TELETOWER Project:

Remote control and telemetry platform for Telecommunication tower management

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25/03/2015 – Rev.1

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CERSA SGQ certificate no. 724-UNI EN ISO 9001:2008
share capital € 1,400,.000.00 paid-in
Rome Companies Register no. 2891/88
Rome C.C.I.A.A. no. 652862
tax code no. 08246500584
V.A.T. registration no. 02000091005

SUMMARY

1 Introduction

In order to be able to offer their services to various customers, the operators of the Telecommunications Industry make use of a series of infrastructures, mostly masts or towers, designed to house the television and radio equipment, as well as telecommunication systems, located throughout the country, mainly in mountainous areas where access during the year is difficult, with service areas in non-urban areas.

These stations house various equipment which require regular, professional maintenance to ensure that they work properly over a period of time.

Tecnorad Italia S.p.A. offers a range of services in this regard, including hosting at its transmission stations and routine and extraordinary maintenance of the equipment.

The maintenance process requires the need for constant monitoring of the station and the structure: access controls, the presence of people, the presence of smoke, state of cleanliness, etc.; and the equipment housed, in order to satisfy the quality criteria required by customers and to comply with the obligations and times laid down in the contracts.

The TELETOWER project therefore has the aim of improving the internal process regarding maintenance, but also and, in particular, of improving the quality of service through the study, analysis and implementation of a remote control and remote management system with innovative functionalities, dedicated specifically to the management and maintenance of remote telecommunication systems.

The transmitter-receiver systems are usually installed in remote areas, which are difficult to reach. To guarantee the best possible operating efficiency and continuity of service required by operators, it is of vital importance to be able to fully control and manage these systems remotely, and, in the event of a fault, to ascertain the type of fault immediately and the replacement parts needed in order to be able to organise the repair operation as efficiently as possible; in this way, the quality of service can be improved and a 30% reduction in the number of site visits achieved at the same time.

1.1 Objectives of the Teletower System

The TELETOWER platform adopts protocols and standards that are currently widely used, which means that one is not tied to a single brand and it is possible, each time, to select the most suitable product without upsetting the configuration that will be implemented, to display the status of the systems at the various platforms, not tied to the operating system used, to adopt a suitable communication channel based on the situation one is in, to allow the implementation of advanced functionalities for the streamlining of maintenance operations, to allow integration with corporate ERP and CRM to make reporting more efficient and cut costs.

Through the TELETOWER system it is possible to keep systems under control in real time and receive alarms if there are faults in the various system components. The architecture of the system and the functions implemented make it possible, if there is an alarm, to remotely analyse and best understand the nature, cause and specific components that need replacement and/or maintenance. This makes it possible to be kept informed extremely quickly, to organise intervention effectively and thereby cut down the time needed to restore operation. This translates into a higher level of continuity of service for customers.

The constant monitoring of the system, the historicization of events and the detailed analyses of the causes of breakdowns, make it possible to implement pro-active maintenance, which consists of managing to anticipate the level of wear and probability of breakdown of components. In this way, it is also possible to plan the replacement of critical components during scheduled visits, reducing operating costs and, at the same time, the probability of breakdowns and the system being out of commission. In addition, the statistical analysis of the data enables energy efficiency functions.

The historicization and reporting functionalities make it possible to always have the status of the maintenance and interventions updated in real time thereby guaranteeing customers maximum visibility and transparency for the work carried out, streamlining and simplifying administrative and management procedures.

1.2 Strong Points of the Teletower platform

- Total modularity, both at hardware and software level, which allows an incremental approach to customers and to the market.
- A platform with an open architecture, produced with the most recent technological solutions capable of guaranteeing the maximum level of interoperability with any type of equipment or brand.
- Ease and speed of programming and personalisation of the functionalities.
- Website monitoring interface and compatibility with mobile platforms to guarantee maximum operational usability.
- Sending of notifications by email, SMS or push on applications for smart phones or tablets.
- Remote management of facilities and systems also through automated management procedures.

