

User Manual

MALIB ver.1.0.0

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Japan Aerospace Exploration Agency (JAXA)

Contents

1. Overview	- 1 -
2. License	- 2 -
3. Instructions	- 3 -
3.1. Additional options	- 3 -
Appendix A : Details of newly added functions	- 4 -
PPP-AR function	- 4 -
Input function compliant with L6E data format for each receiver	- 4 -
Signal selection function	- 6 -

1. Overview

MALIB, which is fork program of RTKLIB¹, is an open-source program package especially for MADOCA²-PPP³. In this document, we explain the differences between MALIB and RTKLIB 2.4.3 b34 and show how the MADOCA-PPP works in MALIB. We hope it will help your better understand. The key features of MALIB are:

- (1) Implementation based on the latest version of RTKLIB (2.4.3 b34 revision)
- (2) Supports real-time processing and post-processing
- (3) Supports of PPP/PPP-AR⁴ with multi-GNSS (GPS/GLONASS/GALILEO/QZSS)
- (4) Supports multiple receiver L6E data formats (Ublox (ubx)/Septentrio(sbf)/MSJ)
and L6E archive data published by the Cabinet Office
- (5) Frequency used for positioning calculations can be selected for each GNSS satellite system
- (6) (Release in FY2025) Supports PPP/PPP-AR with local area ionospheric/tropospheric corrections via Internet

The MALIB directory structure is as follows.

malib_1.0.0

—— app	: Build environment for Aps
└── consapp	:
—— rnx2rtkp	: Post processing
└── rtkrcv	: Real-time processing
—— bin	: Executable binary
—— data	: MALIB sample data
—— doc	: Documentation (Manual of MALIB/RTKLIB)
—— lib	: Library
—— src	: Source programs of RTKLIB library
└── rcv	: Source programs depending on GNSS receivers

¹ RTKLIB : An Open-Source Program Package for GNSS Positioning, <https://www.rtklib.com/>

² MADOCA : Multi-GNSS Advanced Orbit and Clock Augmentation

³ PPP : Precise Point Positioning

⁴ AR : Ambiguity Resolution

2. License

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3. Instructions

3.1. Additional options

The new configuration options added to MALIB are listed in Table 1. In addition, “-rst” shown in Table 2 was added as a command for real-time processing (rtkrcv).

Table 1 Configuration options added in MALIB

No.	Item	Configuration File	Descriptions
1	GNSS used for PPP-AR	pos2-arsys	GNSS selection for PPP-AR with bit array. 1:gps+8:gal+16:qzs
2	Signal selection option	pos2-siggpsIIR-M	signal selection GPS IIR-M 0:L1C/A-L2P,1:L1C/A-L2C
3		pos2-siggpsIIF	signal selection GPS IIF 0:L1C/A-L2P,1:L1C/A-L2C,2:L1C/A-L5
4		pos2-siggpsIIIA	signal selection GPS IIIA 0:L1C/A-L2P,1:L1C/A-L2C,2:L1C/A-L5
5		pos2-sigqzs1_2	signal selection QZS-1/2 0:L1C-L5,1:L1C/A-L2C
6	RTCM option	misc-rtcmopt	-IGNORE_MCSSR_ALERT Ignore the madoca-ssr alert flag.
			-MCSSR_PRN={PRN} Only madoca-ssr with the specified PRN will be decoded.
			-DIS_MCSSR_CB Do not use madoca-ssr Code Bias.
7	Chi-squared test anomaly disable option	pos2-ign_chierr	Ignore chi-square error mode (0:off,1:on) When it's activated, it ignores chi-square error and continues single point positioning.

Table 2 Startup arguments added in MALIB

No.	Item	Startup arguments (rtkrcv)	Description
1	RTCM data playback start time	-rst ds ts (ds=y/m/d ts=h:m:s)	raw/rtcm data start timeSet this if the PC time and data time do not match when checking playback operation.

Appendix A : Details of newly added functions

PPP-AR function

MALIB has modified the PPP-AR function source file “ppp_ar.c” included in RTKLIB 2.4.3 b34 to add the ability to solve AR in PPP as well. In addition, in the MALIB, GPS, GAL, and QZS, excluding GLONASS which are FDMA signals, can be input to AR processing. As shown in Table 3, “pos2-arsys” in the configuration file allows GNSS can be selected. As of 2024 august, the AR function for IFLC (Ionospheric-free linear combination) has not implemented.

