

Macao Geodetic Infrastructure: Permanent GPS Reference Stations

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15-May-2006



The Development of Macao Geodetic System



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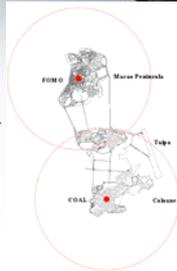
static survey

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GPS Reference Stations - Location

Macao

- Macao Peninsula, Tapia Island and Coloane Island
- Area : 11.6 km² in 1912 → 28.2 km² in 2006
- Extends 7 km from East to West, 11.9 km from North to South



Functionality

- **Collect GPS raw data**
 - Static GPS survey
 - Participate in the APRGP (Asia Pacific Regional Geodetic Project)
 - Provide data to study the geophysical science
- **Broadcast real-time kinematic (RTK) correction messages**
 - Provide differential data with RTCM 2.1 format (Type 3,18,19,22)
 - Apply RTK survey in control survey, topographic survey and demarcation of boundaries

Construction

- Pillar
- Choke ring antenna
 - Leica AT504
- Weatherproof equipment box
 - GPS receiver
 - Communication equipments
- UPS backup power
 - Support 4 days of running in case of A/C power failure
- Concrete platform
- Chain link fence

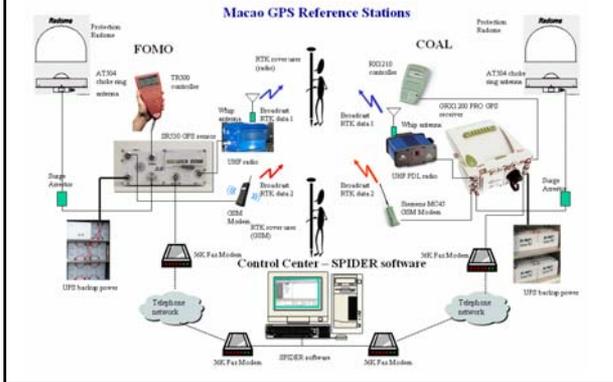


Earthing System

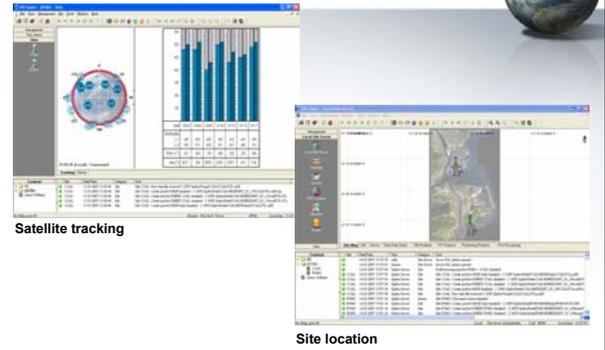
- Station earthing system
 - Grounding net
 - Lightning rod
- Telecom earthing system
- Surge protectors



Structure and Work Flow



Remote control software - Spider Server



Satellite tracking

Site location

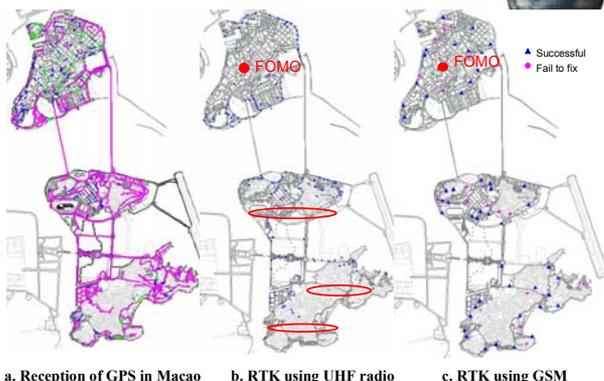
RTK Survey

- **Criteria**
 - Number of visible satellites (≥ 5) and their geometric (PDOP ≤ 5)
 - Distance between the reference station and the rover
 - Error propagation
 - Signal degradation
- **Performance Tests**
 - Compare the usability of different transmission methods
 - Positioning accuracy of RTK over long distances

Different transmission methods (Law, 2004): UHF radio vs GSM modem

- **Check the reception of GPS in Macao**
 - Use a Pocket PC to store NMEA data
 - Collect data from the morning and afternoon sessions
- **RTK survey using UHF and GSM**
 - UHF: 76 successful points in Macao (99% CQ < 5 cm)
48 successful points in Taipa (83% CQ < 5 cm)
39 successful points in Coloane (92% CQ < 5 cm)
 - GSM: 23 testing points in Macao (78% CQ < 5 cm)
22 testing points in Taipa (68% CQ < 5 cm)
22 testing points in Coloane (73% CQ < 5 cm)

Different transmission methods (Law, 2004): UHF radio vs GSM modem



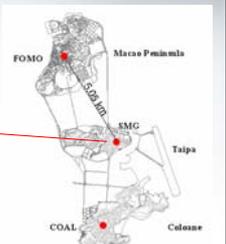
a. Reception of GPS in Macao

b. RTK using UHF radio

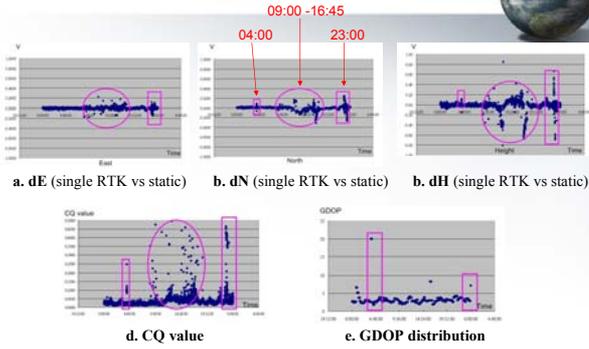
c. RTK using GSM

RTK over long distances

- **Set up GPS receiver for testing**
 - Dual-frequency GPS receiver at the top of Macao Meteorological and Geophysical Bureau (SMG) in Taipa
 - About 5km away from FOMO
 - Continuous 24hrs of RTK data and static data



RTK over long distances



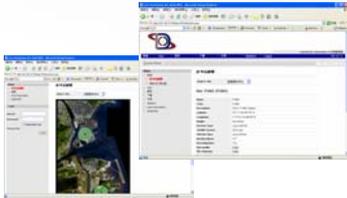
Future Development

- **Network RTK**
 - Model distance-dependent biases
 - Provide redundancy RTK observations
- **GPS+Glonass**
 - GPS reference station → GNSS reference station
 - Better satellite geometry
 - Multiple-frequency ionospheric correction
- **Services**
 - Web-based system – download data via internet
 - Automatic coordinate computation service



Conclusion

- Two Permanent GPS reference stations : GPS post processing and single RTK
- Complementary transmission methods: UHF radio and GSM
- Investigate the accuracy of RTK coordinates over long distance positioning.
- Future development: Network RTK, GPS+Glonass, Web-based data distribution.



Thanks!

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