- Integrated management of systems, equipment, supply systems, access control, security and monitoring of energy and environmental absorption.
- Remote management of access to station. The simple management of access to remote stations often conceals a series of problems, especially in the handing over and return of keys to in-house and external personnel and in the authorisation and registering of these accesses. Better management could therefore provide greater protection to all transmitters housed in the infrastructure, eliminating or, at least, reducing unauthorised installations of aerials, and give an alert in the case of violations for the purpose of theft or damage through acts of vandalism.
- The analysis and historicization of data can implement pro-active maintenance procedures.
- High level of personalisation.
- A platform that is geared up to be rapidly configured for use on other applications as well and in adjacent markets like building management and security.
- Monitoring systems complete with systems through analysis of emission levels through radio frequency.
- The TELETOWER platform and its remote and environmental monitoring functionalities make it possible to implement energy efficiency solutions on-site to cut down operating costs, not only as far as the management of transmitting-receiving equipment is concerned, but also, and above all, as far as the energy component of environment conditioning is concerned.

1.3 Description of the Platform

The main objective of the TELETOWER platform is to optimise the maintenance process and improve the quality of service.

The pilot project presented has been produced and installed on three Tecnorad Italia S.p.A. stations, specifically the Montecompatri, Terminillo and Campocatino sites.

2 General description of the Teletower system

The objective of the TELETOWER platform is a SCADA remote centralised management system which allows the monitoring and control of the status variables of each station and piece of equipment housed therein. It also carries out the acquisition, management, processing, statistical analysis and historicization of data to make maintenance operations increasingly targeted and effective and to provide an innovative support tool for decisions for the optimisation of management and the optimisation of energy consumption (particularly electricity and thermal) of telecommunication sites in general.

The system is composed of the following elements:

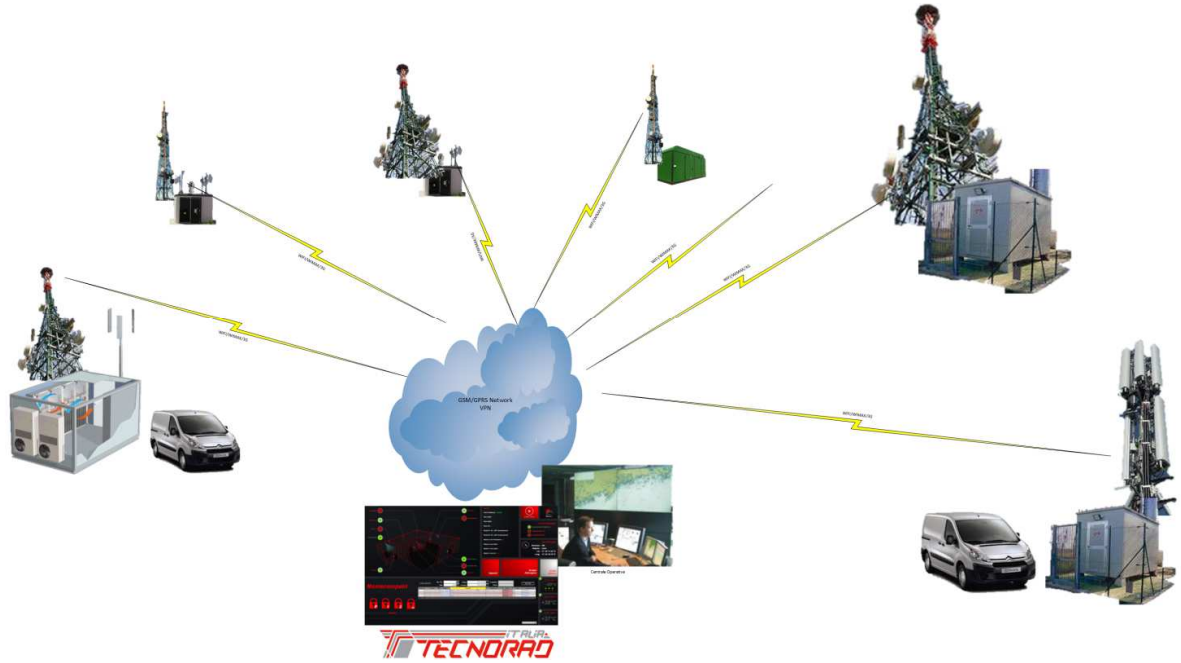
- Field equipment and related application software.
- Data processing central server and operations centre.
- SCADA application software at operations centre.

