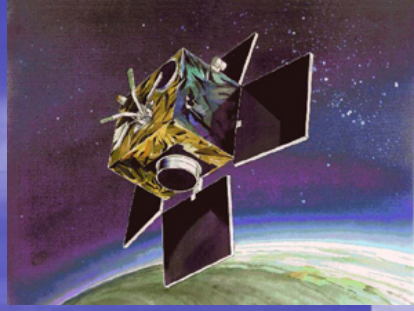

Design and Realization of DMR Based on GPS for Sea Surface Wind Measurement

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Outline

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

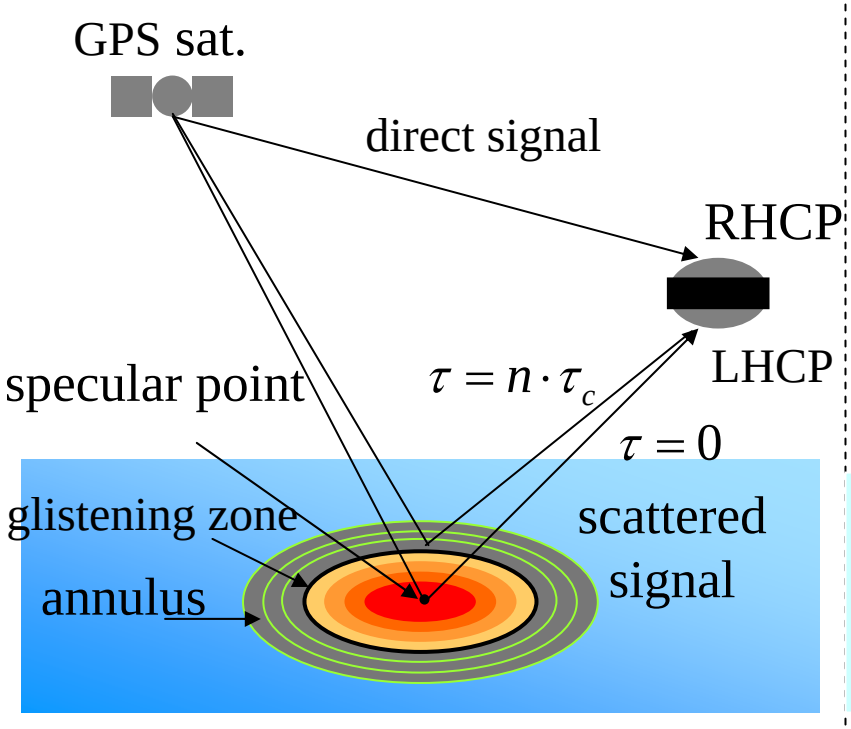
Introduction

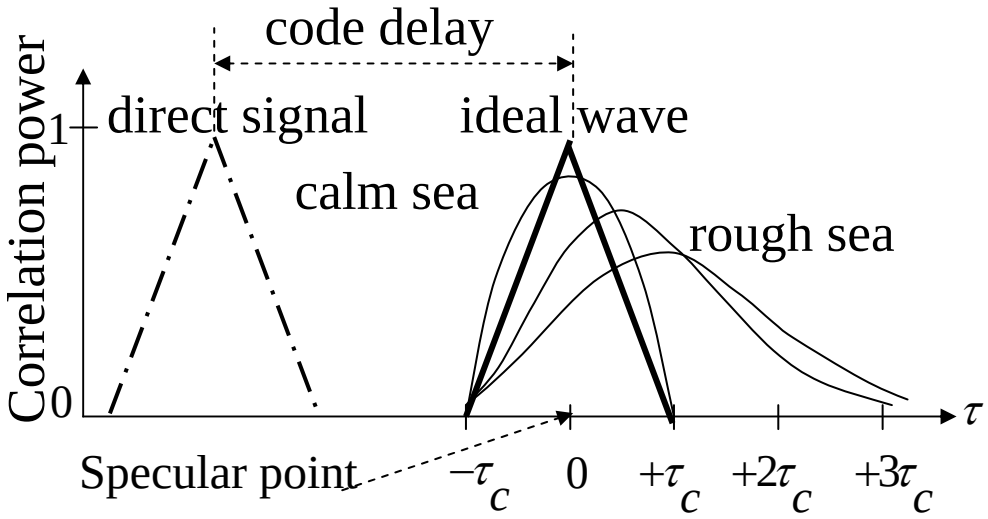
- **Signals of Global Positioning System (GPS) can be used for purposes other than navigation and positioning**
- **The utility of scattered GPS signals from rough surfaces brings a new technology for microwave remote sensing.**
- **The concept is to use GPS in a bistatic radar configuration with the 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**

