





Low-Cost High-Accuracy GNSS Receiver

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High Accuracy Receivers are Expensive

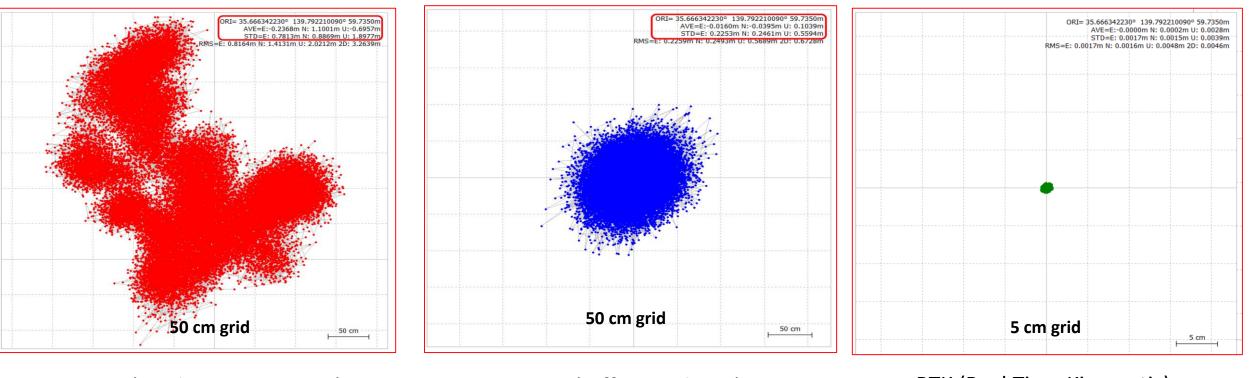
- High-Accuracy Survey Grade Receivers are multi-frequency and multi-system receivers
 - L1/L2/L5, G1/G2, B1/B2/B3 etc
 - GPS, GLONASS, BGALILEO, BeiDou, QZSS etc
 - Price varies from \$5,000 to \$30,000 or more.
- However, Low Cost Receivers are also capable of
 - Multi-System: GPS, GLONASS, GALILEO, BeiDou, QZSS, SBAS etc
 - Currently only in L1-Band Frequency
 - Low Cost: \$300
 - Very soon: Multi Frequency, L1/L5
 - Broadcom already announced production of L1/L5 GNSS chip



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How accurate is GPS Position?



SPP (Single Point Position)

DGPS (Differential GPS)

RTK (Real Time Kinematic)







Errors in GPS Observation (L1C/A Signal)

Error Sources	One-Sign	na Error , m	Comments	
Error Sources	Total	DGPS	Comments	
Satellite Orbit	2.1	0.0	Common errors are	
Satellite Clock	2.1	0.0	removed	
Ionosphere Error	4.0	0.4	Common errors are	
Troposphere Error	0.7	0.2	reduced	
Multipath	1.4	1.4		
Receiver Circuits	0.5	0.5		

If we can remove common errors, position accuracy can be increased.

Common errors are: Satellite Orbit Errors, Clock Errors and Atmospheric Errors (within few km)

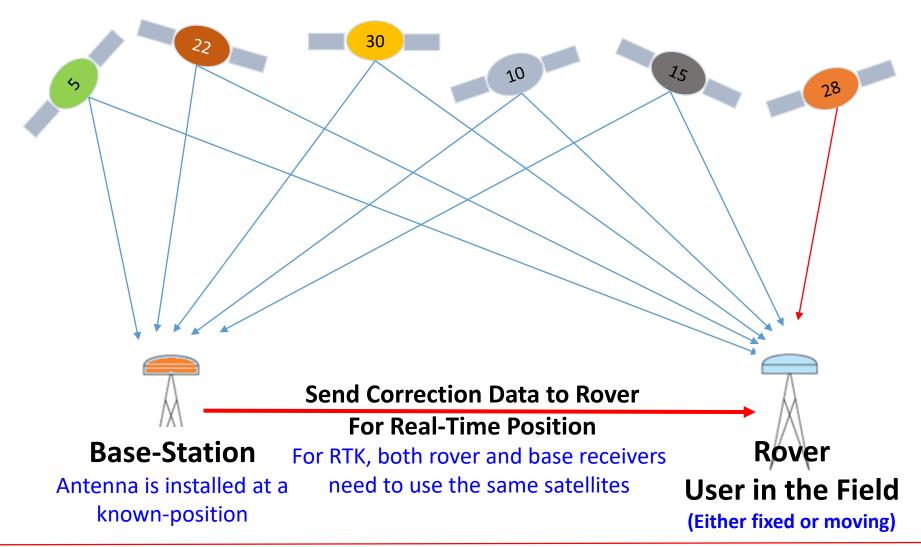
Table Source : http://www.edu-observatory.org/gps/gps_accuracy.html#Multipath