2.1 System architecture

The design of the system architecture, the identification of the hardware and software configuration to use, also integrating third-party components, have been developed by Tecnorad with a view to improving the efficiency and quality of the management service of the operational sites.

The system therefore has a modular architecture to make it easy to incorporate at all levels typically necessary on a remote control/management system, for telecommunication applications, but which can also be used for other applications such as, for example, building/plant management, etc.

The figure below shows the system general architecture:

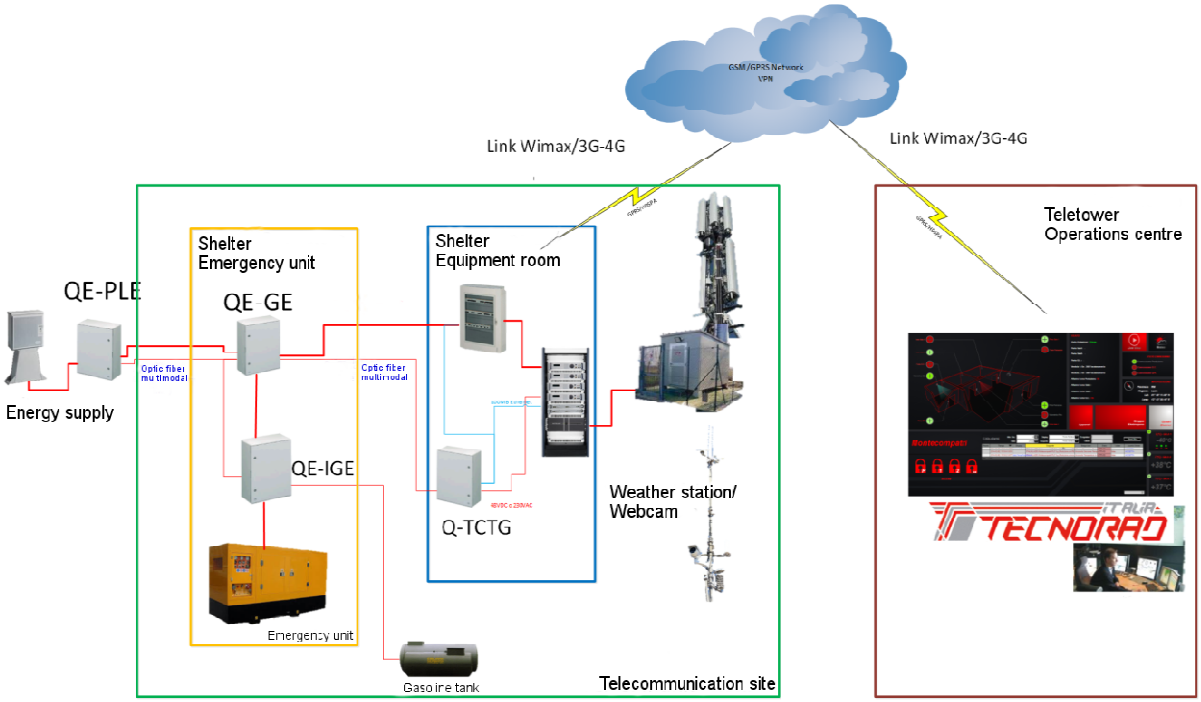


In general, many remote telecommunication sites, made up of electrical systems, shelters, radio equipment, masts, aerials, are managed locally by one or more remote control stations, which communicate with the Tecnorad operations centre, operating 24 hours a day. The remote units, together with the operations centre, monitor the status of the systems, the electrical absorption and all the main operating parameters of the site based on the specific indications of the operators.