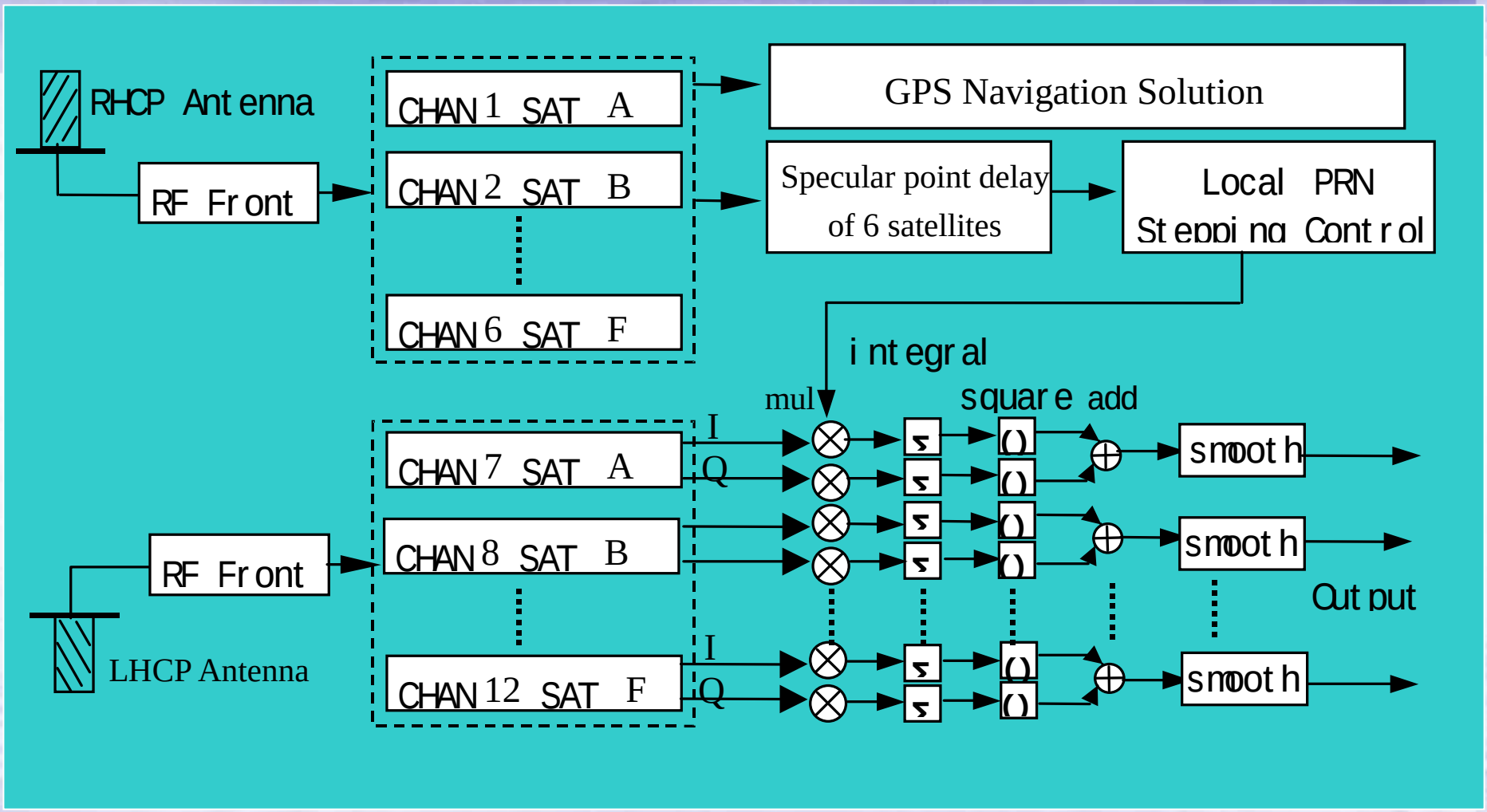
Measure Technique

- 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:

$$Y(\tau, \tau_0, t) = \int_0^{T_i} a(t + \tau_0 - \tau) \cdot u(t + \tau_0) dt$$

