Operational Radar to For Every drill string Under the Street
Grant agreement no: 308356

Bore-head Radar Software Requirements

Deliverable 2.8

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Dissemination level		
PU	Public	☒
PP	Restricted to other programme participants (including the Commission Services)	☐
RE	Restricted to a group specified by the consortium (including the Commission Services)	☐
CO	Confidential, only for members of the consortium (including the Commission Services)	☐

Preface

This deliverable is prepared within the framework of ORFEUS project (Grant agreement no: 308356), supported by the 7th Framework Programme.
ORFEUS aims at progressing the prototype HDD bore-head radar technology that was developed under the preceding FP6 financed project entitled "Optimised Radar to Find Every Utility in the Street".

Horizontal directional drilling (HDD) offers significant benefits for urban environments by minimising the disruption caused by street works. Use of the technique demands an accurate knowledge of underground utility assets and other obstructions in the drill path. its aims is to design a prototype innovative ground probing radar (GPR) based real-time obstacle detection system to increase the safety margins of HDD to allow its use in the widest possible range of conditions.

Extensive testing and validation, as well as supporting the demonstration and exploitation of the final product, is proposed. The crucial testing and evaluation phase will assess the risks, confirm environmental benefits and increase end users' (public authorities and industry) confidence, awareness and uptake of this new technology. Technology transfer, training and standardisation, in cooperation with European standards organisations, will also be a significant element of the project.

Consortium

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Abbreviations

tbd = To be defined (an item where the general requirement principle is established, but the actual values will be defined in the detailed design phase.

tbc. = To be confirmed (an item believed to be correct and to be used as a working value, but will require confirmation during later detailed design phases.

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ORFEUS Deliverable D8 WP2 task 2.1

This document describes the functional requirements that will be addressed during the development of the Bore-head Radar software.

This development is a crucial task for ORFEUS as the software is the main interface between the operator and the machine; the former ORFEUS project has already established key requirements for the software, covering aspects relating to the operability of the system, the multi-language interface, as well as the desired output (2-D or 3D representation).

It is worth remembering that, at the end of the previous research, prototypes of a data acquisition and real-time processing software was available both of which had limited graphical capabilities and real-time performance.

For these reason, the current project aims at filling this gap and at building the capability of generating an exhaustive representation of the underground scenario, easily interpretable from a non-expert user that has to manage all these information to avoid collisions and damages.

In the following paragraphs, after a short overview of the application and a summary of end-user requirements determined from the previous ORFEUS project, the Bore-head Radar is described in terms of its main components, the expected performance of which are specified.

Conclusion

End user requirements for the Bore-head radar software were established during the previous ORFEUS project (Contract n° FP6-2005-Global-4-036856) and listed in the Deliverable D6a.

Task 2.1 of the current project had the objective of summarising functional requirements for the software development by considering the man/machine interfaces (hardware setup, interfaces to the drilling equipment, data display features), the data communication protocol and the system self-test procedures to be executed while collecting the data.

In this deliverable, according to their nature, requirements are split into three main groups (main functionalities, input-output functionalities and internal/external interfaces; moreover, a preliminary software architecture is also proposed.

2   SUMMARY OF USER REQUIREMENTS

The purpose of the bore-head radar is to provide the drill rig operator with sufficient advance warning of obstacles present in the vicinity of the pilot bore so that appropriate action may be decided upon and taken to avoid problems and accidents.

Implicit in the application is the requirement to have an operator display of a processed version of the radar data so that the geometry of the relationship between detected objects and the bore-head can be visualised.

However, the form of the display needed for this purpose is quite different from those that have been developed over a number of years for interpreting data obtained from surface based radars. The information presentation system must be as simple as possible consistent with supplying the required information.

Moreover, the design of the software must take into account that, during the drilling operation, the operator must deal with several items of information about the status of the machine (e.g. pulling force, bentonite flow, etc.). Consequently, the processed output from the radar must be very easy to understand and immediate; it is a key requirement that the software output is user-friendly and extremely robust to withstand the operational environment.

Following paragraphs summarise the end-user specifications as established during the previous ORFEUS project (Contract n° FP6-2005-Global-4-036856, Deliverable D6a).

