

**S.P.I.R.I.I.T**  
Software for Processing IRNSS at IIT Kanpur

**Installation and Operation Manual**

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## Table of Contents

<b><u>ABOUT THIS DOCUMENT.....</u></b>	<b><u>3</u></b>
<b><u>SOFTWARE AND SYSTEM REQUIREMENTS: .....</u></b>	<b><u>4</u></b>
<b><u>SOFTWARE INSTALLATION.....</u></b>	<b><u>5</u></b>
<b>PREPARATION FOR THE INSTALLATION: .....</b>	<b>5</b>
<b>INSTALLATION: .....</b>	<b>5</b>
<b>INSTALLATION VERIFICATION: .....</b>	<b>6</b>
<b><u>SOFTWARE OPERATION .....</u></b>	<b><u>7</u></b>
<b>INPUT FILES .....</b>	<b>7</b>
<b>INPUT OPTIONS .....</b>	<b>7</b>
<b>SAVING FILES AND GENERATING REPORTS .....</b>	<b>9</b>
<b>DEFAULT PARAMETERS .....</b>	<b>9</b>

## About this document

This document is the user manual for the software called “SPIRIT” which is developed by Geoinformatics Laboratory, IIT Kanpur as part of the project “SPIRIT : A Post-processing system for processing NavIC signals for high precision applications” funded by Space Technology Cell, ISRO. The software was developed during the period 2020 – 2023. The developed software is a based on Command Line Interface (CLI), with a few GUI (Graphical User Interface) and is designed to be operated in a Linux environment. This document explains the complete installation and operation procedure for processing Rinex files using the developed software.

## Software and system requirements:

The current version of the software is designed in Python3 and is designed to operate in a Linux environment. This version may also work on a MacOS, since it is a Linux-like environment. Some users have also tested this software in a windows environment (after some modifications). We recommend using this software on Ubuntu 20.04 LTS, where it is tested extensively. The installation and operation instructions are also given with the assumption that user is operating in a Linux environment. For use in other operating systems, the user may need to troubleshoot various issues that may arise during installation and/or operation. This user manual does not provide any instructions for use on any other operating system other than Ubuntu 20.04 LTS. The minimum recommended software requirements are given below.

Recommended operating system: Ubuntu 20.04.6 LTS

Programming language: Python 3.8.10

Processor (minimum): Intel ® Core™ i7-5500 CPU @ 2.40 GHz

RAM (minimum): 8.00 GB; Swap: 2.00 GB

Storage (minimum): 512 GB (SSD)

This software relies on various packages and other libraries for operation. The details of these libraries can be found in “requirements.txt” in the source code and is also given below. All the required libraries are provided along with the source code.

S. No	Package/Library name	Version
1.	Pip3	23.1.2
2.	Python3-tk	8.6
3.	Matplotlib	3.1.2
4.	Numpy	1.22.0
5.	pandas	1.3.5
6.	PyGeodesy	22.11.3
7.	Pymap3d	2.9.1
8.	pyproj	3.3.0
9.	scipy	1.7.3
10.	tqdm	4.62.3
11.	xarray	0.20.2
12.	Progress	1.6
13.	fpdf	1.7.2

For smooth operation, we recommend that the above libraries with the exact version are installed on the system. All the above mentioned libraries (except pip3 and python3-tk) are provided along with the source code, and are used during the installation.

## Software installation

The software can be installed through a shell-script based installer, provided with the source code. The provided installer installs all the required files, along with the libraries in the user's home folder. Specifically, the software will be installed at the location “~/home/USER/.SPIRIIT”, where USER refers to logged in user. To avoid any conflicts with the other versions, it is recommended that any other versions of the libraries used by this software are removed from the system. If it is not possible to remove them from the system, we recommend that user employs a virtual environment to maintain different versions of the libraries/packages.

There are two steps to installing the software. The first step prepares the system for the installation, which includes installation python along with its associated package manager and the software is installed in the second step.

### Preparation for the installation:

Before starting the installation procedure, please ensure that following are installed on the system. If any of the below mentioned packages are not installed, the software installation will fail.

