Wave Glider® SV3 Integrated Sensor User Guide

GPSWaves Sensor Software

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LIQUID ROBOTICS

Wave Glider® SV3 Integrated Sensor User Guide: GPSWaves Sensor Software

Trademarks

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Revision History

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06258	A	September 2014	This is the initial release of this document.

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Preface

This guide provides information on operating the **GPSWaves** wave sensor software included with the LR-1014 Wave Glider SV3 Wave Height Sensor option.

This guide assumes a working familiarity with the Liquid Robotics Wave Glider SV3. The focus is on using the GPSWaves software.

Liquid Robotics manuals are available on the documentation CD included with each Wave Glider vehicle and by contacting the Liquid Robotics Support Organization at:

- Telephone:

  (US) 888-574-4574

  (International) +1-408-636-4205

- Email: support@liquidr.com

  Before contacting LRI support, please have available the serial number of the vehicle(s) or part(s) that you are contacting LRI Customer Support about.

Chapter 1. GPSWaves Software Overview

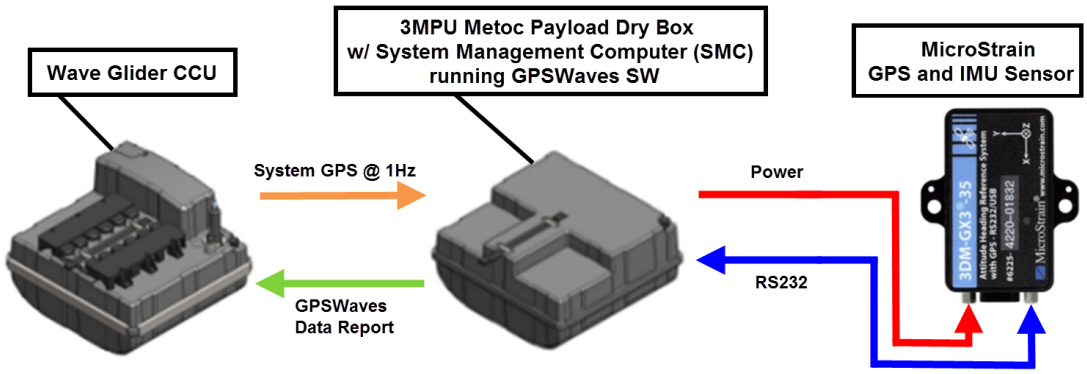
GPSWaves is a versatile application that computes wave height and wave spectrum parameters at a specified period (typically every 30 minutes).

GPSWaves runs on a System Management Computer (SMC) in a Wave Glider SV3 Payload.

GPSWaves receives selected inputs from:

- The 1Hz GPS included with the Wave Glider SV3 system
- An external IMU

Figure 1.1. GPSWaves Architecture



The LR-1014 Wave Glider SV3 Wave Height Sensor option available with Wave Glider SV3 Vehicles includes the GPSWaves application running on a SMC in a payload that includes a Microstrain 3DM-GX3-35 GPS and IMU sensor. The GPSWaves application configures the Microstrain senor to report GPS data (position, velocity, time) at 4Hz and IMU data (AHRS: z acceleration, pitch, roll, orientation) at 4Hz.

Documentation on the Microstrain 3DM-GX3-35 sensor is available at:

http://www.microstrain.com/inertial/3dm-gx3-35

Chapter 2. Commands

There are two ways you can issue commands to the GPSWaves application running on the SMC:

- From WGMS using the Write Console Script command with the Board Address set to decimal 8229 (hex `0x2025`)
- On the SMC using ServerExec to send commands to the process named `GPSWaves`

The GPSWaves commands are:

GWAVES --autostart [<new-state>]

If the `new-state` parameter is given, it sets the state of the automatic start feature. If `new-state` is *`true`*, the service starts sampling and returning data when the program launches; otherwise, the program remains idle after launch and an explicit start command must be sent to start sampling.

If the `new-state` parameter is omitted, the command returns the current state of the automatic start feature: *`true`* (begin sampling on program launch) or *`false`* (idle on program launch.)