The architecture of the TELETOWER system has therefore been designed from a "product" aspect so that it can be easily adapted in a modular fashion to the various configurations with minimal changes, both at hardware level and at software level.

A telecommunications site generally comprises, as illustrated in the figure below, the functional elements described in the list below.

- Electricity supply point from the grid
- Emergency generator(s)
- Transmitter/receiver equipment room
- Aerial mast



The field components communicate with each other through a local network made from fibre optics in order to make the connections secure and reliable, in spite of the complexity of the environment, the sections of connection in the open air and the presence of electromagnetic sources.

The field equipment therefore communicates with the central system and the operations room through the telecommunications sub-system, which involves both the use of wired connections or, where available, wireless connections, Wi-Fi, WiMax or GPRS/3G/4G mobile network. The TT-COM sub-system has been designed to be able to guarantee maximum security and reliability of communications in all weather conditions.

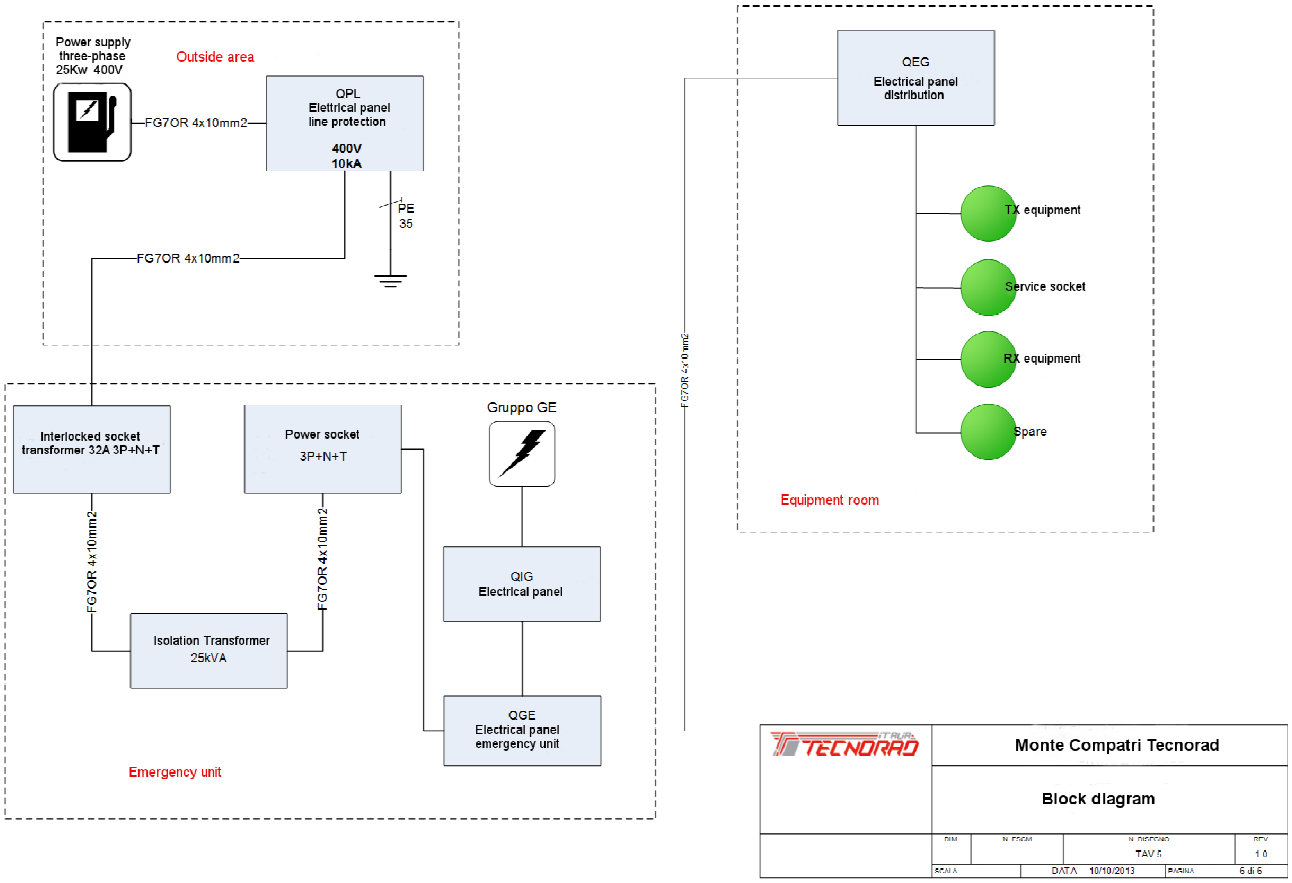
A standard platform was used at application software level, based on widely-used SCADA systems, such as the OPC server, and it is capable of also offering the maximum level of interoperability if existing platforms developed by third-parties need to be integrated.

