Design for restability, manufacturability and cost

How Elemaster helps us to observe the universe

A new generation of low-frequency radio telescope is currently being built in Australia and represents a major challenge for everyone involved. This includes the Elemaster Group, which is tasked with industrialising and producing this highly developed digital processing system in six-figure quantities in which the highest quality is a prerequisite.

A telescope that can penetrate the vastness of the universe 135 times faster and deliver images with significantly higher resolution than most modern telescopes currently available - this is not a dream, but reality. The implementation of this project is being led by the Square Kilometre Array Observatory (SKAO), an intergovernmental organisation headquartered at the Jodrell Bank Observatory in Great Britain with member states in five continents.

The facility is unique: the observatory operates two telescopes. SKA-Low (the telescope located in Australia) and SKA-Mid (in South Africa) will observe the universe at different frequencies in the radio spectrum. Both telescopes are currently under construction. Advanced processing technologies and algorithms are required to process the flood of data they collect, which is why they are often referred to as software telescopes.

The two state-of-the-art radio telescopes will enable research into previously inaccessible scientific areas. They are intended to improve our understanding of fundamental processes, such as the formation and evolution of galaxies, fundamental physics in extreme environments surrounding black holes and even the origin of life.

The scale of the project, when described in numbers is remarkable: the SKA-Low telescope consists of a total of 131,072 antennas distributed across 512 stations. This corresponds to 256 antennas per station. The greatest distance between any two antenna stations measures 74 kilometres. The computing power of the supercomputer used for this project is 25 per cent higher than that of the most advanced supercomputers in use today and achieves a data flow of 157 terabytes per second. This corresponds to five times the global internet traffic of 2015 – a significant step for astrophysics. This makes it all the more important that all components used in the construc-

Bild: SKAO, ICRAR, SARAO

Composite image showing all antenna elements of the SKA in South Africa and Australia. The image combines photos of existing antennas at both sites with an artist's impression of the future SKA telescopes. Left: Illustration of the future SKA parabolic reflectors in conjunction with the existing antennas of the MeerKAT predecessor telescope in South Africa. Right: Illustration of the future low-frequency stations for the SKA in conjunction with existing elements of the AAVS2.0 forerunner station in Western Australia.

tion of SKA-Low comply with the highest quality and performance standards.

Good conditions for a highly complex task

Establishing a state-of-the-art digital processing system for the SKA-Low telescope presented Elemaster, an EMS company with enormous challenges. The signal processing subsystem (SPS) is designed to capture and process a very large volume of data generated simultaneously by tens of thousands of antennas across 65,000 radio frequency bands. The two metre high antennas are relatively simple in design and resemble a tree-like structure. They absorb signals, which are then sent to a smart box that collects the data streams from 16 antennas. There, the electrical signals are converted into optical signals for transmission.

All 131,072 antennas therefore require digital, software-supported circuits to digitise, correlate, combine and optimise the interpretation of the radio waves before they are transported hundreds of kilometres away to a second supercomputer for further processing. Each individual system must be able to communicate permanently and reliably with the others and generate meaningful data. To ensure this, sufficient spare parts are also being produced, which must not age during storage.

Elemaster's task is now to transfer the basic designs created by the Italian National Institute of Astrophysics (INAF) into industrial production, manufacture the resulting products and ensure that all specifications are met. Personnel from numerous countries will contribute to individual parts of the overall project.

In order to successfully produce the required number of components, a well-proven process is being consequently implemented: The 'design for' approach is a key methodology in the ODM (original design manufacturer) and EMS sectors to ensure the efficiency and quality of electronic products. This approach comprises three core phases: Design for Testability, Design for Manufacturability and Design for Cost. The methodology is intended to ensure that all future test and production processes are carried out as efficiently and cost-effectively as possible.

Design for Testability

The high complexity of the project requires the most comprehensive test coverage possible. To this end, a detailed testability analysis was developed after each production step to ensure

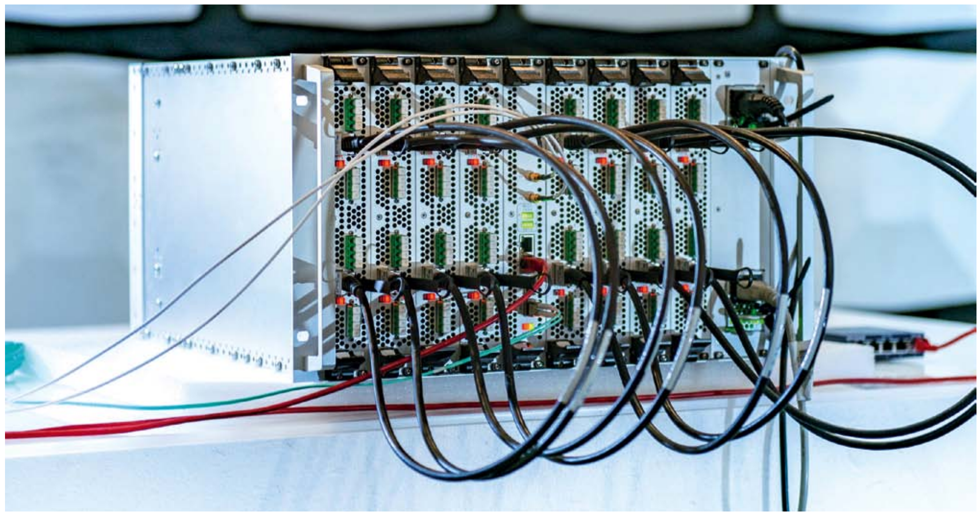

Bild: Elemaster

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complete coverage of the critical parameters of the components. The necessary test series was designed to fulfil all the requirements of the project, as the SKA-Low must function reliably and with extremely high performance for the next 50 years.

Design for Manufacturability

Process validation focuses on avoiding problems during the manufacture of printed circuit boards and in their assembly, improving the reliability of products, controlling their ageing process and reducing overall costs. The components deployed must also continue to be available over many decades to ensure that the SKA-Low functions reliably for years to come.

Design for Cost

Industrialisation of the product emphasised the link between research and development and production. At this point the development team could ascertain whether or not the level of automation planned was adequate considering sales costs and expected quantities. It's a simple calculation: With a large number of products the costs add up quickly which means that strategic purchasing strategies assume greater importance since quality must not be allowed to suffer under price pressure. Furthermore, it must be ensured that all expectations are fulfilled. It is therefore of critical importance that the optimal balance is found between longevity and foreseeable costs for the components used in SKA-Low.

More than 50 members of staff from different departments including manufacturing, purchasing, R&D, as well as test lab, work closely together to ensure a smooth implementation of the project. In the framework of such a project, the product is subject to particularly stringent requirements and it is therefore essential that it functions reliably for many years and fulfils all applicable Australian standards.

The Eletech-Lab is accredited to ISO/IEC 17025:2017 standards and is fully equipped for the implementation of tests related to EMC, climate, vibration and quakes. In this way, requirements relating to reliability can be met and country-specific approval procedures successfully closed.

In order to successfully implement this gigantic project and to transform the ideas and concepts of scientists into industrially manufacturable products, a very pragmatic, target-oriented approach from experienced experts is called for, whereby the focus lies in the "Design for" concept.

Elemaster covers the complete product life cycle from original concept right through to the finished electronic product and beyond. The Italian company with around 1,700 employees worldwide bundles its research and development (R&D) activity in its international design centres in Italy and Germany and has production facilities worldwide. (zü)