GWAVES --period <minutes>

Specifies the period, in minutes, over which Microstrain data samples are collected for processing by Jim Thomson's library to calculate wave height and spectrum. `<minutes>` can be any value between *`20`* and *`120`*. Values lower than *`20`* minutes will result in insufficient data samples to perform wave height calculations. The system default is setting is *`30`* minutes.

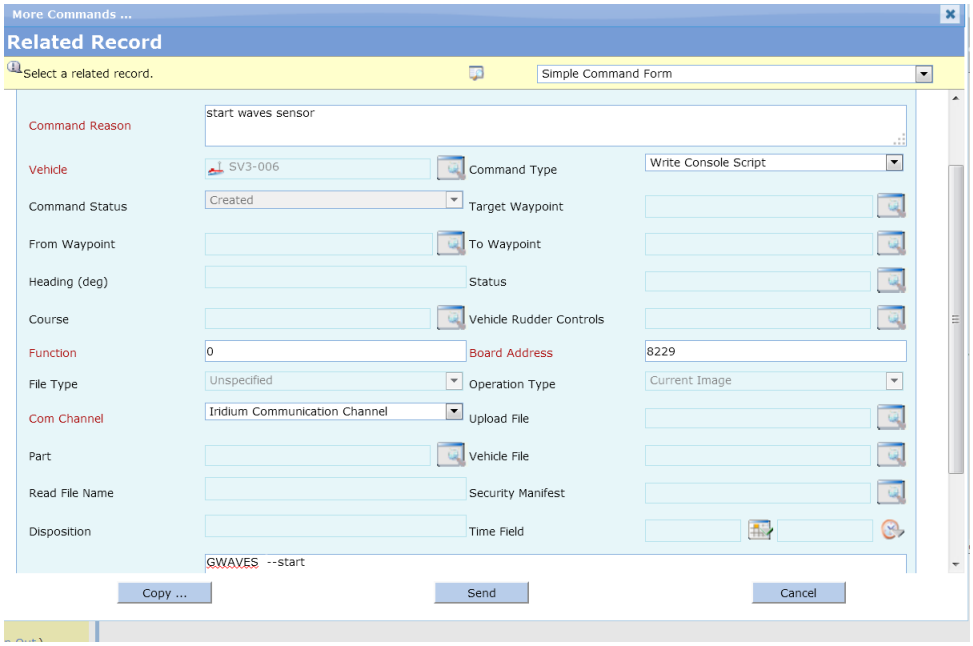
GWAVES --start

Powers on the Microstrain IMU and begins sampling, storing, and processing Microstrain data for wave height calculations.

GWAVES --stop

Stops sampling and sending wave height calculations and powers down the Microstrain IMU.

Example - Using the WGMS Simple Commands form and the Write Console Script command to issue GPSWaves commands:



Example - Using ServerExec to issue GPSWaves start and stop commands:

ServerExec GPSWaves “GWAVES --start”

ServerExec GPSWaves “GWAVES --stop”

Chapter 3. GPSWaves Data

GPSWaves sends out one event (GPSWavesTelemEvent) to report the wave height calculations for each period as determined by the **GWAVES --period <minutes>** setting. Each GPSWaves telemetry event contains the following fields:

Field Name	Type	Description
Hs	DOUBLE FLOAT	Wave height (in meters)
Tp	DOUBLE FLOAT	Peak period (in seconds)
Dp	DOUBLE FLOAT	Dominant direction (in degrees)
Samples	UINT16	Number of samples used for this calculation
Fs	DOUBLE FLOAT	Frequency of data samples during this period's calculation
SampleGaps	UINT16	Number of missing/dropped samples during this period
Ta	DOUBLE FLOAT	Average period (in seconds)

For more information see Chapter 4: *Parameter Descriptions and Output Definitions for the UnifiedWaveProcessing Library*.