The architecture therefore satisfies the requirements for the operation of the system in as far as the structure of the platform is flexible with a second level that can be realised both at software operating level and at hardware/software operating level, according to specific requirements.

It is important to stress that one of the fundamental requirements of the TELETOWER platform is being able to guarantee the collaborative operation of all the various components and sub-systems. As far as the troubleshooting and analysis of any on-site problems, identifying the solution and planning the intervention are concerned, it is necessary to be able to carry out a detailed analysis cross-referencing the various data that can be obtained. Very often a single fault is reported, but if it is not suitably correlated with other information, it is not possible to reach a precise and detailed diagnosis of the problem.

3 General description of the radio-communications site

The diagram below illustrates the Montecompatri radio-communications site, but it can be considered as a typical radio-communications site. The diagram has general validity and tries to clearly and simply extract the main physical and functional blocks which make up a typical site for the purpose of identifying the main sub-systems and functions that need to be monitored and managed by the TELETOWER system.



4 Field operation of the TELETOWER system

- Function of monitoring and managing the supply systems
- Monitoring and managing the network supply line (TT-PLE)
- Monitoring and management of emergency generation system (engine generator)
- Monitoring and management of consumer supply lines
- Measurement of consumption and electrical/energy parameters
- Monitoring of internal location environmental parameters
- Monitoring of external environmental parameters
- Functionality of monitoring telecommunication equipment
- Monitoring telecommunication equipment electrical parameters
- Monitoring telecommunication equipment operating parameters
- Monitoring RF parameters
- Safety functionality for the protection of the site
- Site access control functionality
- Fire-prevention functionality in both emergency generator technical rooms and in the technical rooms.

4.1 Weather station

In order to best plan the intervention in terms of times and/or equipment needed, it is helpful to know the exact weather conditions at the site. Direct knowledge of the weather conditions can also play a vital part in the analysis of certain types of equipment malfunction possibly linked to precipitation and/or snow.

For this purpose, the TELETOWER platform includes the installation of a met mast capable of measuring the main weather data in real time and sending them to the operations centre. There are different types of met masts of various qualities based on the site and its geographic location.

The weather station also uses one or more web cams to provide visual feedback on the weather situation detected by the sensors.

4.2 Communication function

Both for its own operation and to provide service functions, the TELETOWER platform is capable of implementing various type of voice, data and video communication.

The system can manage many of the system functionalities totally independently, without any connection to the central servers or the operations centre, although the presence of stable and effective communication is of vital importance for the overall efficiency of the system.

In order to guarantee continuity of service even if the main carrier fails for technical reasons, the sub-system has been designed to offer the necessary redundancy levels.

The operations centre can communicate on GPRS narrowband, ADSL broadband, WiMax/3G/4G and GSM (SMS).