Principle of Differential Correction



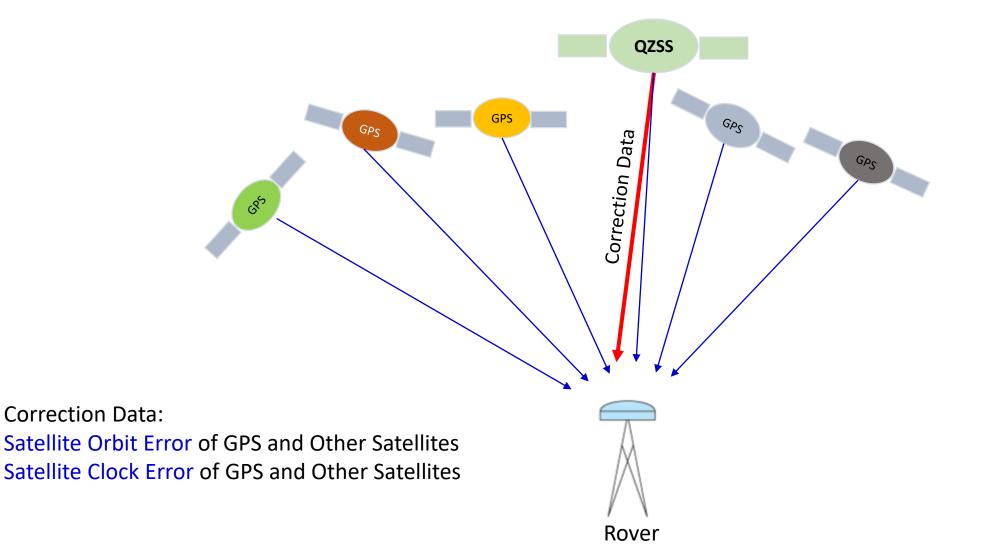
Training on GNSS – Course (T141-30), Organized by: GIC/AIT, S4D/CSIS and ICG, held at: GIC/AIT, Thailand from 23 – 26 JAN 2018 Dinesh Manandhar, CSIS, The University of Tokyo, dinesh@iis.u-tokyo.ac.jp







Principle of QZSS MADOCA / CLAS Service

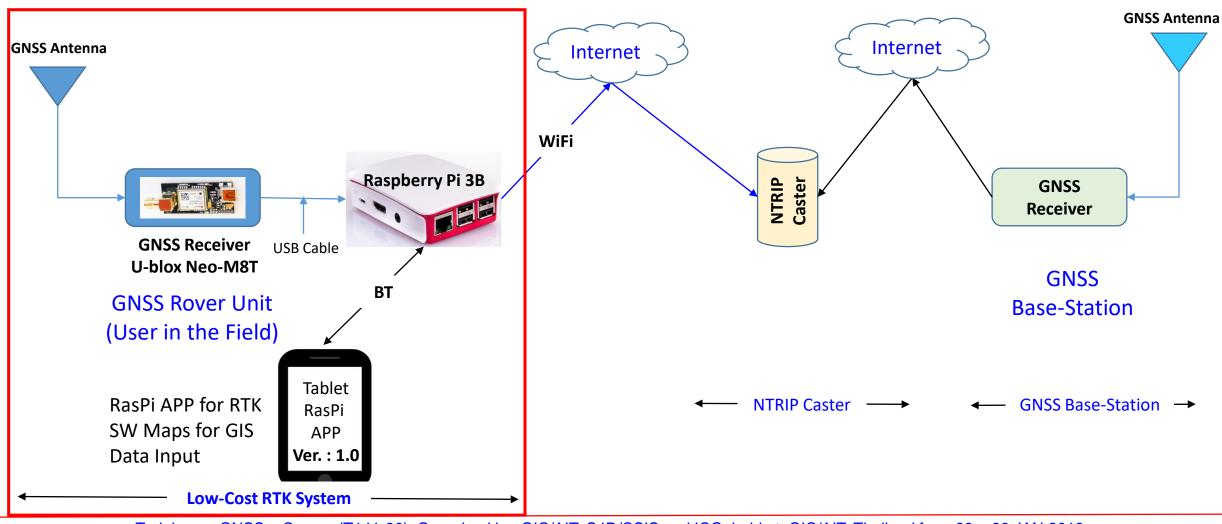




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Low-Cost High Accuracy System



