GNSS Technology Promotion Activities at The University of Tokyo

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Center for Spatial Information Science, The University of Tokyo

Seventeenth Meeting of the International Committee on Global Navigation Satellite Systems (ICG)

Meeting of the Working Group C on Information Dissemination and Capacity Building

15 – 20 October 2023, Madrid, Spain

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Overview

- Conduct GNSS Training, Workshops and Seminars
  - Mainly in Asia
    - Indonesia, Thailand, Vietnam, Philippines, Singapore, Malaysia, India, Nepal
  - Conduct Training in Collaboration with ICG
- Conduct Joint Research and Pilot Projects
  - Low-cost High-Accuracy GNSS Systems
  - Traffic Monitoring
  - Urban City Environment Monitoring
  - Space Weather
  - Any GNSS-based Application of your interest
- JIS (Jamming, Interference and Spoofing) Test
  - Conduct JIS test and demo
  - Create awareness of spoofing attacks
- Installation of GNSS CORS
  - Install GNSS CORS in Universities around the world for joint research, GNSS technology promotion and capacity-building
- Develop Low-Cost Receiver Systems for
  - High-Accuracy based on
    - RTK: RTKDROID - RTK in Android
  - MADOCA PPP
    - MADROID: MADOCA-PPP in Android
    - MAD-WIN: MADOCA-PPP in Windows
    - MAD-PI: MADOCA-PPP in RaspberryPi Device
  - Space Weather Data Analysis
  - Dynamic Air Quality Monitoring
- RPD (Rapid Prototype Development) Challenge
  - Organize RPD Challenge as a part of the MGA (Multi-GNSS Asia) activity
  - Encourage students and researchers to bring solutions and business values by solving real-life problems
- GNSS Summer School
  - Organized by TUMSAT (Tokyo University of Marine science and Technology)

Training on GNSS, Jointly Organized by UTokyo and ICG

- This program began in 2018 and conducted every year until now.
- It will be conducted this year as well.

ICG Programme on GNSS Applications

Upcoming activities carried out in the framework of the ICG Workplan in 2023

Eastern Africa Capacity Building Workshop on Space Weather and Low-latitude Ionosphere, 3 - 12 October 2023, Malindi, Kenya

Announcement (External Link): https://indico.ictp.it/event/10216/material/poster/0.pdf

Website (External Link): https://indico.ictp.it/event/10216

ICTP-SCOSTEP-ISWI School and Workshop on the Predictability of the Solar-Terrestrial Coupling - PRESTO, 29 May - 2 June 2023, Trieste, Italy

Announcement (External Link): https://indico.ictp.it/event/10176/material/poster/0.pdf

Website (External Link): https://indico.ictp.it/event/10176

Technical Seminar on Reference Frames in Practice (FIG Working Week 2023), 27 - 28 May 2023, Orlando, Florida, United States

Website (External Link): https://fig.net/fig2023/rfip.htm

Training programme on Global Navigation Satellite Systems (GNSS), jointly organized by the Centre for Spatial Information Science (CSIS), The University of Tokyo (UTokyo), Japan and the International Committee on Global Navigation Satellite Systems (ICG)/Office for Outer Space Affairs, Vienna, Austria

Announcement

GNSS Training Programme (Hybrid format), 3 - 6 January 2023, Pokhara, Nepal

Programme

Presentations

Workshop on GNSS Applications for Policy and Decision Makers (Online Only), 9 January 2023

Programme

Presentations

Our Work

Secretariat of COPUOS

Programme on Space Applications

UN-SPIDER

International Committee on GNSS

- Overview
- Members
- ICG Terms of Reference
- Providers' Forum
- Working Groups
- ICG Annual Meetings
- ICG Programme on GNSS Applications
  - Workshops
- Resources
- ICG Documents
- ICG Timeline

UN-Space

Space Law

Benefits of Space

Access to Space for All

Space Law for New Space Actors

Space for Persons with Disabilities

Space4Youth

Space4Water

Space4Women

World Space Forum

Worldwide Space Agencies

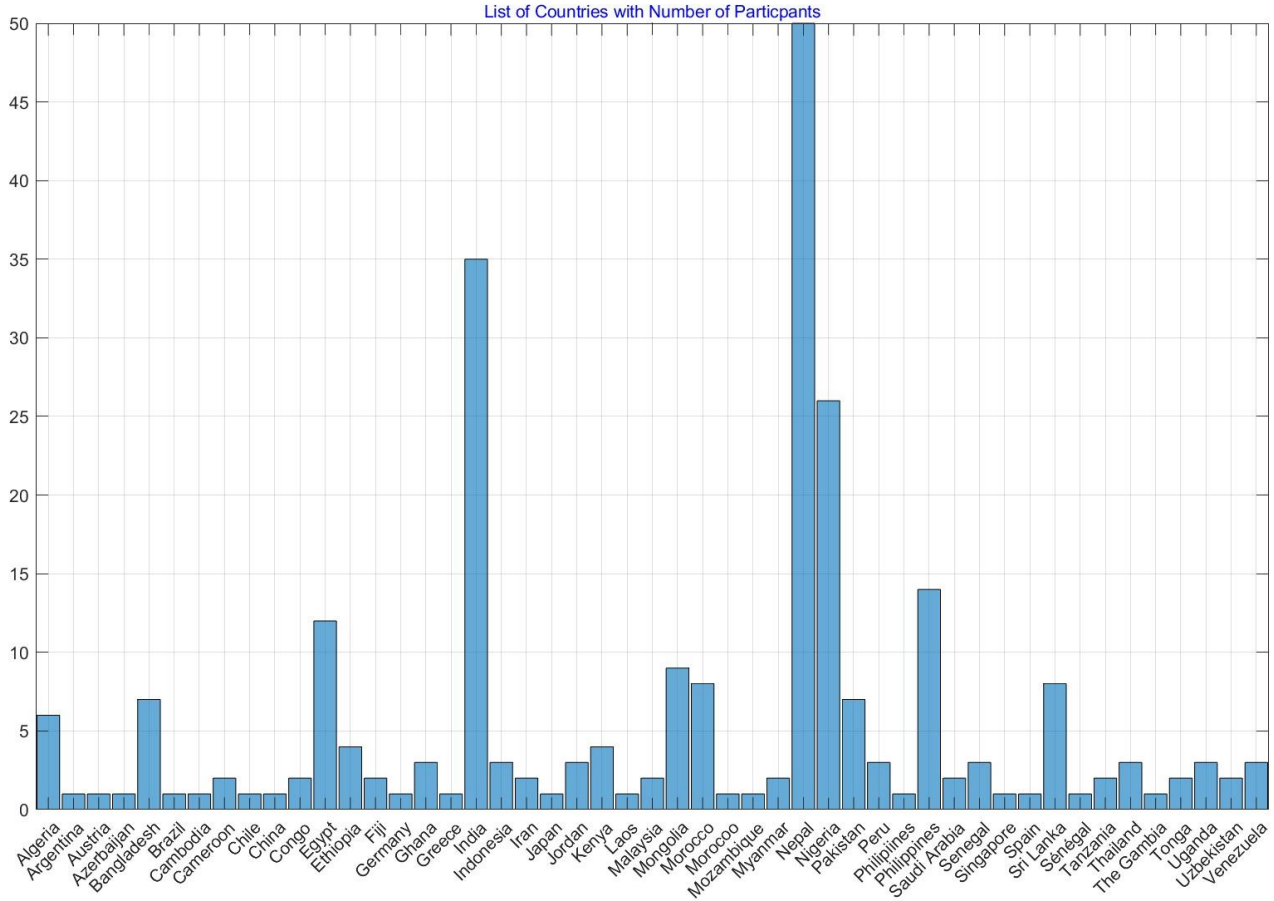
Capacity Building Activities

Summary of GNSS Trainings: Jointly Organized by UTokyo and ICG/UNOOSA

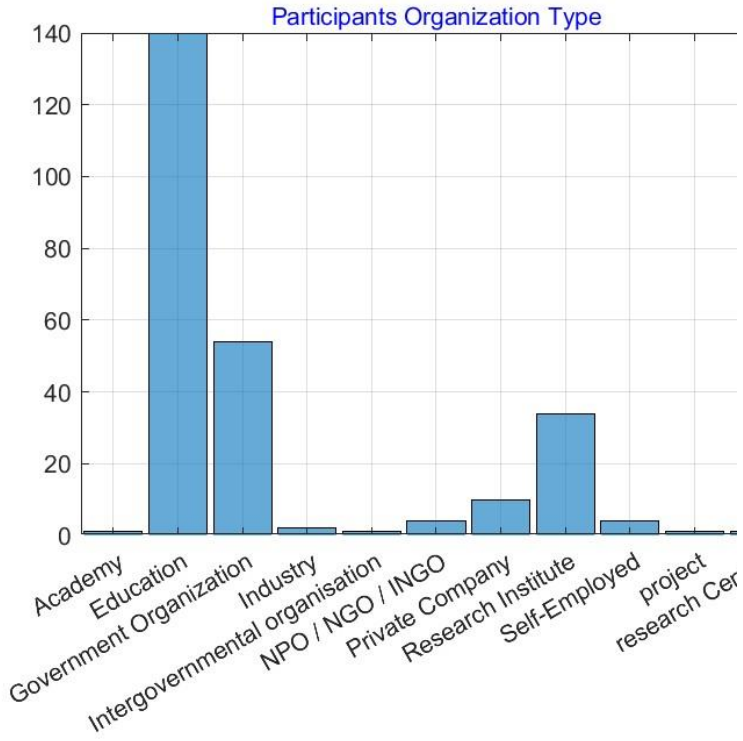
Course A: GNSS Data Processing for High-Accuracy Positioning using Low-Cost Receiver Systems
Course B: GNSS for Policy and Decision Makers