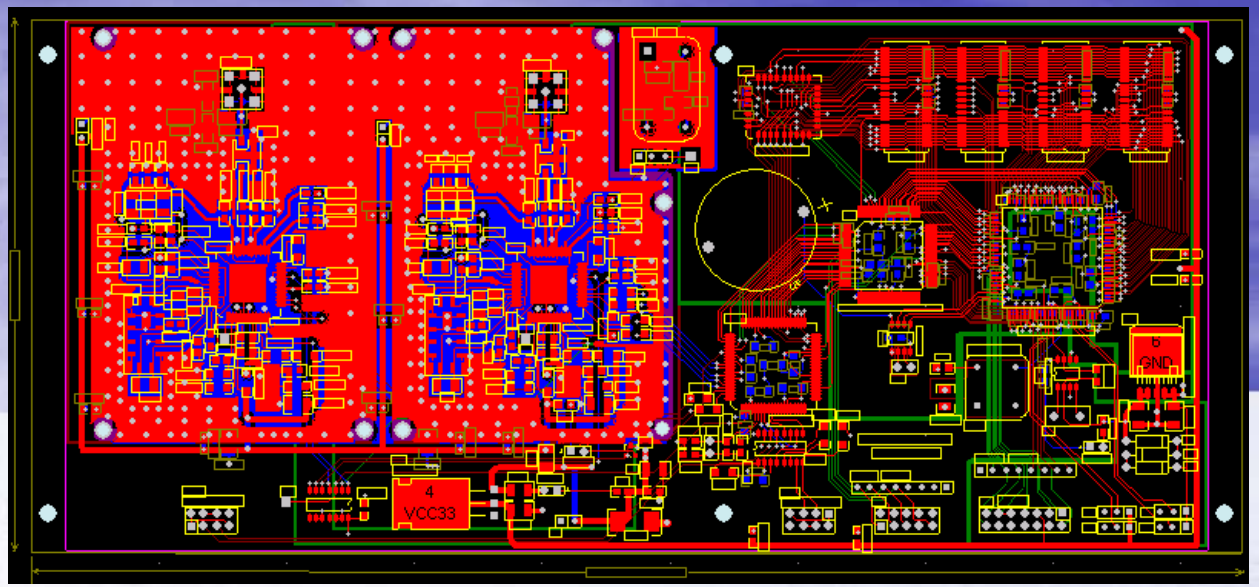
Here $a(t)$ is the locally generated C/A code, $u(t)$ is the received signal, τ_0 is specular point delay, τ is delay between [τ_0 -M, τ_0 +32-M] at half code chip, T_i is integration time,

