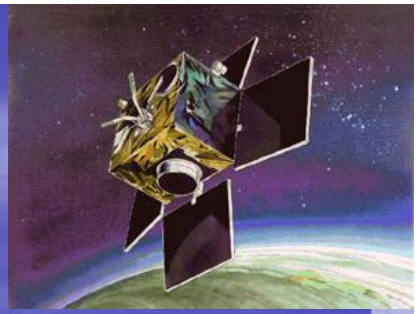

Design and Realization of DMR Based on GPS for Sea Surface Wind Measurement

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Outline

- Introduction
- Geometry of GPS scattered signal
- Measurement Technique
- Delay Mapping Receiver Design
- Data Collection
- Results analysis
- Conclusion

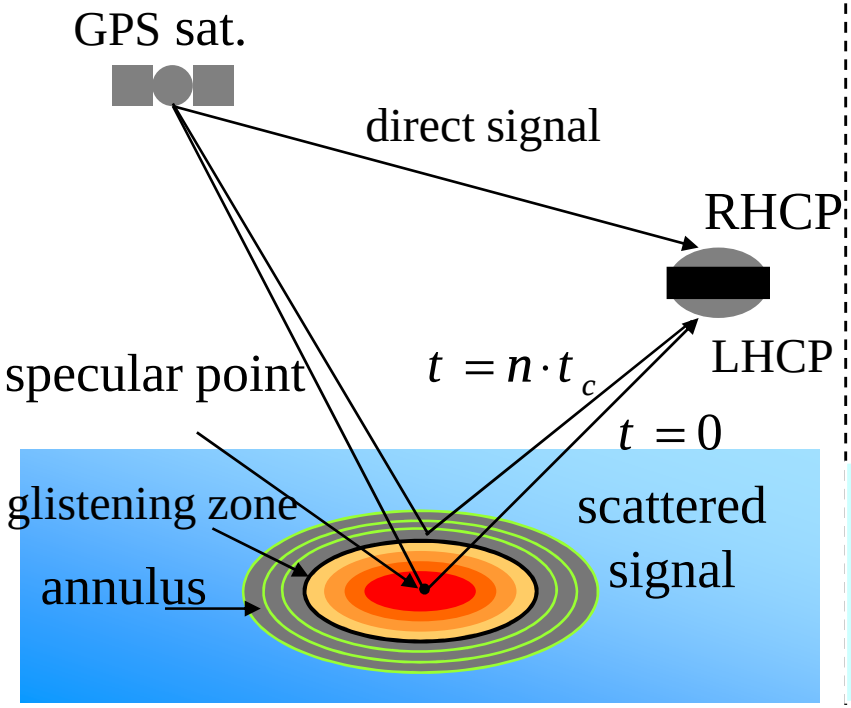
Introduction

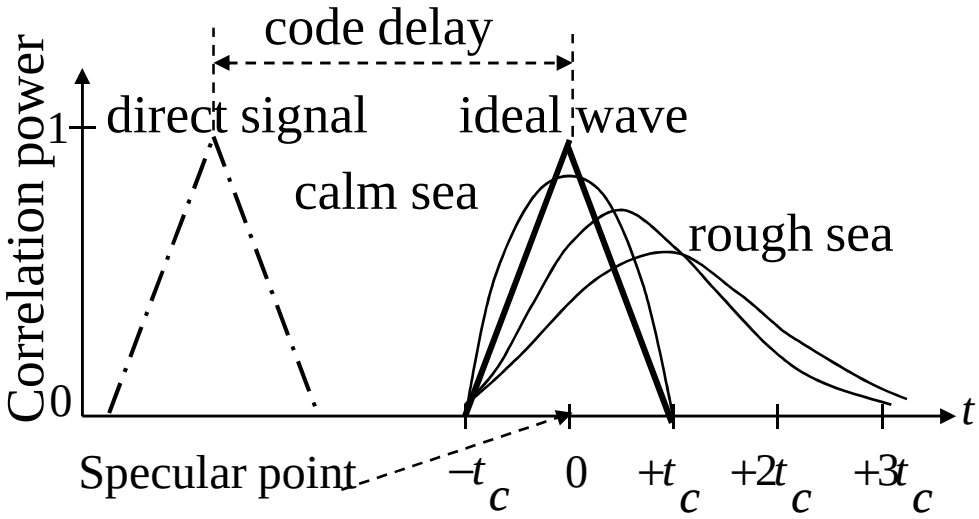
- **Signals of Global Positioning System (GPS) can be used for purposes other than navigation and positioning**
- **The utility of scattered GPS signals from rough surfaces brings a new technology for microwave remote sensing.**
- **The concept is to use GPS in a bistatic radar configuration with the GPS satellite transmitting an L-Band spread spectrum signal, and the receiver on an aircraft or spacecraft platform measuring the reflected signal.**

