1. Introduction

General Acoustics, e.K., founded in 1996, with its origins as an acoustics and sensors research and services partnership, is now a high-end technology producer of sophisticated water level and wave measuring systems (LOG_aLevel), special echo sounders, sub-bottom profilers and corresponding hydro-graphical imaging and analytical software (e.g. for ADCP data evaluation).

General Acoustics has developed a wide range of measurement systems and analysis tools for laboratory as well as for marine and engineering applications. General Acoustics markets its products and services directly and through a network of representatives and partner companies, covering more than 60 countries.

General Acoustics can provide a complete network of airborne acoustic wave and tide gauges that deliver reliable results even at very demanding environmental conditions, withstanding very low and high temperatures, salinity, humidity and dust. Furthermore the proposed system is optimized for a very low maintenance due to the non-contact wave and tide measurement, sensors with no moving parts, special corrosion protection and through the extended temperature range of all electronic components.

Equally important in this respect is the sophisticated measurement of the sound velocity, which enables a total calibration-free operation and a constantly precise measurement. Other measurement systems use only a temperature measurement to compensate for changes in the sound velocity. Sound velocity is however also affected by pressure, humidity and salinity. Additionally, a precise temperature measurement which is mandatory for reliable results is not possible at times with significant solar radiation, thus rendering these methods less reliable and less precise.

Another advantage of the LOG_aLevel wave and tide gauge is the very narrow acoustical beam in combination with a 5 Hz measuring rate, which can fully resolve all waves independent from any formations in the water. Thus, the tide estimation is not influenced by the wave height and there is no disturbance of the water surface leading to faulty readings. Additionally LOG_aLevel measurements provide linear results, which then require no additional effort for calibration or post-processing.

2. Measurement Range / Further specifications of the LOG_aLevel system

The measurement range of the typical LOG_aLevel sensor is 0-11 meters. If needed, sensors with a range greater than 11m can be delivered.

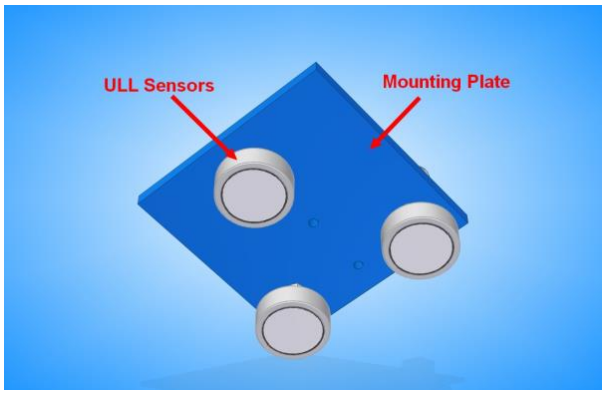

Fig. 1: LOG_aLevel sensor photograph and schematic.

3. Power supply

For the LOG_aLevel system it would be preferred to use a 230VAC power supply. Additionally, in order to account for the possibility of power shortages or other emergencies, we recommend adding an additional buffer battery to the measurement system. A small, compact, safe and excellent value for money LiPo25Ah battery will then be added as an integral part of the measuring system (within the electronics housing).

Fig. 2: Example LOG_aLevel housing with different modules. Visible on the lower part is the separate compartment for a buffer battery.

4. Memory

All measured data will be locally stored on a non-volatile SD-card (durable, with extended temperature range – similar to SanDisk extreme) with a size of 8 GBytes. This size is sufficient for continuous recording of at least 12 months at a 200ms recording interval (5 Hz). This constitutes a backup to the rest of the data communication system that is discussed in following sections.

5. Recording Interval

The LOG_aLevel has different options to change the effective recording interval. The first option is to change the "sampling rate" (1/2/3/4/5 Hz) of the (internal) raw measurement readings. Based on these values an averaging at the station (none/10 s/30 s/1 min/5 min/10 min) is possible resulting in an effective longer sample period. For longer periods, the periodic measuring mode is implemented. Sleeping and measuring intervals can be configured freely from 1 min up to 24 hours.

To provide tide curves, the data are averaged with the LOG_aLevel software. For wave parameter estimation it is mandatory to sample with the 5 Hz mode. The 5Hz will then guarantee a high level of accuracy. A later averaging at the software for visualization only provides high quality tide curves too.