Each GPSWaves telemetry event is displayed as follows in WGMS (GPS Waves Sensor Data)

Figure 3.1. Example - GPSWaves Telemetry Display in WGMS

GPS Waves Sensor Data

TimeStamp	Vehicle	Latitude(deg)	Longitude(deg)	Hs (m)	Ta (s)	Tp (s)	Dp (deg)	Samples	Fs (Hz)	Sample Gaps
6/26/2014 15:30:01	SW_1732 ...	37.41084	-122.00443	0.0646	7.9247	12.4862	9999.0000	7200	4.0006	0
6/26/2014 15:00:01	SW_1732 ...	37.41083	-122.00441	0.0699	8.1569	12.4862	9999.0000	7200	4.0006	0
6/26/2014 14:30:01	SW_1732 ...	37.41079	-122.00441	0.0762	8.4049	12.4862	9999.0000	7200	4.0006	0
6/26/2014 14:00:01	SW_1732 ...	37.41084	-122.00442	0.0684	8.6036	12.4862	9999.0000	7200	4.0006	0
6/26/2014 13:30:00	SW_1732 ...	37.41082	-122.00438	0.0609	8.3212	10.8922	9999.0000	7200	4.0006	0
6/26/2014 13:00:00	SW_1732 ...	37.41085	-122.00441	0.0645	7.9515	12.4862	9999.0000	7200	4.0006	0
6/26/2014 12:30:00	SW_1732 ...	37.41087	-122.00440	0.0536	8.3943	10.8922	9999.0000	7200	4.0006	0
6/26/2014 12:00:00	SW_1732 ...	37.41083	-122.00439	0.0531	8.7202	12.4862	9999.0000	7200	4.0006	0

Wave data that is unavailable or unable to be computed is reported as 9999. This can occur when insufficient or inaccurate GPS & IMU samples have been collected during a reporting period, for example, due to data dropouts.

When the Microstrain 3DM-GX35 is powered on, it may take several minutes before it generates continuous and valid GPS and IMU samples. This will reduce the number of valid samples available for successful wave height calculations during that reporting period.

Chapter 4. Parameter Descriptions and Output Definitions for the UnifiedWaveProcessing Library

These methods are derived from Herbers et al, *Observing Ocean Surface Waves with GPS-Tracked Buoys*, Journal of Atmospheric and Ocean Technology, vol 29, 2012.

Table 4.1. UnifiedWaveProcessing Library Parameter Descriptions and Output Definitions

Parameter	Description
Hs	"significant wave height" = [meters] = four times the square root of the variance in the sea surface elevation, as determined by integrating the wave energy spectrum. Theoretically equivalent, assuming a Rayleigh distribution of random wave heights, to the average of the highest 1/3 of the wave heights.
Ta	"average wave period" = [seconds] = an energy-weighted average period calculated as centroid of the wave energy spectrum.
Tp	"peak wave period" = [seconds] = the period with maximum energy in the wave energy spectrum. Also called the dominant wave period.
Dp	"peak wave direction" = [deg from true north] = the direction waves are coming from (nautical convention) at the peak of the energy spectrum. Also called dominant wave direction.
E	"wave energy spectrum" = [meters^2 / Hz] = spectral energy density of the sea surface elevation, which is partitioning of wave energy into frequency bands. This is an ensemble result, computed using the Fourier transform after windowing and tapering the raw data. The variance is preserved, such that the integral of the spectrum equals the variance of the sea surface time series.
f	"frequency" = [Hz] = frequencies of wave energy. This is the ordinate of the wave energy spectrum, and the bandwidth (difference between neighboring frequencies) is used to normalize the wave energy spectrum into energy density.
dir	"wave directions" = [deg from true north] = dominant wave direction at each frequency, as estimated from the a1, b1 spectral moments. Note that this is NOT the full directional spectrum, which would be an m x n array of energy densities at every combination of frequencies and directions. Rather, this is a single direction that best describes the wave propagation at each frequency. This is analogous to the principal axis of wave motion at each frequency.
spread	"wave directional spread" = [deg] = spread in the dominant wave direction at each frequency, as estimated from the a1, b1 spectral moments. This can be interpreted as the standard deviation, or the uncertainty, of direction at each frequency. It is analogous to the variance perpendicular to the principal axis of wave motion.

Parameter	Description
a1	"first directional moment, east-west component" = [dimensionless] = normalized directional moment at each frequency. Derived from the cospectrum of heave and east-west motion.
b1	"first directional moment, north-south component" = [dimensionless] = normalized directional moment at each frequency. Derived from the cospectrum of heave and north-south motion.
a2	"second directional moment, east-west component" = [dimensionless] = normalized directional moment at each frequency. Derived from the cospectrum of east-west and north-south motions.
b2	"second directional moment, north-south component" = [dimensionless] = normalized directional moment at each frequency. Derived from the cospectrum of east-west and north-south motions.
check	"spectral quality check factor" = [nondimensional] = ratio of vertical motion to horizontal motion. This should be equal to 1 for perfect data in deep water waves (circular particle orbits). Deviations from 1 indicate poor data, in particular poor response of the vehicle to swell motions or biases related to vehicle propulsion.

