The data ready signal from the A/D converter is used as IRQ7 (event 1 in figure 2). This signal produces a tree read cycles (24 bits data) and the data time mark is read. So, the SYSPP driver was designed to time stamp and data read every time that an IRQ7 is received. Data are stored in a buffer and later saved on hard disk. The figure 3 shows the data acquisition process.

This prototype of a digital seismic station was running at the ROA for several months with an excellent results (figure 4 shows an example), and nowadays is being modified including new data format (mseed).

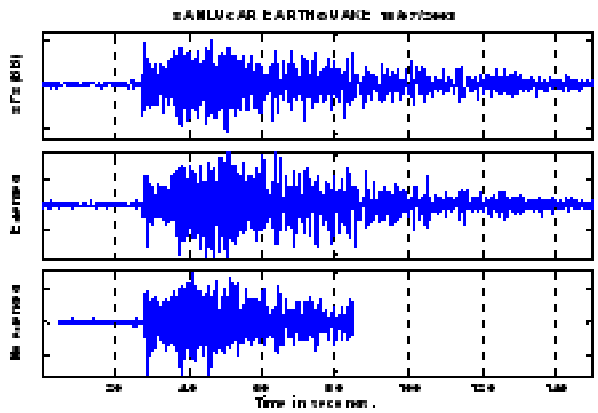

Figure 4. Sanlucar earthquake 18/07/2003 21:23:21, mb=3.7, recorded by 3 stations on the same pier.

3. Conclusions.

A high resolution acquisition system has been developed in the Royal Naval Observatory with an extended response. It is based in a Linux embedded PC.

Data are acquired using the parallel port and it allows save the two serial ports for external and GPS communications.

The software PLL time reference rise an accuracy better than 700 microseconds in the worst case.

EPP mode allows a high data transfer rate (>500KB/s) being the data read cycles hardware controlled.

A prototype was running at ROA for several months and nowadays is being modified. A new prototype will be available in a few months to upgrade the ROA short period network.

4. References

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A new software tool for Wide-Angle reflection/refraction Seismic data Processing And Representation (WASPAR)

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1. Introduction.

The seismic methods are the most powerful existing techniques to image the structure of the Earth's subsurface at different scales. Depending on the system layout, the seismic methods can be divided in: near-vertical reflection (NVS) techniques and wide-angle reflection/refraction (WAS) techniques. In contrast to NVS, where a wide number of tools have been designed by oil industry, the development of WAS pre-processing tools has deserve only minor attention to date. Most existing tools have been developed by research institutions in order to read raw data from their own instruments, construct and display the record sections, and pick the seismic phases. WAS processing is also done using existing tools as Seismic Unix [1], but these tools have been chiefly designed for NVS geometries and not all the techniques are therefore well-suited for proper WAS processing.

With all this information at hand, the main purpose of this work has been to develop a new tool for WAS data representation and signal processing. We have thus created the multi-platform modular software tool WASPAR that allows a user to represent and process data from its initial state (raw data) to its final state (processed record section) using a unique and friendly interface. WASPAR has been designed using a plug-in architecture to manage all processing modules and raw data access. In that way, it is easier to maintain the software tool as well as to expand it with new functionalities. We have chosen C++ programming language to facilitate the development of a multi-platform software tool, which is already available on Linux and MS Windows.

2. Program description

The tool we have developed is an open and free multi-platform software. It has been designed as a generic tool, originally developed to process active wide-angle reflection/refraction data using a unique interface. The main implemented functionalities in this first release are those necessary to process wide-angle data.

Firstly, the program can potentially read raw data recorded by any supported equipment. We have implemented a plug-in architecture to simplify the process of adding any new raw data format. Hence, when adding a new format, one just has to define a new library (or plug-in) which the program will be able to interpret. WASPAR can then use this raw data to create a time representation or a record section.

Secondly, the program is capable of performing two different types of representation: record sections or time series. In the first one the data created in the generation process or the data read from a seismic file in SEG-Y or SU (Seismic Unix) format are displayed into traveltime-offset diagrams (Figure 1). The representation is then made taking into account some parameters such as fixed-gain, distance-gain, threshold and speed reduction. All of them are auto-adjusted by the program but the user can check and modify them by hand. It is also possible to perform phase-picking operations over the record section representation. In time representation mode, the program uses a single trace from the record section or a raw data trace. In both representation modes, the user is able to perform various types of zoom and to send the representation to the printer or to an image file that handles different formats.

Finally, the program includes a number of processing facilities and, thanks to its plug-ins architecture, allows easily implementing new ones. Each processing technique is included into a different library that is recognised by the program. The first release includes two

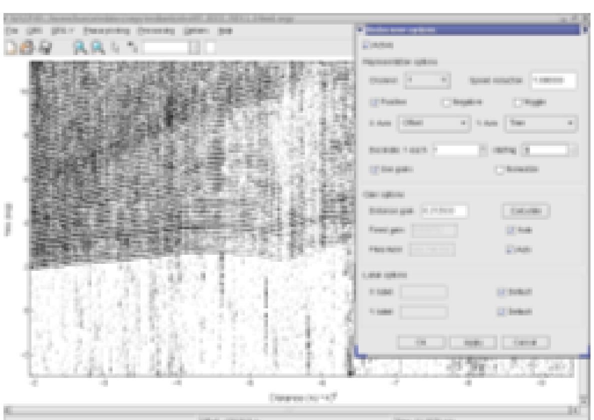

Figure 1. Main program window.

processing techniques consisting in a simple frequency filter and a more elaborated one based on polarization properties [2].