Input function compliant with L6E data format for each receiver

MALIB support L6E proprietary formats (e.g. .sbf, .ubx,) of each receiver in addition to RTCM3 format to perform MADOCA-PPP. A process to read L6E correction information in Compact-SSR format was added to MALIB by reusing the existing correction data process related to the RTCM3 SSR format. Figure 1 and Figure 2 shows a flowchart of the data and processing flow in post-processing and real-time processing.

Table 3 Combination of satellite systems that solve AR,
using bit array similar to pos1-navsys

	NAV	BDS	QZS	GAL	GLO	SBAS	GPS	VALUE (DEC)
GPS	0	0	0	0	0	0	1	1
GAL	0	0	0	1	0	0	0	8
GPS+GAL	0	0	0	1	0	0	1	9
QZS	0	0	1	0	0	0	0	16
GPS+QZS	0	0	1	0	0	0	1	17
GAL+QZS	0	0	1	1	0	0	0	24
GPS+GAL+QZS	0	0	1	1	0	0	1	25

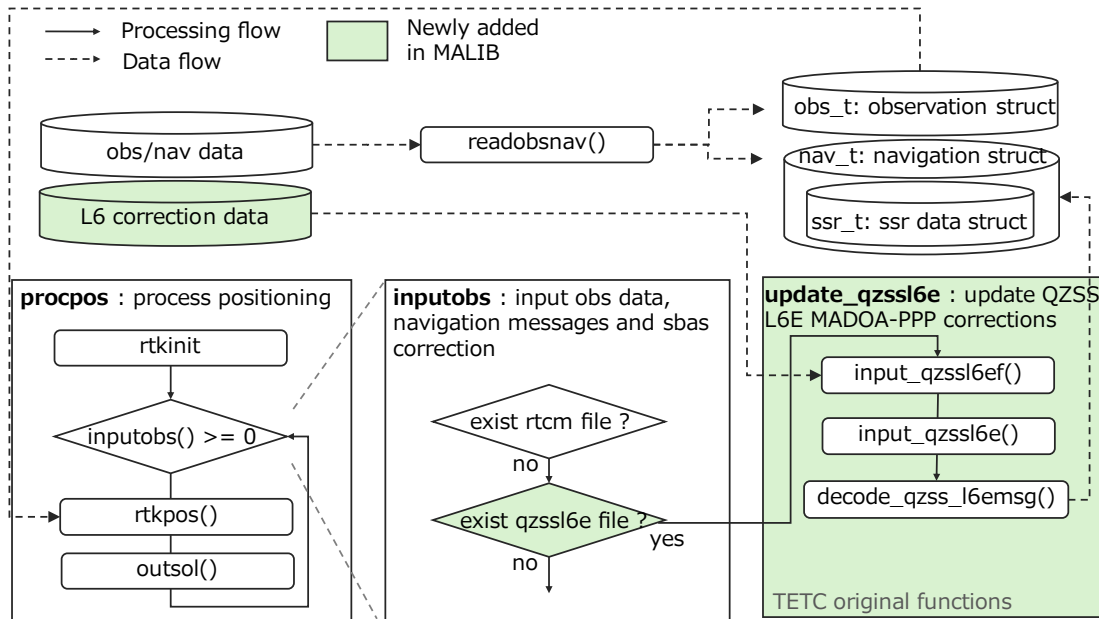


Figure 1 L6E correction data processing flow (post-processing)

