

Low-Cost MADOCA Receiver System 低コストのMADOCAレシーバーシステム

MAD-WIN, MAD- π and MADROID

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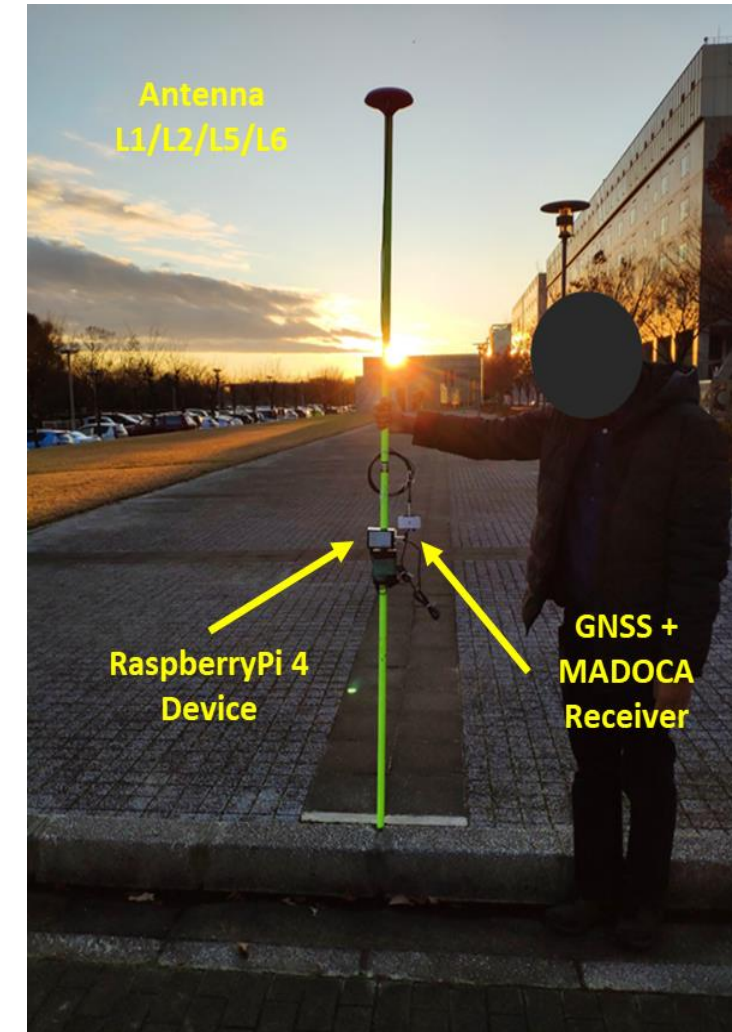
CSIS, The University of Tokyo

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1th January 2022

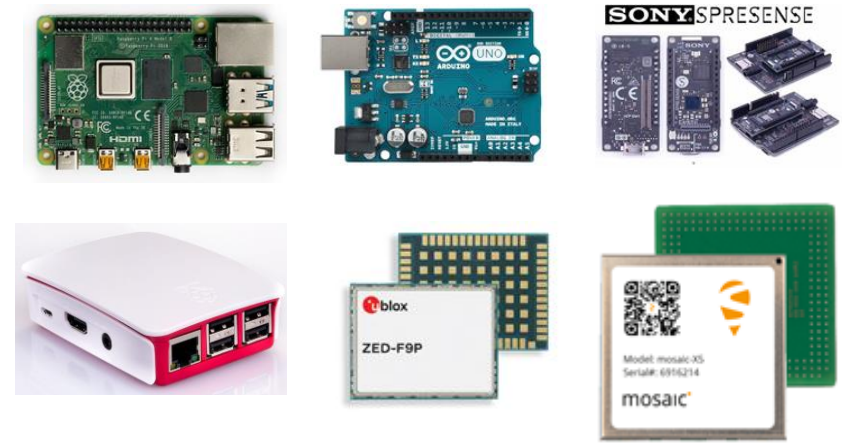
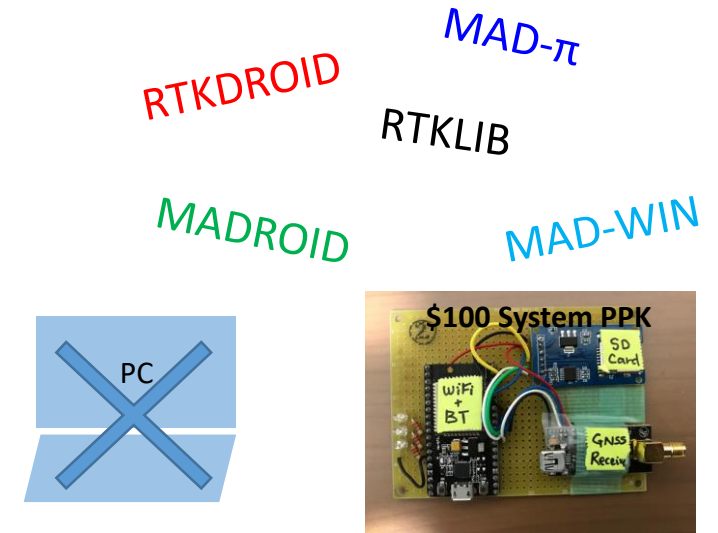
UTokyo/ICG GNSS Training