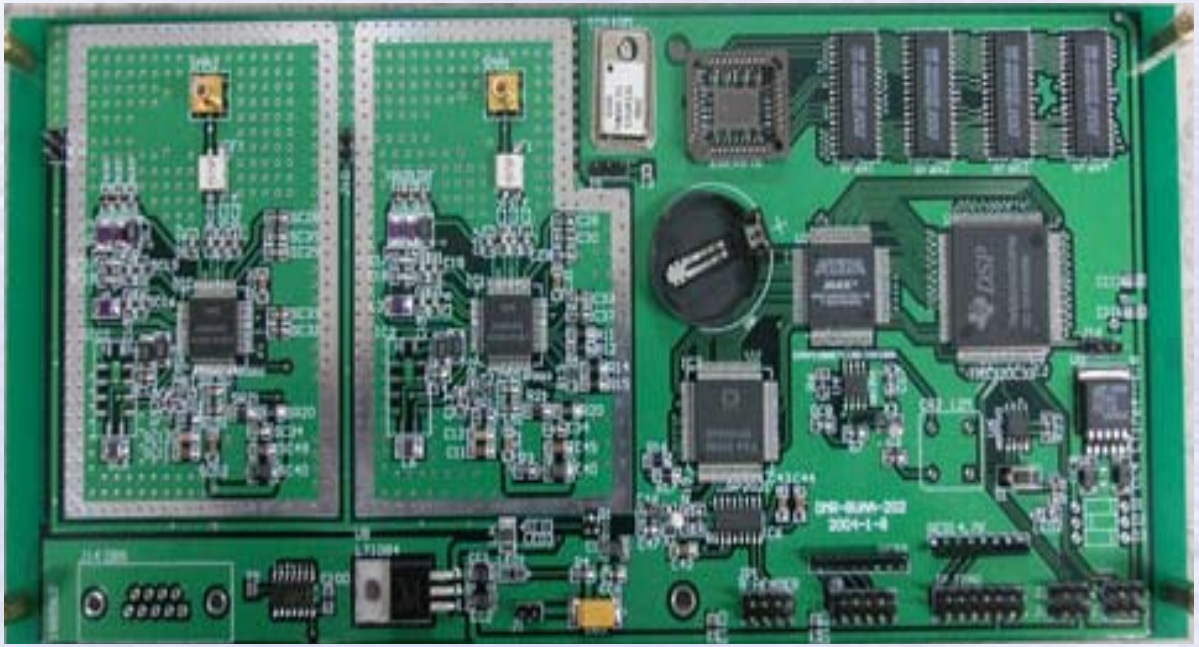
Delay Mapping Receiver Design



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 [$\tau_0 - \mathrm{M}$, $\tau_0 + 32 - \mathrm{M}$] 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.