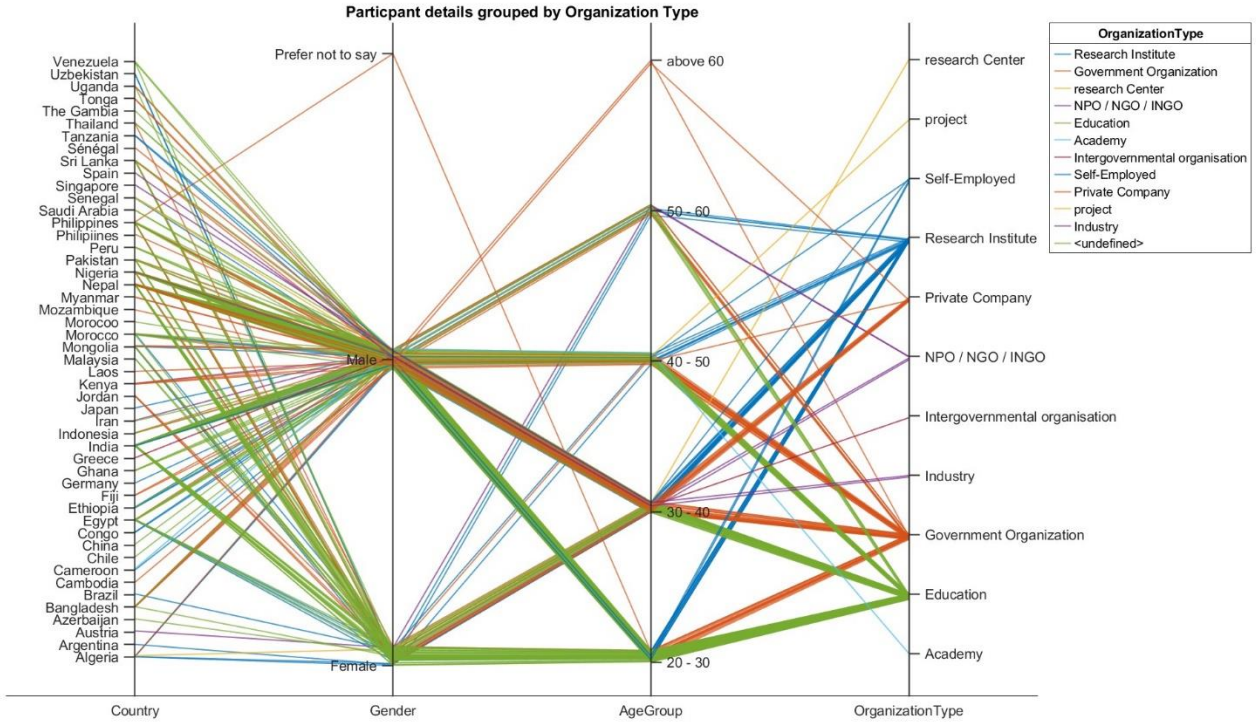
Training Mode / Location	Hybrid-Training Venue: Nepal		Hybrid-Training Venue: Nepal		Online GNSS Training		GNSS Trainings Venue: AIT, Thailand		
Date and Duration	**3 – 6 Jan 2023 (Hybrid)**	**9 Jan 2023 (Online)**	**11 – 14 Jan 2022 3 days**	**28 Jan 2022 1 day**	**19 – 21 Jan 2021 3 days**	**28 Jan 2021 1 day**	**JAN 2020 5 days**	**JAN 2019 5 days**	**JAN 2018 5 days**
Course Type	Course A	Course B	Course A	Course B	Course A	Course B	T-151	T-151/T-131	T-141
(A) ICG Funded International (travel only)	NA	NA	Cancelled due to Corona	NA	NA	NA	19	23	14
(B) Other Funding (travel only)	NA	NA	NA	NA	NA	NA	X	4[E]	X
(C) Self Funded International	3 (India, Sri Lanka)	NA	Cancelled due to Corona	NA	NA	NA	34	40	11
(D) Self-Funded Domestic (Thailand or Nepal)	30 (On-Site Nepal)	NA	30 (On-site Nepal)	NA	NA	NA	18	27	42 (24 + 18)
(E) Online Participants	180	30	**45**	**25**					
Total (A + B + C + D + E)	**210**	**30**	**75**	**25**	**270**	**160**	**71**	**94**	**67**
Number of Applicants	320	200	**90**	**40**	360	190	160+	180+	80+
Number of Resource Persons	12	2	**13**	**3**	15	6	16 7 (Int) + 9 (GIC)	20 11 (Int) + 9 (GIC)	13 7 (Int) + 6 (GIC)
Number of Countries	49		**16**	**10**	70+	60+	15	15	15
Resource Persons' Countries	5	2	**7**	**2**	4	3	4	7	4

UTokyo/ICG GNSS Training 2023 Statistics: Participants' Country

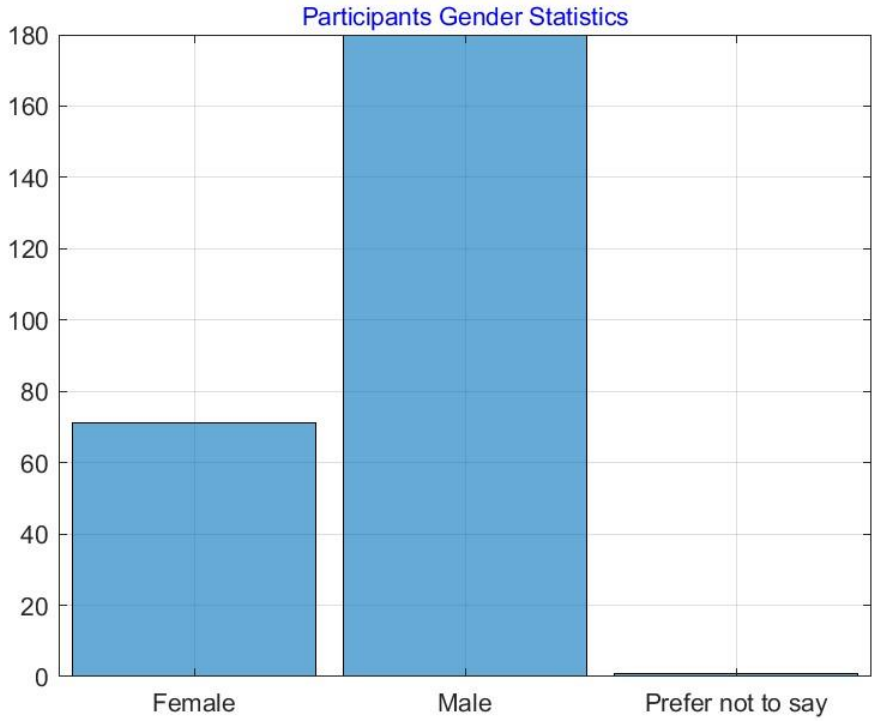


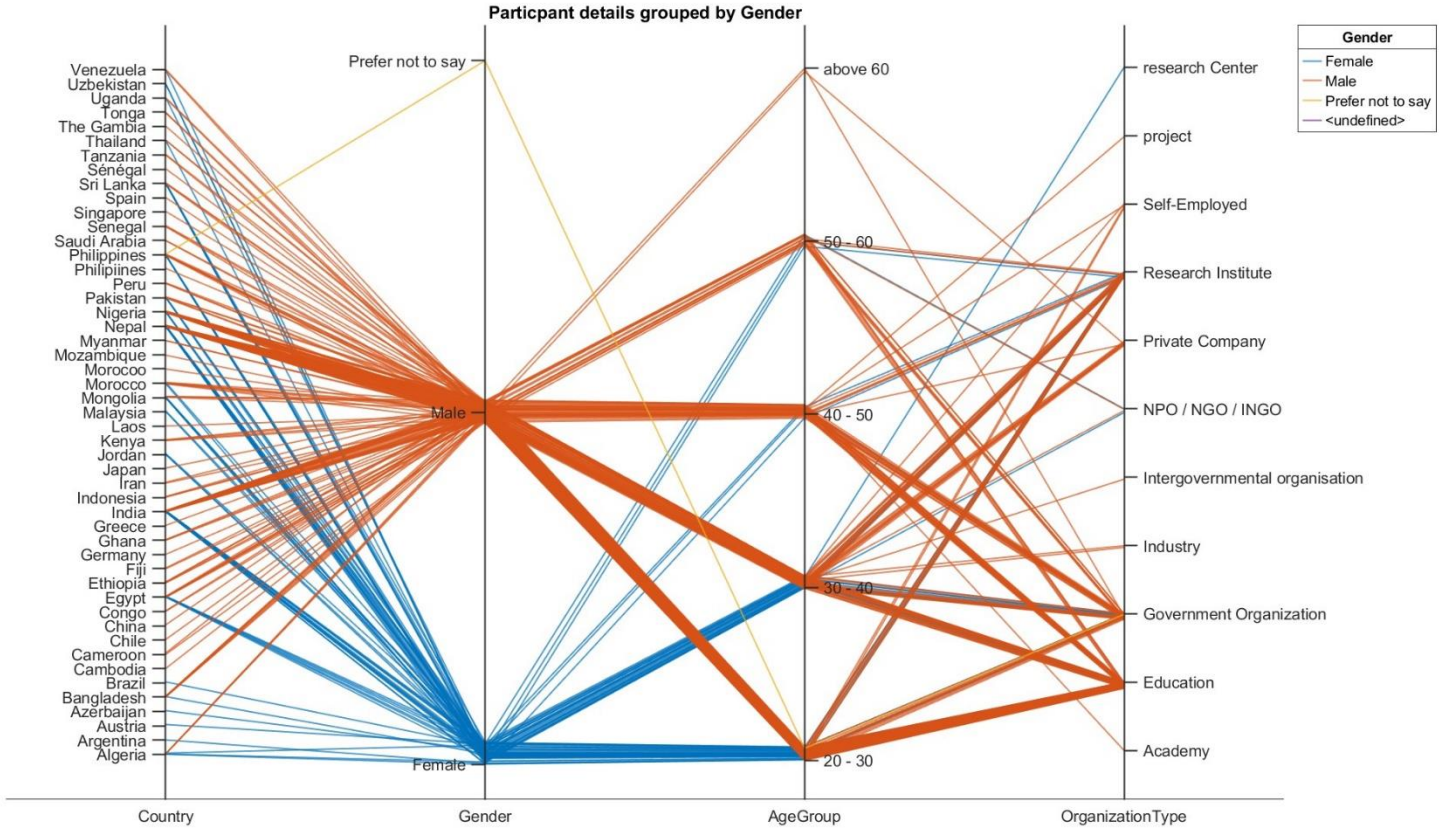
UTokyo/ICG GNSS Training 2023 Statistics: Organization Type