Main Applications

- Ocean Altimetry
- Ocean Surface Wind Retrieval
- Sea Ice Remote Sensing
- Earth Moisture Remote Sensing
- Passive Target Detection
- Terrain Imaging

Geometry of GPS scattered signal





Code Delay-> Path Difference-> **Altimetry**

Wave Characters> **Wind Vector or Other Info**

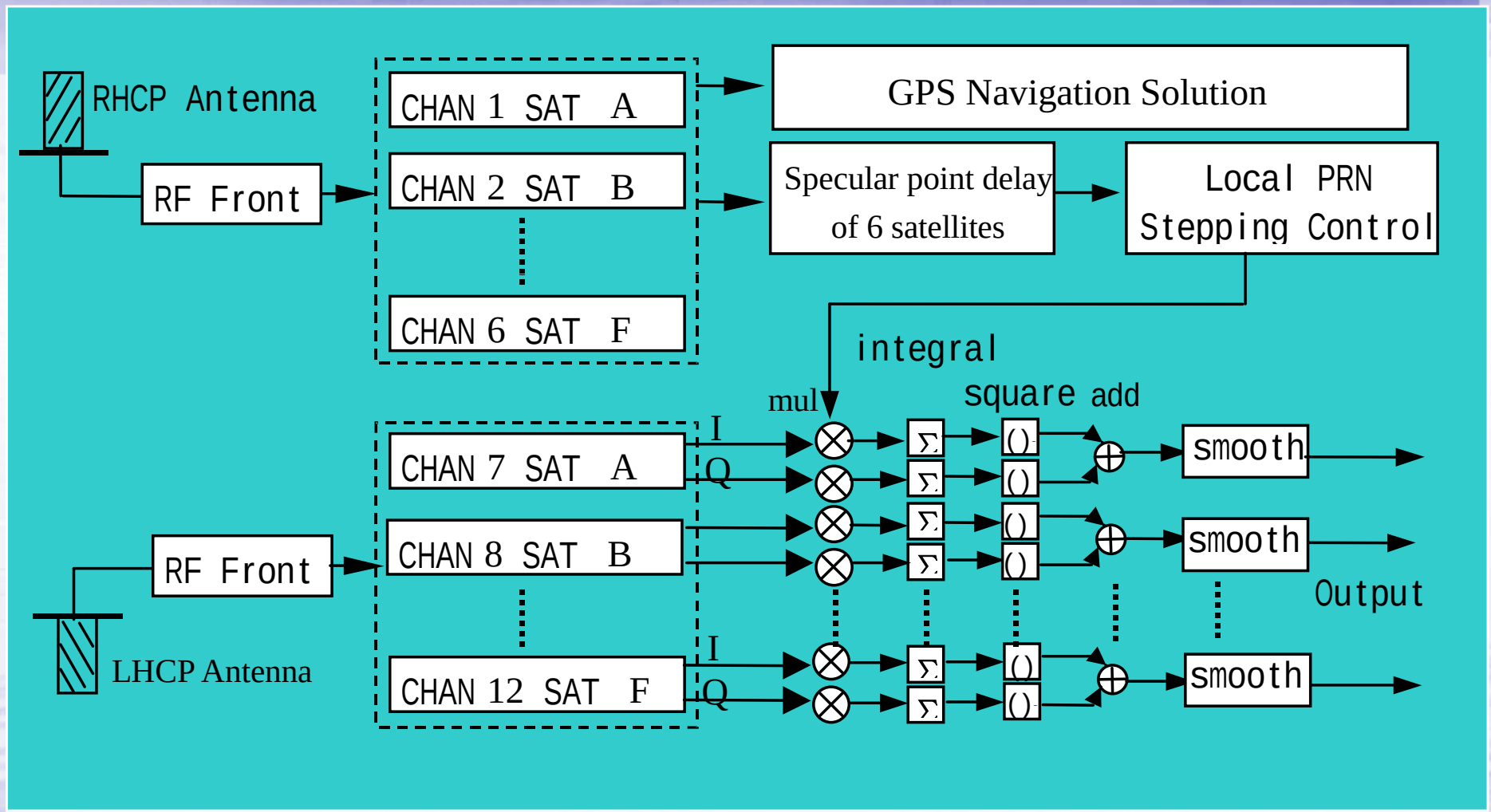
Measure Technique

- Direct Transmitting GPS Signal is RHCP (Right-Hand Circularly-Polarization)
- Scattered signal is LHCP (Left-Hand Circularly-Polarization)due to phase shift at reflection
- Correlation is expressed as the integral:

