

FOSS4G 2009 Tokyo

**RTKLIB:**

**Open Source Program Package for RTK-GPS**



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# Outline

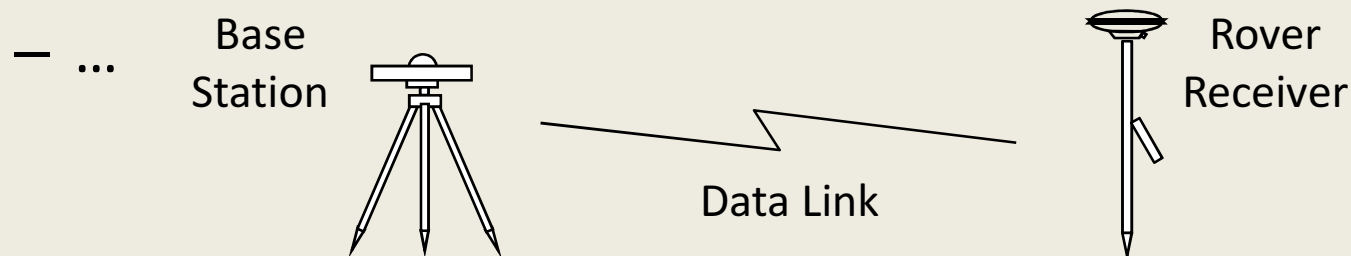
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- **What is RTK-GPS?**
- **What is RTKLIB?**
  - Background
  - History
  - Features
  - APs
  - Low-cost RTK receiver with RTKLIB
- **Future GNSS and Future RTKLIB**

# RTK-GPS

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- **Real-time kinematic GPS**
  - Most precise positioning technique with **cm-level** accuracy (100-times accurate compared to general GPS positioning)
  - Use carrier-phase measurement as well as ranging code
  - Determine relative rover position wrt base-station (baseline vector)
  - Need (wireless) communication link between rover and base-station



# RTK Applications



Geodetic Survey



Construction  
Machine Control



Precision Agriculture



ITS (Intelligent  
Transport System)



Mobile Mapping  
System



Sports

# Cost Issue

- **High operational cost for RTK-GPS**

- Expensive geodetic-grade receivers
- Expensive RTK F/W Options
- Expensive post-processing software
- Limited applications by cost issue



**\$10,000-\$30,000**

- **RTK-GPS with consumer-grade receiver**

- Feasible and practical, little performance degradation with high-performance antenna
- Public/commercial service to provide base-station measurement data via Internet
- Needs **external RTK-GPS processing**



**\$30-\$300**

# RTKLIB

- **Open source program package for RTK-GPS**
  - Distributed under GPLv3
  - Has been developed by the authors since 2006
  - Latest version: 2.2.2 (stable), 2.3.0 (devel.)
- **Portable C library + several positioning APs**
  - GUI APs on Windows
  - Console APs on Linux etc...

The screenshot shows the RTKLIB website with a navigation menu (Overview, Release Notes, Support, Documents, References, Porting to BB, To Do) and a 'Download' section. The download section contains a table with columns for Version, Date, Binary AP Package for Windows, and Full Package with Source Programs. The table lists versions 2.2.0, 2.2.1, and 2.2.2 with their respective dates and file sizes. Below the table, there is an 'Overview' section that describes RTKLIB as an open source program package for RTK-GPS, listing 17 application programs (APs) and their functions. The website also includes a 'License' section stating that RTKLIB is distributed under GPLv3 license.

Version	Date	Binary AP Package for Windows	Full Package with Source Programs
2.2.0	2009/01/31	<a href="#">rtklib_2.2.0_bin.zip</a> (10.7MB)	<a href="#">rtklib_2.2.0.zip</a> (23.4MB)
2.2.1	2009/05/17	<a href="#">rtklib_2.2.1_bin.zip</a> (15.3MB)	<a href="#">rtklib_2.2.1.zip</a> (30.6MB)
2.2.2	2009/09/07	<a href="#">rtklib_2.2.2_bin.zip</a> (21.4MB)	<a href="#">rtklib_2.2.2.zip</a> (33.8MB)

Please refer the [support information](#) to get the latest patches.

**Overview**

RTKLIB is an open source program package for RTK-GPS. RTKLIB consists of a simple and portable program library and several application programs (APs) utilizing the library. The program library of RTKLIB provides:

- (1) Matrix and vector functions
- (2) Time and string functions
- (3) Coordinates transformation and geoid model
- (4) Navigation processing
- (5) Positioning models (troposphere, ionosphere, antenna PCV)
- (6) SBAS DGPS correction
- (7) Single point positioning
- (8) Carrier-based and code-based relative positioning
- (9) OTF integer ambiguity resolution
- (10) Receiver raw binary data input
- (11) Positioning solution/NMEA input/output
- (12) RINEX observation data/navigation message input/output
- (13) Precise ephemeris input
- (14) Stream data communication library
- (15) NTRIP (Networked Transport of RTCM via Internet Protocol) library
- (16) RTK-GPS positioning server
- (17) RTCM 2.3 and 3.0/3.1 message handling

The GUI and console (command line) APs of RTKLIB includes:

- (1) Real-time positioning (RTKNAVI)
- (2) Post-mission baseline analysis (RTKPOST, RNX2RTKP)
- (3) Communication utility (STRSVR)
- (4) Plot graph of positioning solution and observation data (RTKPLOT)
- (5) RINEX converter of receiver raw data log (RTKCONV, CONVBN)
- (6) Other positioning utilities

All of the executable binary APs for Windows are included in the package as well as whole source programs of the library and the APs.

The receiver have to output raw measurement data of pseudorange/carrier-phase and satellite ephemerides. NRTK (Network RTK) service supporting RTCM 2 or 3 can also be used for the base-station. Please refer [Release Notes](#) for supported receivers and data messages. The post-mission baseline analysis can process [RINEX 2.10 or 2.11](#) observation data and navigation messages supported by many receivers. Future version will support other GNSSs such as GLONASS, Galileo or QZSS.