3. Program design

We have designed the program to be modular in order to simplify its development and maintenance but specially its expansion. For that reason, all the functionalities described above have been encapsulated into modules trying to make them as transparent as possible. As shown in figure 2, the program has three main modules: the program base (M-I), the record section generation (M-II) and the plug-in module (M-III).

The program base has been sub-divided in three modules (as depicted in figure 2). M-I performs the main functions of the program and controls the execution of the other two modules. It controls all the file access operations such as loading, saving and format conversion. It also performs all the representation operations such as zoom, phase-picking, control of parameters and image output to printer or file.

The record section generation module performs the fusion of navigation data with station data based on some parameters given by the user. With a wizard-like interface, the module incorporates all the necessary information to correct station clock drifts and perform the fusion. The result of this fusion is a record section that can be saved to a file.

The plug-in architecture makes the program scalable and easily expandable: usually, when a new functionality has to be added to a software package, the source code must be modified and re-compiled. With this architecture, when a new functionality is needed, it only has to be created

Figure 2. Program Flux Diagram

a new plug-in without changing the program source code. We have used this architecture to manage all the processing techniques and the different raw data formats.

4. Future work

There are still some functionalities to be added to this software package. The most important one is an algorithm to relocate receivers in marine experiments using OBS (Ocean Bottom Seismometers), where the position of the instrument is not exactly known.

Apart from this, we are developing new signal processing techniques suitable for wide-angle seismology that will be added to the program in the future. We are now working on phase-weighted stack algorithms [3], in order to adapt them to the processing sequences of wide-angle seismics.

5. Acknowledgement
This work was supported by the project SigSensual ref. REN2003-08341-C03-C01-02 and CTM2004-04510-C03-02, the Marine Technology Unit, the Public University of Navarra and the Catalan Polytechnical University, SPAIN. I. Rodriguez and C. Simon are financed by I3P contracts.

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Signal processing techniques applied to seismic signal detection

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1. Introduction
Wide-angle reflection/refraction seismics (WAS) is one of the most commonly used techniques to determine the structure of the Earth's crust. The acquisition system includes a number of energy sources and receivers located at increasing distances from the sources that record both the reflections and the continuous refractions of the seismic waves propagating into the medium. Data are represented in the so-called record sections, which display recordings of the different sources registered by a given receiver (or vice-versa) into offset-travel time diagrams.

Useful seismic phases present in the record sections are usually masked by different types of noise, which may be caused by the instrument (electronic noise, quantification ...), by the environment (ship noise, cetacean, sea wave course, currents ...), or even by the signal itself (higher order reverberations and scattered signals which obscure later arriving prominent phases). In order to obtain as much of the valuable information contained in the record sections as possible, it is necessary to process the collected data in order to either (1) improve the signal to noise ratio, or (2) remove or attenuate some well characterized phases, such as the water wave or the first reverberations.

Most of existing techniques to improve the signal to noise ratio assume that noise is stationary and Gaussian. However, this is usually not the case, so it is necessary to apply alternative techniques for an improved signal detection. These methods are usually based on nonlinear signal processing techniques that make use of other signal properties that are more robust against outliers, such as median estimators.

2. Polarization filters
One of the techniques used in order to distinguish signal form noise are filters based on the degree of polarization [1-2]. [1] and [2] define a signal by an arbitrary but constant polarization throughout the course of the signal. This means that these filters use the complete wavefield, i.e., the three components of the geophone, to measure the variation of polarization along traces regardless its category (lineal, circular or elliptic) or direction.

According to the characteristics of the signal to process, we have considered two related techniques: one works in the time domain, whereas the other one works in the time-frequency domain through a windowed Fourier Transform (e.g., Short Time Fourier Transform, S-Transform). Alternative approaches, such as the Wavelet Transform can be employed.

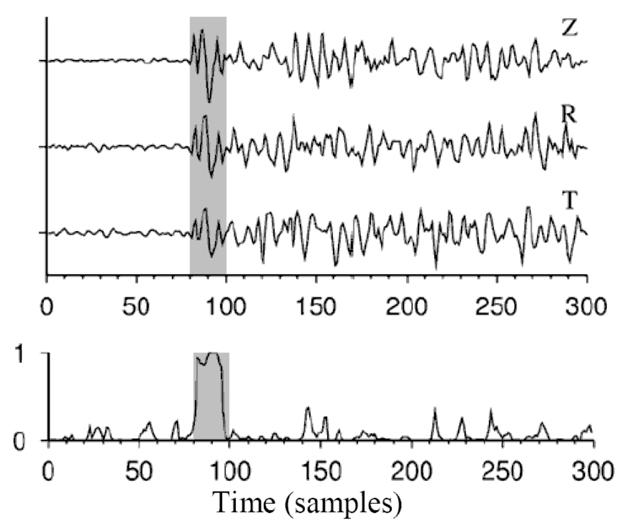

Figure 1: Three-component test data and its degree of polarization. The polarized signal is indicated by the grey background.