11 – 14 January 2022



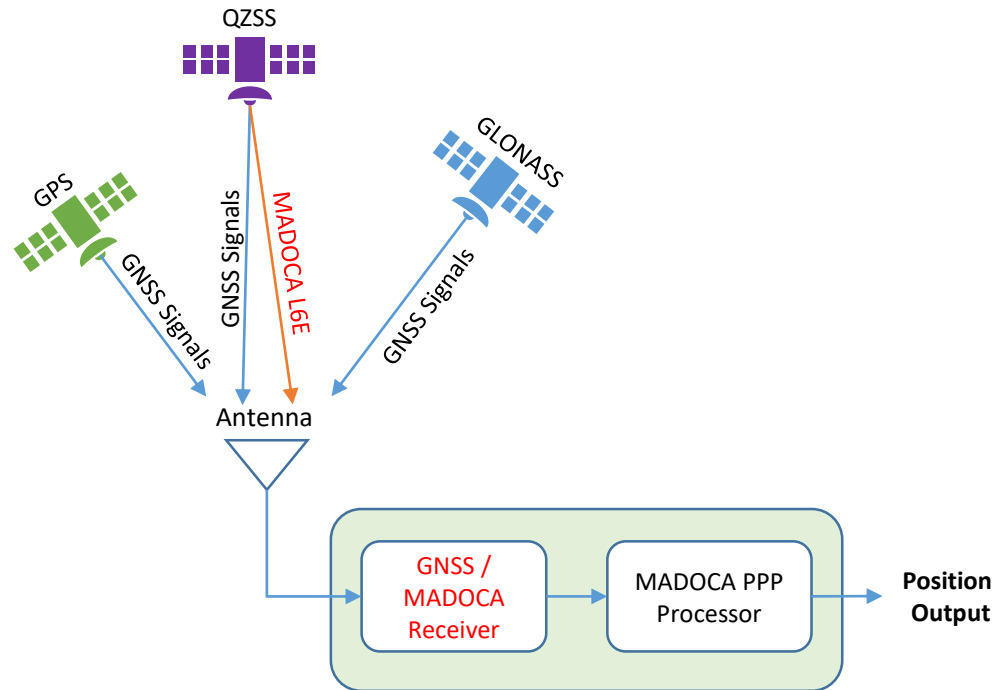
Objectives

- Develop Low-Cost High-Accuracy Positioning Systems (L-CHAPS)
 - System Integration of commercially available receiver or module
 - For RTK and MADOCA
 - Avoid use of computer to minimize the cost
 - Use Single Board Computer (SBC)
 - RaspberryPi, Arduino, Spresense
 - Use Tablet or Smart-Phone
 - Android devices are quite flexible and easier to use
- Develop Easy to Use System in Field
 - A user without GNSS knowledge shall be able to use
 - Self-understanding interface
 - Suitable for remote operation and data logging
 - Operate with mobile power-banks
- Promote GNSS and MADOCA Technologies Abroad through
 - Lectures, Trainings, Seminars, Workshops and Events
 - Joint Research and Joint Projects



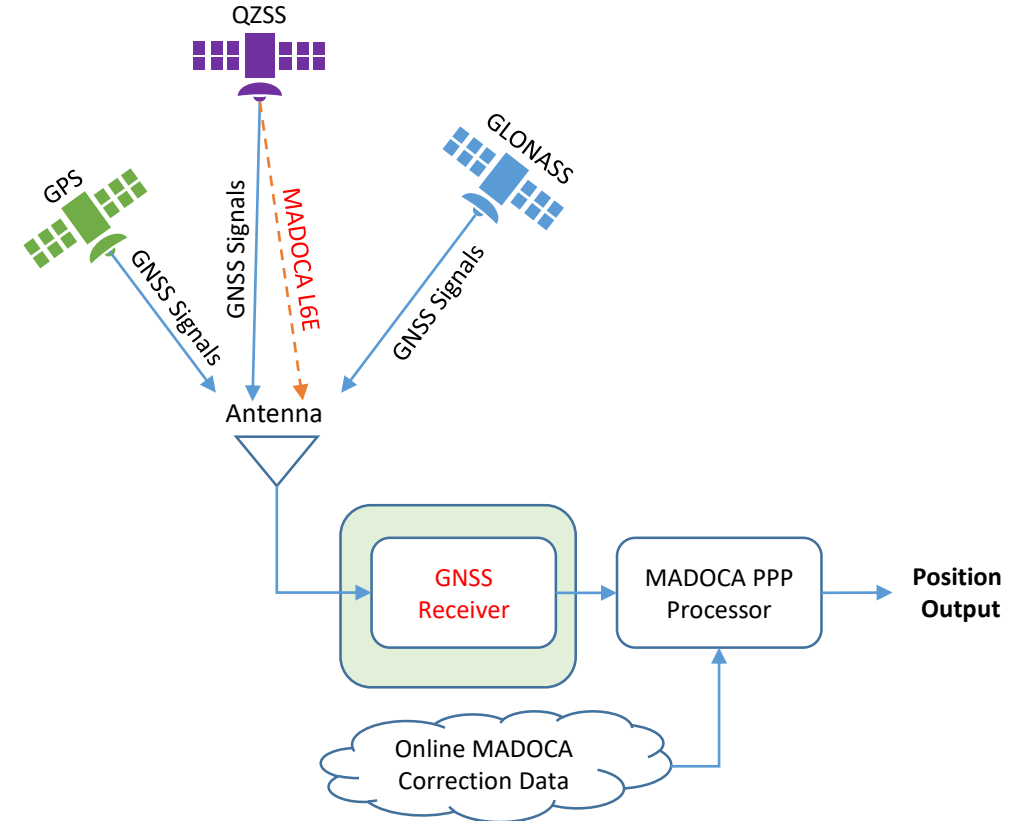
MADOCA System: Direct from QZSS or Online Correction Data

GNSS Receiver + MADOCA Decoder



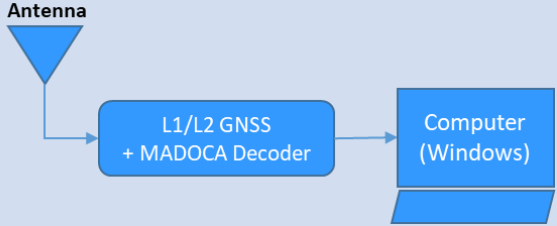
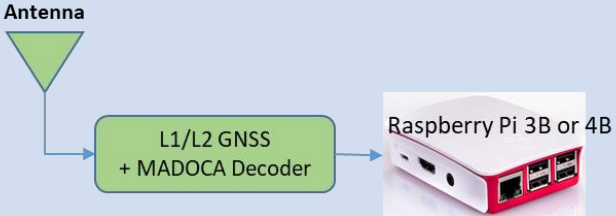
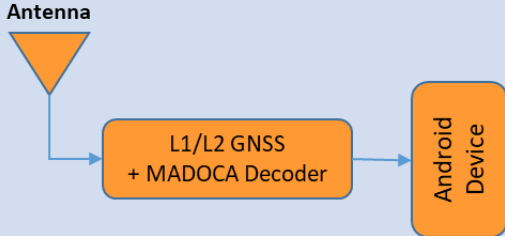
If QZSS is visible in your location and if you have MADOCA receiver