There is a network front end, which can be reached by a public IP address with the capacity to establish connections with any of the services required and, specifically in VPN mode with the TELETOWER system field units.

The router creates the local network and the VPN through the operations centre remote server. The connection is made through the preferential communication channel for each site and, if there is no connection, through the backup channel.

The local network at a typical telecommunications site comprises 3 different levels of connection:

- external data between the various technical rooms/shelters
- internal data to the technical rooms
- wireless

Given the particularly different environment from an electromagnetic aspect, the external connections between the various technical rooms and/or electrical panels are created solely by means of multi-modal type fibre optics.

In general, there has been no need to use redundant solutions, however for particularly critical types of site it is possible to simply and without big changes to the basic architecture, implement redundant solutions such as HiPER-ring with redundancy on the same type of network, or on different networks, e.g. wireless.

In general, the equipment installed inside TELEPOWER panels has fibre/copper conversion and concentrators, as necessary.

The remote control system manages a local access point wireless network aimed at providing local and/or more/internet connectivity to the operators during maintenance. The local wireless network is therefore used for connecting laptops, tablets and smart phones to the local site network or the Internet.

The local network has a hidden SSID that is not visible and all the necessary wireless cryptographic protection to prevent unauthorised access. In future, hot-spot type access mechanisms with radius server access control and notification of the connection in the operations centre will be implemented.

The TELETOWER operations centre will therefore be capable of controlling all Internet traffic generated by the sites through the WAN connection in VPN.

There are also plans for voice over IP and video over IP (TT-VOIP) for onsite operational personnel provided by a server in the operations centre.

4.2.1.1 Telecommunications network remote management

TELETOWER uses a broadband or narrowband connection between the remote sites and the operations centre for the correct operation of the system. The connection must be able to comply with all the safety criteria applicable to this type of application and necessary to protect the integrity of the telecommunications sites.

Communication takes place at an adequate level of encryption, via VPN connection always activated by a peripheral unit to the operations centre. For safety reasons, the remote site cannot accept incoming connection requests.

Connectivity is guaranteed by broadband services already present at the site, such as, for example, the WiMax networks. However, to guarantee maximum redundancy in communication and ensure that the remote units can always be reached, there will also be a GPRS/3G/4G connection which will be automatically activated if the main connection fails.

The GSM service guarantees an SMS call back capacity from registered numbers to activate the VPN connection to the control centre if the remote unit does not connect automatically.

The system monitors and provides information on band consumption and occupation and, where possible, configures QOS services to optimise the quality of services and differentiates between basic TELETOWER services and additional services like video/VoIP.

4.2.1.2 Broadband communication

The field equipment has routers and an ADSL/Wi-Fi/WiMax communication gateway for broadband communication. In this instance there are no particular problems in using VPN crypto-graphed networks.

Communications can use TCP/IP and/or UDP protocol depending on the applications used.

In this case too, the address of the field equipment may not be static and public and a connection mechanism which involves the field equipment to establish the connection with the operations centre router will always be used. The connection can be activated through a call back command sent by SMS (where a GSM modem is available).

The VPN configuration parameters will be provided during the installation stage or during the kit configuration.

The system has a broadband communications monitoring system which provides all the data and statuses of the various telecommunication systems used in the system in real time and it records them on a topological diagram of the network.

5 System architecture

The solution implemented is based on the Beckhoff platform. The system, which has been entirely designed and developed by Tecnorad, also incorporates third-party components and aims at achieving the required functionalities.

The system has a modular architecture which makes it easy to combine with all the levels typically required from a BMS (Building Management System).