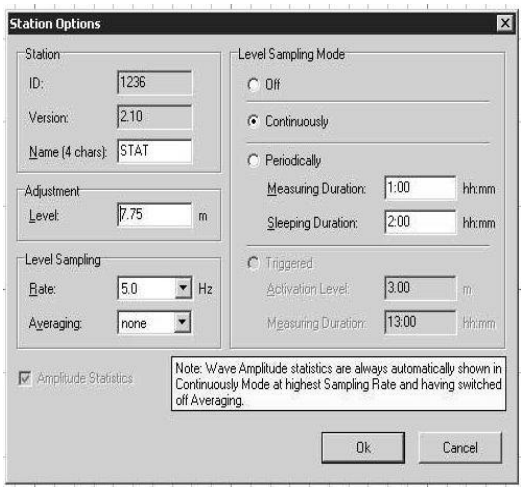

Fig. 3: Station Options.

6. Sampling Frequency

The measurement sampling frequency can be changed from 1 Hz to 5 Hz in 1 Hz increments. For optimal resolution of the waves and an effective good quality tide the 5 Hz sampling is recommended. Only at a very smooth water surface is a lower sampling possible.

7. Accuracy for Level and Wave

The accuracy of the level measurement is 1 cm with no drift and no need for calibration or additional adjustments. The system will be customized to the desired measurement parameter, whether mean wave level or otherwise.

8. Sensor

The LOG_aLevel sensor is a high quality, narrow beam, ultrasound sensor array with a measurement range of 11 m and a resolution of 1mm. This narrow beam is required to avoid disturbances at wavy surfaces or from nearby structures and to assure a proper spatial resolution for all kind of waves, thus achieving a high quality (wave level) measurement, independent from wave height. The narrow beam is essential for reliable wave parameter estimation and reliable measurements at extreme environmental conditions.

A separate high quality sound velocity measurement unit (REF300) for real-time sound velocity compensation results in a level measurement accuracy of 1cm. The sensor is made from stainless steel and is connected to the controller with a shielded, UV-stable, PUR sensor cable. This enables a robust and reliable measurement.

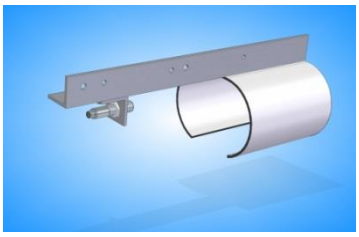

Fig. 4: The reference sensor REF300 unit.

LOG_aLevel Main Specifications:

Measuring range:	up to 11 m
Field accuracy:	1 cm
Resolution:	1 mm
Sample rate:	up to 5 Hz (1, 2, 4, 5 Hz selectable)
Averaging (HW):	none/10 s/30 s/1 m/5 m/10 m
(Software):	none/1 s/2 s/5 s/10 s/20 s/30 s 1 m/2 m/5 m/10 m
GPS synchronized RTC time accuracy:	25 ms (NMEA of WX150)
Telemetry output:	RS 232 (RS 485, LAN optional)
Frequency:	80 kHz
Sensor size/weight:	200x200x100 mm / 1.3 kg (incl. mounting plate)
Power supply:	230 VAC / 12V DC
Working temp:	-20 °C up to +70 °C
Storage temp:	-40 °C up to +80 °C
Size of housing:	50x50x20 cm

9. Flow / Discharge measurements

The flow and/or discharge measurements can be performed using different methods. The 1st method is with an initial survey of the region using ADCP technology and then calculating and predicting flow and discharge depending on tide, water level and actual environmental conditions. The 2nd method is using hand-held Electromagnetic flowmeters and periodically performing in-situ measurements. This implies simultaneous measurement of the depth of the flow-meter measuring point and the flow speed and the subsequent processing of the data for the estimation of the effective flow at the cross section. The 3rd method is to use Doppler Radar to measure surface flow and then combine this with a level measurement.

Of course, other measurement scenarios are possible, depending on the goal of the project, financial and time factors (also the available man-hours for in-situ measurements), as well as access to the measuring locations etc.

10. Meteorological and Hydrological Sensors

A vast range of Meteorological and Hydrological Sensors covering all possible phenomena can be connected to the LOG_aLevel system. This also includes complete Weather Stations. General Acoustics would recommend incorporating at least a rain gauge and a wind gauge for each measurement station.

11. Data communication

As shown in Fig. 5 below, any number of stations can be connected to a central station that collects all information and performs necessary processing and issues warnings (for flood, etc.).