UTokyo/ICG GNSS Training 2023 Statistics: Gender



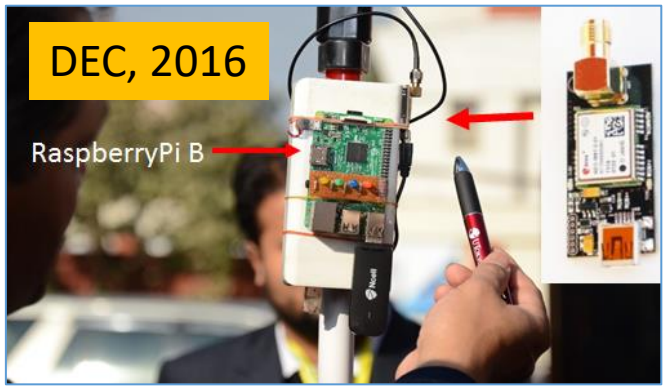


Installation of Base-Stations in Universities for Capacity Building

Country	Place	University	Receiver Type
Indonesia	Jakarta	University of Indonesia	GNSS, GNSS + MADOCA
Japan	Tokyo-A	The University of Tokyo	GNSS, GNSS + MADOCA
Japan	Tokyo-B	Tokyo University of Marine Science & Tech.	GNSS, GNSS + MADOCA
Japan	Tokyo-C	KEIO University	GNSS
Laos	Vientiane	National University of Laos	GNSS
Malaysia	Kuala Lumpur	Malaysia Japan International Institute of Tech.	GNSS, GNSS + MADOCA
Myanmar	Yangon	Yangon Technological University	GNSS
Thailand	Bangkok	Chulalongkorn University	GNSS, GNSS + MADOCA
Thailand	Pathumthani	Asian Institute of Technology	GNSS
Thailand	Bangkok	Kasetsart University	GNSS
Thailand	Khon Kaen	Khon Kaen University	GNSS
Philippines	Manila	University of the Philippines	GNSS, GNSS + MADOCA
Vietnam	Ho Chi Minh City	International University Vietnam National University	GNSS
Vietnam	Hanoi	Will be installed early next year	GNSS + MADOCA
Mozambique*	Maputo	Universidade Eduardo Mondlane	GNSS
Singapore	Singapore	Nanyang Technological University	GNSS + MADOCA
Australia	Perth	Curtin University	GNSS + MADOCA

Low-Cost High-Accuracy Receiver system Development Cycle

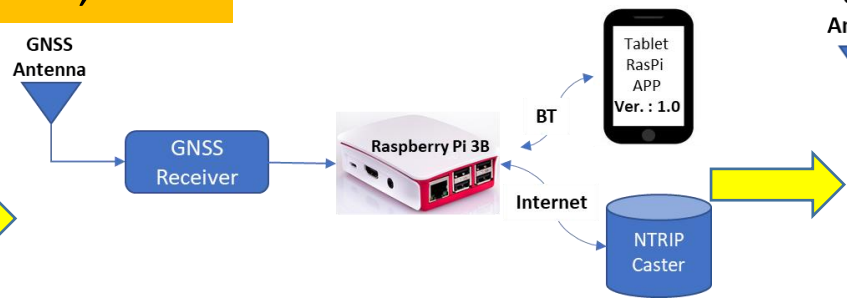
DEC, 2016



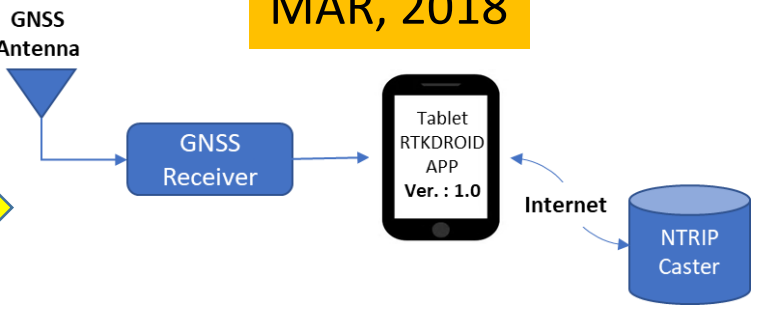
Demo during UN/Nepal GNSS workshop

MAY, 2017

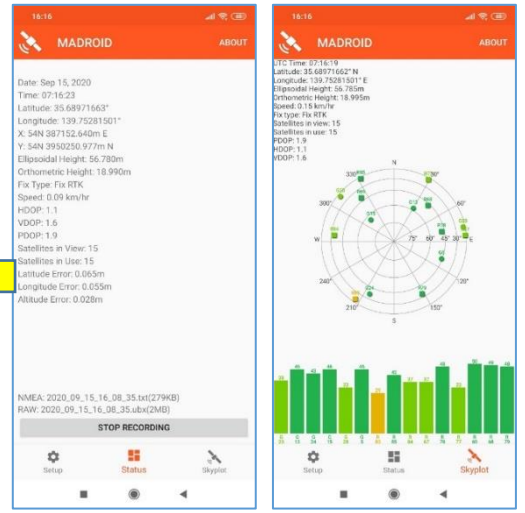
Low-Cost RTK

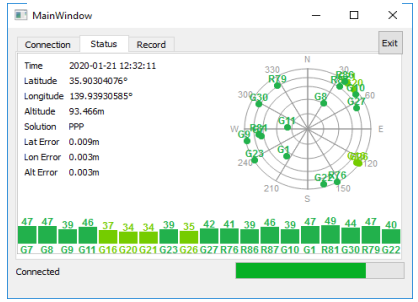


MAR, 2018



Low-Cost MADOCA





DEC, 2019

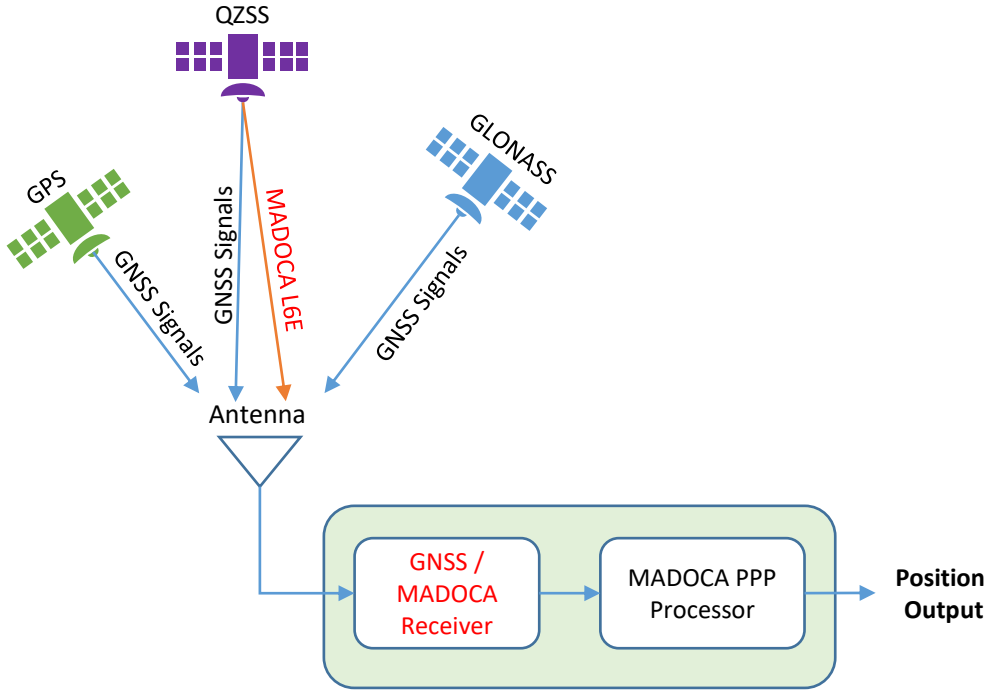
What Application or System Do you Want?