**License**

RTKLIB is distributed under GPLv3 license. (<http://gplv3.fsf.org/>)

<http://gpspp.sakura.ne.jp/rtklib/rtklib.htm>

# History

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- 2006/4 v.0.0.0 First version for RTK+C prog. lecture
- 2007/1 v.1.0.0 Simple post processing AP
- 2007/3 v.1.1.0 Add windows GUI AP
- 2008/7 v.2.1.0 Add APs, support medium-range
- 2009/1 v.2.2.0 Add real-time AP, support NTRIP, start to distribute it as **open source**
- 2009/5 v.2.2.1 Support RTCM, NRTK, many receivers
- 2009/9 v.2.2.2 Fix bugs, provide English manual
- 2009/E v.2.3.0 Support GLONASS, INS/GPS, ...

# Download

	rtklib_ 2.2.0	rtklib_ 2.2.0_bin	rtklib_ 2.2.1	rtklib_ 2.2.1_bin	rtklib_ 2.2.2	rtklib_ 2.2.2_bin
2009/1	57	16	-	-	-	-
2009/2	352	38	-	-	-	-
2009/3	93	104	-	-	-	-
2009/4	98	53	-	-	-	-
2009/5	45	57	123	63	-	-
2009/6	1	0	221	434	-	-
2009/7	0	0	138	132	-	-
2009/8	1	0	327	191	-	-
2009/9	0	0	74	52	314	187
2009/10	0	0	21	6	701	407
<b>Total</b>	<b>645</b>	<b>268</b>	<b>904</b>	<b>878</b>	<b>1015</b>	<b>594</b>

Japan, Network (net), Commercial (com), Germany, Poland, Italy, Canada, Educational (edu), Ukraine, Austria, Australia, Switzerland, Portugal, Taiwan, Non-Profit (org), Russia, France, Finland, Spain, United Kingdom, Czech, ...



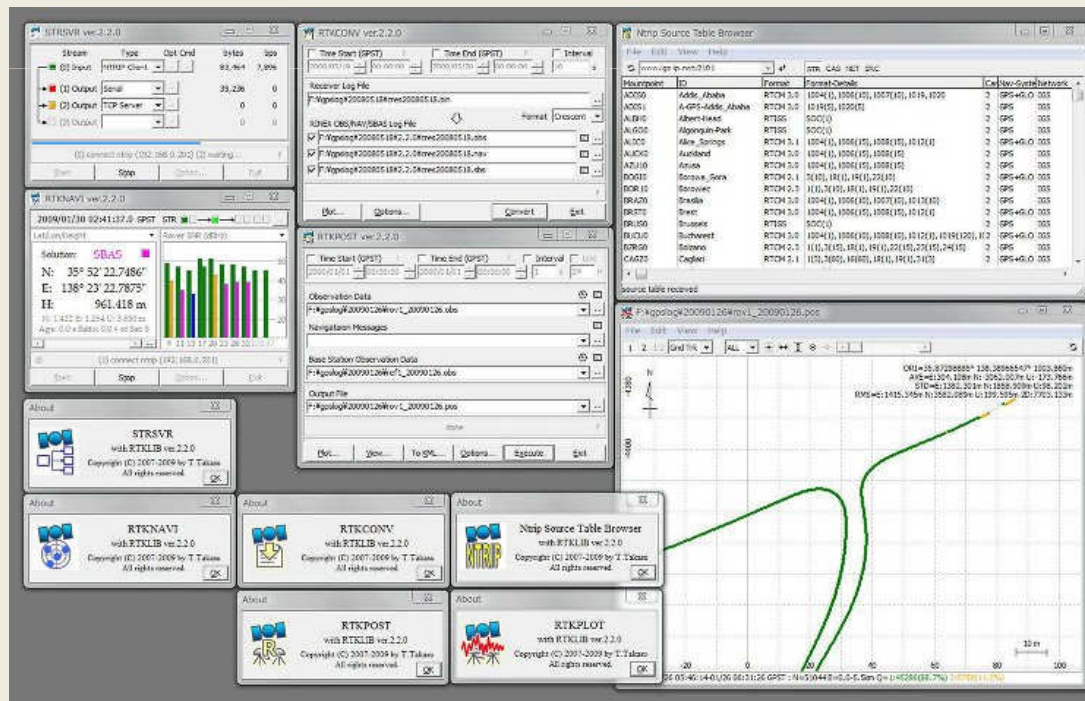
# RTLIB Library/APIs: ANSI-C

```
/* matrix and vector functions */
mat(),imat(),zeros(),eye(),dot(),norm(),matcpy(),matmul(),matinv(),solve(),lsq(),filter(),smoother(),matprint(),matfprint()
/* time and string functions */
str2num(),str2time(),time2str(),epoch2time(),time2epoch(),gpst2time(),time2gpst(),timeadd(),timediff(),gpst2utc(),utc2gpst(),
timeget(),time2doy(),adjgpsweek(),tickget(),sleepms()
/* coordinates functions */
ecef2pos(),pos2ecef(),ecef2enu(),enu2ecef(),covenu(),covecef(),xyz2enu(),geoidh(),loadatump(),tokyo2jgd(),jgd2tokyo()
/* input/output functions */
readpcv(),readpos(),sortobs(),uniqueph(),screent()
/* positioning models */
eph2pos(),geph2pos(),satpos(),satposv(),satposiode(),satazel(),geodist(),dops(),ionmodel(),ionmapf(),tropmodel(),tropmapf(),
antmodel(),csmooth()
/* single-point positioning */
pntpos(),pntvel()
/* rinex functions */
readrnx(),readrnxt(),outrnxobsh(),outrnxnavh(),outrnxnavb(),uncompress(),convrnx()
/* precise ephemeris functions */
readsp3(),readsap(),eph2posp(),satposp()
/* receiver raw data functions */
getbitu(),getbits(),crc32(),crc24q(),decode_word(),decode_frame(),init_raw(),free_raw(),input_raw(),input_rawf(),input_oem4(),
input_oem3(),input_ubx(),input_ss2(),input_cres(),input_oem4f(),input_oem3f(),input_ubxf(),input_ss2f(),input_cresf()
/* rtcm functions */
init_rtcm(),free_rtcm(),input_rtcm2(),input_rtcm3(),input_rtcm2f(),input_rtcm3f()
/* solution functions */
readsol(),readsolt(),outsolheads(),outsols(),outsollexs(),outsolhead(),outsol(),outsollex(),setsolopt(),setsolformat(),
outnmea_rmc(),outnmea_gga(),outnmea_gsa(),outnmea_gsv(),
/* SBAS functions */
sbsreadmsg(),sbsreadmsgt(),sbsoutmsg(),sbsupdatestat(),sbsdecodemsg(),sbssatpos(),sbspntpos()
/* integer least-square estimation */
lambda()
/* realtime kinematic positioning */
rtkinit(),rtkfree(),rtkpos()
/* post-processing positioning */
postpos(),postposopt(),readopts(),writeopts()
/* stream data input/output */
strnitcom(),strnit(),strlock(),strunlock(),stropen(),strclose(),strread(),strwrite(),strsync(),strstat(),strsum(),strsetopt(),
strgettime()
/* stream server functions */
strsvrinit(),strsvrstart(),strsvrstop(),strsvrstat()
/* rtk server functions */
rtksvrinit(),rtksvrstart(),rtksvrstop(),rtksvrlock(),rtksvrunlock(),rtksvrstat(),rtksvrstat() ...
```