$$Y(t, t_0, t) = \int_0^{T_i} a(t + t_0 - t) \cdot u(t + t_0) dt$$

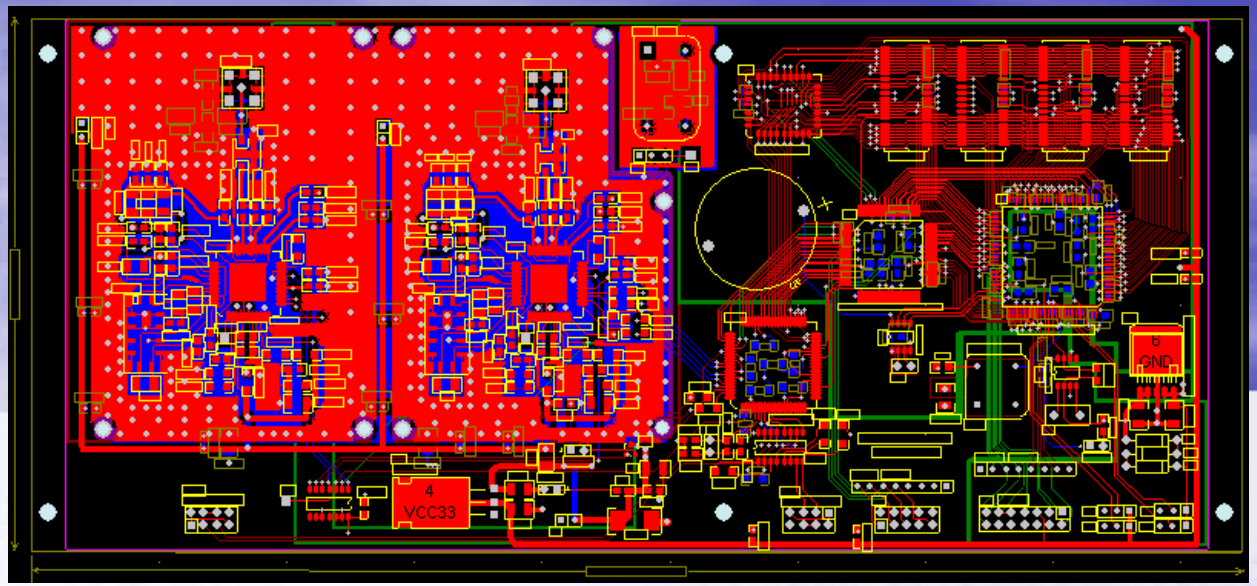
Here $a(t)$ is the locally generated C/A code, $u(t)$ is the received signal, t_0 is specular point delay, t is delay between [t_0 -M, t_0 +32-M] at half code chip, T_i is integration time,