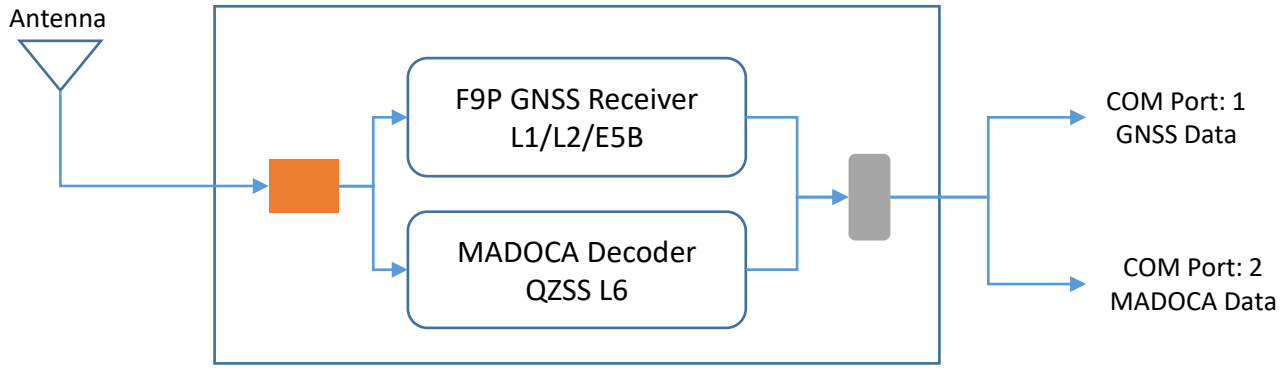
- Enhancement of MADOCA System 2022 / 2023
- Android Device based Applications RTK / MADOCA / EWS / SAR
- Space Weather Applications
- Dynamic Air Quality Monitoring System

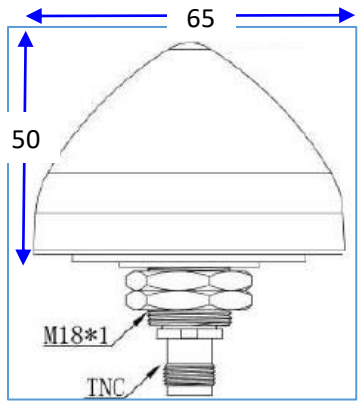
2022 - 2023

Low-Cost MADOCA Receiver System

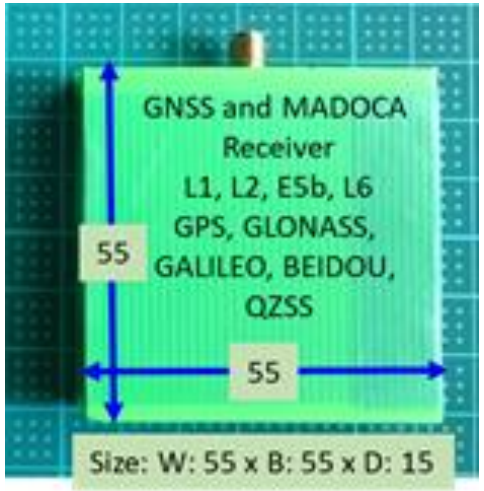
GNSS Receiver + MADOCA Decoder



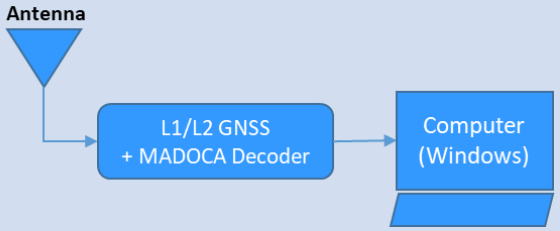
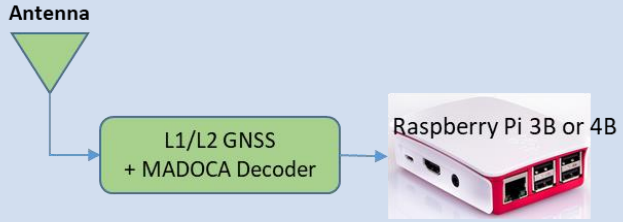
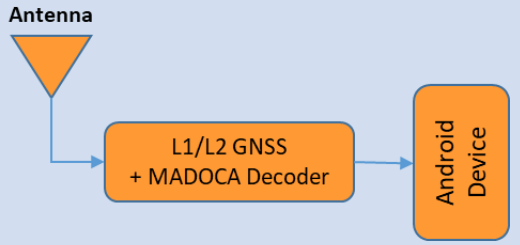




GNSS Antenna



Low-Cost MADOCA Receiver Systems: Product Types

	MAD-WIN	MAD-π	MADROID
Platform / OS	Windows	RaspberryPi 3B or 4B	Android Device
GNSS Receiver	Default : u-blox F9P Other: Any dual-frequency Receiver	Default : u-blox F9P only	Default : u-blox F9P Other: Any dual-frequency Receiver
MADOCA Receiver	U-blox D9 only	U-blox D9 only	NA (MADOCA Online Correction Data only)
GNSS Receiver Data Format	UBX, SBF, RTCM3	UBX SBF, RTCM3 (For online GNSS data)	UBX
MADOCA Correction Data Format (Satellite)	UBX only	UBX only	UBX only
MADOCA Correction Data Format (Online)	UTokyo (Test Level) UBX or RTCM3	Online Services UTokyo (Test Level) Online Services UBX or RTCM3	Online Services UTokyo (Test Level)
System Architecture			

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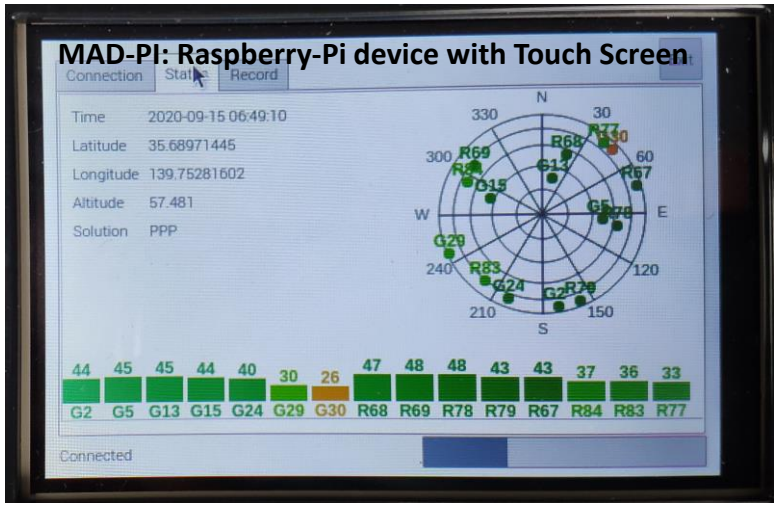
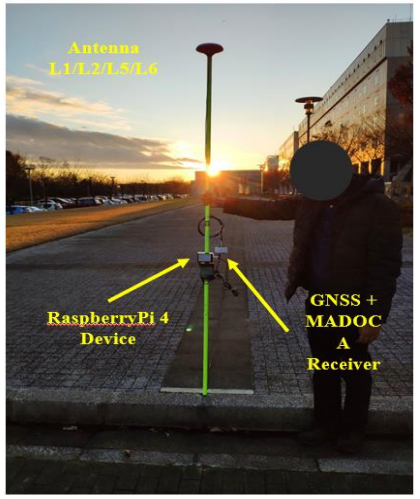
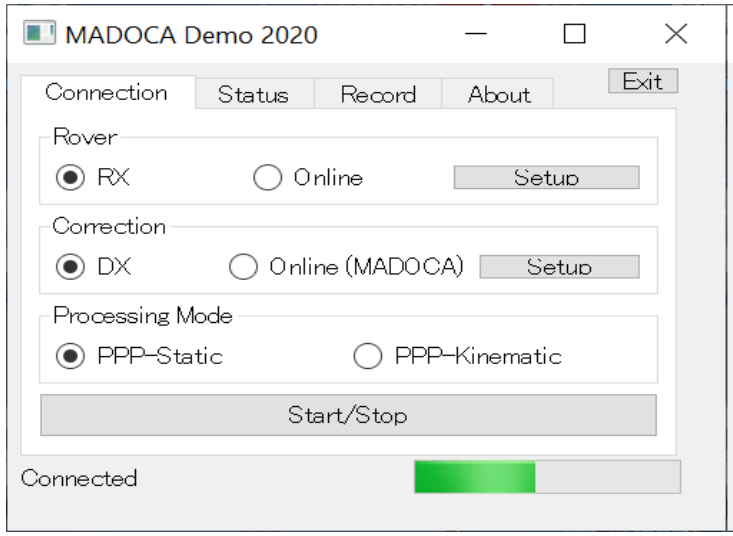
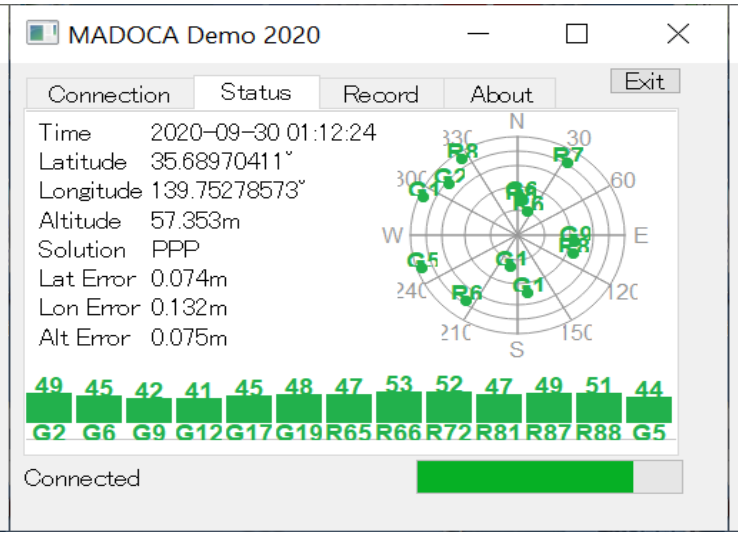
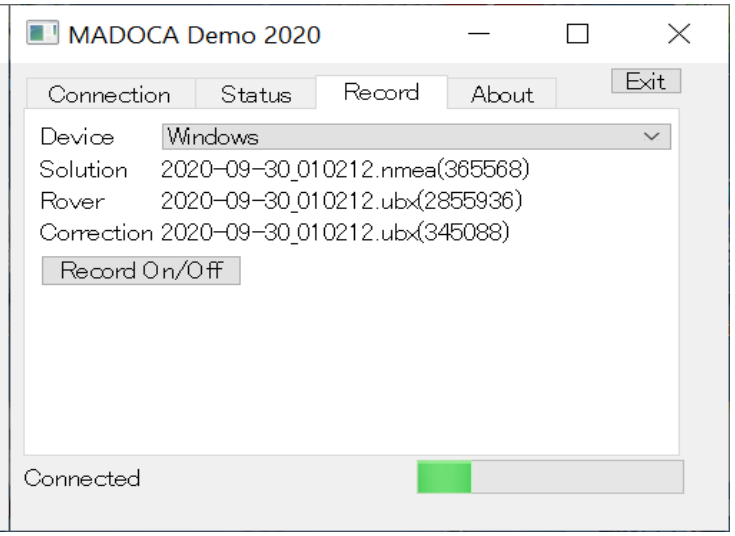
MAD-WIN and MAD-PI System and User Interface