GNSS Receiver Only

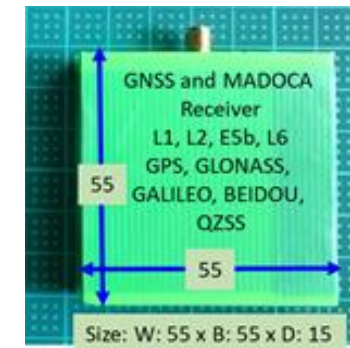
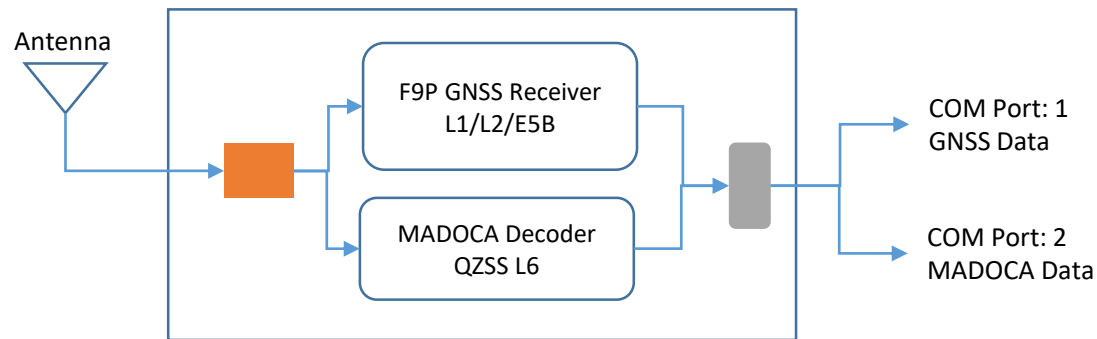
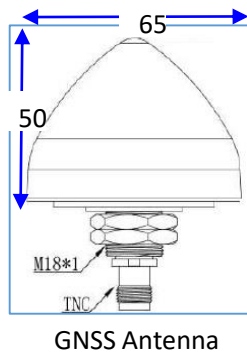
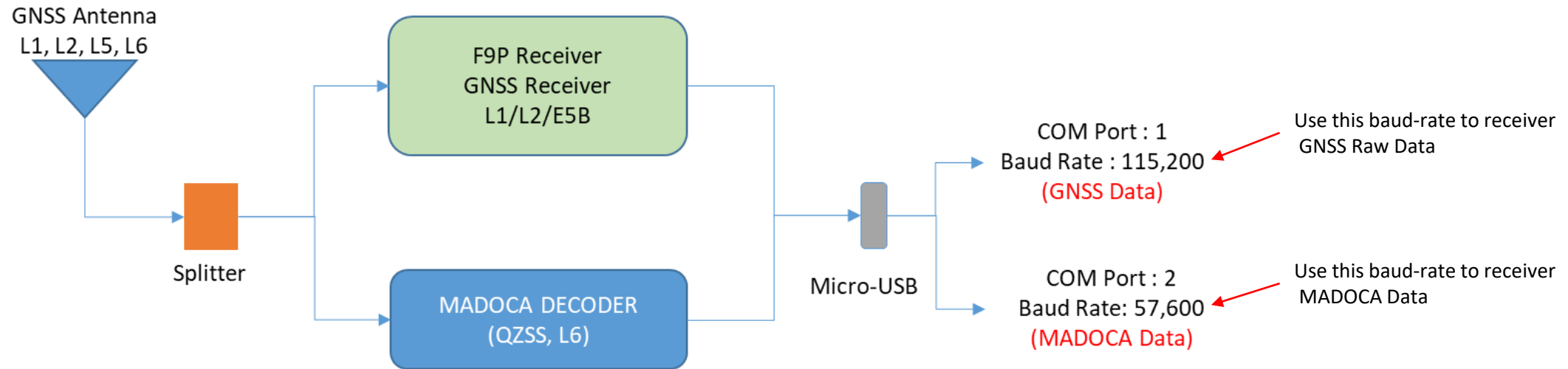


If you do not have MADOCA receiver

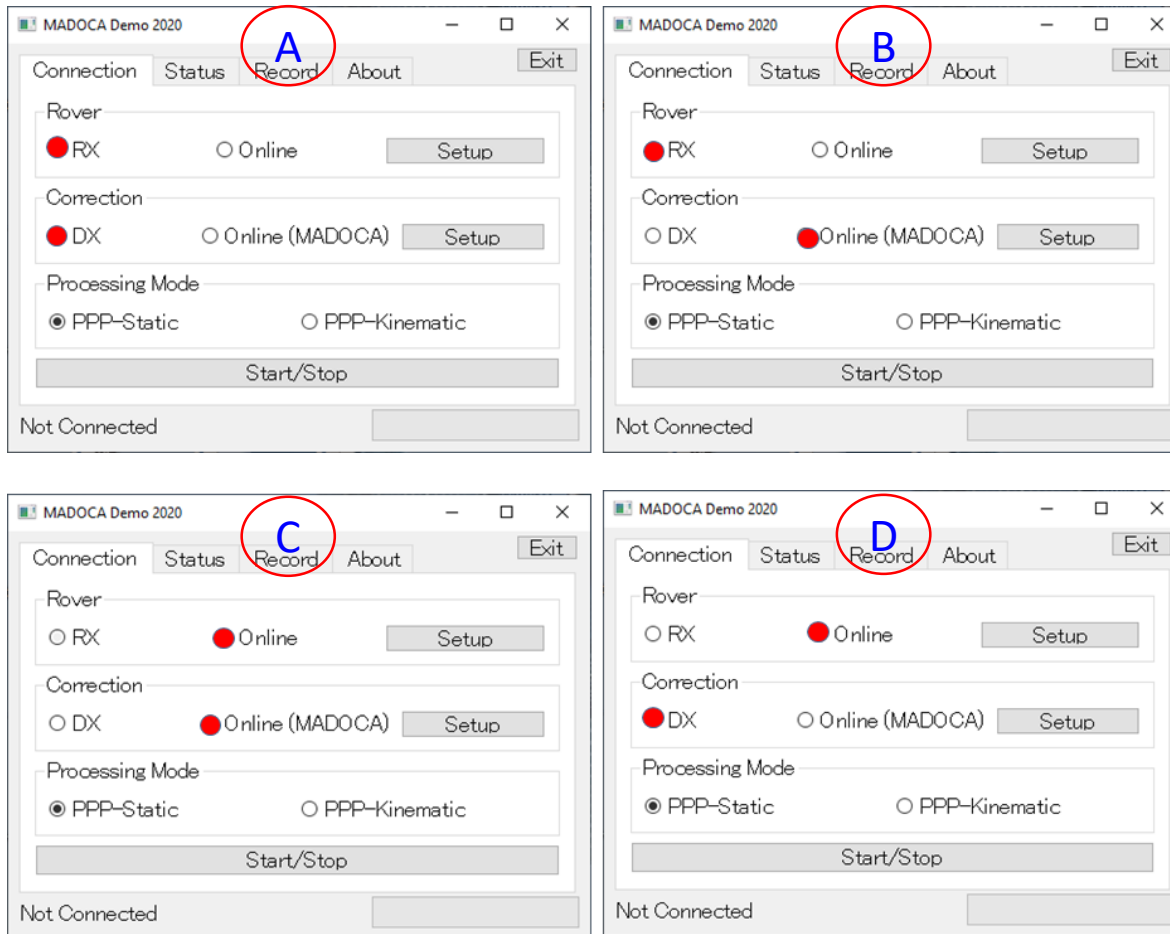
Low-Cost MADOCA Receiver Systems: Product Types

	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	NA
MADOCA Correction Data Format (Online)	Online Services from GPAS, UTokyo (Test Level) UBX or RTCM3	Online Services from GPAS, UTokyo (Test Level) Online Services UBX or RTCM3	GPAS Services, RTCM3 UTokyo Online Service in the next release
System Architecture			

System Architecture



MAD-WIN / MAD-PI User Interface



Cases	GNSS Receiver	MADOCA Correction Data	Selection Setting in the Program
Case A	Connect Receiver Directly	Connect MADOCA Receiver Directly	RX and DX
Case B	Connect Receiver Directly	Get MADOCA correction data through NTRIP	RX and Online (MADOCA)
Case C	Connect Receiver though NTRIP	Get MADOCA correction data through NTRIP	Online and Online (MADOCA)
Case D	Connect Receiver though NTRIP	Connect MADOCA Receiver Directly	Online and DX

MAD-WIN / MAD-PI User Interface

The image displays three screenshots of the MADOCA Demo 2020 software interface, showing configuration options, real-time data, and device information.