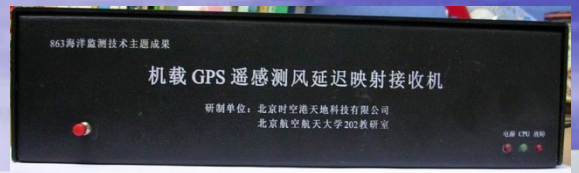

4
VCC33
5
GND



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



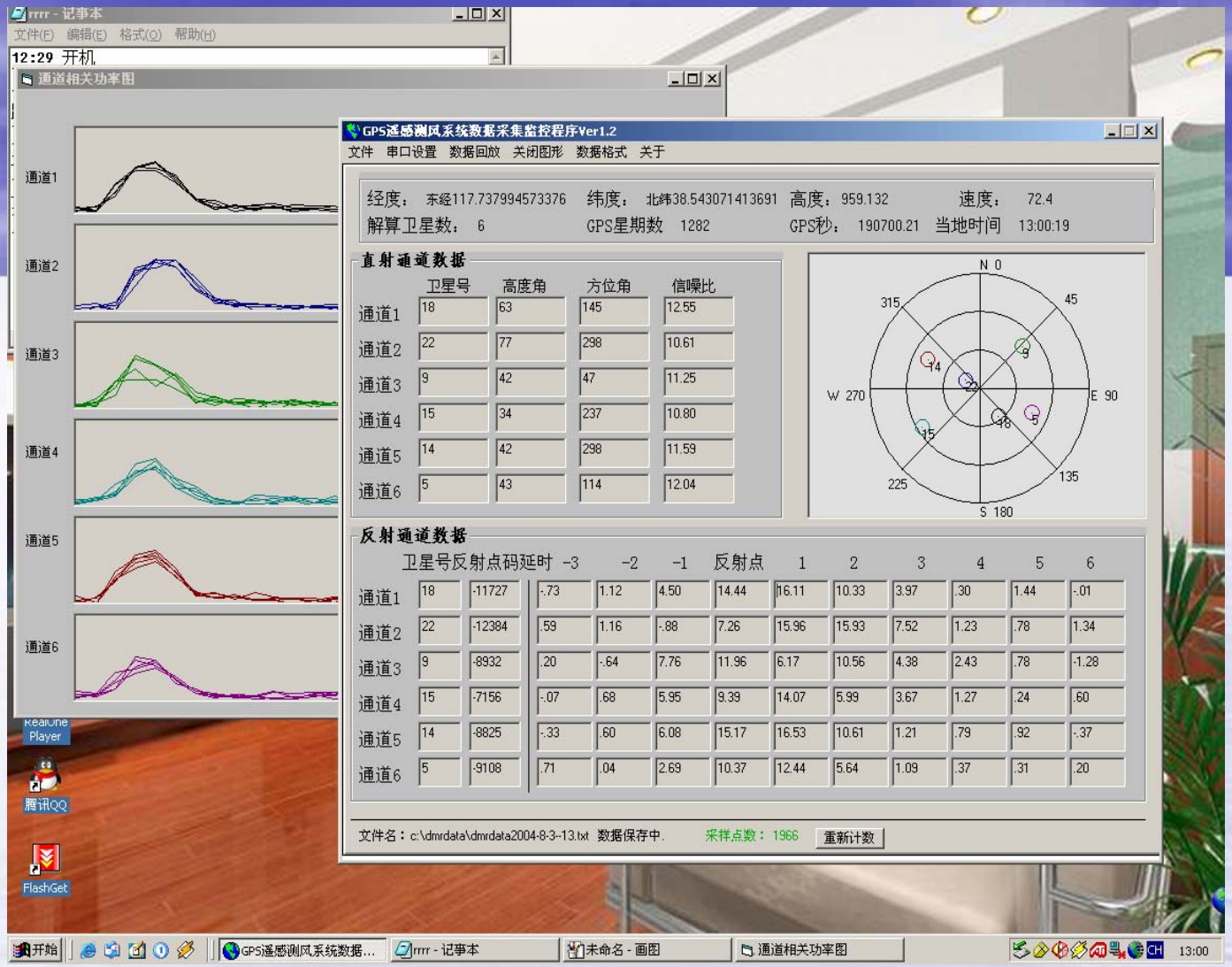
Equipped DMR

RHCP Antenna

YUN-12 Airplane For Test

LHCP Antenna

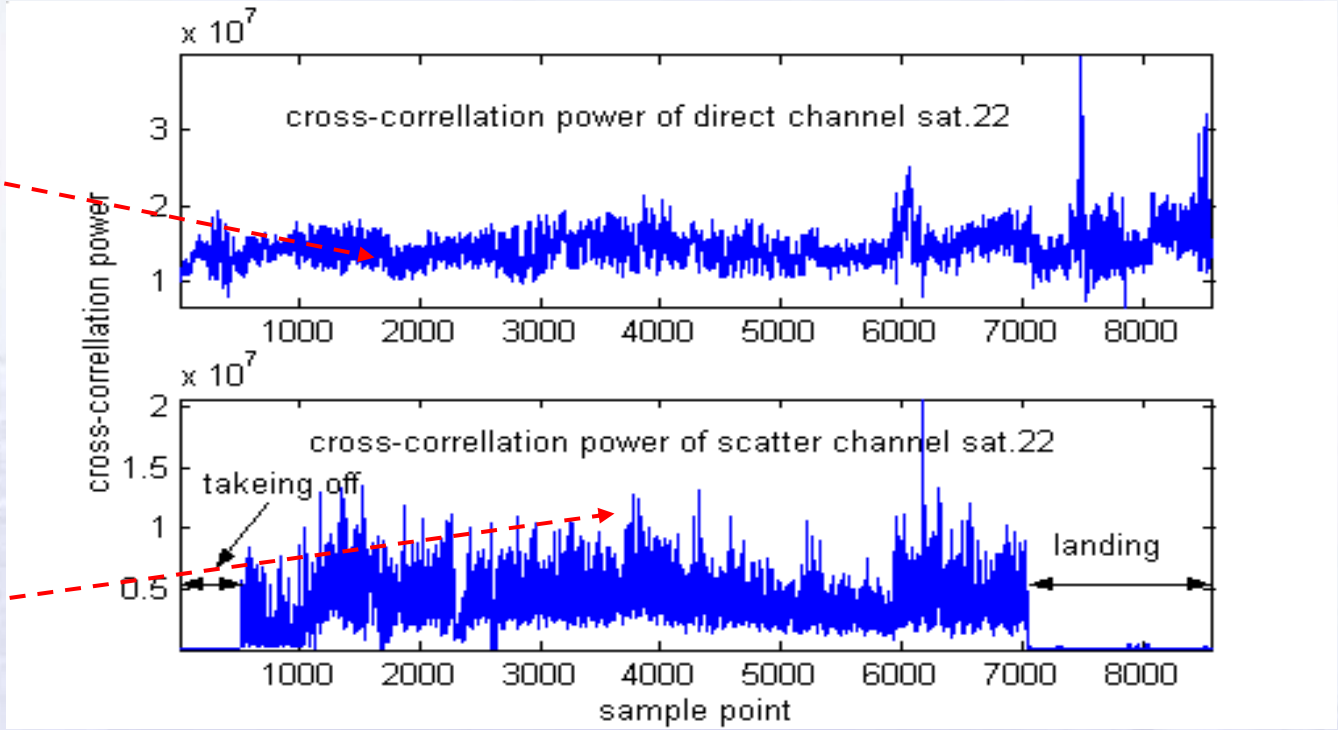
Laptop & Software


rrrr - 记事本
文件(F) 编辑(E) 格式(O) 帮助(H)
12:29 开机
通道相关功率图
通道1
通道2
通道3
通道4
通道5
通道6
GPS遥感测风系统数据采集监控程序Ver1.2
文件 串口设置 数据回放 关闭图形 数据格式 关于
经度： 东经117.737994573376 纬度： 北纬38.543071413691 高度：959.132 速度： 72.4
解算卫星数： 6 GPS星期数 1282 GPS秒： 190700.21 当地时间 13:00:19
直射通道数据
卫星号 高度角 方位角 信噪比
通道1 18 63 145 12.55
通道2 22 77 298 10.61
通道3 9 42 47 11.25
通道4 15 34 237 10.80
通道5 14 42 298 11.59
通道6 5 43 114 12.04
N 0
45
E 90
135
S 180
225
W 270
315
反射通道数据
卫星号反射点码延时 -3 -2 -1 反射点 1 2 3 4 5 6
通道1 18 -11727 -.73 1.12 4.50 14.44 16.11 10.33 3.97 .30 1.44 -.01
通道2 22 -12384 .59 1.16 -.88 7.26 15.96 15.93 7.52 1.23 .78 1.34
通道3 9 -8932 .20 -.64 7.76 11.96 6.17 10.56 4.38 2.43 .78 -1.28
通道4 15 -7156 -.07 .68 5.95 9.39 14.07 5.99 3.67 1.27 .24 .60
通道5 14 -8825 -.33 .60 6.08 15.17 16.53 10.61 1.21 .79 .92 -.37
通道6 5 -9108 .71 .04 2.69 10.37 12.44 5.64 1.09 .37 .31 .20
文件名：c:\dmrdata\dmrdata2004-8-3--13.txt 数据保存中. 采样点数： 1966 重新计数
RealOne Player
腾讯QQ
FlashGet
开始
GPS遥感测风系统数据...
rrrr - 记事本
未命名 - 画图
通道相关功率图
13:00