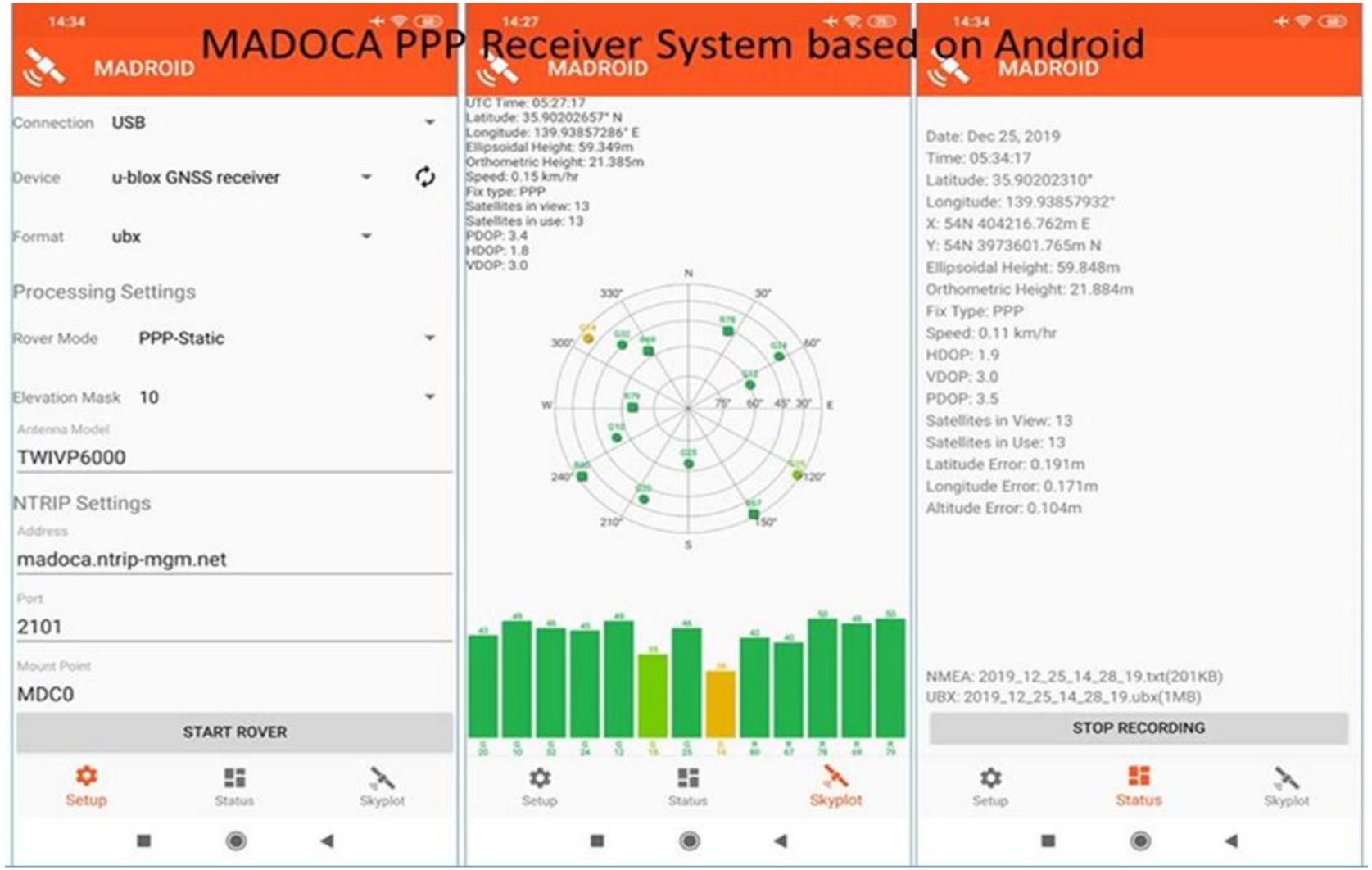








MADROID: MADOCA with Android Device



MADOCA / GNSS Training at AIT, Thailand and UI, Indonesia


MADOCA / GNSS Training at AIT, Thailand


MADOCA / GNSS Training at AIT, Thailand


MADOCA / GNSS Training at AIT, Thailand

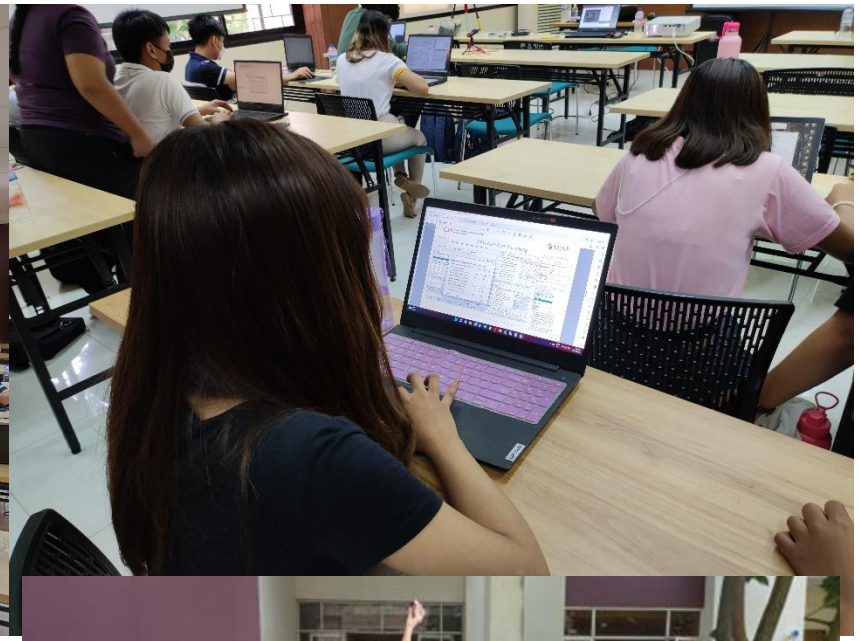

GNSS Lecture at University of Indonesia

UT / ICG GNSS Training, Tribhuvan University (TU), Nepal

Construction of Bench Mark for GNSS Training
Purpose: Compare GNSS accuracy based on various processing techniques such as SPP, DGPS, SBAS, RTK, PPK, MADOCA PPP, PPP etc.

GNSS Base-Station setup at TU, Paschimanchal Campus, Pokhara

GNSS / MADOCA Training at IU/VNU, HCM City, Vietnam



MADOCA Observation

MADOCA Observation

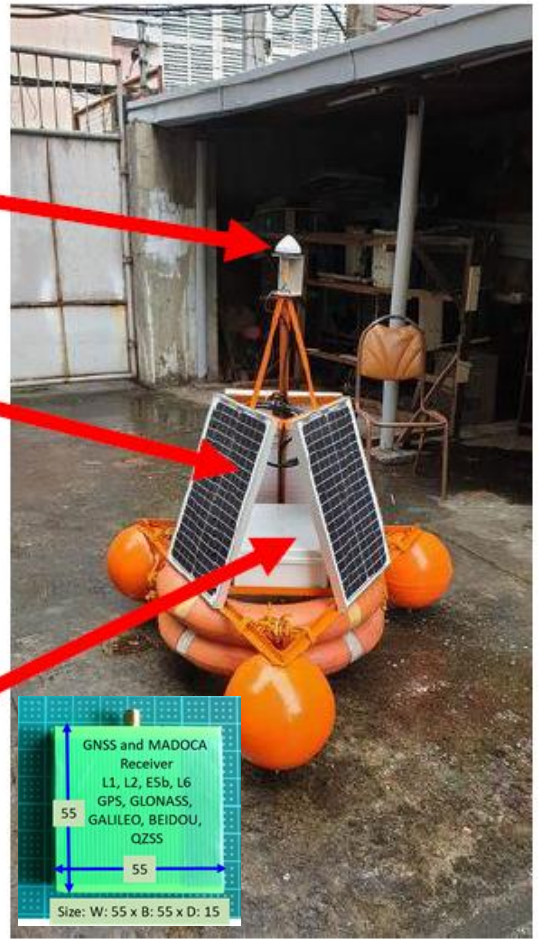
GNSS / MADOCA Training at University of Philippines