2.1   REQUIRED OUTPUT

2.1.1   MAIN REQUIREMENT

Data display should:

- present the position of detected objects to the operator, preferably in 3D, but, alternatively, the 3 views may be displayed in three separate graphs
- present the position of detected objects to the operator in one of at least **30°** segments in the plane orthogonal to the axis of the bore-head (measured from the vertical position in a clockwise direction from the operator's perspective)
- be located at the display unit of the seat in the operator's cabin at the drill rig.

2.1.2   OPTIONAL REQUIREMENT

When the bore process has been stopped because of the detection of an obstacle, more detailed data about the obstacle (classification, material, size, distance to bore-head, angle) shall be presented in the operator display, and the information shall be retained. Also, time, roll angle of bore-head, length of bore so far shall be retained

2.2 REQUIREMENTS ON MAN-MACHINE INTERFACE

2.2.1 LANGUAGE

The software man-machine interface should be available in several European, and other, languages

2.2.2 USABILITY OF THE SOFTWARE

The software must be designed to be used by a properly trained operator, who has, at least, a secondary modern school qualification and is able to read and understand simple technical drawings and plans (3D imaginative capability)

2.3 REQUIREMENTS ON SOFTWARE INTERFACES

2.3.1 INTERFACE WITH THE DIRECTIONAL DRILLING EQUIPMENT

The communication protocol must ensure that there is a permanent communication between the down-hole electronics and the HDD machine control. Moreover, the software must not interfere with the control system of the HDD machine.

2.3.2 INTERFACE WITH OTHER SOFTWARE

An interface between the HDD bore planning software and the bore-head radar data processing software is required to allow data comparison and to produce an alarm event report

3 BORE-HEAD RADAR SOFTWARE REQUIREMENTS

3.1 SOFTWARE FUNCTIONALITIES

The software has to accomplish the following features:
- Collect, process in real-time and display data generated by the Bore-Head Radar
- Configure the system parameters
- Produce a warning, in real-time, if an object is too close to the drilling trajectory
- Store the collected data into a permanent support system and allow data review

3.1.1 OPERATIONAL

The software must be synchronously activated/de-activated synchronously with the HDD operation; particularly, a new data collection process is started each time a new rod is connected and the data-link with the radar is established and stopped before connecting the next.

All the software parameters/variables shall be properly dimensioned.

3.1.2 RADAR SETUP

The software must programme the radar control board according to pre-defined or custom parameters; in detail, it has to set
- The antenna energising sequence
- The inspection range
- The number of samples being extracted from the radar trace
- The transmission frequency.

3.1.3 RADAR DIAGNOSTICS

Once the radar board has been programmed, the software has to verify that the operation was successfully completed and, eventually, to produce a warning message.

The following self-test operations have to be executed and verified:
- Power supply verification (voltage level)
- Data-link test
- Radar signal test (presence/amplitude)

If a test is not passed, the software has to inform the operator with a suitable message, the description of the problem and some hints on its solution (if applicable).

The diagnosis is repeated in real-time during the acquisition to assure the correct working of the system.

3.1.4 MANAGEMENT OF POSITION INFORMATION

The software shall manage the position information generated by the HDD and by the tilt angle sensor; the information is used to reconstruct the position of every collected radar trace.

3.1.5 REAL-TIME PROCESSING

The software shall be capable of real-time processing the radar traces by executing (at least) the following steps:
- Band-pass filter
- "time-zero" correction
- Background removal
- Moving average filter
- Gain

3.1.6 TARGETS DETECTION

A double-threshold detection strategy will be implemented and used to produce a warning, in real-time, if an obstacle is too close to the drilling path.

3.1.7 DATA STORAGE

All the collected radar signals and the position information will be permanently stored in appropriate media.

3.2 MAN-MACHINE INTERFACE

3.2.1 USER INTERFACE

The software will implement user-friendly graphical interfaces that can be operated by using a touch-screen.

3.2.2 DIMENSION AND CHARACTERISTICS OF THE DISPLAY

The software will be designed to be compatible with the operator display on-board the HDD. A 3-D view of the collected data (in polar coordinates) shall be available.

3.2.3 SOFTWARE COMMANDS

Main software commands will be operated by pressing graphical buttons on the display, whose dimensions will be optimised according to the screen resolution and the typical fingertip size..

3.2.4 LANGUAGE AND MEASUREMENT UNIT

Commands that are not identified by a graphical symbol, will display a textual description that can be translated into all of the languages allowed by the software.

The change of the software language will be operated by using a proper command in the software itself.

Similarly, it will be possible to switch between different units of measurement (i.e. SI and Imperial).

