GNSS Technology Promotion Activities at The University of Tokyo

Dinesh MANANDHAR, Associate Professor (Project)
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

dinesh@csis.u-tokyo.ac.jp
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.
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

<table>
<thead>
<tr>
<th>Training Mode / Location</th>
<th>Hybrid-Training Venue: Nepal</th>
<th>Hybrid-Training Venue: Nepal</th>
<th>Online GNSS Training</th>
<th>GNSS Trainings Venue: AIT, Thailand</th>
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<tbody>
<tr>
<td>Date and Duration</td>
<td>3 – 6 Jan 2023 (Hybrid)</td>
<td>9 Jan 2023 (Online)</td>
<td>11 – 14 Jan 2022</td>
<td>19 – 21 Jan 2021 3 days</td>
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<td>28 Jan 2022 1 day</td>
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<td>Course Type</td>
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<td>Course B</td>
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<td>Course A Course B T-151</td>
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<td></td>
<td>NA</td>
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<td>Cancelled due to</td>
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<td>30 (On-Site Nepal)</td>
<td>30 (On-Site Nepal)</td>
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<td>NA</td>
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<td>42 (24 + 18)</td>
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<td>(E) Online Participants</td>
<td>180</td>
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<td>Total (A + B + C + D + E)</td>
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<td>30</td>
<td>75</td>
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<td>15</td>
<td>6</td>
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<td></td>
<td>16 (Int) + 9 (GIC)</td>
<td>20 (Int) + 9 (GIC)</td>
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<td></td>
<td></td>
<td></td>
<td>13 (Int) + 6 (GIC)</td>
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<td>Number of Countries</td>
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<td>16</td>
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<tr>
<td>Resource Persons’ Countries</td>
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<td>7</td>
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<td>4</td>
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</tbody>
</table>
UTokyo/ICG GNSS Training 2023 Statistics: Participants’ Country
UTokyo/ICG GNSS Training 2023 Statistics: Organization Type

### Participants Organization Type

![Bar chart showing the distribution of participants by organization type.]

- Academy
- Education
- Government Organization
- Intergovernmental organization
- NPO / NGO / INGO
- Private Company
- Research Institute
- Self-Employed
- Industry
- Research Center
- project
- Other

### Participant details grouped by Organization Type

![Graph showing participant details grouped by organization type.]

- Country
- Gender
- Age Group
- Organization Type

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UTokyo/ICG GNSS Training 2023 Statistics: Gender
## Installation of Base-Stations in Universities for Capacity Building

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

*Note: The installation in Mozambique will be early next year.*

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Dinesh Manandhar, CSIS, The University of Tokyo, dinesh@csis.u-tokyo.ac.jp
Low-Cost High-Accuracy Receiver system Development Cycle

DEC, 2016
RaspberryPi B
Demo during UN/Nepal GNSS workshop

MAY, 2017
Low-Cost RTK

MAY, 2017
GNSS Receiver
GNSS Antenna
GNSS Receiver
GNSS Antenna

MAR, 2018
Low-Cost MADOCA

Low-Cost MADOCA

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

Dinesh Manandhar, CSIS, The University of Tokyo, dinesh@csis.u-tokyo.ac.jp
Low-Cost MADOCA Receiver System

GNSS Receiver + MADOCA Decoder

Antenna

F9P GNSS Receiver
L1/L2/E5B

MADOCA Decoder
QZSS L6

COM Port: 1
GNSS Data

COM Port: 2
MADOCA Data

GNSS Antenna

Size: W: 55 x B: 55 x D: 15
# Low-Cost MADOCA Receiver Systems: Product Types

<table>
<thead>
<tr>
<th></th>
<th>MAD-WIN</th>
<th>MAD-π</th>
<th>MADROID</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Platform / OS</strong></td>
<td>Windows</td>
<td>RaspberryPi 3B or 4B</td>
<td>Android Device</td>
</tr>
<tr>
<td><strong>GNSS Receiver</strong></td>
<td>Default : u-blox F9P Other: Any dual-frequency Receiver</td>
<td>Default : u-blox F9P only Other: Any dual-frequency Receiver</td>
<td>Default : u-blox F9P Other: Any dual-frequency Receiver</td>
</tr>
<tr>
<td><strong>MADOCA Receiver</strong></td>
<td>U-blox D9 only</td>
<td>U-blox D9 only</td>
<td>NA (MADOCA Online Correction Data only)</td>
</tr>
<tr>
<td><strong>GNSS Receiver Data Format</strong></td>
<td>UBX, SBF, RTCM3</td>
<td>UBX SBF, RTCM3 (For online GNSS data)</td>
<td>UBX</td>
</tr>
<tr>
<td><strong>MADOCA Correction Data Format (Satellite)</strong></td>
<td>UBX only</td>
<td>UBX only</td>
<td>UBX only</td>
</tr>
<tr>
<td><strong>MADOCA Correction Data Format (Online)</strong></td>
<td>UTokyo (Test Level) UBX or RTCM3</td>
<td>Online Services UTokyo (Test Level) Online Services UBX or RTCM3</td>
<td>Online Services UTokyo (Test Level)</td>
</tr>
<tr>
<td><strong>System Architecture</strong></td>
<td>![Antenna](L1/L2 GNSS + MADOCA Decoder) ![Computer (Windows)]</td>
<td>![Antenna](L1/L2 GNSS + MADOCA Decoder) ![Raspberry Pi 3B or 4B]</td>
<td>![Antenna](L1/L2 GNSS + MADOCA Decoder) ![Android Device]</td>
</tr>
</tbody>
</table>
MAD-WIN and MAD-PI System and User Interface
MADROID: MADOCA with Android Device