# Application Programs (APs)

- RTKNAVI** : Real-time positioning
- RTKPOST** : Post-processing baseline analysis
- RTKPLOT** : Plot raw observation data and solutions
- RTKCONV** : RINEX converter for raw receiver log

...



# RTKNAVI: Real-Time Positioning

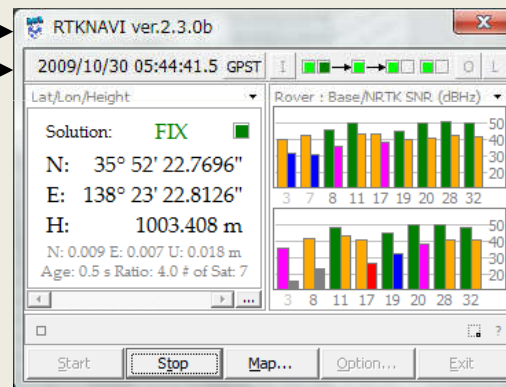


## I/O Stream Types

- Serial (RS232C/USB)
- TCP Server/Client
- NTRIP Server/Client
- Local File

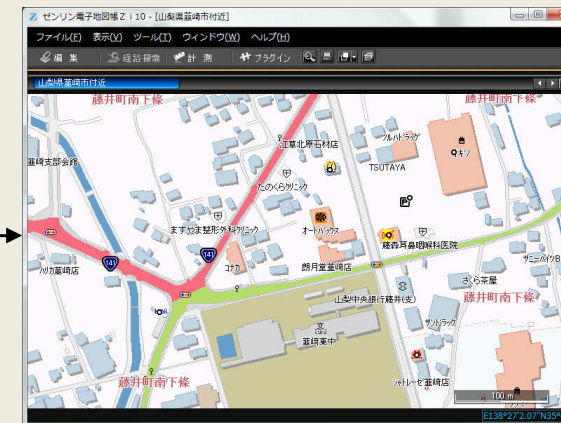
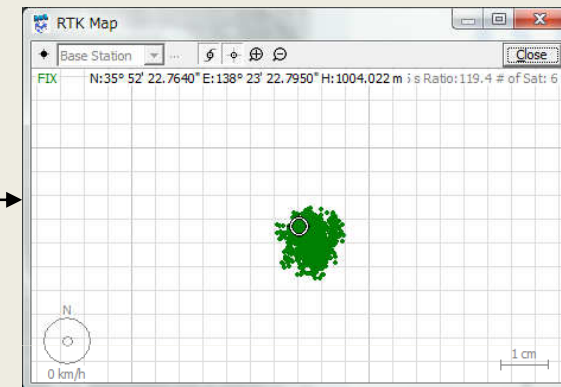
## Input Formats

- RTCM v.2.3
- RTCM v.3.1
- NovAtel OEM4/V
- NovAtel OEM3
- NovAtel Super Star II
- Hemisphere Eclipse
- Hemisphere Crescent
- u-blox LEA-4T/5T
- SkyTraq S1315F