Direct & Scattered Signal

Direct Signal

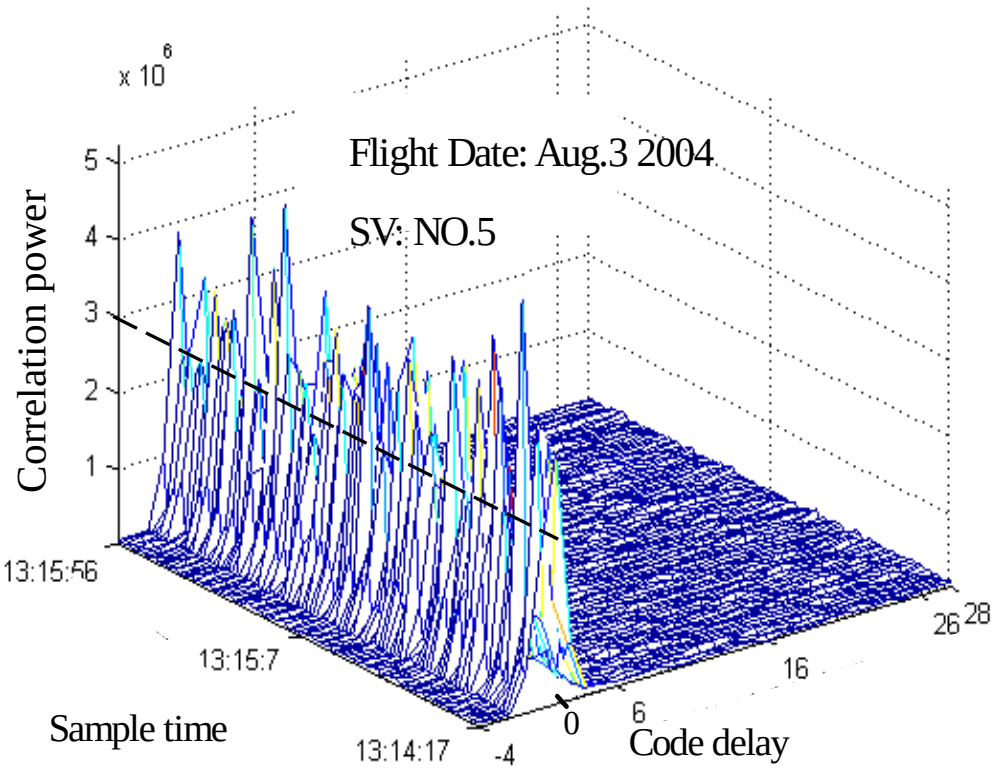
Scattered Signal



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



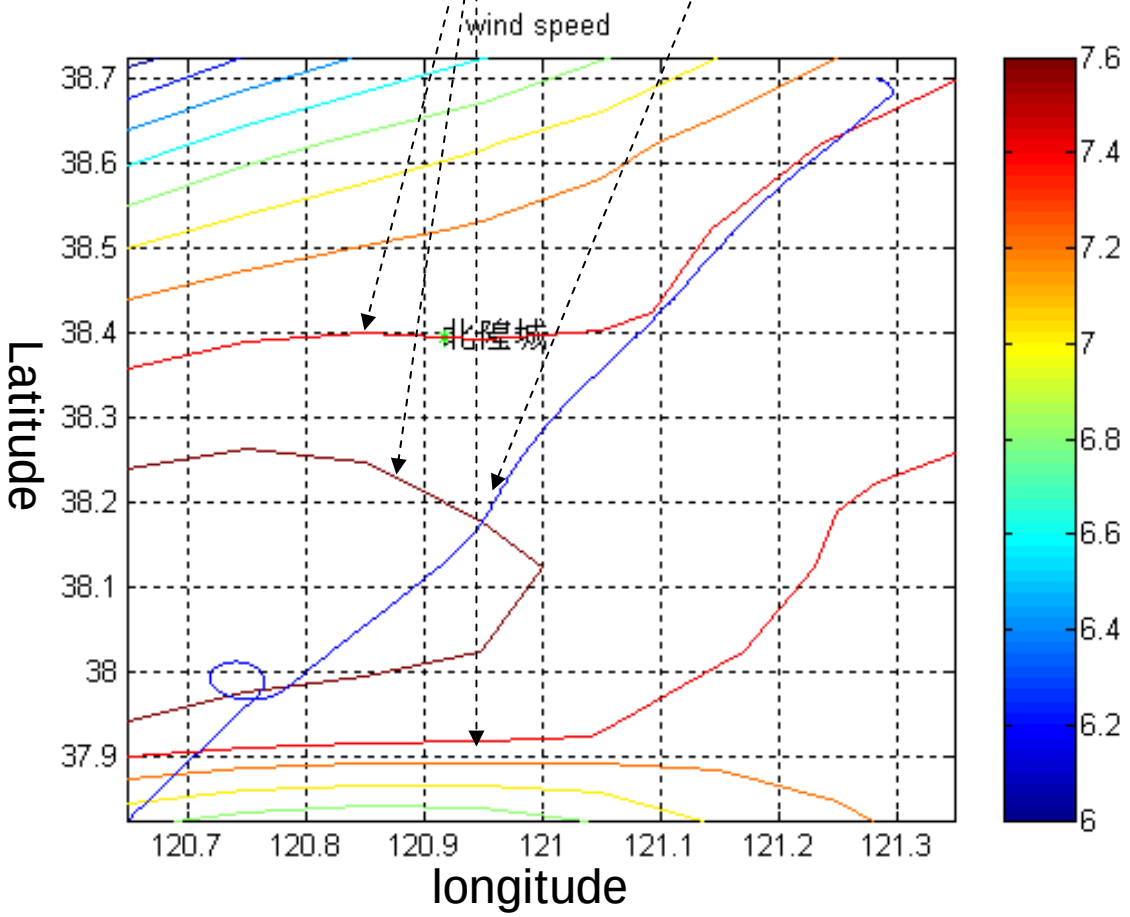
Signal of LHCP Antenna

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

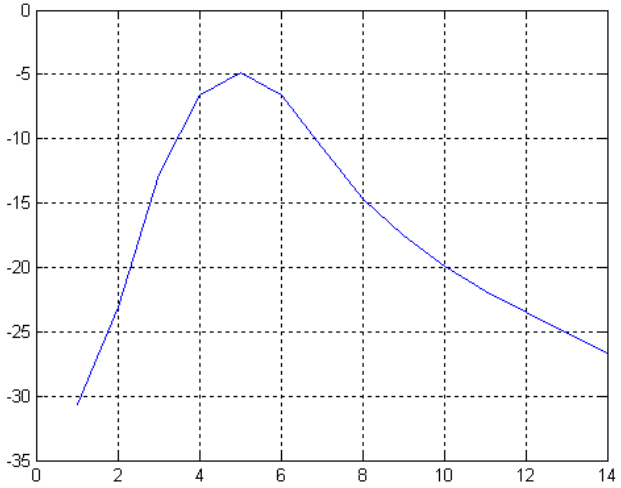
Example of Sep.9.2004

Wind Speed Contour
(From **scatterometer**)