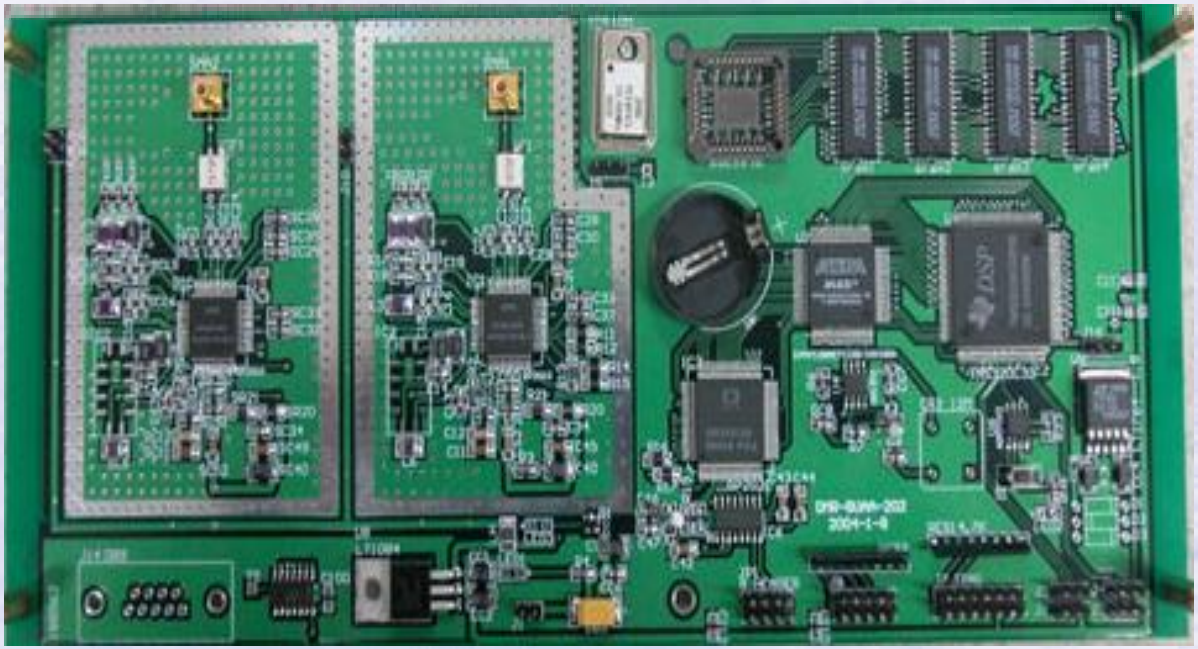
Delay Mapping Receiver Design



Delay Mapping Receiver

- 12 parallel channels
- Channel 1-6 connected to RHCP antenna to receive direct signal from GPS satellite, working in close loop for code tracking, and positioning calculation.
- Use 2hsin(Θ) to calculate the path delay of the specular points relative to the direct signals for each satellite.
- Channel 7-12 connected to LHCP antenna to receive scattered signal, working in open loop mode.
- Channel 7-12 is configured to the code phase and carrier frequency calculated from direct channels.
- Local replica is then moved between [$t_0 - M$, $t_0 + 32 - M$] to record the cross-correlation power stepped by half chip bins.
- At each step, the signal is integrated for one millisecond ,measurements are filtered and output at 1Hz.

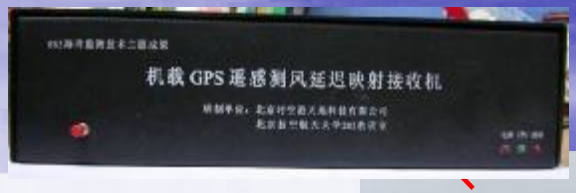




Data Collection

- 9 Test flights were done at TianJin, QingDao, DaLian with the DMR mounted on YUN-12 airplane.
- RHCP antenna is mounted on the top of the airplane to receive the direct signal from GPS satellite
- LHCP antenna at the bottom of the airplane, facing downward to sea surface to receive scattered signals.