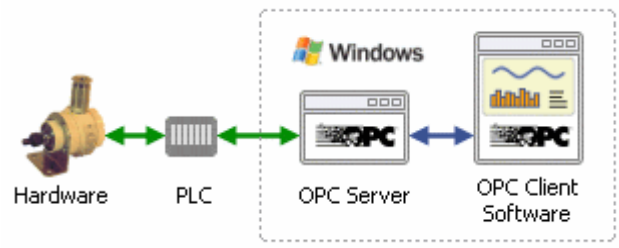
5.1 Operations centre functionality

The operations centre has been designed as a fully virtual information technology structure and can therefore be installed locally on Tecnorad's premises on the dedicated servers or in a hosting ambient either on shared/cloud type machines or on a dedicated server. The main requirement is a front end capable of establishing VPNs with the TELETOWER field units.

Access to the operations centre functionalities is guaranteed through WEB pages for visual management and through web services for the direct exchange of data with other systems.

5.1.1 Data server OPC communication

In order to ensure maximum compatibility with other SCADA systems, the TELETOWER platform, PLC and any field devices already installed on-site, use OPC architecture for data acquisition and management.



The OPC server application is capable of interfacing any type of commercially available bus and PLC data and it is available both on Windows and Linux thereby guaranteeing compatibility with a wide range of hardware platforms.

The Beckhoff PLC platform has a large number of field protocols and a dedicated configuration operating framework which makes it possible to realise the necessary physical interfaces with the large number of sensor systems for remote stations.

Further satellite units then allow the coverage of the system to be extended through remote installations, connected via Ethernet, Wireless LAN and/or Power Line Communication. Each unit has the necessary physical interfaces and makes them available to the TELETOWER station at central level. This

interface capacity is essential for modular solutions that can be configured to suit all situations and scenarios that may be encountered in the field.

The use of two different types of OPC architecture is planned.

- An OPC server resident at the field and operations centre equipment with a direct connection at the field OPC server.
- An OPC server resident at both the field equipment and the operations centre server.

In the former case, against greater operating simplicity, greater traffic is generated on the connection network because each data acquisition and display request requires the reading of the data in the field system. The field system enters the data in the OPC server, which then processes them based on the functionalities required and makes them available at the display interfaces.

The data are then also transferred to the operations centre service and the old data can also therefore be displayed locally at the centre. All new data should be downloaded in the field.

In the configuration with the OPC server spread out, an inter-server alignment mechanism, which uses an optimised binary protocol, is adopted. In this case, the band required for field-centre communications is considerably lower.

It is also the best response of the WEB interface which needs to access data locally rather than remotely for display.

5.2 SCADA functionalities

The TELETOWER system's basic configuration is a typical SCADA system (Supervisory Control and Data Acquisition), aimed at acquiring data and information from systems to allow their supervision and guarantee correct operation in all conditions.

SCADA functionalities therefore mainly take place peripherally, where the systems are located, however, for monitoring purposes, the capacity to interact with numerous field units and the ability to effectively manage the large amount of data received are important.

In this regard the functionalities carried out by the operations centre application software play a vital role. The functionalities can be divided into the following typical components:

- gateway sub-system
- data management server sub-system
- automation sub-system
- display sub-system

The platform for safety, logistics and maintenance function requirements has been designed using an HA (High Availability) architecture with a medium/high operating redundancy level.

In geographically distributed systems, like in the case of the telecommunications sector, the control systems may be very diverse, and are usually established from the integration of SCADAs with the control devices in the field, with local HMI software and with wide-area communications, which use a combination of wireless, fibre optic and telephonic services technologies. In both cases it is vital to have a solution capable of managing communication between the applications and devices.

The Server system therefore typically memorises the data in a database where they can be historicized, analysed and made available for various types of display.

In addition to these functionalities, in the main provided by the OPC system, additional functionalities are often required relating to the integration of other data, not specifically related to the systems, such as weather, images and video data, audio communication services, integration with ERP and CRM systems and the management of logistic interventions, etc.

A more complete and modular application is usually installed alongside the data server system, in this case realised through an OPC UA infrastructure, in order to be able to include and collaborate with other open systems.

5.2.1 Gateway sub-system

The gateway sub-system acts as a front end for communications with remote units and carries out high-level functionalities often required to manage connectivity and various types of connections.