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RtkPi APP for Low-Cost RTK System

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RtkPi			RtkPi		F	RtkPi			С
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Board Computer for Low-Cost RTK System Raspberry Pi 3B for Raspberry Pi Zero w/WiFi & BT

Realtime and Postprocessing RTK

for Post-processing RTK



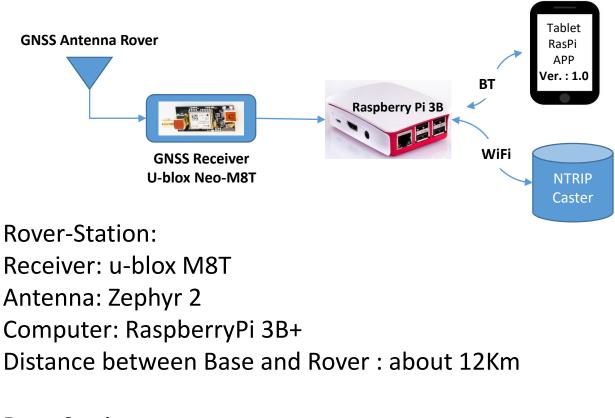
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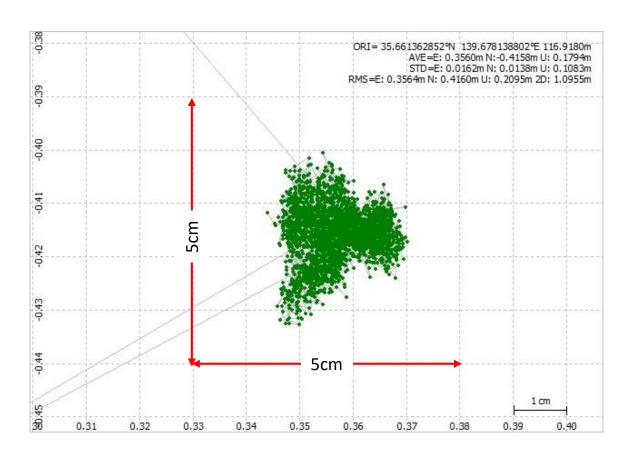




Accuracy from Low-Cost RTK System



Base-Station: Receiver: Trimble NetR9 Antenna: Zephyr 2



Slide : 10



Ready

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Data from Low-Cost RTK System

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- RLM (Return Link Messae - RTCM (RTCM input statu - SFRB (Subframe Data) R17 L10F 4 20504419.86 107315221.51 2260.3 57680 45 0.32 0.004 0.512 • Y • Y • Y - SFRB (Subframe Data) R17 L10F 4 20504419.86 107315221.51 2260.3 57680 45 0.32 0.004 0.512 • Y • Y • Y R09 L10F -4 20502600.33 109405739.36 1759.8 57660 36 0.64 0.004 0.512 • Y • Y • Y S137 L10/A - 35066503.25 184275722.38 -425.9 35000 39 0.32 0.004 0.512 • Y • Y • Y				00/07/02
-SFRB (Subframe Data) R09 L10F -2 22370432.66 119456772.21 -3119.6 57660 36 0.64 0.004 0.512 • Y.• Y.• Y	RLM (Return Link Messa			08:27:36
-SFRB (Subframe Data) S137 L1C/A - 35066503.25 184275722.38 -425.9 35000 39 0.32 0.004 0.512 • Y.• Y.• Y.• Y.• Y.• Y.• Y.• Y.• Y.• Y	RTCM (RTCM input statu			NUMBER OF STREET
	- SFRB (Subframe Data)			
	SFRBX (Subframe Data N			ž ,
-SVSI (SV Status Info) E24 E1C - 22721209.02 119400766.85 1920.7 59000 37 0.32 0.004 0.512 • Y.• Y.• Y		E24 E1C - 22721209.02 119400766.85 1920.7 59000 37 0.32 0.00		
C (Security)				=