- Connection: USB
- Device: u-blox GNSS receiver
- Format: ubx
- Processing Settings: PPP-Static
- Antenna Model: TWVIP6000
- NTRIP Settings: Address - madoca.ntrip-mgm.net, Port - 2101

MADOCA PPP Receiver System based on Android

- Date: Dec 25, 2019
- Time: 05:54:17
- Latitude: 35.90202310°
- Longitude: 139.93857932°
- Ellipsoidal Height: 59.848m
- Orthometric Height: 21.884m
- Speed: 0.11 km/hr
- HDOP: 1.9
- POOD: 3.0
- NMEA: 2019, 12, 25, 14, 28, 19.txt (20KB)
- UBX: 2019, 12, 25, 14, 28, 19.ubx (1MB)
MADOCA / GNSS Training at AIT, Thailand and UI, Indonesia
Construction of Bench Mark for GNSS Training
Purpose: Compare GNSS accuracy based on various processing techniques such as SPP, DGPS, SBAS, RTK, PPK, MADOCAPPP, PPP etc.
GNSS / MADOCA Training at IU/VNU, HCM City, Vietnam
GNSS / MADOCA Training at University of Philippines
Low-Cost MADOCA Receiver for Sea-Level Rise Measurement

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

### Prototype Device for Dynamic Air Quality Monitoring
- Size is about 85mm x 65mm x 55mm
- 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

### Pokhara City, Nepal
- Data Collection:
  - Before: During Corona Lockdown period
  - After: During dusty and forest fire days

**PM2.5 Concentration of Pokhara Valley**
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.

Output of TEC computation from Matlab based software: FLEURY

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.
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

<table>
<thead>
<tr>
<th><strong>GNSS</strong></th>
<th><strong>U-Blox F9P</strong></th>
<th><strong>Septentrio MOSAIC</strong></th>
<th><strong>Other Brand (To be Explored)</strong></th>
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</thead>
<tbody>
<tr>
<td>Frequency Bands</td>
<td>L1, L2, E5b</td>
<td>L1, L2, L5</td>
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<tr>
<td>Raw Data</td>
<td>Code Phase, Carrier Phase, Doppler, Signal quality related data</td>
<td>Code Phase, Carrier Phase, Doppler, Signal quality related data</td>
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<tr>
<td>Navigation Frame Data</td>
<td>Yes including data bits</td>
<td>Yes including data bits</td>
<td></td>
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<tr>
<td>Output Rate</td>
<td>Max 20Hz</td>
<td>Upto 100 Hz for Measurement 50Hz for RTK</td>
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<tr>
<td>RTK / PPP Capable</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
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<tr>
<td>TEC Computation</td>
<td>Yes (To be checked)</td>
<td>Yes (To be checked)</td>
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<tr>
<td>S4 Computation</td>
<td>To be explored</td>
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</tr>
<tr>
<td>Price (USD)</td>
<td>300</td>
<td>700</td>
<td></td>
</tr>
</tbody>
</table>

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


Dinesh Manandhar, CSIS, The University of Tokyo, dinesh@csis.u-tokyo.ac.jp
Comparison of Low-Cost GNSS Receiver Data for Space Weather
Compute VTEC and TECU

Dinesh Manandhar, CSIS, The University of Tokyo, dinesh@csis.u-tokyo.ac.jp
Comparison of VTEC Results

Computed by using K-TEC software (from KMITL, Thailand)
Comparison of ROTI Results

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

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

Dinesh Manandhar, CSIS, The University of Tokyo, dinesh@csis.u-tokyo.ac.jp
MGA (Multi-GNSS Asia) and RPD Challenge

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

Dinesh Manandhar, CSIS, The University of Tokyo, dinesh@cis.u-tokyo.ac.jp
GNSS Summer School 2023 in Tokyo

- **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
## GNSS Summer School 2023: Course Schedule

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

### 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 
- **Class B-5,6,RTK-LIB Practice, Dr. Nobuaki. Kudo**
- **Class C - Receiver**: C1,2,3 Dr. Toshiaki Tsujii
- **C4, C5, SDR-Practice, Dr. Taro Suzuki**
- **QZSS Present Status and Future by Ms. Yoko Sakai**
- **GPS/GNSS Meteorology by Dr. Yoshinori Shoji**
- **by Ms. Masae Inoue, Septentrio**
- **by Dr. Dinesh Manandhar**

Dinesh Manandhar, CSIS, The University of Tokyo, dinesh@cis.u-tokyo.ac.jp
## Participants in 2013-2019

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### 2019 Participants
22 of them are invited, selected from 100 applicants for the scholarship.
# Participants in 2023

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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

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