Left Screenshot: Configuration

- Connection: Status, Record, About, Exit
- Rover: RX, Online, Setup
- Correction: DX, Online (MADOCA), Setup
- Processing Mode: PPP-Static, PPP-Kinematic
- Start/Stop button
- Connected status bar with green indicator

Middle Screenshot: Real-time Data

- Time: 2020-09-30 01:12:24
- Latitude: 35.68970411°
- Longitude: 139.75278573°
- Altitude: 57.353m
- Solution: PPP
- Lat Error: 0.074m
- Lon Error: 0.132m
- Alt Error: 0.075m
- Signal strength plot (Radar chart) showing satellites G1-G12 and R65-R88.
- Signal strength bar at the bottom: 49 45 42 41 45 48 47 53 52 47 49 51 44
- Connected status bar with green indicator

Right Screenshot: Device Information

- Connection: Status, Record, About, Exit
- Device: Windows
- Solution: 2020-09-30_010212.nmea(365568)
- Rover: 2020-09-30_010212.ubx(2855936)
- Correction: 2020-09-30_010212.ubx(345088)
- Record On/Off button
- Connected status bar with green indicator

Log Files:

1. Solution: MADOCA PPP Solution in NEMA format
2. Rover: Rover RAW Data in receiver's proprietary format
Can be used for PPK (Post-Processing Kinematic) Solution or Post-Processing PPP
3. Correction: MADOCA PPP Correction Data in receiver's proprietary format
Can be used for Post-Processing MADOCA

MAD-WIN Data Observation

Receiver: Online receiver access in Kashiwa / Correction Data: MADOCA Receiver in Bali

MADOCA Demo 2020

Connection Status Record About Exit

Rover
 RX Online Setup

Correction
 DX Online (MADOCA) Setup

Processing Mode
 PPP-Static PPP-Kinematic

Start/Stop

Not Connected

MainWindow After three hours observation

Connection Status Record Exit

Time 2020-01-21 13:13:26
 Latitude 35.90304075°
 Longitude 139.93930597°
 Altitude 93.464m
 Solution PPP
 Lat Error 0.006m
 Lon Error 0.003m
 Alt Error 0.002m

46 44 39 46 34 34 34 39 35 38 41 39 41 38 51 51 45 51 43 38 39 38
 G7 G8 G9 G11 G16 G20 G21 G23 G26 G27 R76 R86 R87 G10 G1 R81 G30 R79 G22

Connected

MainWindow After two hours observation

Connection Status Record Exit

Time 2020-01-21 12:32:11
 Latitude 35.90304076°
 Longitude 139.93930585°
 Altitude 93.466m
 Solution PPP
 Lat Error 0.009m
 Lon Error 0.003m
 Alt Error 0.003m

47 47 39 46 37 34 34 39 35 42 41 39 46 39 47 49 44 47 40
 G7 G8 G9 G11 G16 G20 G21 G23 G26 G27 R76 R86 R87 G10 G1 R81 G30 R79 G22

Connected

MainWindow After few minutes observation

Connection Status Record Exit

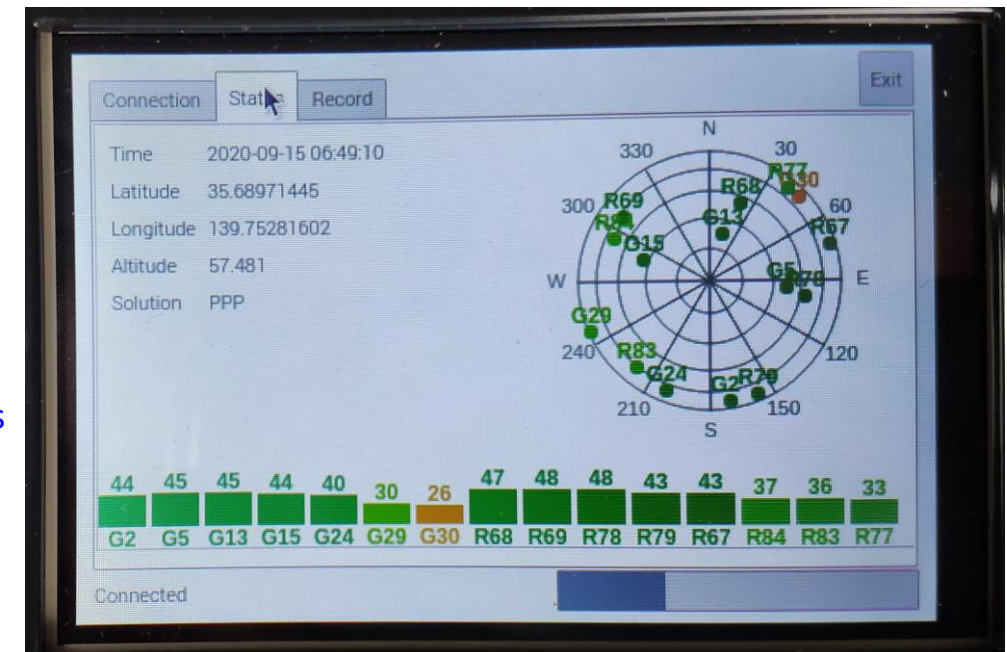
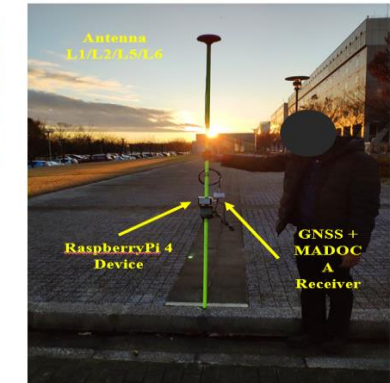
Time 2020-01-21 10:32:02
 Latitude 35.90304319°
 Longitude 139.93931172°
 Altitude 92.955m
 Solution PPP
 Lat Error 0.703m
 Lon Error 0.556m
 Alt Error 0.448m