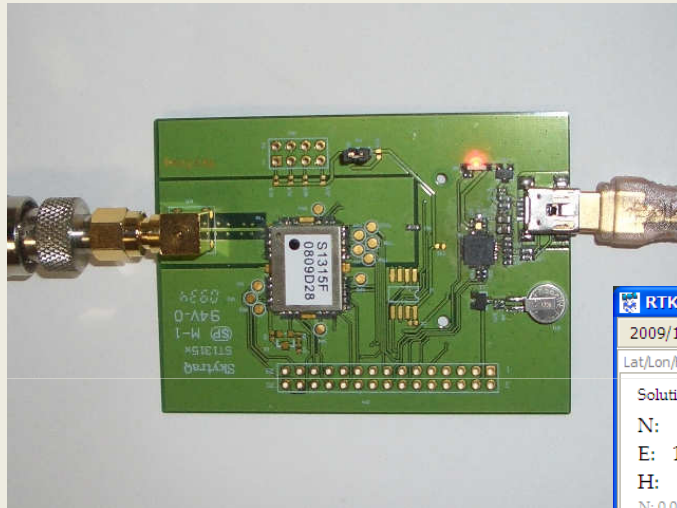
## Output Formats

- NMEA-0183
- Lat/Lon/Height
- X/Y/Z-ECEF
- E/N/U-baseline

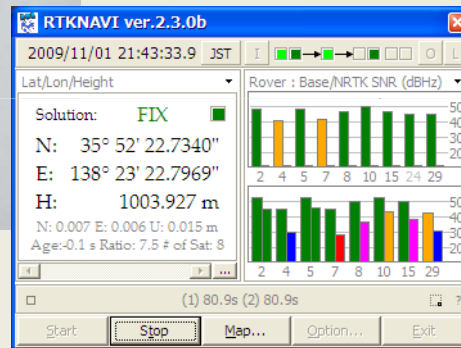


Copyright (C) Zenrin 2009

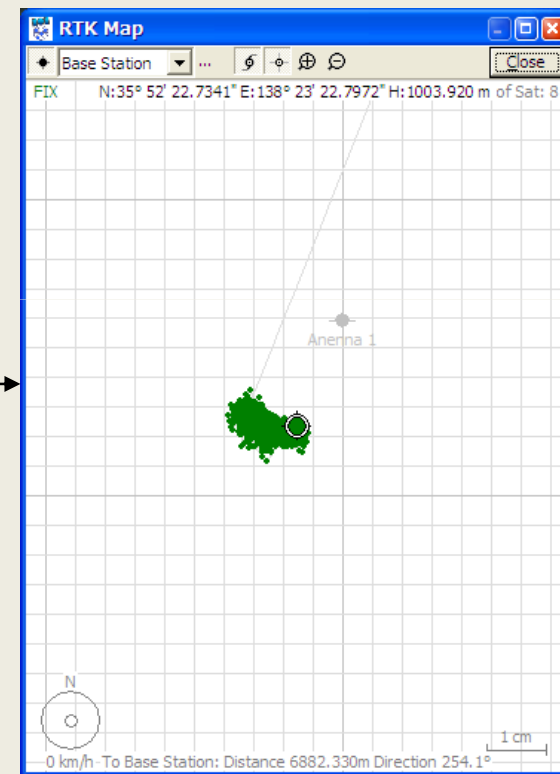
# RTKNAVI: Example 1



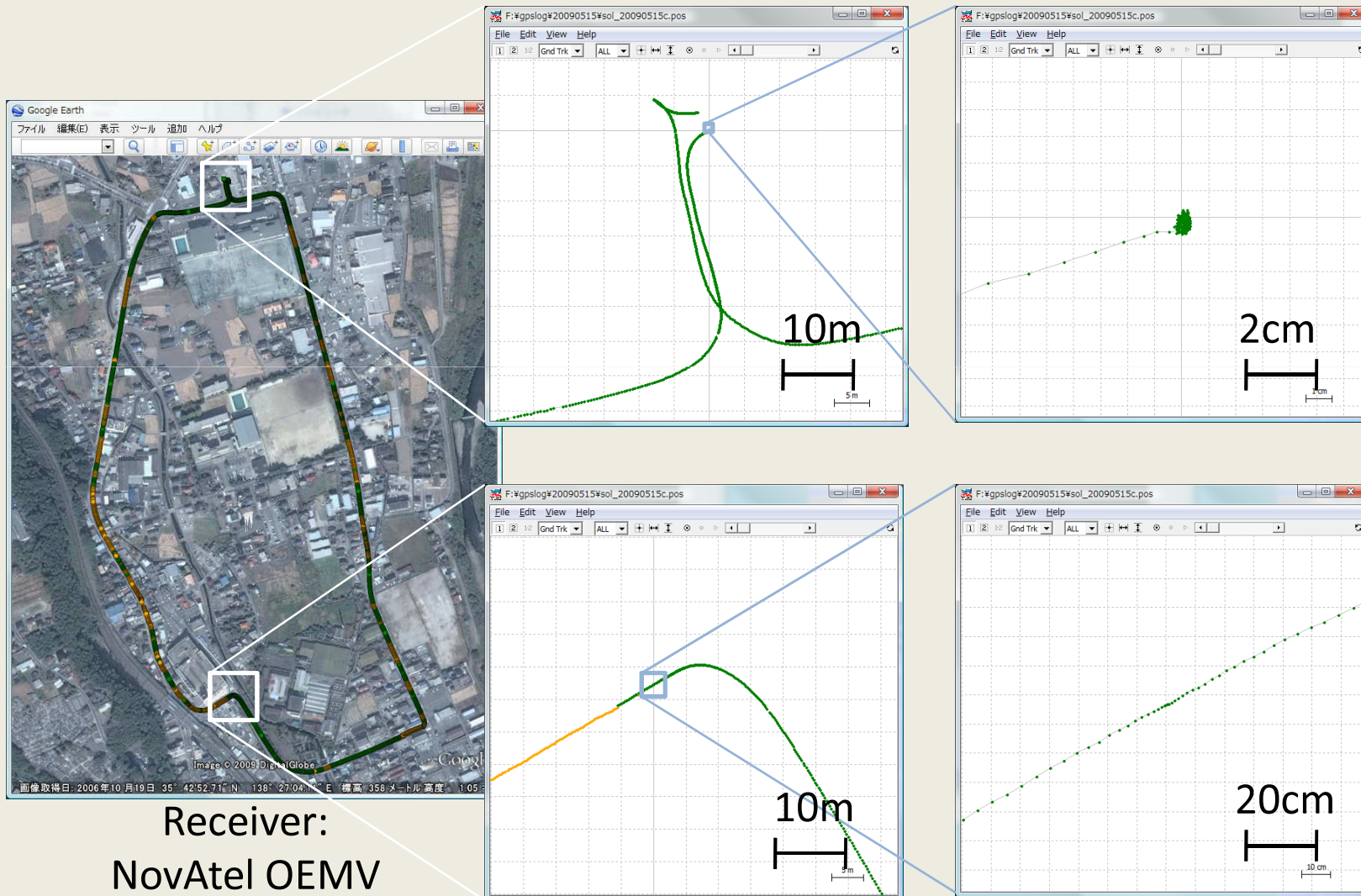
Receiver:  
**SkyTraq S1315F**  
(Venus 6 raw F/W)  
**\$25@sample**  
(module)