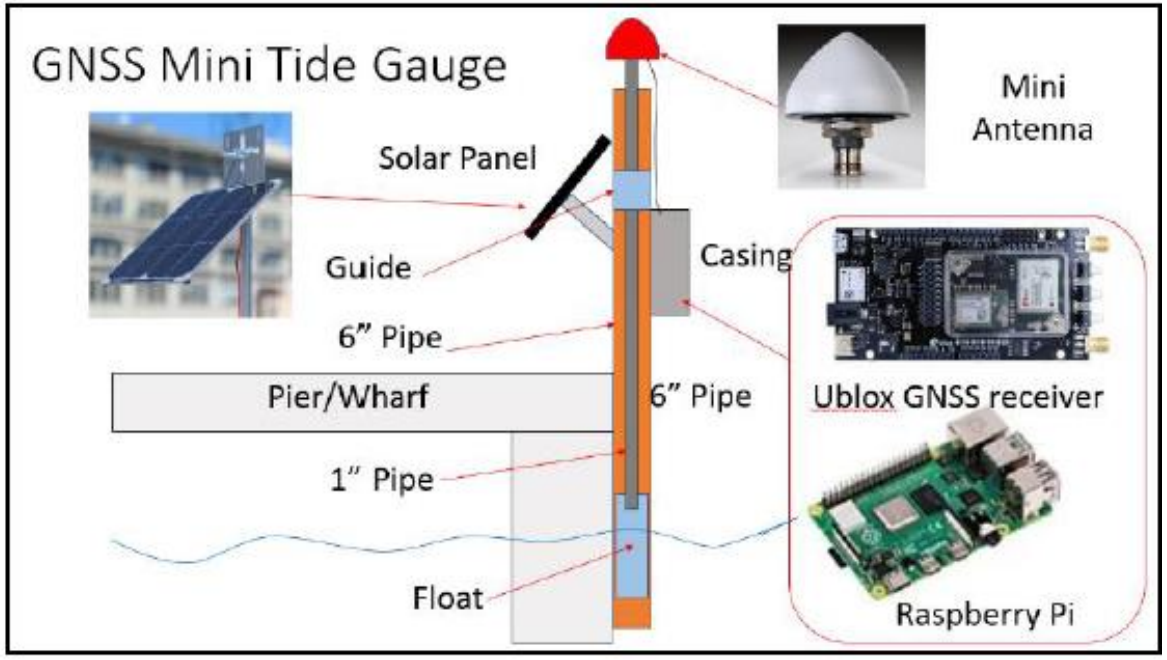
Low-Cost MADOCA Receiver for Sea-Level Rise Measurement

GNSS antenna

Solar power

TiBox enclosure containing the battery, raspberry pi and Ublox and MADOCA decoder





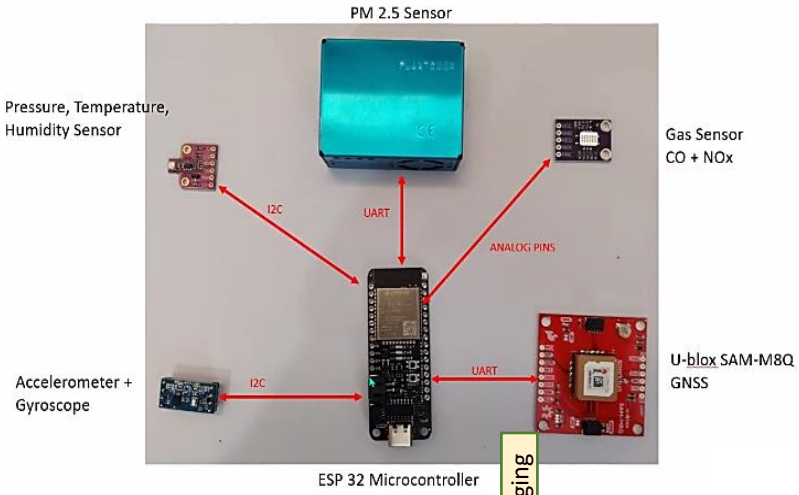
Source: Technical Report, GNSS/QZSS MADOCA PPP Data Acquisition for Sea Level Rise Measurement, DR. ROSALIE B. REYES, UP DGE and Project Leader, CLSR-Phil Project

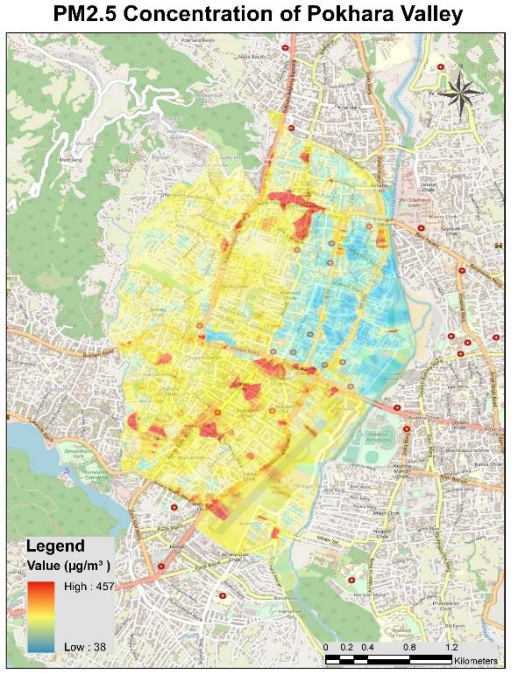
Low-Cost Dynamic Air Quality Monitoring System

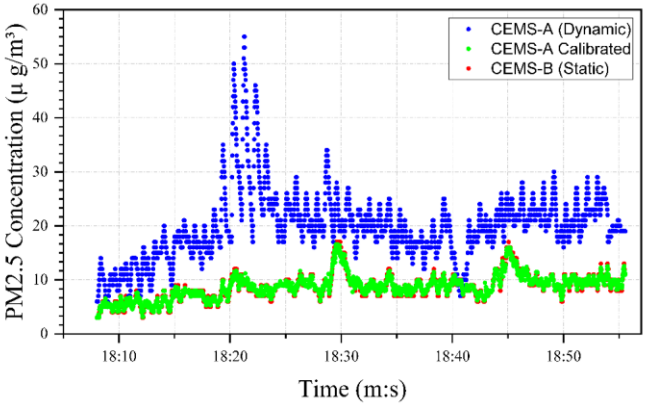
Pokhara City, Nepal
Top: During Corona Lockdown period
Bottom: During dusty and forest fire days

Source : RONB

- GPS, Accelerometer, Gyroscope
- PM1.0, 2.5, 10 sensor
- Pressure, Humidity, Temperature (PHT) Sensor
- Gas Sensor (CO and NOx)
- WiFi, BT and SD Micro Memory Card
- Total Device Cost: $200





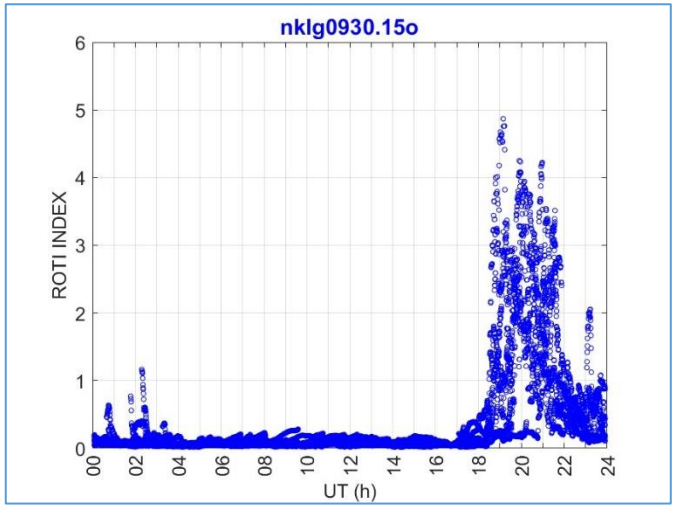


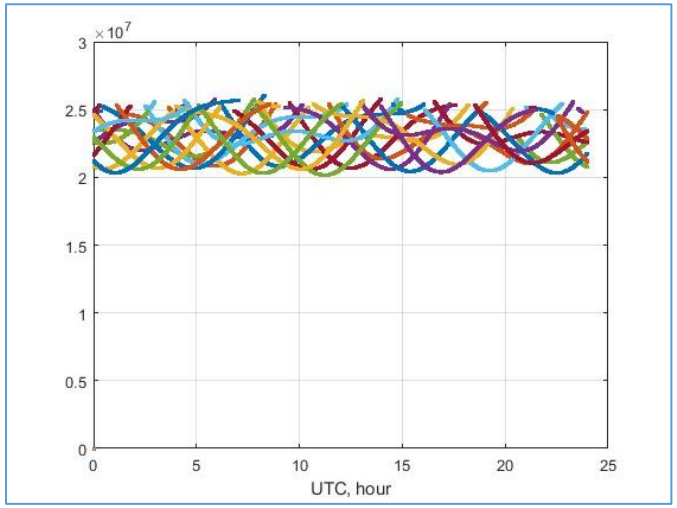
Low-Cost GNSS Receiver System for Space Weather Applications

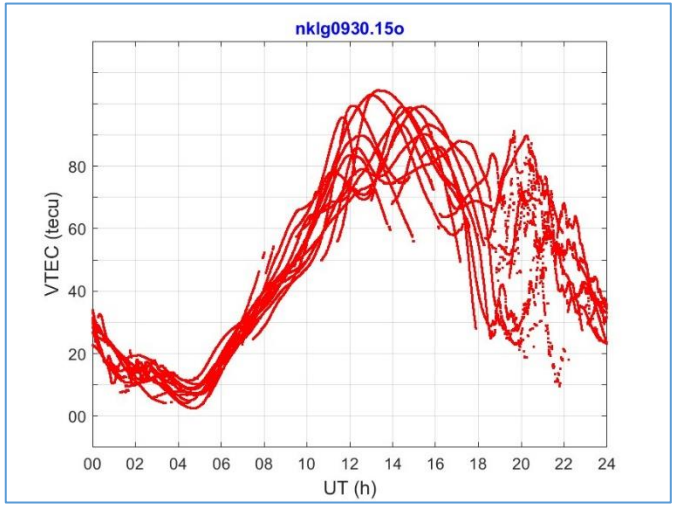
- Explore Low-Cost GNSS Receivers that can be used to compute ionosphere related parameters TEC, S4 index etc.
- Explore software that can be used for processing data from low-cost GNSS receivers to compute TEC, S4 and other space weather related parameters.
- Develop prototype low-cost GNSS receiver system for remote unattended data logging.