42 50 42 43 45 34 37 41 42 50
 G7 G8 G9 G11 G16 G20 G21 G23 G26 G27

Connected

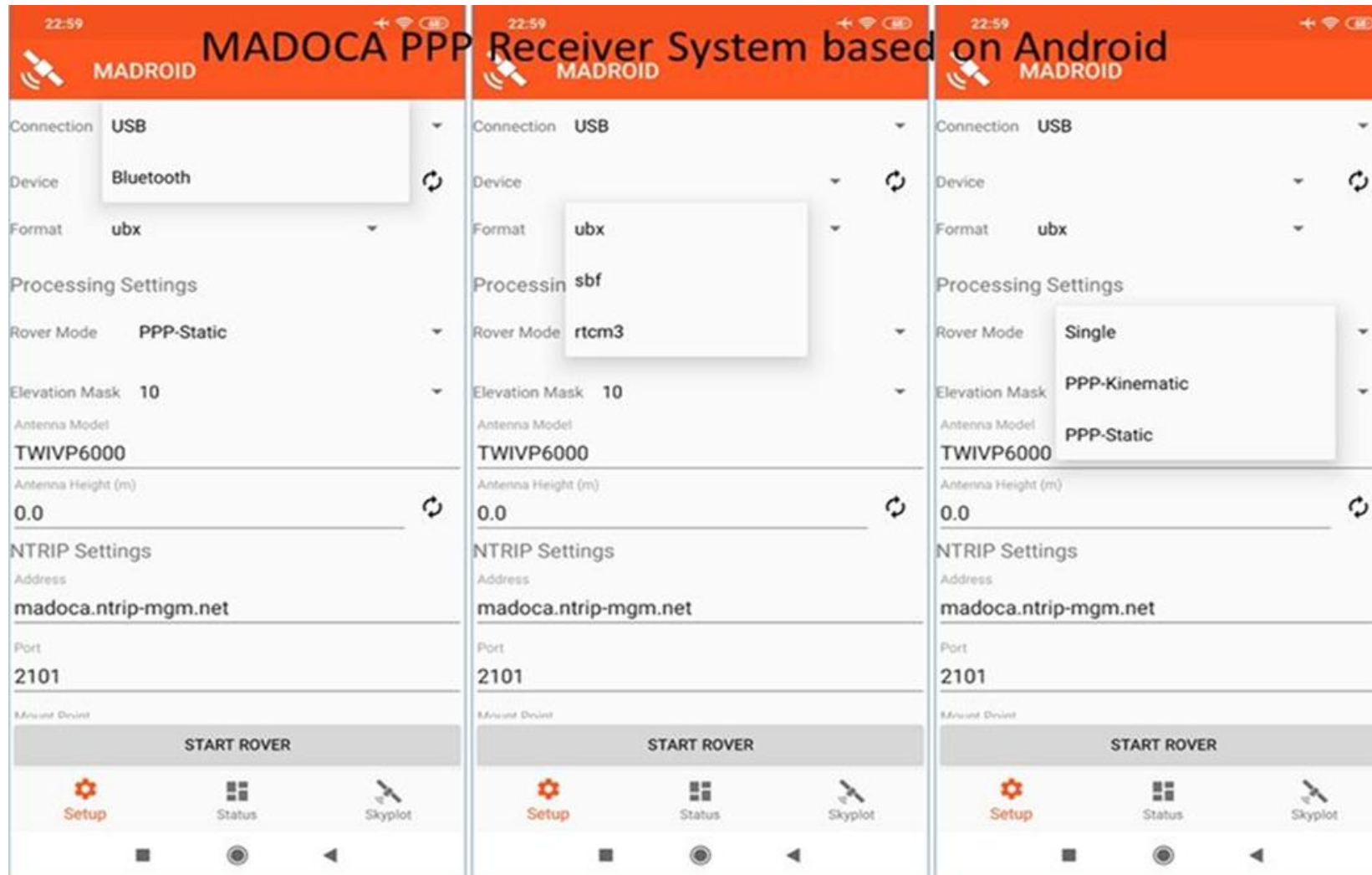
MAD-PI: MADOCA with RaspberryPi Device

- MAD-Pi has been tested with RaspberryPi-3B device
 - It also works with RaspberryPi-4B
 - If the device does not work, please try with a different USB port
- Do not remove and insert SD Card several times. It may get damaged.
- Observation data can be logged to an external USB memory disk. Memory drive of upto 64GB is supported.
 - Files are created at 6-hour interval with Date/Time based filename.
- Ras-Pi 4 device consumes more power than Ras-Pi 3 device. Continuous operation of the device will generate heat. Keep the device in well ventilated area
 - Do not keep the device in a closed box
- We have set both Ras-Pi 3 and Ras-Pi 4 devices with touch screens for easy operation.
 - Mouse and External keyboard can be connected either via BT or USB ports
- Ras-Pi device can be connected by an Android device using BT



Raspberry-Pi device with Touch Screen

MADROID: MADOCA with Android Device



MADROID: MADOCA with Android Device

The image displays three screenshots of the MADROID application interface, which is used for MADOCA PPP Receiver System based on Android.

Left Screenshot (14:34): Shows the configuration screen. The title is "MADROID". It includes sections for Connection (USB), Device (u-blox GNSS receiver), Format (ubx), Processing Settings (Rover Mode: PPP-Static, Elevation Mask: 10, Antenna Model: TWIVP6000), and NTRIP Settings (Address: madoca.ntrip-mgm.net, Port: 2101, Mount Point: MDC0). A "START ROVER" button is visible at the bottom.

Middle Screenshot (14:27): Shows the real-time data and skyplot. The title is "MADROID". It displays UTC Time: 05:27:17, Latitude: 35.90202657° N, Longitude: 139.93857286° E, Ellipsoidal Height: 59.349m, Orthometric Height: 21.385m, Speed: 0.15 km/hr, Fix type: PPP, Satellites in view: 13, Satellites in use: 13, PDOP: 3.4, HDOP: 1.8, and VDOP: 3.0. A skyplot shows the positions of 13 satellites. A bar chart at the bottom shows signal strength for various satellites.

Right Screenshot (14:34): Shows the status screen. The title is "MADROID". It displays Date: Dec 25, 2019, Time: 05:34:17, Latitude: 35.90202310°, Longitude: 139.93857932°, X: 54N 404216.762m E, Y: 54N 3973601.765m N, Ellipsoidal Height: 59.848m, Orthometric Height: 21.884m, Fix Type: PPP, Speed: 0.11 km/hr, HDOP: 1.9, VDOP: 3.0, PDOP: 3.5, Satellites in View: 13, Satellites in Use: 13, Latitude Error: 0.191m, Longitude Error: 0.171m, and Altitude Error: 0.104m. A "STOP RECORDING" button is visible at the bottom.