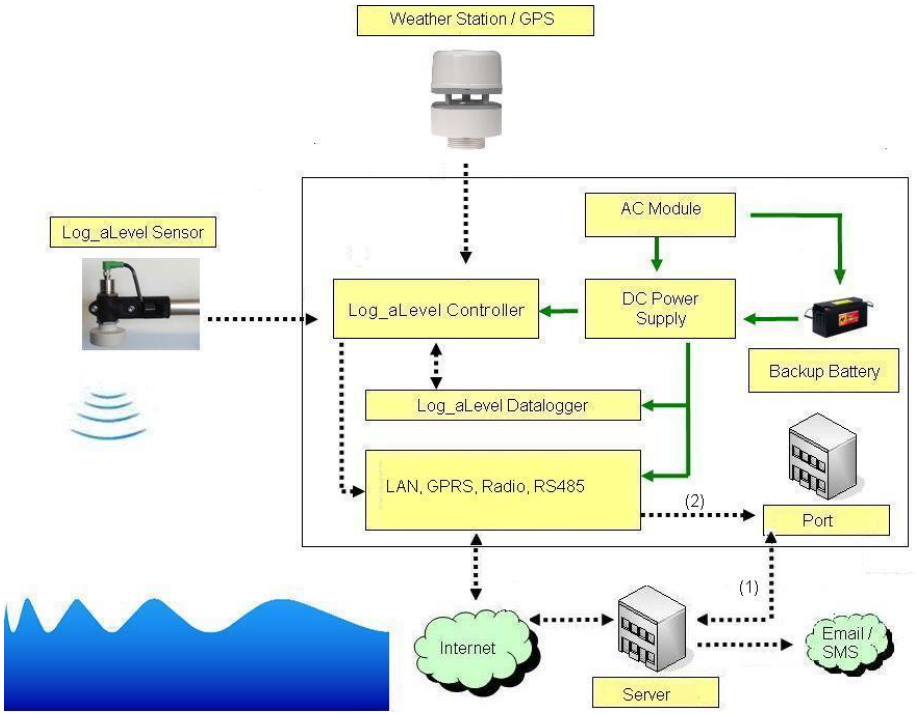

Fig.5: A typical monitoring network diagram. Any number of LOG_aLevel stations can be connected to a central system (given as "Server" above). A multitude of different meteorological and hydrological sensors and communication options can be seamlessly connected to the LOG_aLevel controller.

The data from all measurement systems (water level and weather stations) in each measurement location will be transmitted to a central station / server. Centrally, the data will be arranged in database(s) and websites for each measurement position with actual and historical data in textual and graphical formats. Furthermore, the central system will check that all data is completely and correctly received and if necessary ask the local systems to resend information. Also, the central system will process the data and issue warnings which will be forwarded by Email and SMS (Receiver lists are stored at the central station). At each measurement location it will then be possible to access the website(s) and view the data using any available equipment with Internet access.

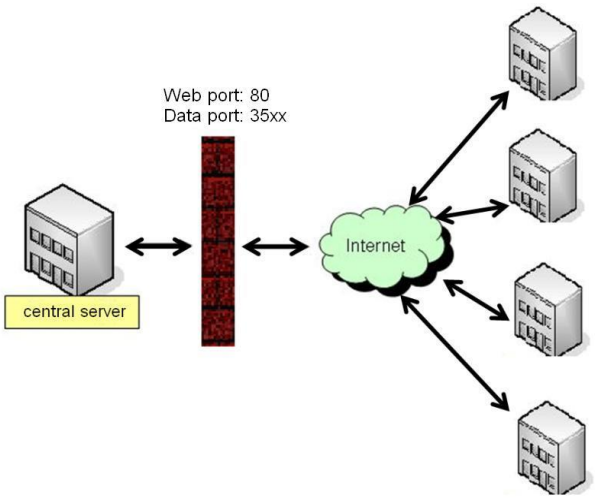

Fig.6: Central Station, firewall and terminals for data viewing.

Data will be send via GPRS from the measurement system to the central database. Regarding GPRS, it should be verified that the regions of interest are covered. General Acoustics can provide a number of other communication options as well.

For the central system, it will include a central database that will receive data from all stations. This can be implemented as a virtual machine with a Windows server running on a PC.