RTKNAVI



# RTKNAVI: Example 2



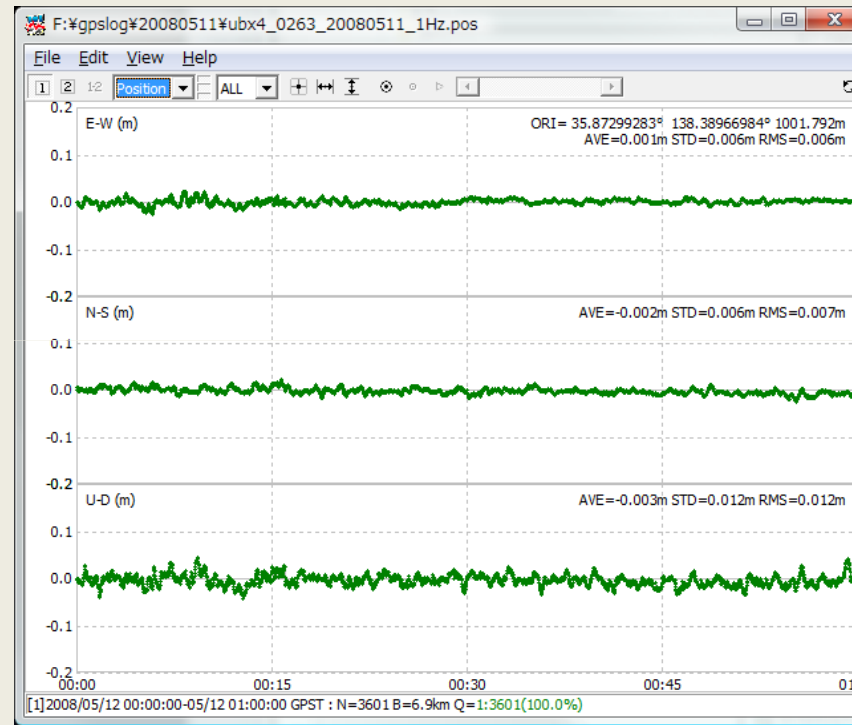
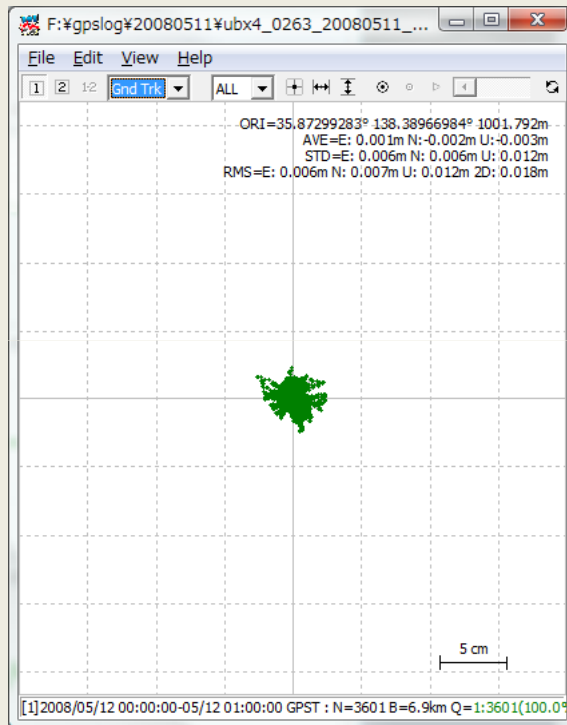
# RTKPOST: Post Processing Analysis

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- Input : standard RINEX OBS/NAV files
- Positioning mode:
  - Kinematic/Static/Moving-Baseline
- Smoother solution
- High-rate analysis with GEONET 30s data
- long baseline analysis (<1000 km)
  - Ionosphere/troposphere estimation
  - Support precise ephemeris (SP3) (v.2.2.0~)

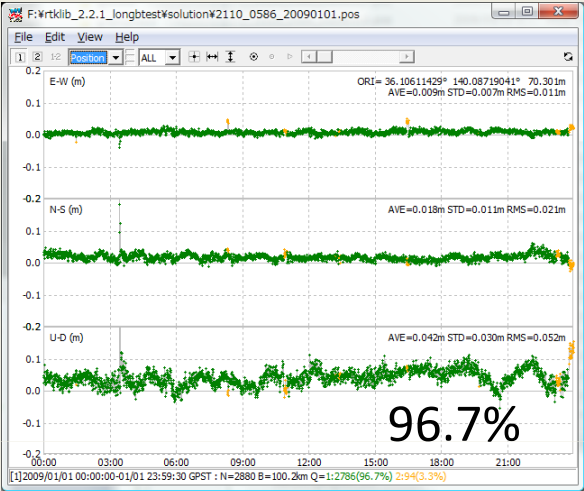
# RTKPOST: Example 1

## KGPS with GEONET 30s data

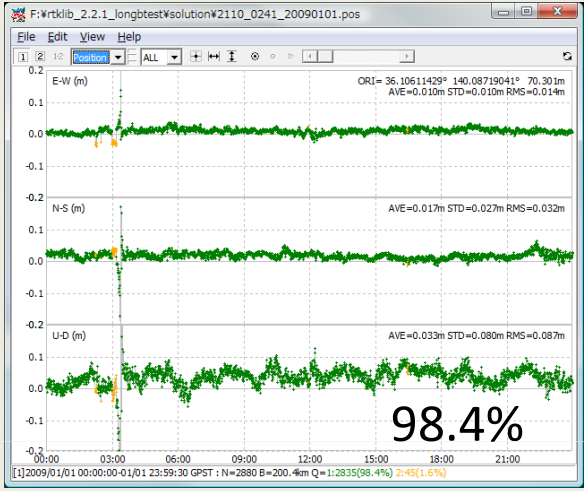


Receiver: u-blox AEK-4T (Single-freq), 1Hz × 1hr,  
Base station: GEONET 0263 (30s), Baseline: 6.9km  
Fixing ratio: 100%, STD: E 0.6cm, N 0.7cm, U:1.2cm

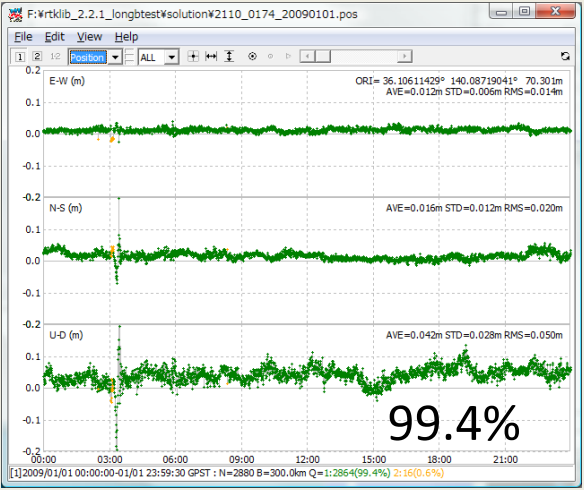
# RTKPOST: Example 2



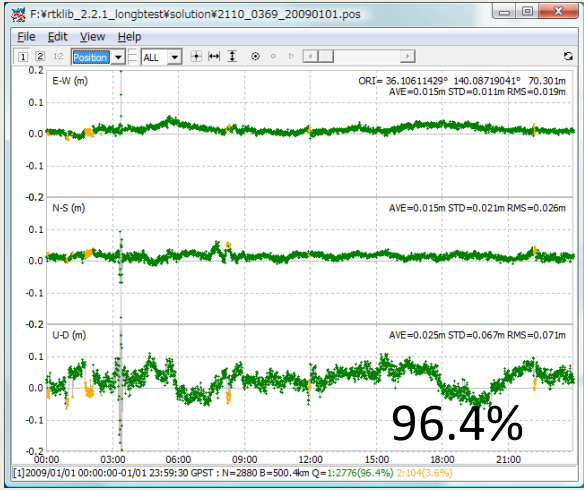
Baseline: 100.3km (2101-0586)