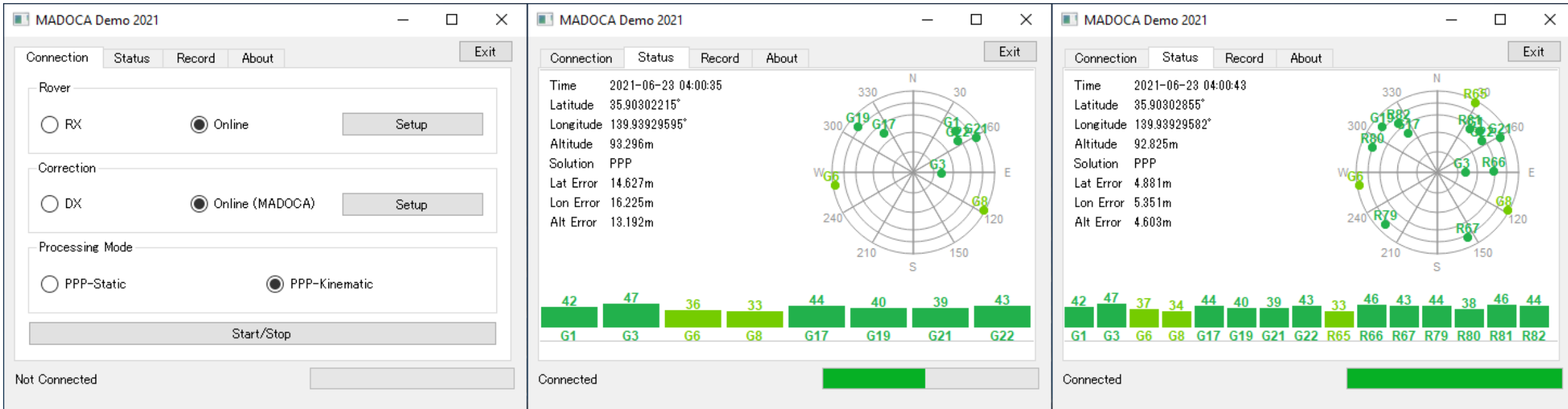
MADROID: PPP-RTK Test

The image displays five sequential screenshots of the MADROID mobile application interface, showing the configuration and real-time data for a PPP-RTK test.

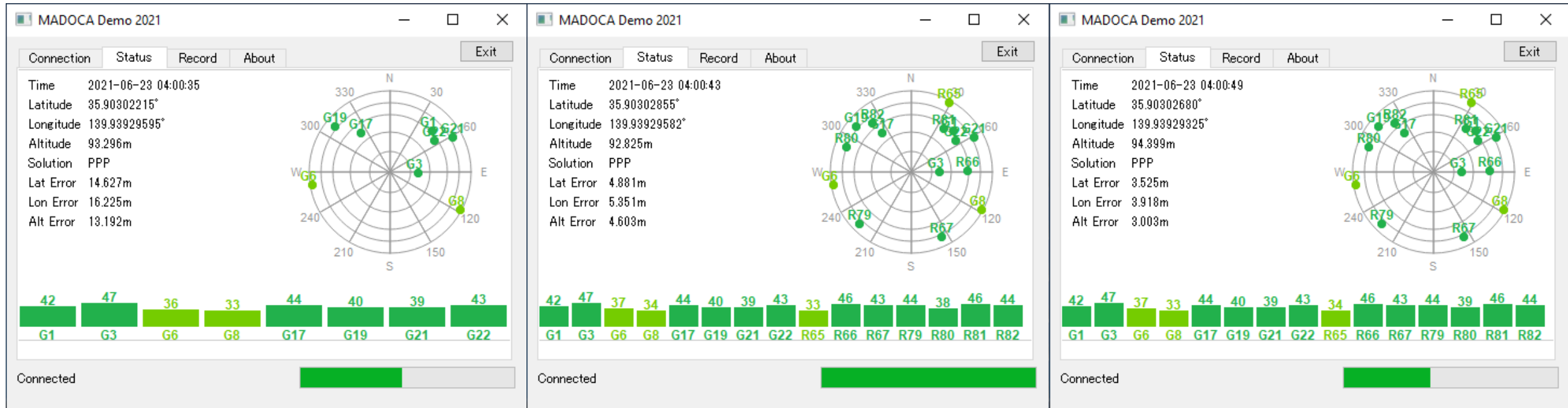
- Screenshot 1 (Setup):** Shows the main configuration menu. Key settings include:
 - Connection: USB
 - Device: u-blox GNSS receiver
 - Format: ubx
 - Processing Settings:
 - Rover Mode: PPP-Static
 - Elevation Mask: 10
 - Antenna Model: TWIVP6000
 - Antenna Height (m): 0.0
 - NTRIP Settings:
 - Address: madoca.ntrip-mgm.net
 - Port: 2101
- Screenshot 2 (NTRIP Settings):** Shows the NTRIP Settings screen with fields for:
 - Address: madoca.ntrip-mgm.net
 - Port: 2101
 - Mount Point: MDC0
 - User Name: dinesh@csis.u-tokyo.ac.jp
 - Password: *****
- Screenshot 3 (Local Correction Settings):** Shows the Local Correction Settings screen with fields for:
 - Address: [Empty]
 - Port: 80
 - Mount Point: [Empty]
 - User Name: [Empty]
 - Password: *****
- Screenshot 4 (Skyplot):** Shows the Skyplot screen displaying real-time data:
 - UTC Time: 07:16:19
 - Latitude: 35.68971662° N
 - Longitude: 139.75281501° E
 - Ellipsoidal Height: 56.785m
 - Orthometric Height: 18.995m
 - Speed: 0.15 km/hr
 - Fix type: Fix RTK
 - Satellites in view: 15
 - Satellites in use: 15
 - PDOP: 1.9
 - HDOP: 1.1
 - VDOP: 1.6
 The skyplot shows 15 satellites in use, with a bar chart at the bottom indicating signal strength for each satellite (e.g., G 20, G 13, G 24, G 15, G 28, G 5, R 83, R 85, R 84, R 37, R 67, R 78, R 77, R 69, R 68, R 79).
- Screenshot 5 (Status):** Shows the Status screen with the following information:
 - Date: Sep 15, 2020
 - Time: 07:16:23
 - Latitude: 35.68971663°
 - Longitude: 139.75281501°
 - X: 54N 387152.640m E
 - Y: 54N 3950250.977m N
 - Ellipsoidal Height: 56.780m
 - Orthometric Height: 18.990m
 - Fix Type: Fix RTK
 - Speed: 0.09 km/hr
 - HDOP: 1.1
 - VDOP: 1.6
 - PDOP: 1.9
 - Satellites in View: 15
 - Satellites in Use: 15
 - Latitude Error: 0.065m
 - Longitude Error: 0.055m
 - Altitude Error: 0.028m
 - NMEA: 2020_09_15_16_08_35.txt(279KB)
 - RAW: 2020_09_15_16_08_35.ubx(2MB)

