Waves play a central role in coastal formation. The creation of waves and their movement are therefore central factors in coastal morphology. LEGI (Laboratoire des Ecoulements Géophysiques et Industriels à Grenoble) is dedicated to this topic: scientists from the institute study wave dynamics, especially in flat environments, in order to gain detailed knowledge about the energy exchange between waves. The aim is to develop a wave meteorology whose effects are not only of immediate importance for shipping, but in the longer term should even serve to simulate the effects of climate change.
Waves in shallow waters have a different dynamic than so-called offshore dunes. LEGI is currently investigating random flat wave patterns and their effects on coastal morphology. In particular, the researchers are observing the formation and interaction of so-called solitons. These are waves that propagate without change of shape. The interaction of two solitons is elastic, i.e. there is no energy exchange but only a time delay. If many solitons interact, their frequency can become completely random, which especially changes their swelling. This in turn can affect the interaction between waves and structures, such as port infrastructures or wind farms.

The observation of these specific wave conditions requires a measuring tool that allows both spatial and time-resolved measurements. LEGI uses a specially constructed 36 m long and 50 cm wide wave channel.

This dimension requires cameras with a particularly large field of view in order to record the wave profile over a maximum length.

**High level of technical use**

LEGI commissioned the French company R&D Vision to integrate an appropriate camera system. The solution: a multi-camera application with eight synchronised IDS USB 3 UI-3060CP Rev. 2 cameras. Each of these cameras visualises a two metres long section through the glass side walls, with a millimetre horizontal resolution. This makes it possible to visualise a total length of 16 metres of the central section of the channel.
Two of the biggest challenges of this system are the throughput of the cameras and the associated storage capacity. For many years, R&D Vision has been developing specific know-how for recording images “direct to disk” at very high speed over long periods of time. The application described here has a RAID structure consisting of very powerful SSD disks, which guarantees lossless raw data acquisition up to a throughput of 1.2 Gb/s. The RAID structure is based on a high performance SSD disk. For recordings longer than 3h30, the storage capacity of the video disk is 15Tb - an important prerequisite for observing phenomena over long periods of time and investigating a longer sequence of experiments.

To ensure camera configuration and image sequence capture, R&D Vision has developed its own software suite that fully integrates all the specific functions of the IDS cameras. With a resolution of 1936 x 1216 pixels and a frame rate of 166 fps, the UI-3060CP-MGL Rev.2 is the perfect camera for the special speed and resolution requirements. The spectral sensitivity of the Sony CMOS sensor and low noise were also important selection criteria to ensure optimal image quality.

The USB 3 interface was chosen due to the large number of cameras, the throughput and the length of the cables. For the power supply of the cameras 20 m active cables are used.

The 36 m long and 50 cm wide wave channel is used to observe the specific states of the waves.
**Results**

Once the images are taken, LEGI scientists extract the water contact line at the side windows to reconstruct the water elevation, i.e. the change in water level, over a length of 16 metres. The selected camera model allows the researchers to achieve a very high vertical resolution of the water elevation of less than 100 micrometres, which guarantees very high measurement accuracy. In addition, the cameras’ maximum frame rate allows the temporal dynamics of the waves to be recorded.

For Nicolas Mordant, Professor of Mechanics in the LEGI Diphasic Flow and Turbulence Team, this is an innovative solution: “This camera system is the ideal tool for us to experimentally study the sea state, especially in the case of random events. The use of these 8 synchronized HD cameras represents a very original approach for extremely accurate, simultaneous space-time measurements”.

**Perspective**

Next, the scientists plan to build an artificial sandy beach at one end of the canal. The IDS cameras will be used to visualise the entire beach at the end of the canal and to carry out measurements using the PIV (Particle Image Velocimetry) method. The multi-camera system, consisting of 8 IDS USB 3 UI-3060CP Rev. 2 cameras, contributes to a better understanding of the effects of wave regimes on beach morphology.

The results of the investigations can provide important insights for the planning of coastal infrastructure, e.g. to better protect harbours or other settlements from the effects of climate change, such as flooding.
About R&D Vision:

R&D Vision is an innovative French company specialized in researching and developing measurement solutions with integrated acquisition and analysis of images for a wide range of applications.

http://www.rd-vision.com/r-d-vision-eng

About LEGI:

LEGI - Laboratory of Geophysical and Industrial Flows - is a public research laboratory of the University of Grenoble Alpes. The research in the field of fluid mechanics and transfer covers numerous fields of application within environmental as well as industrial issues.

http://www.legi.grenoble-inp.fr/web/

Camera:

USB 3 uEye CP - Incredibly fast, incredibly reliable, incredible sensors.

Interface: USB 3.0
Model: UI-3060CP-M-GL Rev.2
Sensor type: CMOS
Manufacturer: Sony
Frame rate: 166 fps
Resolution: 1936 x 1216
Shutter: Global Shutter
Optical Class: 1/1.2"
Dimensions: 29.0 x 29.0 x 29.2 mm
Weight: 52 g
Connector: USB 3.0 Micro-B, screwable
Applications: Astronomy, Biotechnology, IST (Intelligent Transport System), Visualisation and analysis, Low-light conditions, Quality assurance