Baseline: 200.4km (2101-0241)



Baseline: 300.0km (2101-0174)



Baseline: 500.4km (2101-0369)

20cm

20cm



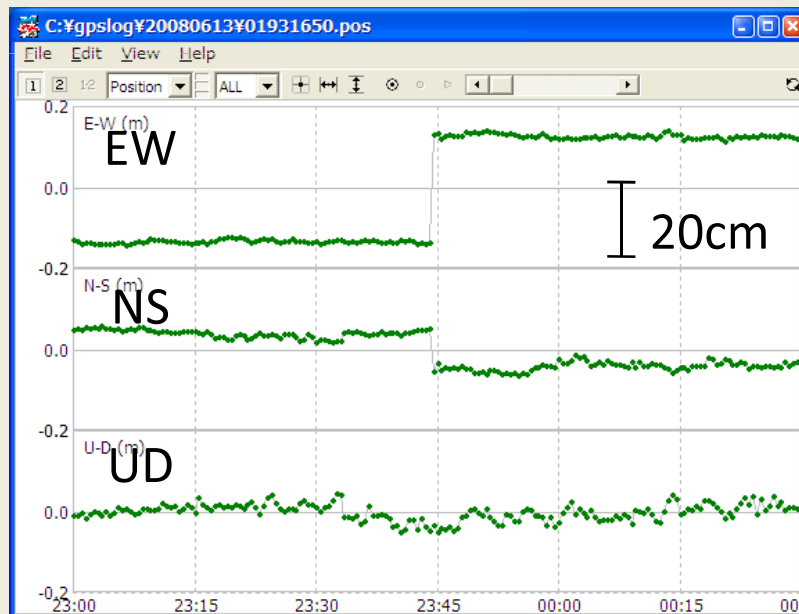
# RTKPOST: Example 3

## Iwate-Miyagi Earth Quake

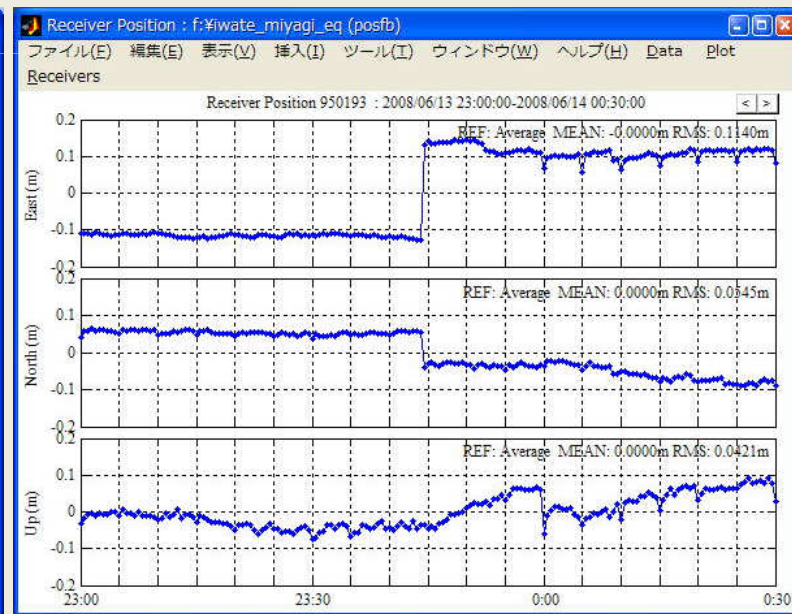
2008/6/13 22:00-6/14 0:30 : GSI 0193 Minase

Post Processing KGPS  
(Ref:0041, Eph: IGS Final, Baseline:  
219km)

Kinematic PPP  
(Ephemeris: IGS Final+  
IGS 30s Clock)