MADOCA Data Observation

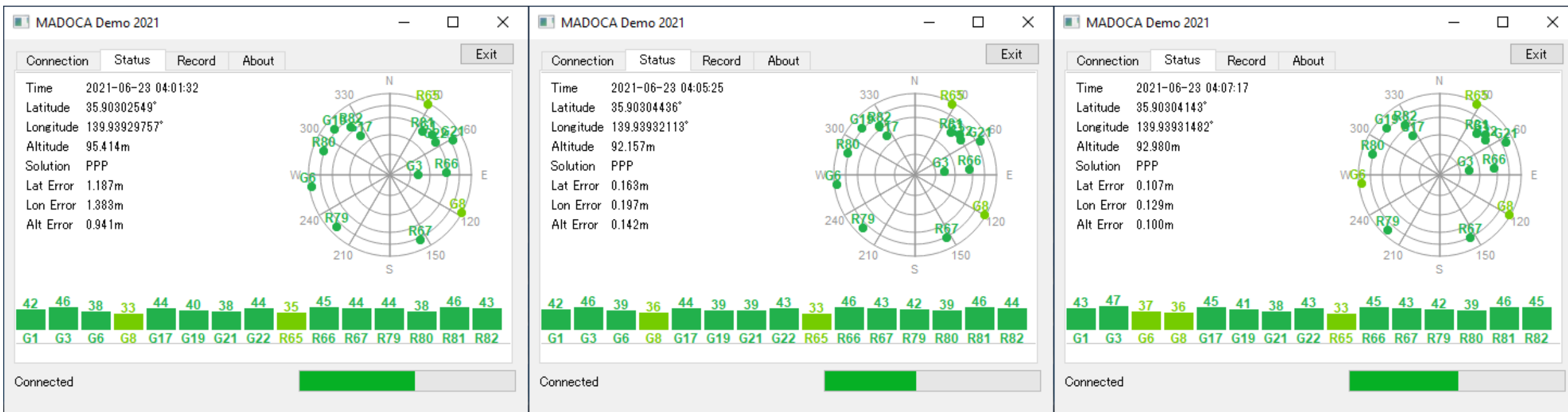
MADOCA PPP Test Results



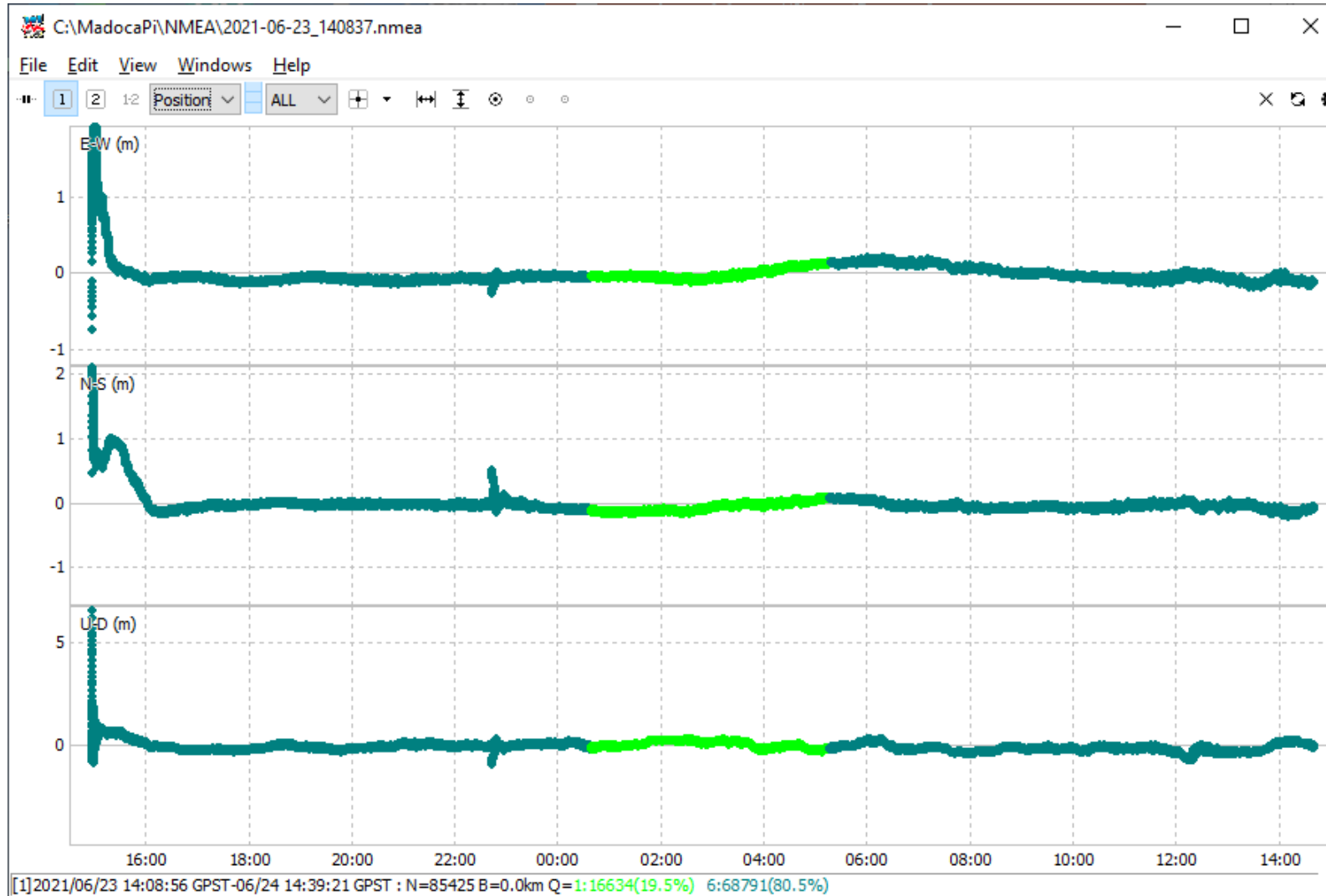
MADOCA PPP Test Results



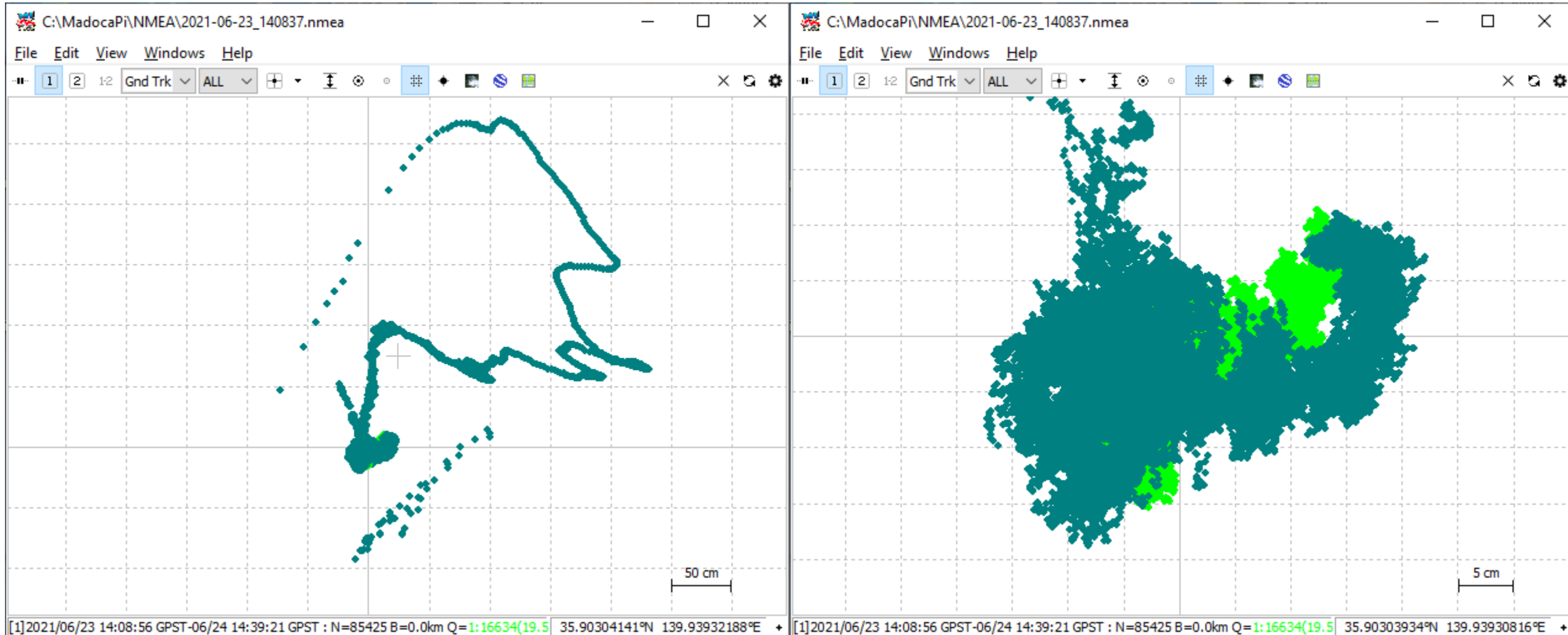
MADOCA PPP Test Results



MADOCA PPP Test Results (24 hours)

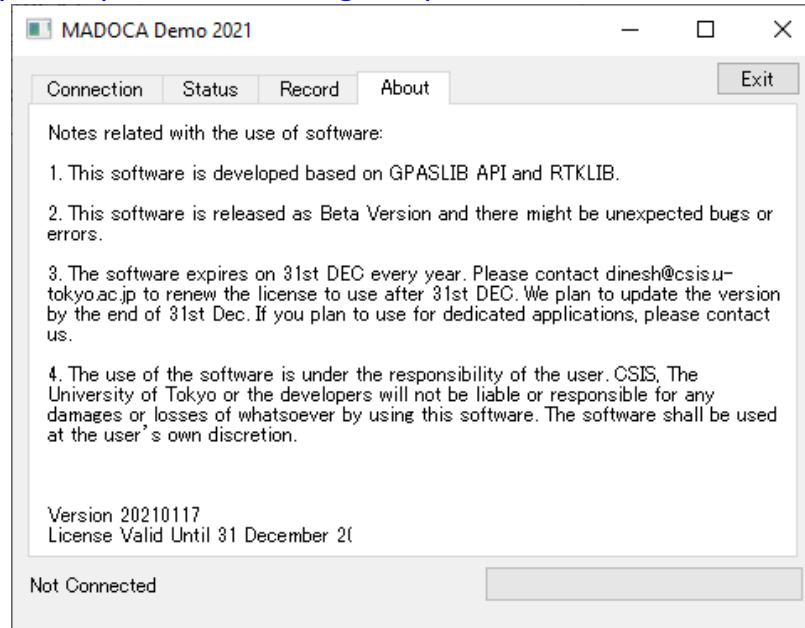


MADOCA PPP Test Results (24 hours)



Request for HW/SW

- MADOCA Receiver Systems are distributed to overseas universities for joint research and pilot projects
 - Includes HW and SW
 - Signing of MTA (Material Transfer Agreement) Document is necessary for HW
 - If only SW is required, please send request through
 - <https://home.csis.u-tokyo.ac.jp/~dinesh/LCHAR.htm>
 - SW is provided under the understanding that the recipients provide feedbacks and some sample data
 - Feedbacks are necessary to improve and debug the products



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Low-Cost High-Accuracy Receiver Systems

Receiver Systems: [Type A](#), [Type B](#), [Type C](#), [Type D](#)

Note: APKs can be downloaded from the following links:
Please send e-mail to dinesh@csis.u-tokyo.ac.jp for password.
Following information are necessary:

1. Name
2. Affiliation (Organization Name)
3. Purpose (Optional)

	APK Name	Description
1	RTKDROID (click to download) Register for Password and Updates	RTK based on RTKLIB 2.4.3 Receiver Type: Single or Dual Frequency Receiver Receiver and Data Compatibility: u-blox: M8T, M8P, F9P in UBX Format Septentrio in SBF Format Other Receivers in RTCM3 Format Connection: (1) USB using OTG cable with Android Device (2) Bluetooth