Data Collection



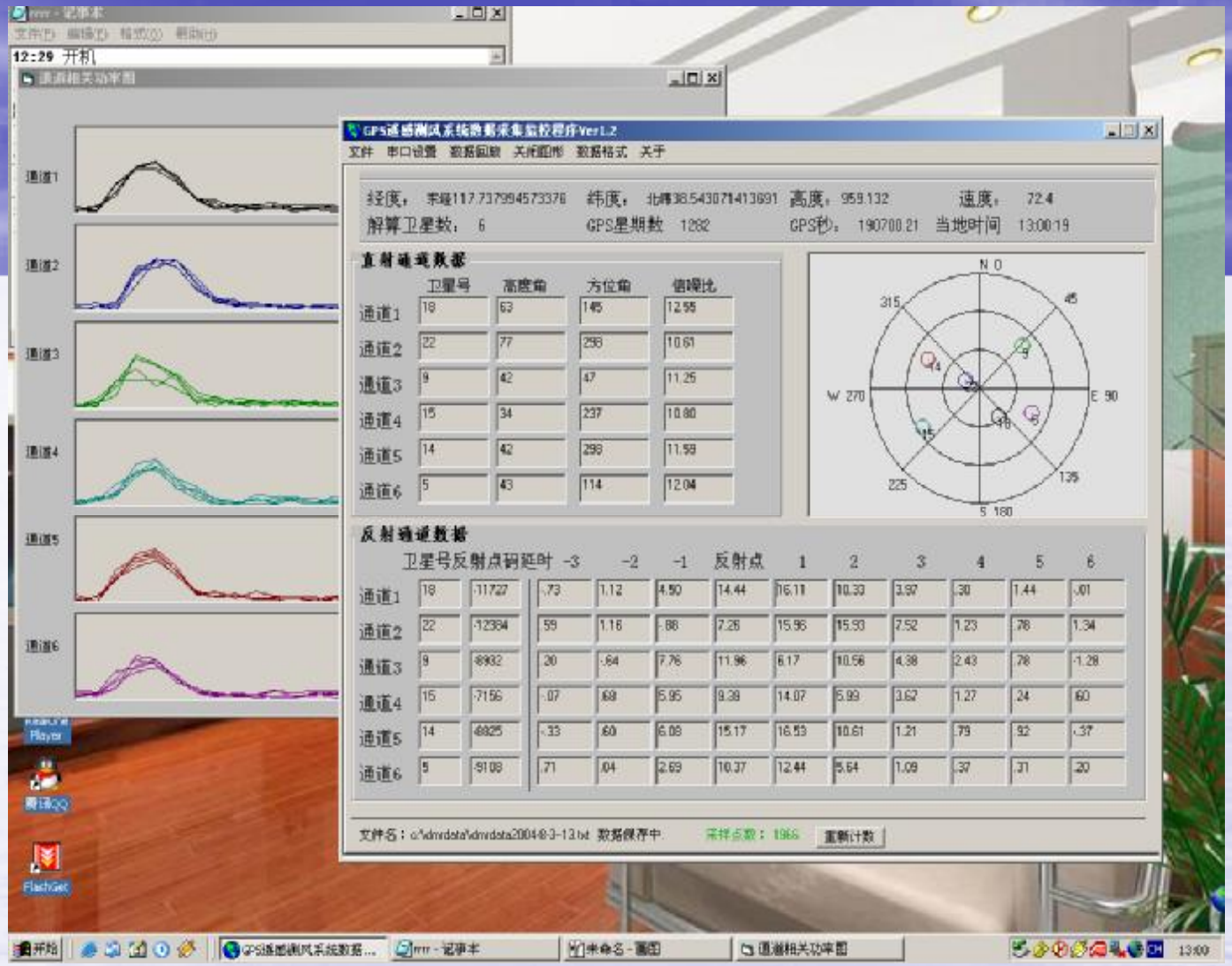
Equipped DMR

RHCP Antenna

LHCP Antenna

YUN-12 Airplane For Test

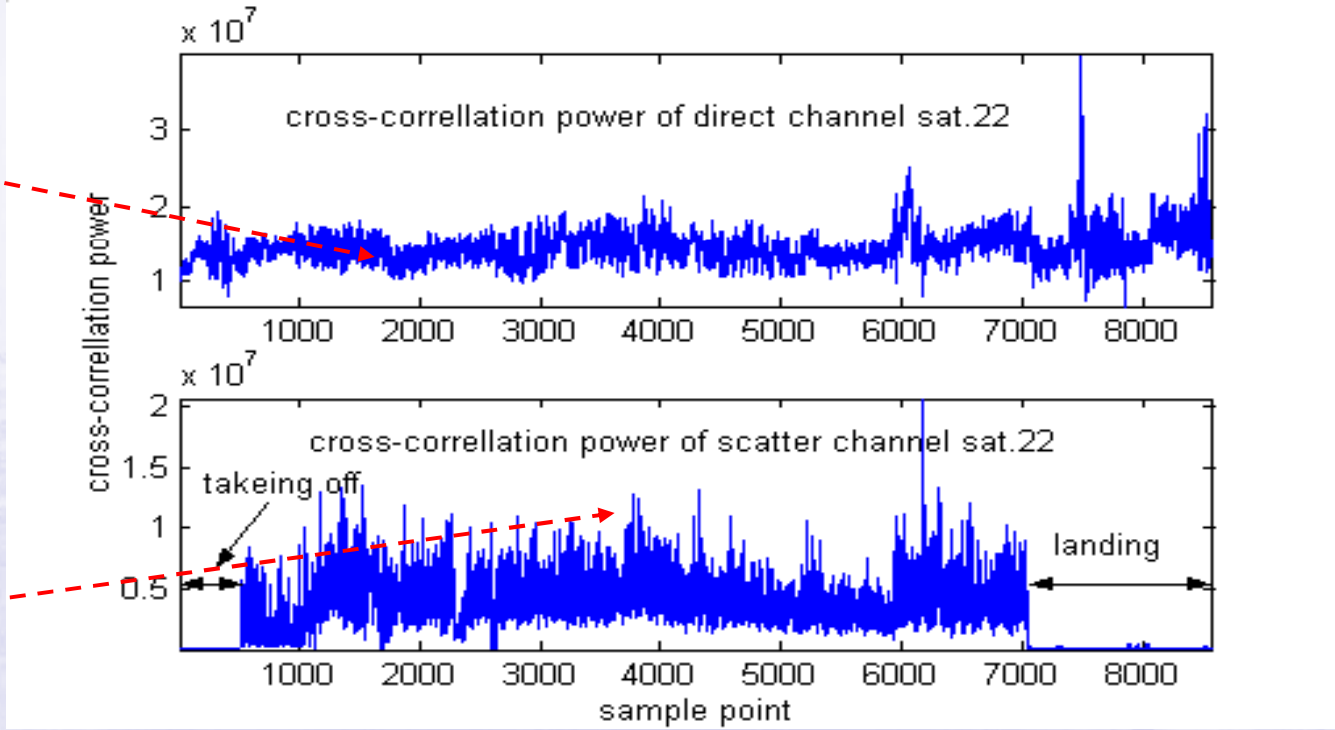
Laptop & Software



Direct & Scattered Signal

Direct Signal