Flight Path

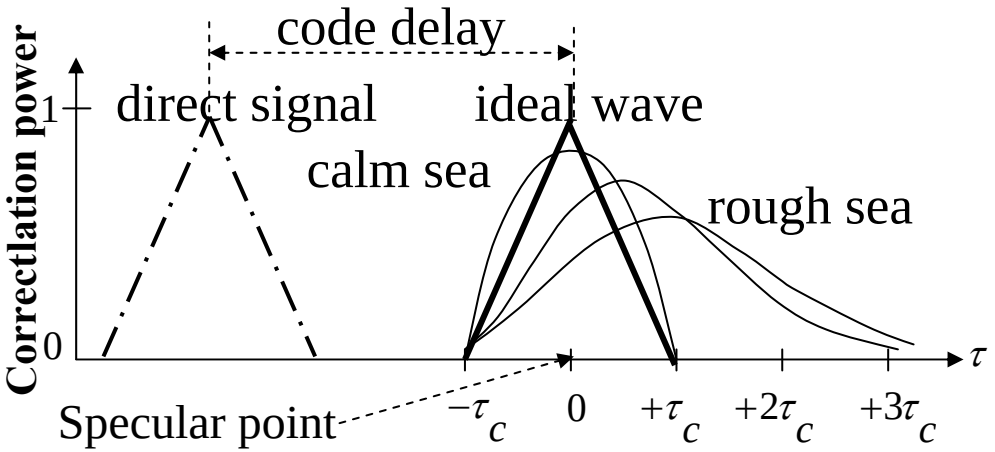


Ocean Reflected Wave Form
(Measured)



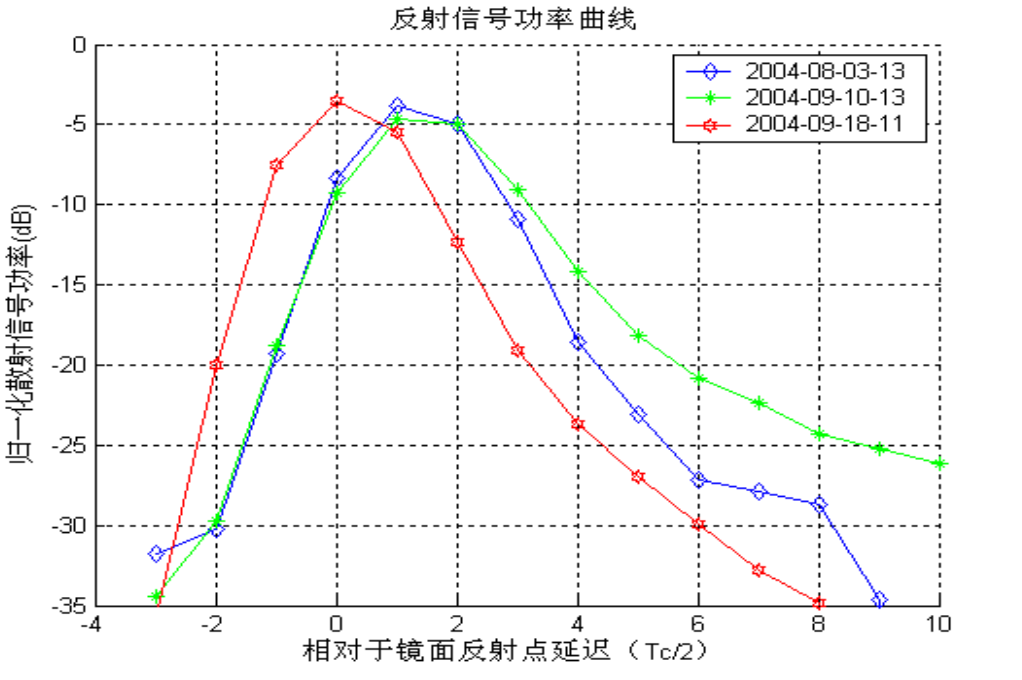
Flight Height: ~3000m
Flight Date: Sep.9.2004
Mean Wind Speed: ~7.2m/s

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!