RTKPOST v.2.2.1



GpsTools v.0.6.3

# Low-Cost RTKR with RTKLIB

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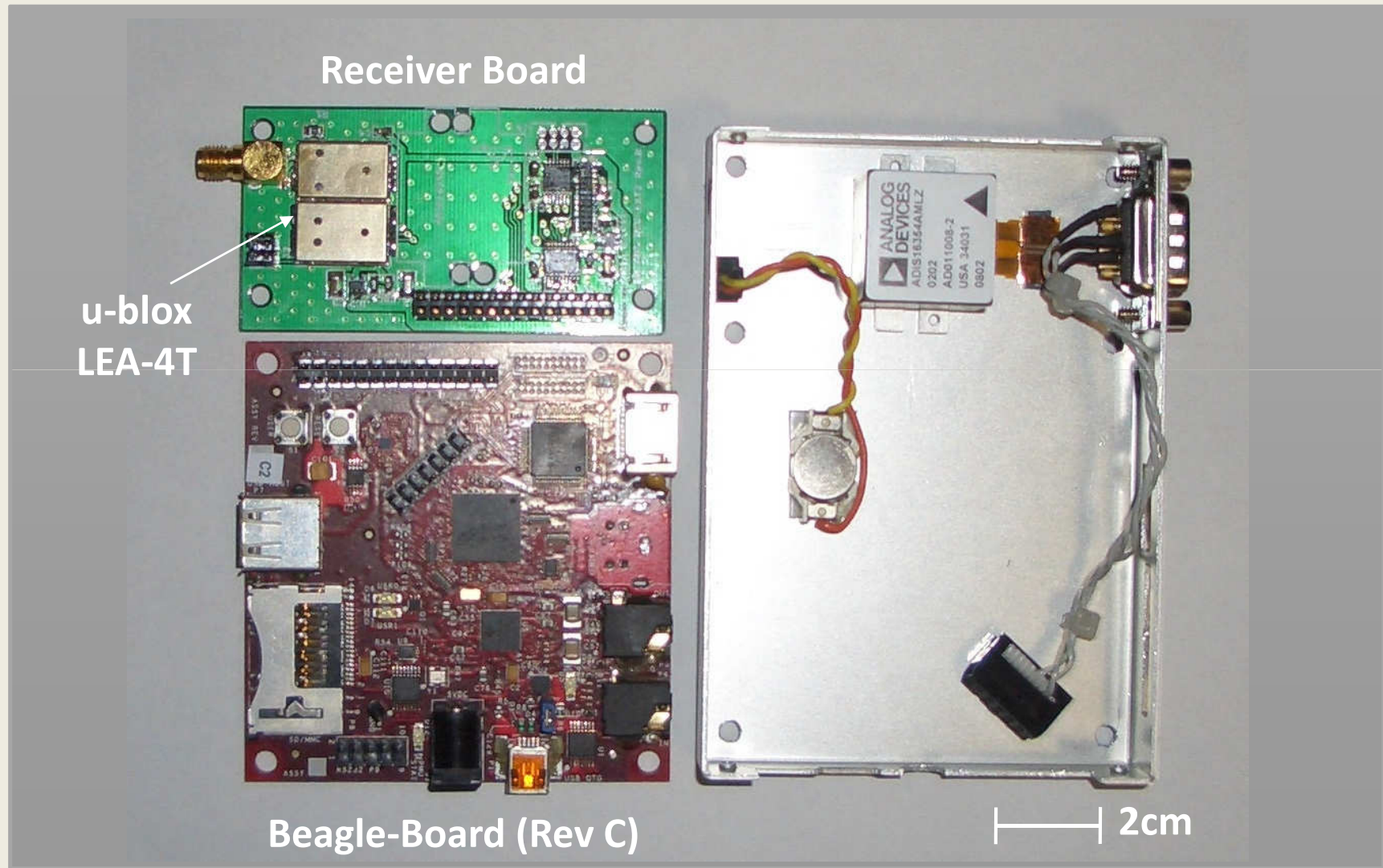
- **Objective**

- To demonstrate and verify the low-cost RTK-GPS receiver
- To evaluate production cost, CPU load, memory usage, power consumption, RTK performance, etc.
- To provide a platform for various RTK applications

- **Implementation**

- **Beagle Board + u-blox LEA-4T + Ubuntu Linux**
- Total parts cost: about **\$400** w/o options
- RTKRCV AP in **RTKLIB v.2.3.0**
- Support WiFi, Bluetooth, HSDPA (mobile internet)

# Low-Cost RTKR with RTKLIB (cond.)



# Low-Cost RTKR: CPU Load

- 10 Hz update of RTK-GPS solutions
- Receiving RTCM v.3 via NTRIP with E-Mobile HSDPA modem
- Logging all raw measurement data and solutions to SD card

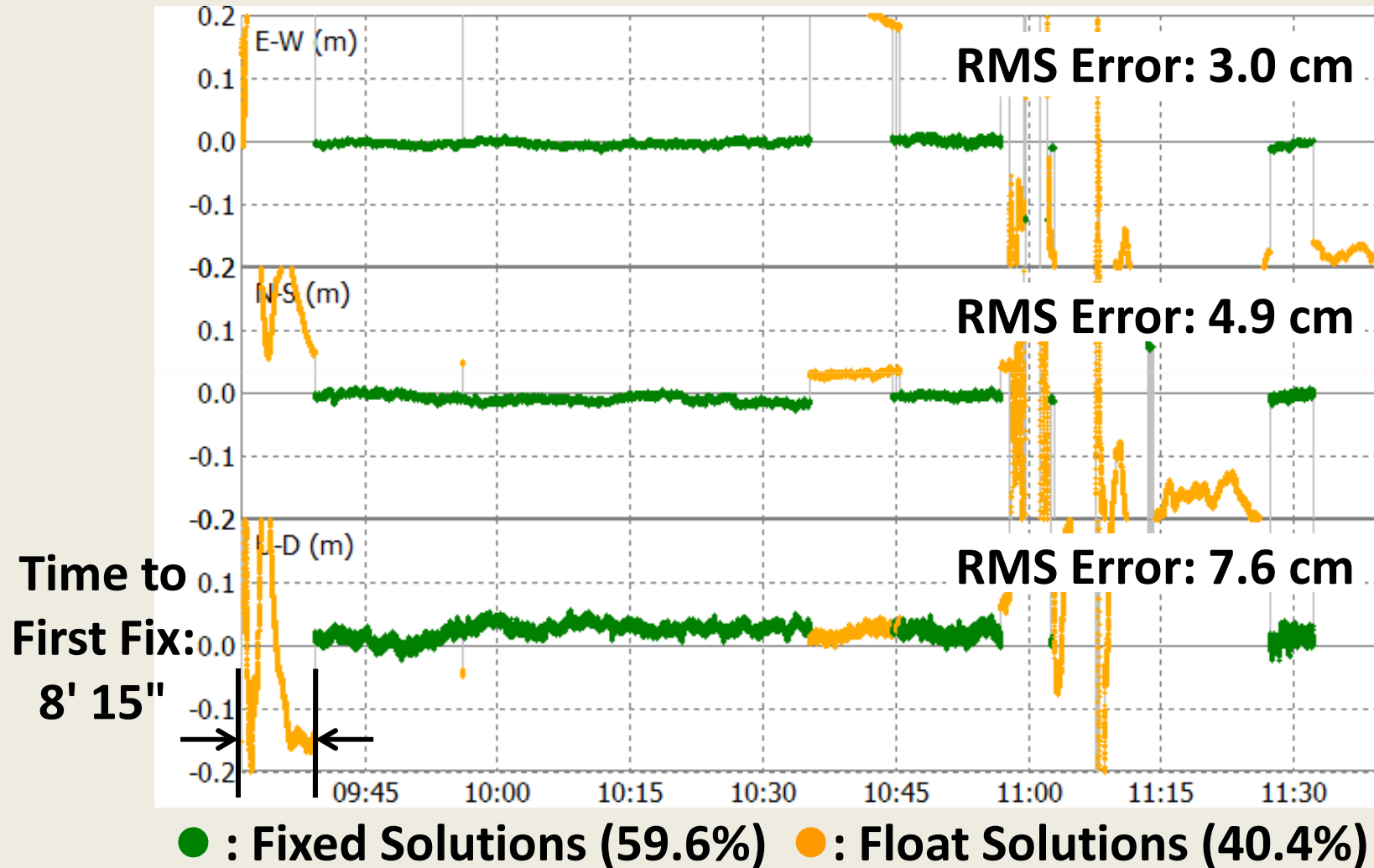
```
$ top

top - 00:08:24 up 24 min,  1 user,  load average: 0.16, 0.24, 0.18
Tasks:  46 total,  1 running, 45 sleeping,  0 stopped,  0 zombie
Cpu(s):  24.3%us,  1.3%sy,  0.0%ni,73.4%id,  0.7%wa,  0.3%hi,  0.0%si,  0.0%st
Mem:    239616k total,  30476k used,  209140k free,    3540k buffers
Swap:      0k total,    0k used,    0k free,   12492k cached

 1876 ubuntu    20    0 11896 2344 1256 S 25.1  1.0   4:13.09 rtkrcv
 1894 ubuntu    20    0  2492 1160   936 R  0.7  0.5   0:00.16 top
    1 root       20    0  2860 1896   572 S  0.0  0.8   0:01.49 init
    2 root       15   -5     0    0     0 S  0.0  0.0   0:00.00 kthreadd
    3 root       15   -5     0    0     0 S  0.0  0.0   0:00.07 ksoftirqd/0
    4 root       RT   -5     0    0     0 S  0.0  0.0   0:00.00 watchdog/0
    5 root       15   -5     0    0     0 S  0.0  0.0   0:00.04 events/0
    6 root       15   -5     0    0     0 S  0.0  0.0   0:00.05 khelper
...