Training on GNSS – Course (1141-30), Organized by: GIC/AIT, S4D/CSIS and ICG, held at: GIC/AIT, Thailand from 23 – 26 JAN 2018

Dinesh Manandhar, CSIS, The University of Tokyo, dinesh@iis.u-tokyo.ac.jp





Data from Low-Cost RTK System

	- [Messages - UBX - RXM (Receiver Manager) - SFRBX (Subframe Data NG)]	- 🗆 ×
🞐 File Edit View Player Receiver Tools 🕚	Window Help	_ 8
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T-NMEA ^		×
₽ RTCM3	UBX - RXM (Receiver Manager) - SFRBX (Subframe Data NG)	1 s
∃ UBX		
⊕ ACK (Acknowledge)		
AID (GPS Aiding)	## denotes data received on subChn Strip Parity Bits	
E-CFG (Config)	SV MSG DATA (* denotes invalid words)	J ++++++++++++++++++++++++++++++++
	GAL 3 E1B 0 E0 00955555 5555555 4EB9C000 83A74000 0000002A AAAA632E 87BF4000	
ESF (External Sensor Fusion)	GAL 5 E1B 0 E0 00955555 55555555 4EB9C000 83A74000 0000002A AAAA632E 87BF4000 GAL 9 E1B 0 E0 00955555 55555555 4EB9C000 83A74000 0000002A AAAA632E 87BF4000	-
HNR (High Navigation Rate)	GAL 2 E1B 0 E0 00955555 5555555 4E95000 83A74000 0000002A AAAA322 878F4000 GAL 22 E1B 0 E0 00955555 55555555 4E950000 83A74000 0000002A AAAA322 878F4000	
INF (Information)	GAL 24 E1B 0 E0 00955555 55555555 4EB9C000 83A74000 0000002A AAAA632E 87BF4000	30 0 250
E LOG (Data Logger)	GLO 1 L10F 1 14 1/3156 752856E0 5D706C48 0A4B0000	
	GLO 2 L1OF -4 14 1/3156 752856E0 5D706C48 0A4B0000	
MGA (Multiple GNSS Assistance)	GLO 8 L10F 6 14 1/3156 752856E0 5D706C48 0A4B0000	
	GLO 9 LIOF -2 14 1/3156 752856E0 5D706C48 0A4B0000	······································
• NAV (Navigation)	GLO 10 L1OF -7 14 1/3156 752856E0 5D706C48 0A4B0000 GLO 11 L1OF 0 14 1/3156 752856E0 5D706C48 0A4B0000	
	GLO 11 LIOF 0 14 1/3156 752856E0 5D706C48 0A4B0000 GLO 17 LIOF 4 14 1/3156 752856E0 5D706C48 0A4B0000	0.00 m/s = 0.0 km/h
RXM (Receiver Manager)	GLO 1/ 1107 4 14 1/3150 1/220020 5D706048 0A4B0000	
ALM (Almanac)	GLO 24 L10F 2 14 1/3156 752856E0 5D706C48 0A4B0000	·······
EPH (Ephemeris)	GPS 2 L1C/A 0 2 22C3AE0B 25A34ABB 0E3D5BD5 8D7EF996 B00ED3CB 3DB44210 2EDCDC5A 8402E875 832C83CB 1C909F7C	
	GPS 5 L1C/A 0 2 22C3AE0B 25A34ABB 033FF65A 8CE7D348 36E920B1 BFF58087 2A4E4660 05792861 831E5F97 1C9093EC	TENERORO DE SE ELEVER O INT ZAVER DA MITTARIO GEZ VARABE 8 SI VILLA DA MITTARIO GEZ VARABE
IMES (IMES Status)	GPS 6 L1C/A 0 2 22C3AE0B 25A34ABB 183CCB64 0BCFF6F7 37D36E26 BD394002 925E8E14 0437A870 037FF228 1C909F2F	
MEASX (Measurement Data)	GPS 7 L1C/A 0 2 22C3AE0B 25A34ABB 03404DD3 0C196F58 02CFB2D9 802A174 2A8FDAF4 0523E852 83729150 1C909478	- 17 × 5
	GPS 13 L1C/A 0 2 22C3AE0B 25A34ABB 06002439 8CA2FB8A AD89E7F6 8014C070 328B1F03 03462848 03407BCA 9C909F0	The second se
	GPS 15 L1C/A 0 2 22C3AE0B 25A34ABB 17C07442 8F35037A B9639CDC 0075C135 B9BD06FE 82EBE859 8336425B 1C909F2F GPS 20 L1C/A 0 2 22C3AE0B 25A34ABB 0A800B59 8E01C218 21702E31 801D0098 149C0D26 8576A85D 8378DEDF 1C909F7C	6 4
	GPS 29 L1C/A 0 2 22C3AE0B 25A34ABB 01BF15E0 0BDA92A ADA76857 3F1E8029 90F5C377 01A96847 03220618 1C909478	N 118.500 m ⁵ x1
- RAWX (Multi-GNSS Raw Measu	GPS 30 L1C/A 0 2 22C3AE0B 25A34ABB 0A805139 8D0B6F0B 01C4A960 00238048 246C1FD9 85416853 0343752B 1C909F2F	
	QZSS 1 L1C/A 0 2 22C0AA24 25A34254 10494F43 067A62DE 8A7BAAB5 84AB49A3 1D0554C4 0AF1F2AF 3BC08DFD 9C585FC7	08:27:58 U
	QZSS 1 L1SAIF 0 50 53CAC767 E0000070 31027FDD FD8FD8FE 502F0000 00000000 00000000 3294C0A6	
RTCM (RTCM input status)	QZSS 2 L1C/A 0 2 22C0AA81 A5A3524F 107D9E77 037ECC21 BCA9FE77 3F294966 B57BC11D 879B728F 3B22D081 9C585F94	
	QZSS 2 LISAIF 0 50 53CAC767 E0000070 31027FDD FD8FD8FE 502F0000 00000000 3294C0A6	
⊞ SFRBX (Subframe Data NG)	SBAS 128 L1C/A 0 3 530D9FFF FF9FFDFF C011FFC0 00001FFD FF797B9 B95BBA16 B71493A6 SBAS 129 L1C/A 0 25 536611C7 EBFDC05F EC7FFE81 7F9DBA80 00000000 00000000 0D6D0226	- 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
SVSI (SV Status Info)	SBAS 129 L1C/A 0 25 536611C7 EBFDC05F EC7FFE81 7F9DBA80 000000000 00000000 000000000	
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E SEC (Security)		
⊞- TIM (Timing)		S-S- Mannak
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Dinesh Manandhar, CSIS, The University of Tokyo, dinesh@iis.u-tokyo.ac.jp