The central system infrastructure will include the PC running the virtual server (Proxmox VE 3.1 server) and an external UPS (uninterruptible power supply). The central system will verify that data are completely and correctly received, it will update the database, display actual and historical data through (password protected) websites, and post alerts when set thresholds for water level, wave height, flow or discharge are exceeded. The system will also issue alerts regarding the condition of the system and associated system maintenance information. Email alert service and business-grade SMS service provider can be used.

The server 19”, 3U comprises of an industrial mainboard with extended temperature range for reliable operation in non-air conditioned rooms. Interchangeable front modules provide configurations to exactly meet customer requirements. With the latest CPU technology and many expansion options such as front network ports or 2.5"/3.5" drive caddies, solutions for almost any demands can be satisfied on a single platform range. Operational servers can be upgraded just as easily.

Fig.7: Example IPC-Server (Database).

Optionally, the technology is available for 1U and 2U also. Finally, a long term availability of the IPC design/chassis for at least 12 years ensures availability of maintenance and service parts.

Additionally, the system is equipped with a redundant power supply and the system will be extended with an UPS for uninterrupted operation and an external NAS (3TB) for backup reasons (fast recovery after accidentally breakdowns).

Server specifications:
Destined server (Database) hardware:

- Processor……..Intel® Xeon® E3-1230 V3 (4 core, 3.3 GHz)
- Memory……..8 GB
- Storage controller……SATA, Raid
- Internal mass storage……SSD (operating system); 2x3.5”HDD-Raid 3TB (VMs and database)
- Hard Drive Bays……2x 3.5” SATA
- Removable Media Bays (DVD)……1
- Expansion Slot……1
- Form factor / Height……Rack / 3U
- Networking……..Integrated Dual Port Gigabit Server Adapter
- Redundant Power Supply……1 built-in power supply 460 Watt

If desired, a Hot Failover system can be implemented (complete backup to the server which will take over automatically if the primary server fails).

All systems will be ideally locally synchronized through a GPS. GPS information enables drift-free real-time clock synchronization and thus a reliable and identical time base for all measured data that minimizes time/date errors in the database and makes easier to make comparisons across stations.

If the server needs to be integrated to existing IT infrastructure, then the central system will be a (virtual) server running Windows. It is then required for the server to have a fixed WAN IP address (port with WAN connection and firewall access), where the measurement stations will be remotely connected.

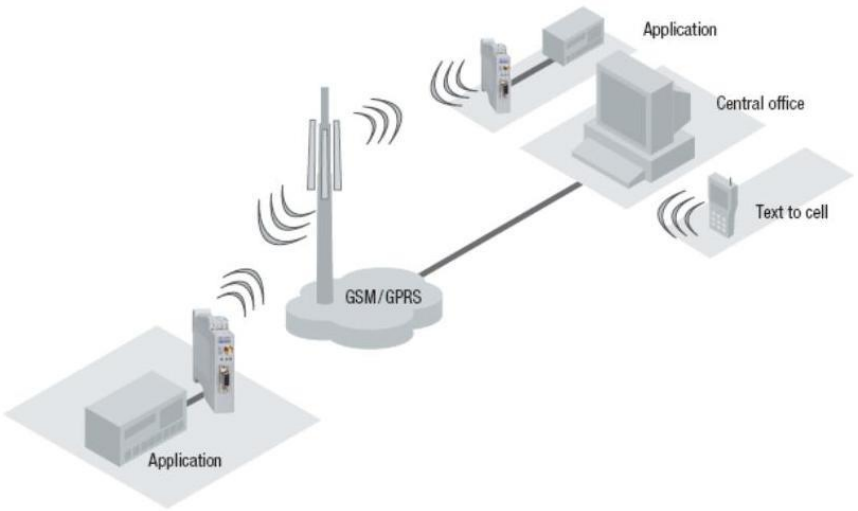

Fig.8: Principle of GPRS Data transmission

Although it is possible to send all data from the measuring system to the central database system, we consider this as a not sensible solution, because of the huge amount of data that will have to be transferred. We assume that it is desired to send a reduced data set instead of the 5Hz complete raw data, in order to reduce data bandwidth and storage issues. In this case, the actual water level, wave height,

flow/discharge and weather parameters will be transmitted, processed on 1 min periods or as otherwise agreed.

The system portal/websites can provide following actual and historical information in textual and/or graphical form (UTC-time based):

- Water Level
- Flow / Discharge
- Wind (speed, direction),
- Rain (Precipitation Sensor)
- Warnings