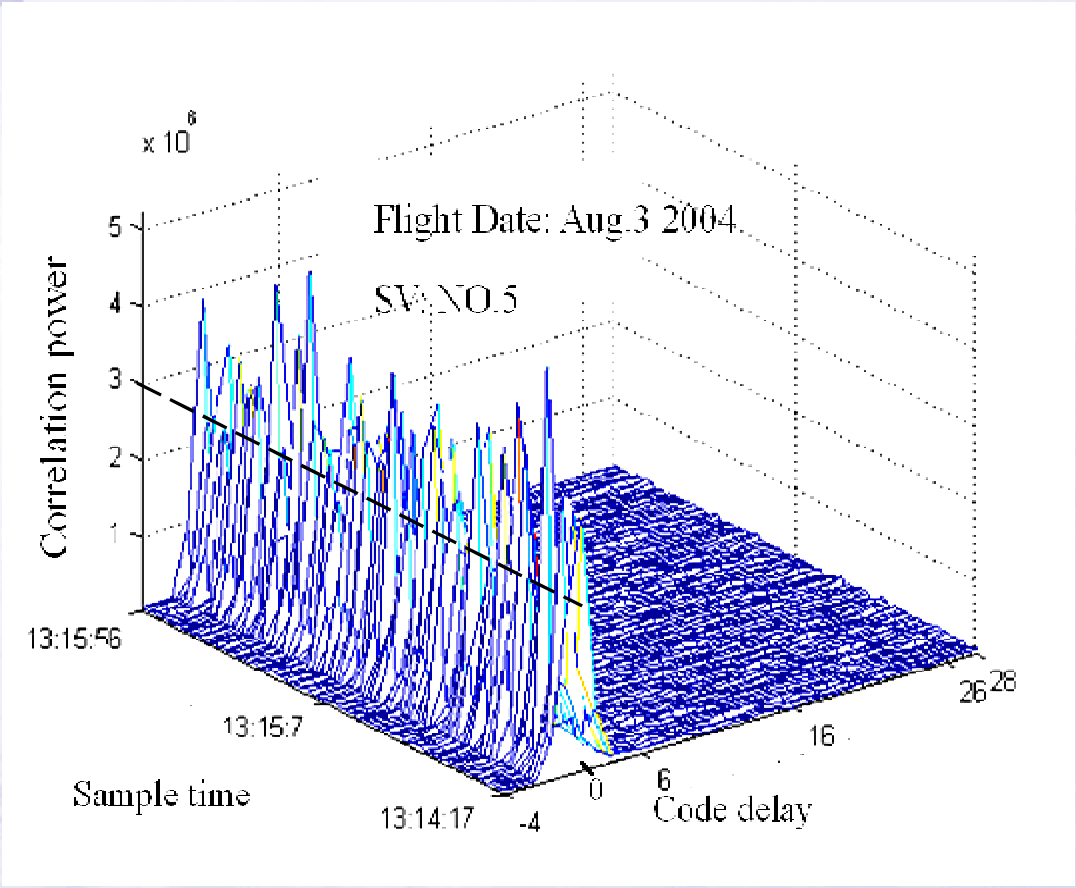
Scattered Signal



direct and scattered cross-correlation power of satellite NO.22

During Taking Off & Landing, Test Window Closed, LHCP antenna was Shielded

Example of Output Data



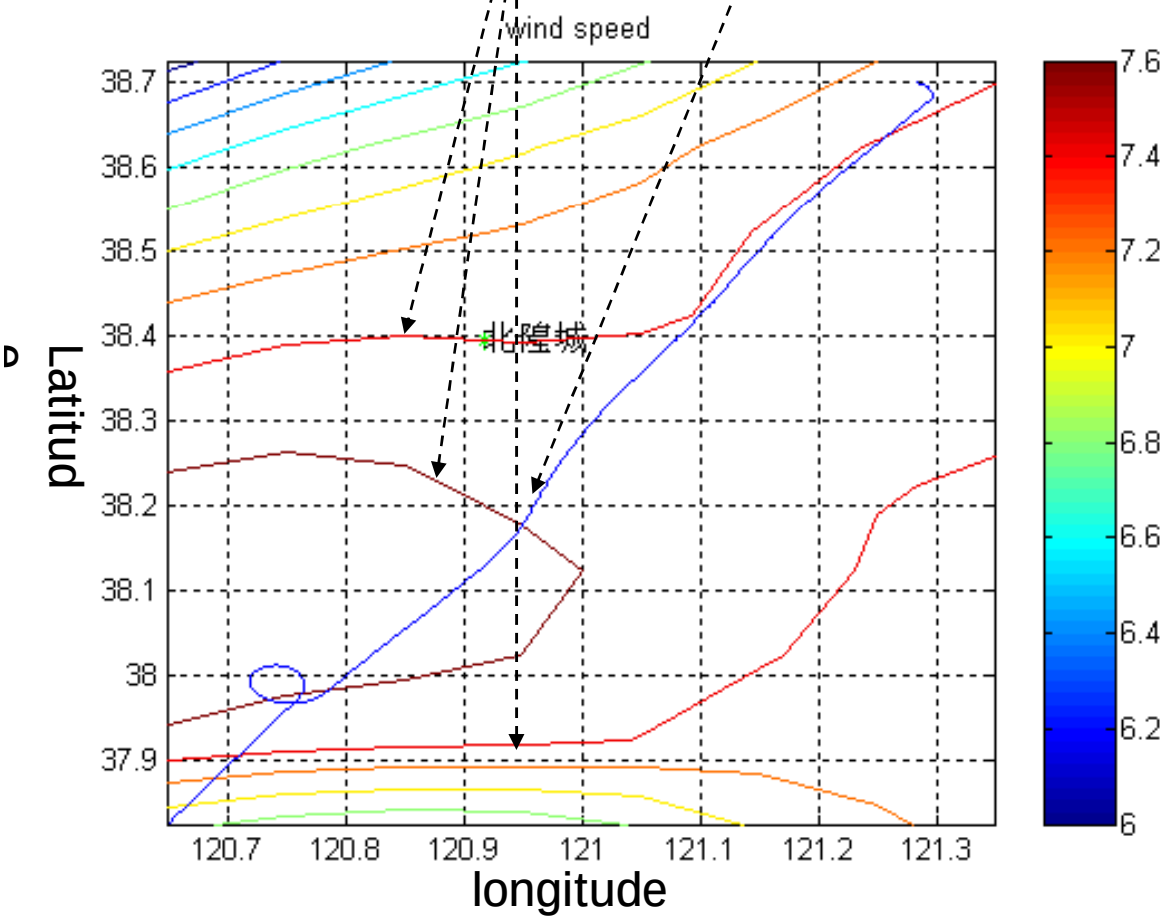