1. Python 3.8.10
2. Pip3 (Version 23.1.2 or above)
3. Tkinter (Python3-tk version 8.6 or above)

PIP is the package manager for python packages and is typically installed along with Python3. However, if it is not installed, it should be installed manually. Once Python3 is installed on the system, the user can install pip3 via the terminal using the following command:

**sudo apt-get install python3-pip**

Tkinter is the standard Python interface to Tcl/Tk GUI toolkit and is used for providing various GUI based functionalities. Tkinter can be installed via the terminal using the following command:

**sudo apt-get install python3-tk**

The system is now ready for installation of the SPIRIIT software. Please note that the user will need to have internet access in order to install the above mentioned packages. Once, these packages are installed, the remaining installation can be carried out in an offline mode.

### Installation:

Once the system is ready for installation, please open the terminal and migrate to the folder containing the source code and shell script “installer.sh”. To begin installation of the software, please type the following command in the terminal:

**bash installer.sh**

Running this command will install the required packages, with the exact required versions, and create a shortcut on the Desktop for running the software. The software will be installed in the home directory of the user. Please note that this directory is hidden from a normal user and must not be deleted. If it is deleted, the user will need to repeat the above mentioned steps to install the software again. Also, note that the user does not need any internet access for the installation. The software can now be run through the shortcut which is automatically created on the desktop.

### Installation verification:

To verify that the software has been installed correctly, please double click the shortcut icon on the desktop. Double clicking the icon will launch the software in a terminal window and you should be able to see the welcome screen. This denotes that the software is now correctly installed on your machine. Please take care not to launch more than one instance of the software. Once the software has finished processing, the terminal window will close. The second instance of the software must be launched only after the terminal window of the first instance has closed.

## Software operation

To being processing using the software, please launch the software by double clicking the shortcut icon on the desktop. The welcome screen will open up in the terminal window, which also provides basic information about the software. It also lists the various operating modes that this software supports. As of date, this software supports processing of GPS, NavIC and Beidou constellations, and L1, L2, L5 bands, either in a standalone mode or in dual mode. The software also allows the user to either carry out standalone processing using code observations, or relative positioning using code observations, or relative positioning using carrier phase observations. Highest accuracy (of the order of  $\sim 3\text{-}5$  cm) is achievable using the carrier phase observations.

The software requires the observation and navigation files in the rinex format (version 3.04). Further, the software requires that the files must be named using a standard naming convention. The software will generate an error message if incorrection rinex version is used or file naming is not as per the specified convention. The next section explains the format of the input files and their naming conventions.

### Input files

The software takes rinex file as the input. It needs at least two files: Observation file containing the raw code/carrier phase observations, and Navigation file containing the satellite ephemeris information. As of now, the software uses the broadcast ephemeris information. The user must ensure that rinex version for both the observation and navigation files must be 3.04. Further, the observation and navigation files must be named as follows:

Observation file: *filenameO.rnx*

Navigation file: *filenameN.rnx*

Where “*filename*” can be anything chosen by the user. The *filename* for the observation and navigation file can also be different. Note that the extension of both the observation and navigation files must be “.rnx”. The observation file name must end with “O”, while the navigation file name must end with “N”. Please ensure that these conventions are followed before inputting the files to the software.

The software first asks the observation file, followed by the corresponding navigation file. In case, incorrect observation/navigation file is provided, or if there is no time overlap between the observation and navigation files, the software will terminate after providing the necessary warnings and error message. The user must make appropriate rectifications to proceed further.