International Committee on Global Navigation Satellite Systems



Simple to Use, Low-Cost System

Simple to Use, No Commands, Just One Time Setting Connect Antenna, Receiver and Battery Pack Device Starts Logging GNSS Raw Data required for RTK Post-Processing





Center for Spatial Information Science The University of Tokyo



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SW Maps APP to integrate GPS Data into GIS

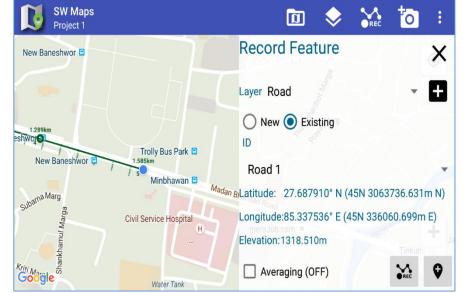
SW Maps

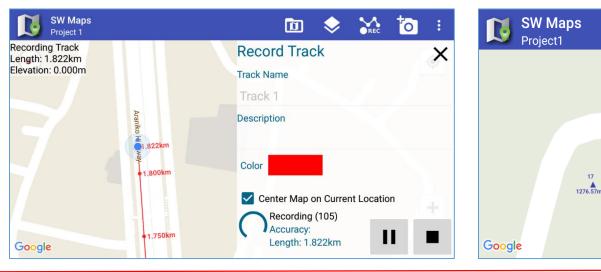
A free Android based GIS app for collecting, presenting and sharing geographic information.

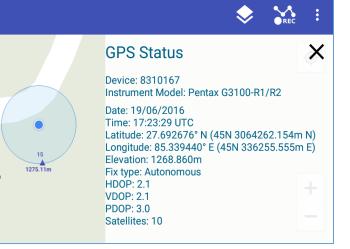
🍈 Get SW Maps 👘

User's Manual (PDF)

Current Version: 1.6







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