Specific monitoring and control functionalities have been implemented for the field remote units in addition to the typical communication functionalities managed by the routers, servers and typical network equipment.

To manage a large number of remote systems it is necessary to monitor that the various units in the periodic connections connect as required and planned; if this does not happen attempts need to be made to analyse the problem and identify the causes and, in any event, the operators must be notified of the problem.

Keeping up to date with the various software versions, scheduling updates at the most suitable times, monitoring the development of events, forwarding and managing data flows to other gateways and/or redundant servers, these are all functionalities which have a great impact on communication and for this reason they are entrusted to a specific application component dedicated to perform these tasks.

Communications not directly aimed at the gateway are therefore forwarded to the server sub-system.

5.2.2 Server sub-system data management

The server sub-system performs all data reception, management and archiving functionalities, of vital importance for the SCADA and automation system. It was decided to use a standard platform for the data component capable of guaranteeing maximum interoperability with the majority of systems already in use in the sector.

The solution is based on the OPC server; the functions for the data server are interface with various local devices present in the field but also those which may be present on other installations with an OPC UA infrastructure.

The server must be able to operate on the field machine in order to be able to work fully independently even without connecting to the operations centre; the architecture allows a

distributed solution with the server installed, even centrally at the operations centre or elsewhere, and is capable of communicating and aligning through protocols optimised with other distributed servers.

The server system also provides other intercommunication services with other sub-systems, mainly through web services.

5.2.3 Automation sub-system

The automation sub-system provides all the highest-level functionalities which allow automation of the various management and maintenance processes and procedures. Specifically, the planning and implementation of fault analysis and problem-solving procedures (e.g. automatic resetting and analysis of the causes of the fault) monitoring and data analysis.

The operations centre is responsible for:

- Controlling, monitoring and reporting faults
- Receiving, alarms and generating reports on the mailing list
- Management, data analysis and report generation

5.2.4 Display sub-system

The HMI (Human Machine Interface) allows users with synoptic panels and boards to use the system functionalities. The human machine interfaces allow the rapid and simple display of data and any possible faults and alarms and provide operators with guided procedures to analyse and solve problems.

The interface is also available on mobile devices, such as smart phones or tablets so that the system can also be used on the go or during operations in the field.

6 Conclusions

The initial study into the project requirements needed on the one side an in-depth knowledge of the dynamics at a telecommunications station and the equipment housed therein, the typical types and critical urgencies of breakdowns, which together give rise to a very advanced level of automatism, capable of reacting to the problems which usually occur. On the other side, the implementation of automation processes that are too complex and complicated could led to the implementation of systems which generate a high number of alarms and/or are then too complex to manage and maintain, making the systems ultimately less reliable and increasing the operational management workload of the sites.

The difficulty has been in then carrying out an in-depth analysis of all the different variables present and the statuses they can assume, evaluating the possible cases which can occur and trying to avoid the generation of incorrect automatic commands which could cause both economic damage, and also harm to the structure or personnel present.

From this perspective, the time variables necessary for the temporary inhibition of certain automatic commands have a very important role for safety reasons.

Another critical aspect has been the choice of solutions capable of guaranteeing the functionalities required, but which are also scalable and with the lowest field equipment costs. From the general perspective of telecommunication sites, there are many smaller ones for which the adoption of a system which is too expensive could prove uneconomical and thereby limit the development of the market.

The economic goal relating to the proposed innovation will allow Tecnorad to offer the market a service with added value, without involving a substantial rise in costs. According to one estimate, the average savings in the maintenance of a station could reach 30% with a break-even for the recovery of the planned investment in the space of 2-3 years.

In recent years, the radio systems maintenance sector has seen a constant request for a reduction in agreement prices by issuers and by mobile operators. The new telemetry and remote control system would allow these requests from customers to be balanced, offering a more complete service and higher added value.

Thanks to the know-how acquired, the service offered can also be extended to other sectors where requirements demand the support of Telemetry/Remote Control.