3.3 INTERFACES WITH OTHER HARDWARE/SOFTWARE

3.3.1 HDD HW/SW COMPATIBILITY

The software will run on the same computer operating the HDD machine control; therefore, computational load and graphics have to be compatible with its performance and features, as well as with the software implementing the HDD guidance.

3.3.2 INTERFACE WITH OTHER SW

The Bore-head radar software will be capable of accepting input from the drilling planning software and to export data in a format readable by that software.

4 PRELIMINARY SOFTWARE ARCHITECTURE

Based on the content of previous paragraphs, it is possible to imagine a preliminary architecture for the Bore-head radar software.

Particularly, the following modules will be integrated in the software package

1. **Main User interface**, which includes the radar data display;
2. **Application manager**, that manages all the processes and the data flow from/to the user interface;
3. **Linear position sensor data acquisition**, which manages the position information communicated by the HDD;
4. **Angular position sensor data acquisition** that manages the angular information produced by the tilt angle sensor;
5. **GPR acquisition** which manages the radar data throughput and constitutes the main interface with the radar;
6. **Data Manager** which includes two sub-modules and performs the following features:
    a. Receive the radar data, process and store them in a data file (Processing manager).
    b. Correlate the radar data with the position information (Trajectory manager)
7. **Diagnostic Module** that verifies the proper working of the system by performing a continuous check of the whole hardware.

Following

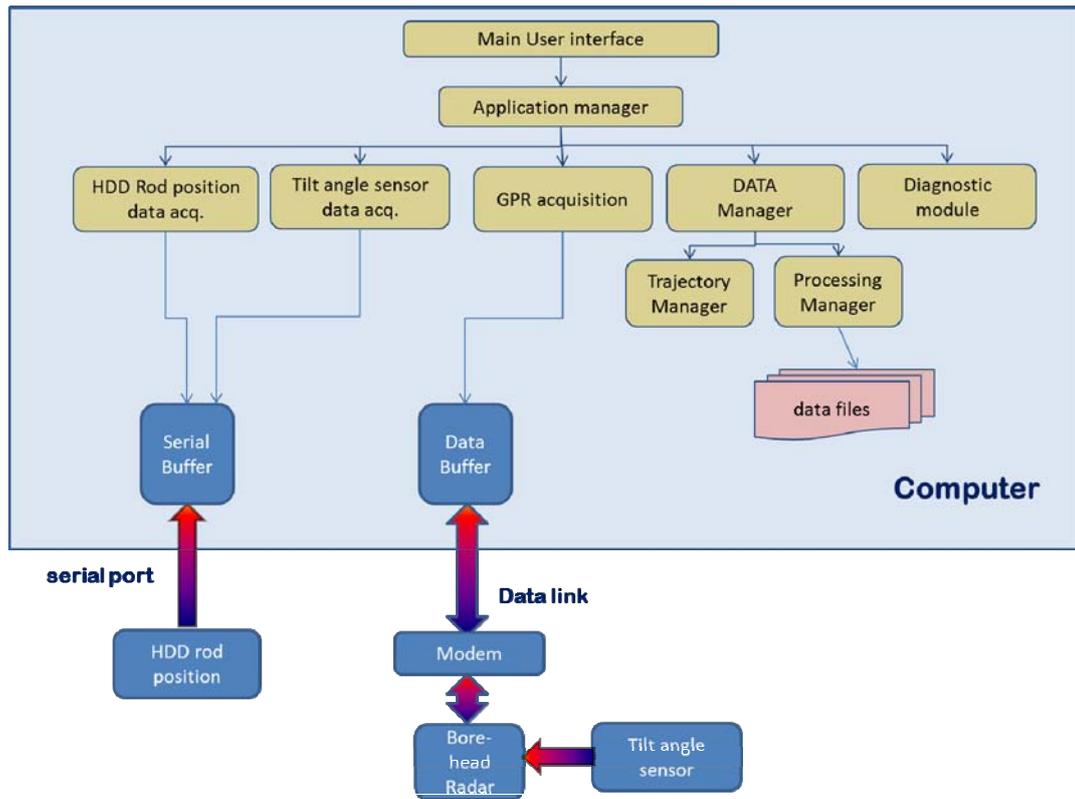Figure 1 sketches a preliminary architecture for the software and the links between the different modules.

Figure 1: a preliminary architecture for the bore-head radar software