2	MADROID We will provide software for joint research and pilot projects based on MADOCA. Please contact me if your institute or organization is interested. Register here for MADOCA PPP Software	PPP with MADOCA Correction Data Receiver Type: Dual Frequency Receiver Receiver and Data Compatibility: u-blox: F9P in UBX Format Septentrio in SBF Format Other Receivers in RTCM3 Format Connection: USB using OTG cable with Android Device Download Presentation File

Summary and Future Plans

- Three types of Low-Cost MADOCA receiver systems are developed.
 - MAD-WIN, MAD-PI and MADROID
- MAD-PI will be improved for remote data logging.
- MADROID will be improved for using MADOCA data directly.
- Integration of current system with other systems
 - Traffic monitoring, EWS Application, GIS data collection tool,
- Detail field tests will be conducted in this fiscal year.
- Trainings, Seminars, Workshops and Joint Projects with foreign universities will be conducted
 - With support from MELCO, GPAS, TUMSAT and CAO

References

- Main Page
 - <https://home.csis.u-tokyo.ac.jp/~dinesh/>
- Request for Low-Cost Receiver System
 - <https://home.csis.u-tokyo.ac.jp/~dinesh/LCHAR.htm>
- Other Training Materials
 - https://home.csis.u-tokyo.ac.jp/~dinesh/GNSS_Train.htm
- Webinar Links
 - <https://home.csis.u-tokyo.ac.jp/~dinesh/WEBINAR.htm>
- Link to MADOCA Information at GPAS
 - https://www.gpas.co.jp/service_madoca.php
- QZSS Main Page
 - <https://qzss.go.jp/en/>