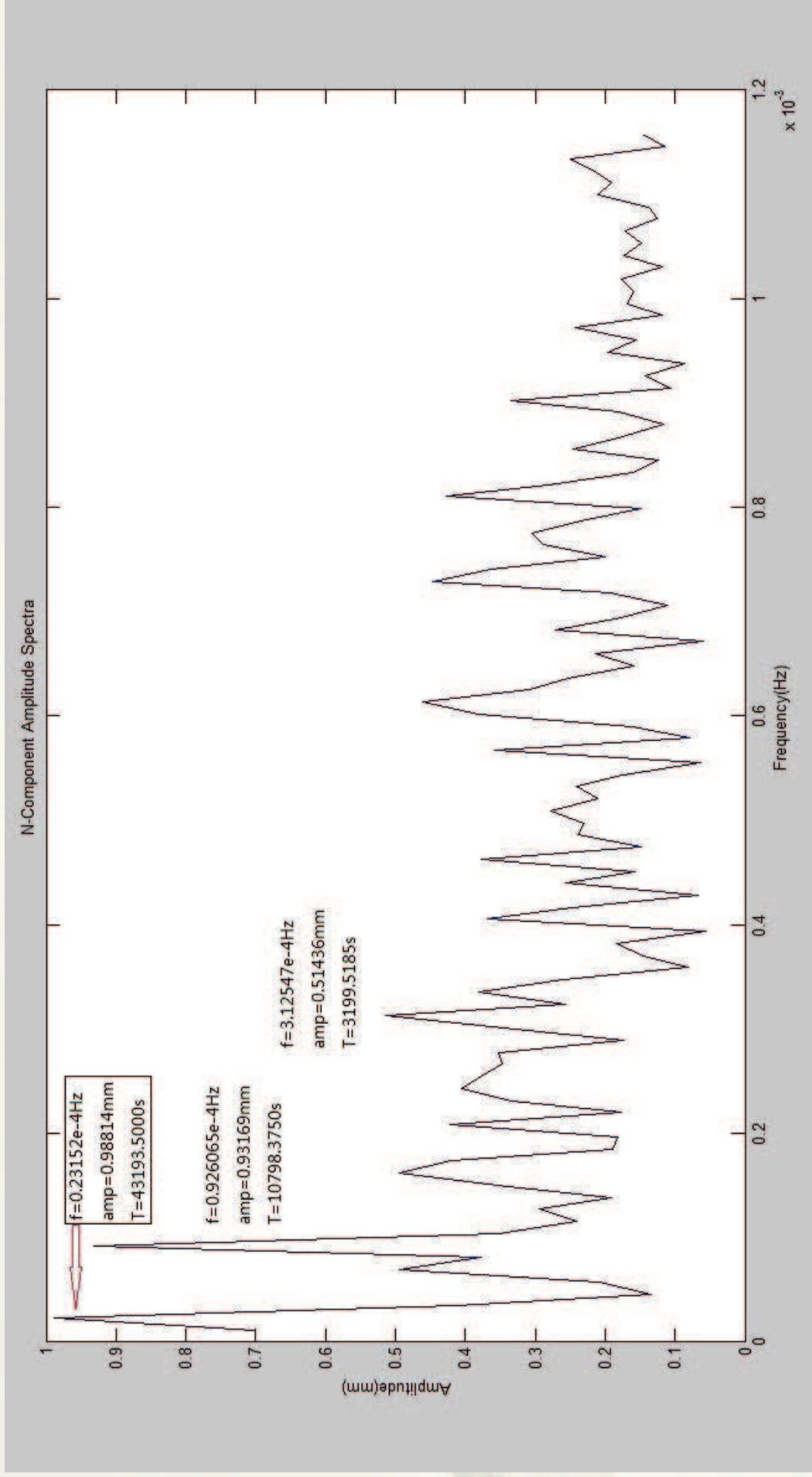




# Spectral Analysis

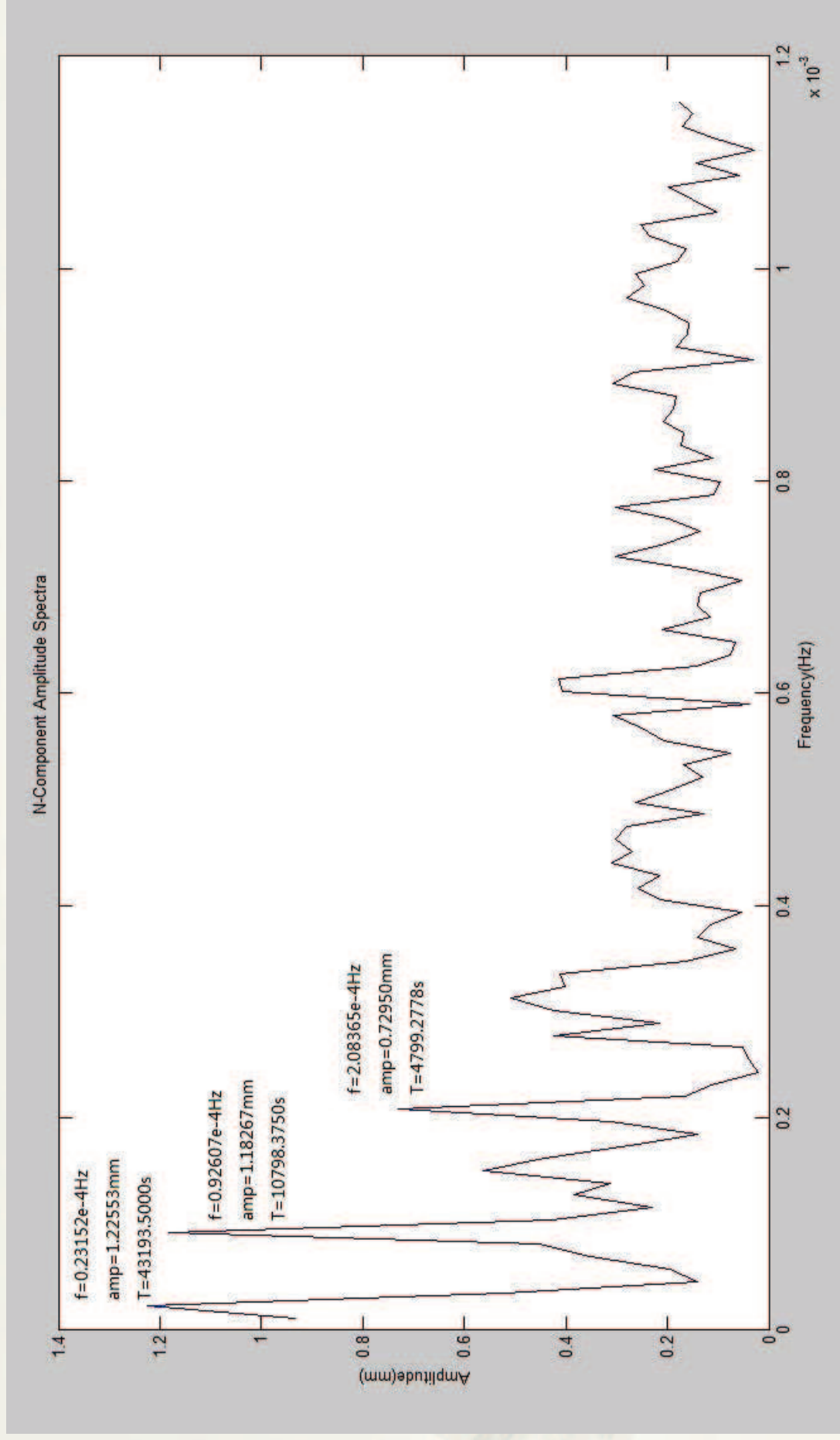


# Spectral Analysis



Nov.8, 2012

# Spectral Analysis



Nov.9, 2012



# Conclusions

- \* A realtime deformation monitoring system is proposed for structure health assessment and research.
- \* An experiment using COMPASS/GPS receivers to obtain dynamical displacements of Tongji mansion A building is implemented and initial results are obtained.
- \* The accuracy of the dynamical horizontal displacement obtained is about 5mm.
- \* We will develop more accurate realtime dynamic positioning method and include observation data from COMPASS satellites.



**Thanks for your attention!**