Chapter 5. Output Files

GPSWaves stores all raw and processed data in the following files on the SMC file system:

- `/mnt/XDATA/GPSWaves/raw.log`
- `/mnt/XDATA/GPSWaves/waves.log`
- `/mnt/XDATA/GPSWaves/spectrum.log`

The `/mnt/XDATA/GPSWaves/raw.logfile` contains all the **raw data** received while GPSWaves is running. Microstrain data packets are logged as lines of text beginning with `PACKET, <received date & time>`, followed by the hexadecimal bytes. System GPS samples are logged as lines of text in the following format: `SYSGPS, <date & time>, <latitude and longitude>`

The `/mnt/XDATA/GPSWaves/waves.log` contains the **wave height** report parameters for each reporting period. Each reporting period is specified by a line of text beginning with `PERIOD`, followed by the start time, latitude, longitude, end time, latitude, longitude, number of samples, and the sampling frequency (based on the GPS samples used for the wave height and spectrum calculations during this reporting period). This is followed by the line `GPSWAVES,Hs,Ta,Tp,Dp`.

The `/mnt/XDATA/GPSWaves/spectrum.log` contains the **wave spectrum** parameters computed during each reporting period. Each reporting period is specified by a line of text beginning with `PERIOD`, followed by the start time, latitude, longitude, end time, latitude, longitude, number of samples, and the sampling frequency (based on the GPS samples used for the wave height and spectrum calculations during this reporting period). This is followed by the `ENERGYSPECTRA, FREQUENCY, DIRECTION, SPREAD, A1, B1, A2, B2,` and `CHECK` data bytes.