Signal of LHCP Antenna

Flight Time: Aug.03.2004
Flight Height: About 1000m
SNR:>15dB
Cross-correlation of 32
half code Delay was Measured

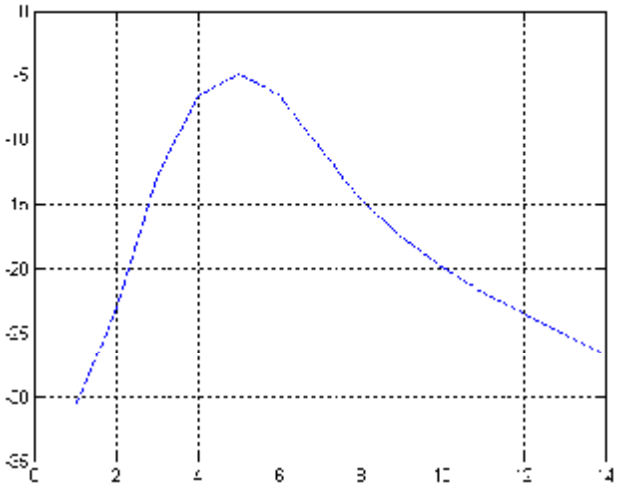
Example of Sep.9.2004

Wind Speed Contour
(From **scatterometer**)