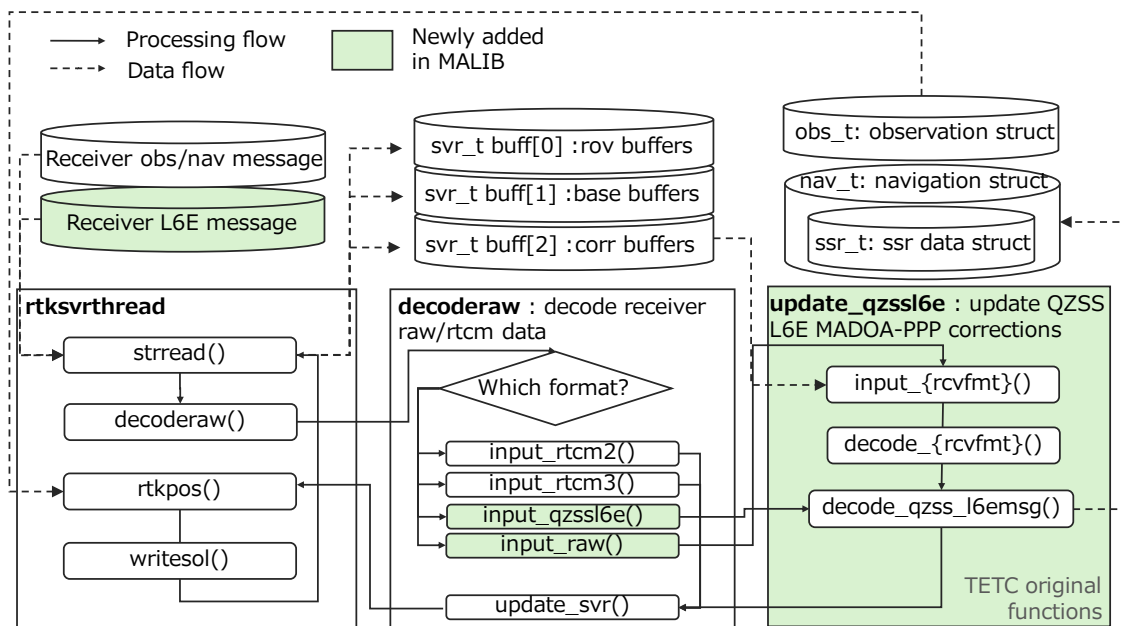


Figure 2 L6E correction data processing flow (real-time-processing)

The epoch time of the MADOCA-PPP correction information is defined as “GPS epoch time” or “GNSS epoch time” and no week number is defined. In the case of post-processing, the epoch time of the observation data is used to calculate the correction week number. On the other hand, in the case of real-time processing, the current time of the computer is used as the basis for processing, which may

cause problems when replaying past data to check operation. Therefore, MALIB uses “-rst” command as a startup option and has a function to specify the playback start time. (*Note: The computer time must be adjusted to the time of the past data.)

Table 1 shows the L6E format of each receiver supported by MALIB: U-blox and Septentrio receivers store one QZSS L6E data per epoch, and MSJ receivers store three QZSS L6E data per epoch. When decoding data with multiple QZSS PRNs per epoch, such as MSJ receivers, the first QZSS PRN processed is continued to be used as the processing target. If the data in the QZSS PRN to be processed is interrupted due to satellite invisibility, etc., MALIB switches to another QZSS PRN to be processed.

Table 4 Each L6E receiver format supported in MALIB

<i>Class&ID</i>	<i>Message</i>	<i>Content description</i>	<i>L6E file extension</i>
0x0273	UBX-RXM-QZSSL6	QZSS L6 message	.ubx (Ublox)
4069	QZSSRawL6	QZSS L6 navigation message	.sbf (Septentrio)
4050		QZSS LEX signal raw data	.rtcm3 (Magellan Systems Japan (MSJ))

Signal selection function

The combination of GNSS satellite signals used can be switched by settings (GPS_IIR-M, GPS_IIF, GPSIIIa, QZSS1-2, GAL) as shown in Table 5. For satellites other than those defined here, L1C/A-L2P for GPS, L1C-L5 for QZSS, E1-E5a for Galileo, and G1-G2 for GLONASS. When performing PPP, the “pos1-frequency” option in the configuration file must be set to “l1+2” (*Note: “pos1-frequency” must be set to “l1+2” even if the L1+L5 signal is selected.) .

Table 5 Signal type and frequency setting in MALIB

GNSS	Signal Type	pppobs[0]	pppobs[1]	Setting
GPS	IIR	L1C/A	L2P	-
	IIRm	L1C/A	L2P	0
			L2C	1
	IIF	L1C/A	L2P	0
			L2C	1
			L5	2
	IIIa	L1C/A	L2P	0
			L2C	1

			L5	2
QZSS	Up to 1R	L1C/A	L5	0
			L2C	1
	Q5-Q7	L1C	L5	-
Galileo			E5b	0
			E5a	1
GLONASS		G1	G2	-

ACKNOWLEDGMENTS

We would like to appreciate Mr. Tomoji Takasu for providing RTKLIB, the baseline software for MALIB. We also thank Toshiba Electronics Technology Corporation for their cooperation in the development of MALIB. We hope that MALIB will contribute to boosting the GNSS industry in Japan and abroad.