GPSWaves Configuration File

The following is an example of the **`/home/smc/roots/200_GPSWaves/GPSWaves-config.xml`** file:

```
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
<!DOCTYPE boost_serialization>
<boost_serialization signature="serialization::archive" version="10">
<rootlevel class_id="0" tracking_level="0" version="1">
 <sensorProgramSettings class_id="1" tracking_level="0" version="1">
  <serverName>GPSWaves</serverName>
  <serverKind></serverKind>
  <softwareVersion class_id="2" tracking_level="0" version="1">
   <majorVer>0</majorVer>
   <minorVer>0</minorVer>
   <subminorVer>1</subminorVer>
  </softwareVersion>
  <loggerSettings class_id="3" tracking_level="0" version="0">
   <logLevel>LT_INFO</logLevel>
   <processName>GPSWaves</processName>
   <isFileDes>1</isFileDes>
   <fileDes>1</fileDes>
   <fileName></fileName>
```

```
 <pipeName></pipeName>
</loggerSettings>
<commandCompleteEvent class_id="4" tracking_level="0" version="0">
 <eventName>CommandComplete</eventName>
 <eventType class_id="5" tracking_level="0" version="0">
  <typeName>SendCommandCompleteEvent</typeName>
  <domainName>LiquidR-SMC</domainName>
 </eventType>
</commandCompleteEvent>
<gpsEvent>
 <eventName>GPSSample1Sec</eventName>
 <eventType>
  <typeName>GPSSample</typeName>
  <domainName>LiquidR-SMC</domainName>
 </eventType>
</gpsEvent>
<shutdownEvent>
 <eventName>Shutdown</eventName>
 <eventType>
  <typeName>EventBase</typeName>
  <domainName>LiquidR-SMC</domainName>
 </eventType>
</shutdownEvent>
<eventTransceiverSettings class_id="6" tracking_level="0" version="2">
 <eventServiceName>EventManager</eventServiceName>
 <eventServiceKind></eventServiceKind>
 <receiveEnable>1</receiveEnable>
 <aliasToEvent class_id="7" tracking_level="0" version="0">
  <count>0</count>
  <item_version>0</item_version>
 </aliasToEvent>
 <eventFilterEnabled>1</eventFilterEnabled>
 <eventNameFilter class_id="8" tracking_level="0" version="0">
  <count>2</count>
  <item_version>0</item_version>
  <item>GPSSample1Sec</item>
  <item>Shutdown</item>
 </eventNameFilter>
 <eventTypeFilter class_id="9" tracking_level="0" version="0">
  <count>0</count>
  <item_version>0</item_version>
 </eventTypeFilter>
 <displayReceivedEvents>0</displayReceivedEvents>
 <fullyDescribeReceivedEvents>0</fullyDescribeReceivedEvents>
 <doNotDisplayList>
  <count>0</count>
  <item_version>0</item_version>
 </doNotDisplayList>
</eventTransceiverSettings>
<payloadManagerClientSettings class_id="10" tracking_level="0" version="0">
 <serviceName>PayloadManager</serviceName>
 <serviceKind></serviceKind>
 <deviceAddedEventName>PayloadDeviceAdded</deviceAddedEventName>
 <deviceChangedEventName>PayloadDeviceChanged</deviceChangedEventName>
```

```
  <deviceRemovedEventName>PayloadDeviceRemoved</deviceRemovedEventName>
  <commonEventType>PayloadRegistrationEvent</commonEventType>
  <commonEventDomain>LiquidR-SMC</commonEventDomain>
  <payloadDescription class_id="11" tracking_level="0" version="2">
   <boardID>255</boardID>
   <taskID>37</taskID>
   <description>GPS Wave Sensor</description>
   <ior>(This will be overwritten)</ior>
   <readableName>GPSWaves</readableName>
   <descriptiveJSON></descriptiveJSON>
  </payloadDescription>
 </payloadManagerClientSettings>
</sensorProgramSettings>
<controllerSettings class_id="12" tracking_level="0" version="1">
 <serialPortSettings class_id="13" tracking_level="0" version="0">
  <portName>/dev/ttyLX1</portName>
  <baudRate>115200</baudRate>
  <parity>NONE</parity>
  <characterSize>8</characterSize>
  <stopBits>2</stopBits>
  <flowControl>NONE</flowControl>
  <rts>1</rts>
  <dtr>1</dtr>
  <breakTimeoutMultiplier>1</breakTimeoutMultiplier>
 </serialPortSettings>
 <powerOnVerb>sudo SetPowerSwitch 4 1 &amp;amp;&amp;amp; sleep 30</powerOnVerb>
 <powerOffVerb>sudo SetPowerSwitch 4 0 &amp;amp;&amp;amp; sleep 1</powerOffVerb>
 <outputFileName>/mnt/XDATA/GPSWaves/raw.log</outputFileName>
 <processedDataFileName>/mnt/XDATA/GPSWaves/waves.log</processedDataFileName>
 <spectrumFileName>/mnt/XDATA/GPSWaves/spectrum.log</spectrumFileName>
 <samplingFrequency1000>4000</samplingFrequency1000>
 <seaStateInterval>30</seaStateInterval>
 <lfnr>20</lfnr>
 <nStdDev>10</nStdDev>
 <RC>20</RC>
 <inputType>0</inputType>
 <AHRSorientation>0</AHRSorientation>
 <AHRSpitchRoll>0</AHRSpitchRoll>
 <enableRawDataEvent>false</enableRawDataEvent>
 <enableSpectrumEvent>false</enableSpectrumEvent>
 <enableTelemEvent>true</enableTelemEvent>
</controllerSettings>
<rawDataEventSettings>
 <eventName>GPSWavesRawData</eventName>
 <eventType>
  <typeName>GPSWavesRawDataEvent</typeName>
  <domainName>LiquidR-SMC</domainName>
 </eventType>
</rawDataEventSettings>
<telemEventSettings>
 <eventName>GPSWavesTelem</eventName>
 <eventType>
  <typeName>GPSWavesTelemEvent</typeName>
  <domainName>LiquidR-SMC</domainName>
```

```
  </eventType>
 </telemEventSettings>
 <spectrumEventSettings>
  <eventName>GPSWavesSpectrum</eventName>
  <eventType>
   <typeName>GPSWavesSpectrumEvent</typeName>
   <domainName>LiquidR-SMC</domainName>
  </eventType>
 </spectrumEventSettings>
</rootlevel>
```