Flight Path

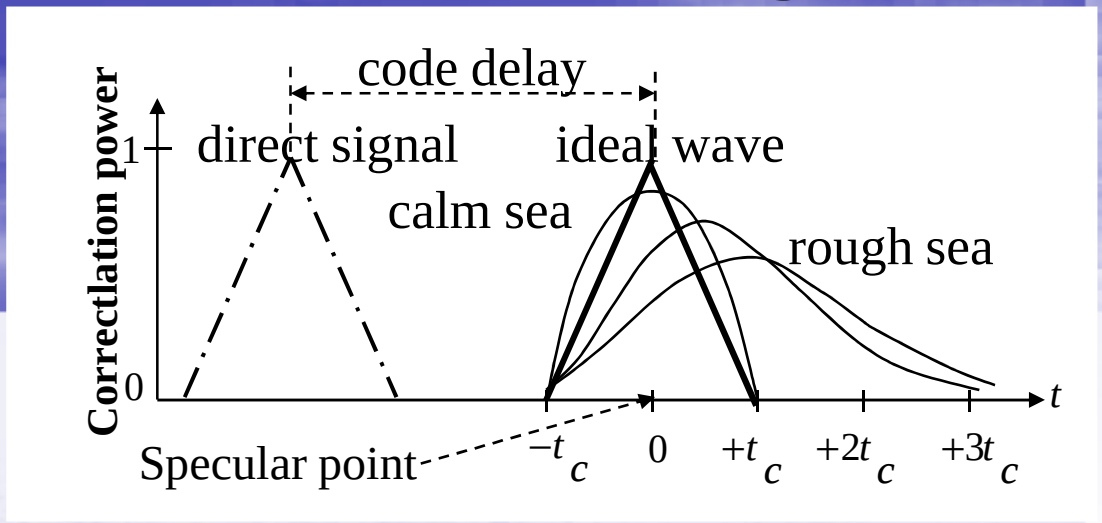


Ocean Reflected Wave Form
(Measured)



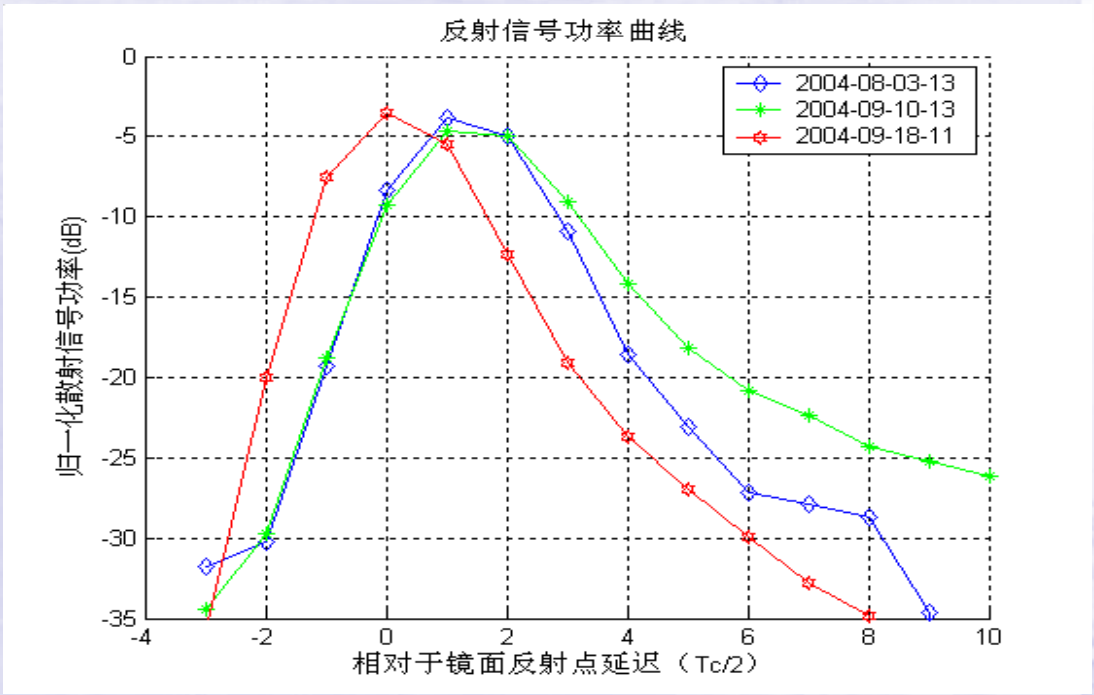
Flight Height: ~3000m
Flight Date: Sep.9.2004
Mean Wind Speed: ~7.2m/s

Reflection Waveform of 3 Flights



Wind From Scattermeter (Mean of 1 hour)

13:00 Sep.10.2004 >6m/s
13:00 Aug.03.2004 ~2m/s
11:00 Sep.18.2004 <1m/s



Wind Retrieval

Sea surface wind vector can be obtained by comparing the analyzed model and measured data

Conclusion

- Ocean Scattered GPS Signal was Successfully Detected
- Cross-Correlation Expansion Was Demonstrated
- Wind Information can be get from the wave characteristics

Thanks for your attention!