```

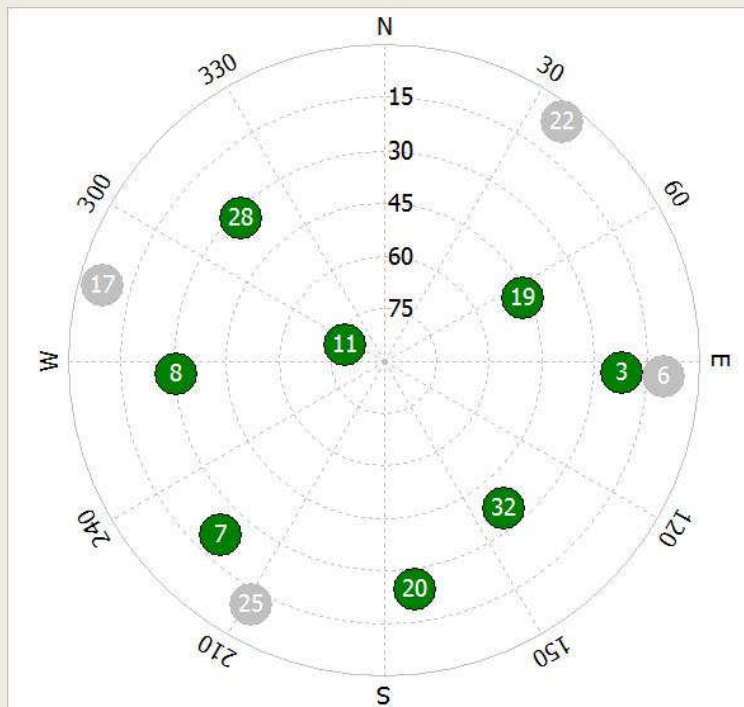
# Low-Cost RTKR: Performance



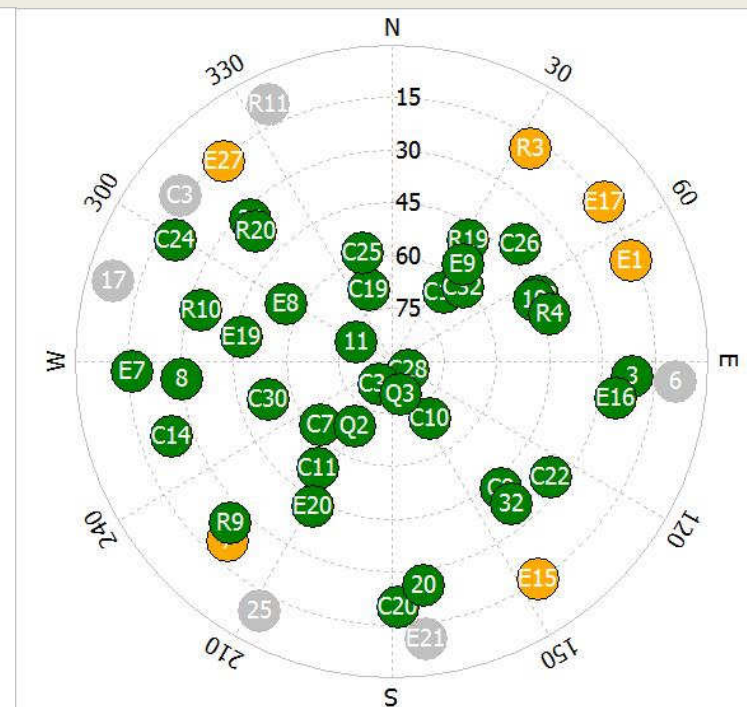
# Future GNSS

**GPS: 32 (US)**  
**GLONASS: 30 (Russia)**  
**Galileo: 30 (EU)**

**Compass: 35 (China)**  
**QZSS: 3 (Japan)**  
**IRNSS: 8 (India)**



**GPS in 2009**



**GNSS in 2015**

# Future RTKLIB

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- **Ver. 2.3.0: end of 2009**
  - Support GLONASS, Galileo, QZSS
  - Add console real-time positioning AP on Linux
  - Support receiver dynamics
  - Support INS/GPS integration (experimental)
- **Ver. 2.4.0: 2Q (?) of 2010**
  - Support real-time PPP
  - Change GUI toolkit to Qt (?)
  - Integrated map

# Summary

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- **RTK-GPS**
  - cm-level accuracy with GPS carrier-phase measurement
  - Many existing and potential applications
  - Cost issue
- **RTKLIB**
  - Open source program package for RTK-GPS
  - Portable C library + several APs
  - Support low-cost receivers, NRTK
- **Future GNSS and Future RTKLIB**