### Input options

The software requests for various inputs and parameters from the user. The software has inbuilt checks to ensure that the parameters entered by the user are correct and in the required format. The first input the software seeks from the user is regarding the choice of the processing method to use. Following three options are available to the user:

1. Single point positioning

2. Relative code based positioning
3. Relative carrier phase based positioning

The user must provide two different observation files when processing is carried out using either option-2 or option-3. One observation file is for the base station, whose coordinates must be known apriori to the user, and second observation file is for the rover station, whose coordinate the user desires to estimate. This is not required when the user would like to carry out single point positioning. The user must provide only one navigation file when processing using any of the above-mentioned options. Also, note that the software will process only those satellite constellations whose ephemeris information is available in the navigation file. Furthermore, note that software can only process those signals whose observations are available in the observation file. Also, note that of the three processing modes mentioned above, only option-3 allows the user to utilize the carrier phase based observations. Otherwise, only code based pseudoranges are used for positioning which typically result in a localization accuracy of  $\sim 5$  m.

Once, user has chosen the processing mode, the software asks for the source of “input files”, i.e. which type of receiver is used by the user. If the user has used “Accord” receiver, he/she must select “Accord”. Otherwise, the user must select “Trimble”. Note that user must select “Trimble”, even if the user has chosen other receiver such as the one from “Leica”. Also, note that this list is not exhaustive and the software should accept the file from any other receiver as long as the format is similar to the format of either “Accord” or “Trimble” receiver. The software can also accept rinex files from “smartphones” and hence, the user must select the third option, if a smartphone is used for data collection.

After selecting the source, the software requests for the observation file via a GUI. As mentioned earlier, the observation file must be in “.rnx” format and must be named as per the naming convention. Please migrate to the location of the observation file and select the observation file. If everything is correct, the software will accept the file and request for navigation file. The same procedure must be repeated for inputting the navigation file. In case single point positioning is not used, the user must input base station observation file first, followed by rover observation file and then the navigation file.

After accepting the input files, the software will request the user to input the constellation (GPS, NavIC, GPS L1 + Navic L5, Beidou) to be used, and then the band or band combinations to be used for processing. The user can select L1, L2, L5 or a combination of these bands, depending on the availability. Following this, the user must select the number of epochs he/she desires to process. If the user desires to process the complete file, he/she must enter “0”. Following this, the user must select the processing method to deploy (WLS or EKF), followed by whether the user desires to use a tropospheric and/or ionospheric correction model. Note that no ionospheric correction model is used in case of dual band processing and ionospheric errors are eliminated using a dual frequency combination. The user must then provide the “true” coordinates of the rover antenna. Note that these true coordinates are used for error estimation and absolute/relative error statistics. Some of the “true” rover station coordinates are inbuilt into the software. If the true coordinates of your rover are not available, the user can enter the new coordinates. Note that these coordinates must be cartesian coordinates (in meters) with WGS84 as the reference ellipsoid.



Following this, the software reads the input files, extracts the relevant information and starts processing the observations. The software provides a real-time status of observations being read, and the real-time processing status, along with elapsed time and an estimate of the time taken by the software to complete processing.

### Saving files and generating reports

Once the processing is finished, the software reports epoch-wise coordinates of the rover in a .txt file. Hence, the software requests for the file name of the txt file, where the coordinates should be saved. In addition to the coordinates, the software generates a processing report summarizing the overall statistics and also provides various graphs to enable easy understanding of the results. The user can specify the name of the PDF report, or let the software save using the default file naming format. The same graphs are also stored as separate files in “.png” format for use by the user. All the results including estimated coordinates, graphs and reports are saved in the user’s home folder in a directory. The folder name and location is given as: `“/home/USER/results_ObservationFileName_Constellation_Band”`, where “ObservationFileName” denotes the name of the observation file, “Constellation” denotes the constellation used (GPS/NavIC/Beidou) and band used (L1/L2/L5/Dual etc.). In case a folder with the same name exists, the software will overwrite the existing folder. Please ensure to rename the existing folder or move it to a different location if you do not wish to overwrite the existing folder.

### Default parameters

The software uses a variety of default parameters during processing. These default parameters are stored with the source code. Although, the user will not need to modify these default parameters in a majority of cases, he/she can modify it, if he/she desires. The default parameters can be found in `“/home/USER/.SPIRIT/src/pack/assets/”`. Please note that the software may not function correctly if incorrect values of the default parameters are used and hence, the user is advised to be cautious while changing these parameters.