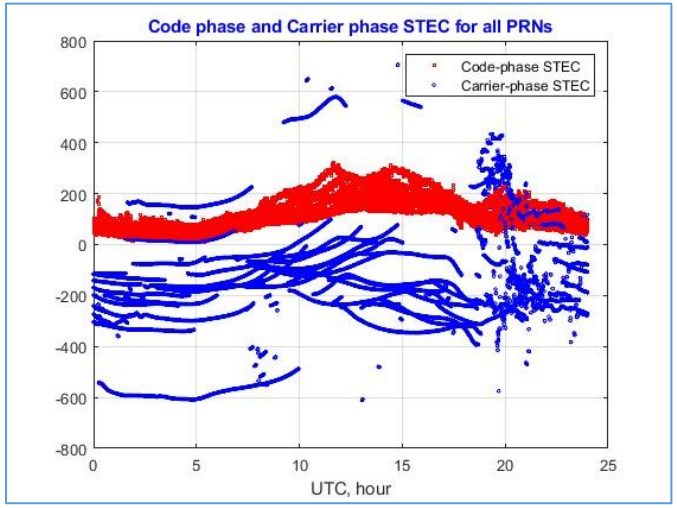
Matlab source files to compute TEC parameters are provided by Rolland Fleury
These outputs are from sample data provided by Fleury
We will modify the software to process data from low-cost GNSS receivers in different RINEX version.

Output of TEC computation from Matlab based software: FLEURY









Explore Low-Cost GNSS Receivers for Space Weather Applications

We will explore two types of receivers

- u-blox F9P
- Septentrio (MOSAIC)

Criteria for Receiver Selection

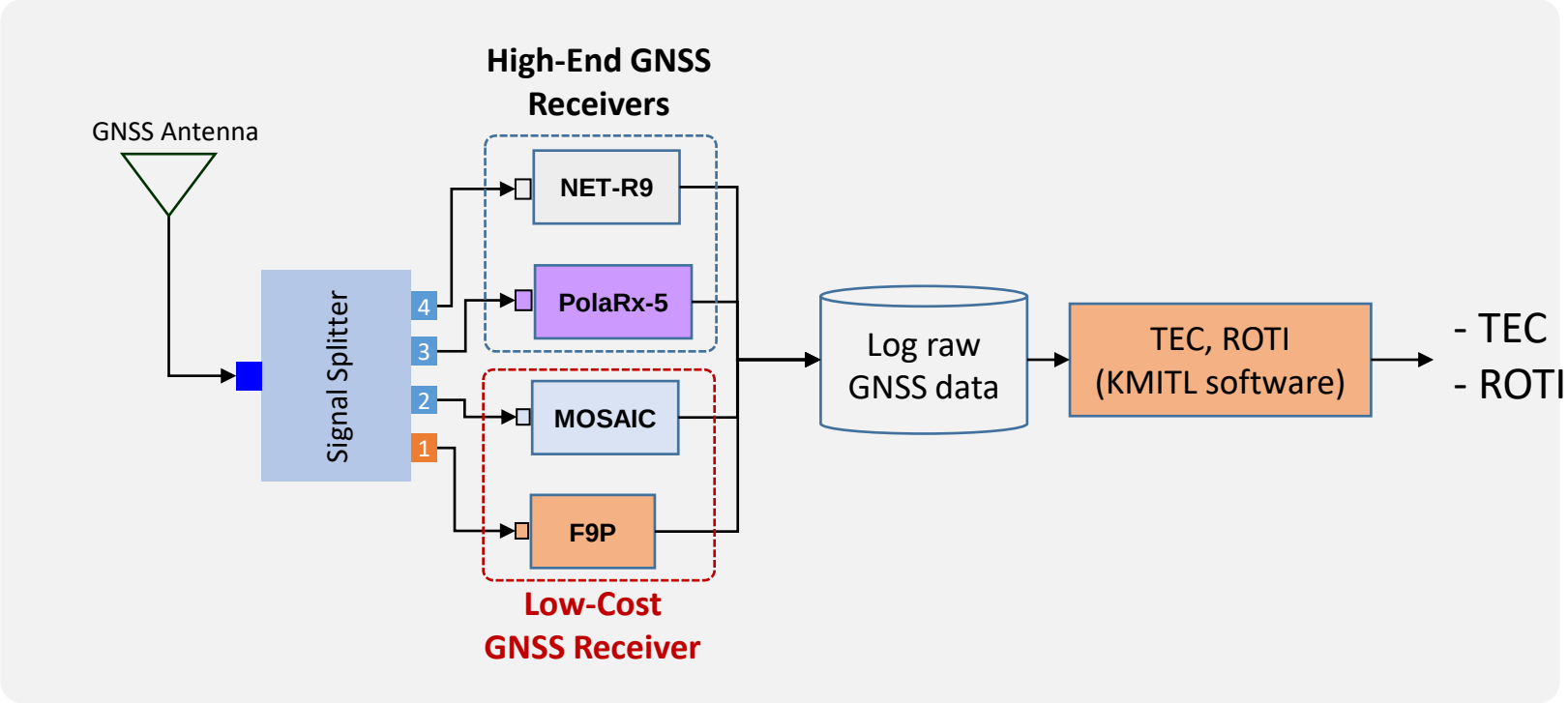
- Any receiver that is capable to output raw data
- Dual frequency receiver
- Price less than $1,000

	U-Blox F9P	Septentrio MOSAIC	Other Brand (To be Explored)
GNSS	GPS, GLONASS, Galileo, BeiDou, QZSS, SBAS	GPS, GLONASS, Galileo, BeiDou, QZSS, SBAS	
Frequency Bands	L1, L2, E5b	L1, L2, L5	
Raw Data	Code Phase, Carrier Phase, Doppler, Signal quality related data	Code Phase, Carrier Phase, Doppler, Signal quality related data	
Navigation Frame Data	Yes including data bits	Yes including data bits	
Output Rate	Max 20Hz	Upto 100 Hz for Measurement 50Hz for RTK	
RTK / PPP Capable	Yes	Yes	
TEC Computation	Yes (To be checked)	Yes (To be checked)	
S4 Computation	To be explored	To be explored	
Price (USD)	300	700	

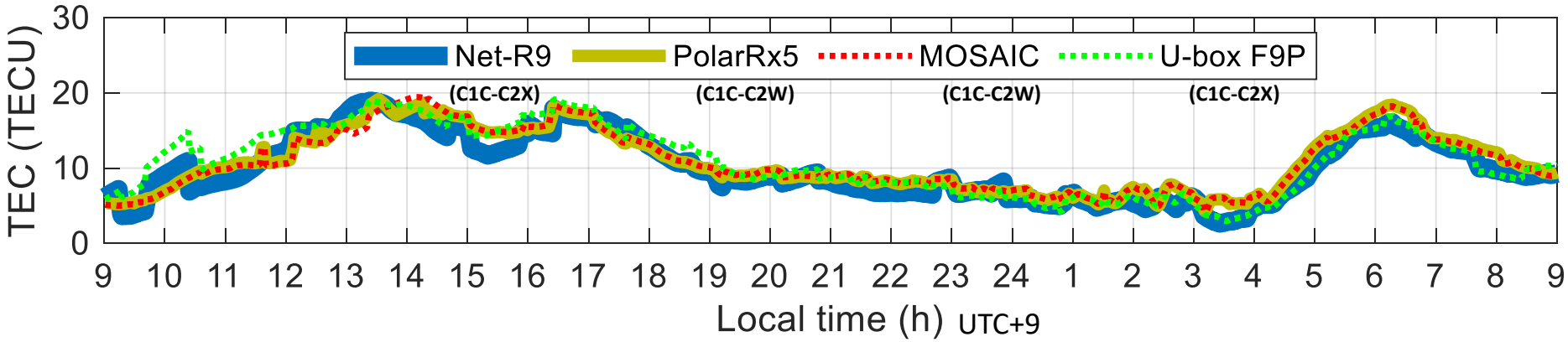
https://shop.septentrio.com/en/shop/mosaic-go-gnss-module-receiver-evaluation-kit
https://content.u-blox.com/sites/default/files/ZED-F9P_ProductSummary_UBX-17005151.pdf

Please note that we do not have any intentions to favor any specific brand.

Comparison of Low-Cost GNSS Receiver Data for Space Weather
Compute VTEC and TECU



Comparison of VTEC Results



Computed by using K-TEC software (from KMITL, Thailand)

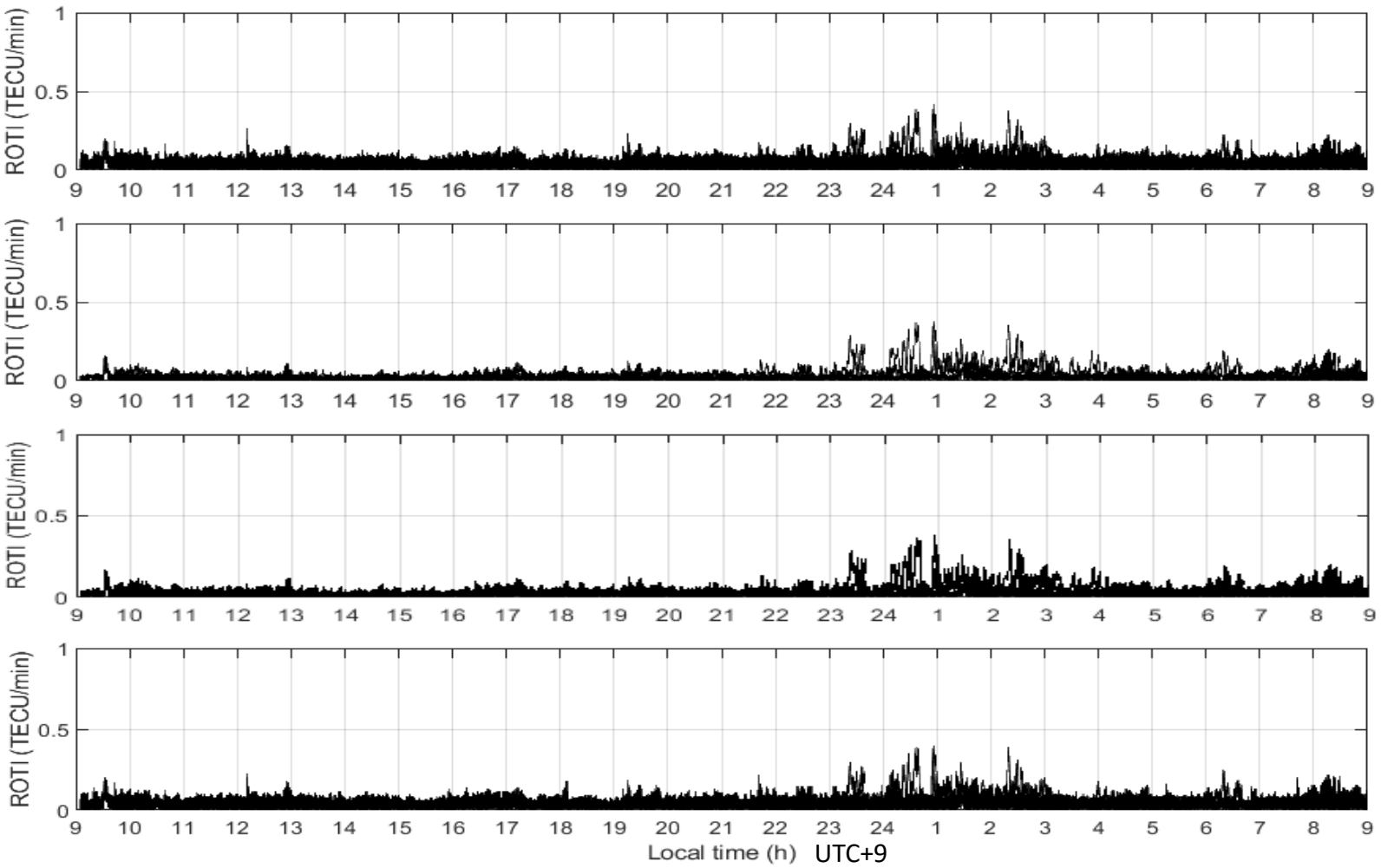
Comparison of ROTI Results

Net-R9
(C1C-C2X)

PolarRx5
(C1C-C2W)

MOSAIC
(C1C-C2W)

U-box F9P
(C1C-C2X)



➢ **This day should be the local quiet day due to ROTI < 0.5 TECU/min.**

Computed by using K-TEC software (from KMITL, Thailand)

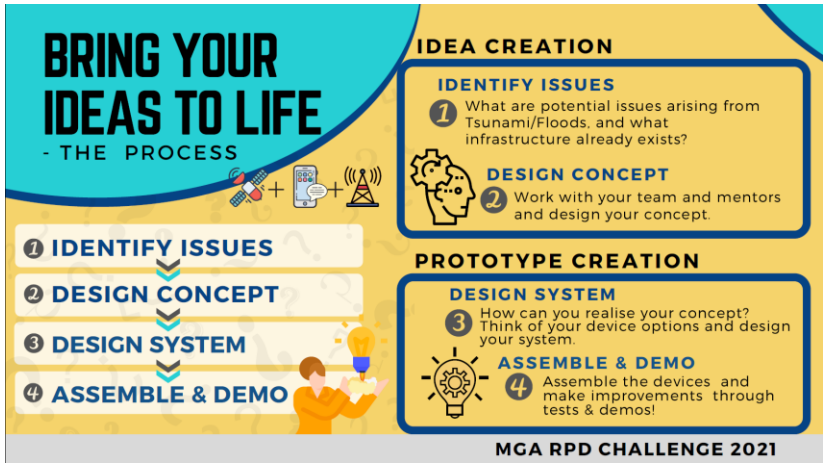
MGA (Multi-GNSS Asia) and RPD Challenge

The 14th
Multi-GNSS Asia
Annual Conference

30th Jan. - 2nd Feb. 2024

https://www.mga-conference.com/

https://www.rpdchallenge.com/



GNSS Summer School 2023 in Tokyo

FURUNO

septentrio

- Period : 2023/08/28- 09/02
- Venue : Tokyo University of Marine Science and Technology (TUMSAT)
- Organized by School of Marine Technology, TUMSAT
- Co-organized by Institute of Positioning, Navigation and Timing of Japan (IPNTJ)
- Sponsored by Japan Science and Technology Agency (JST)
- Supported by https://www.furuno.com/jp/
  https://www.septentrio.com/ja
  https://www.kominemusen.co.jp/
  https://www.u-blox.com/ja
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GNSS Summer School 2023: Course Schedule

	28-Aug	29-Aug	30-Aug	31-Aug	1-Sep	2-Sep
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
0830-1000	Introduction	Class B-1	Class C-1	Class B-5	Class C-4 SDR I	QZSS Early Warning System****
1000-1010	Break	Break	Break	Break	Break	Break
1010-1140	Class A-1	Class B-2	Class C-2	Class B-6	Class C-5 SDR II	GNSS Signal Authentication****
1140-1230	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch
1230-1400	Class A-2	Class B-3	Class C-3	**Port Cruise G-I** RTK-LIB Practice G-II	SDR Practice	Low-Cost Receiver Systems****
1400-1410	Break	Break	Break	Break	Break	Break
1410-1540	Class A-3	Class B-4	Special Lec-Ⅱ **	**Port Cruise G-II** RTK-LIB Practice G-I	Practice for System Design SD-workshop	Pariticipants Workshop
1540-1550	Break	Break	Break	Break	By Dr. Akira Kodaka	Break
1550-1720	Class A-4	Special Lec-Ⅰ *	GNSS Receiver ***	RTK-LIB Practice	and U, Keio Group	Closing
1730-	Welcome Party	1 class=90 minutes			Farewell party	

Instructors	Introduction	Dr. Akio Yasuda	
	Class-A Fundamentals	A-1,2,3,4, Dr. Ivan G. Petrovski	
	Class-B Software	B-1,2,3,4 Dr. Toru Takahashi	*QZSS Present Status and Future by Ms. Yoko Sakai
		B-5,6,RTK-LIB Practice, Dr. Nobuaki. Kubo	** GPS/GNSS Meteorology by Dr. Yoshinori Shoji
	Class-C Receiver	C1,2,3 Dr. Toshiaki Tsujii	***by Ms. Masae Inoue, Septentrio
		C4, C5, SDR-Practice, Dr. Taro Suzuki	****by Dr. Dinesh Manandhar

Participants in 2013-2019

Country	13	14	15	16	17	18	19
Pakistan	0	5	2	3	2	1	1
Taiwan	6	3	5	4	6	4	0
Thailand	4	2	2	3	4	1	2
Philippines	2	2	2	4	2	2	2
Nepal	1	0	0	1	1	1	1
Mongol	0	2	1	1	1	1	3
China	0	3	2	1	1	7	1
Indonesia	2	2	2	4	2	2	2
Sri Lanka	1	0	1	1	1	2	3
Viet Num							1
Cambodia							1

Country	13	14	15	16	17	18	19
Brunei				1	2	0	0
Malaysia	0	1	1	1	2	0	1
Myanmar					1	1	1
India			1	1	1	1	3
Mozambique					1	1	
Singapore					1	1	1
Nigeria				1			
Korea						1	
Turkey						1	
Japan	20	17	15	14	16	12	17*
Total	40	39	39	41	44	39	40

2019 Participants

22 of them are invited, selected from 100 applicants for the scholarship.

Participants in 2023

Country(Nationality)	Student	Teacher	Researcher	Engineer	Surveyor	Total
Spain (Pakistan)	1					1
Taiwan	2					2
Finland (Egypt)			1			1
Philippines	1	2				3
Germany (India)	1					1
Nepal	1	1			2	4
Mongol					1	1
China	2					2
Indonesia			1			1
UK (South Africa)			1			1
Ethiopia		1				1
Brunei				2		2
Malaysia (Oman)			1			1
Japan	3	1		5		9
Total	11	5	4	7	3	30

9 of them are invited by JST fund, selected from 100 applicants for the scholarship.

GNSS Summer School 2023

System Design Workshop

Data Acquisition on Cruise Boat

GNSS Lectures

Link for Reference Materials

- Lab Home Page
  - https://www.csis.u-tokyo.ac.jp/en/
  - https://home.csis.u-tokyo.ac.jp/~dinesh/
- GNSS Training Materials, Data etc.
  - https://home.csis.u-tokyo.ac.jp/~dinesh/GNSS_Train.htm
- Low-Cost High-Accuracy Receiver Systems
  - https://home.csis.u-tokyo.ac.jp/~dinesh/LCHAR.htm
- GNSS Webinar
  - https://home.csis.u-tokyo.ac.jp/~dinesh/WEBINAR.htm
  - https://gnss.peatix.com
- Link to Documents, Software, Android APP etc.
  - https://home.csis.u-tokyo.ac.jp/~dinesh/Download.htm
- Facebook : https://www.facebook.com/gnss.lab (GNSS Related)
- Contact : dinesh@csis.u-tokyo.ac.jp