Case Study

Hanson Quarry Products
Collision avoidance system

Improving safety for the UK's largest supplier of ready-mixed concrete

Hanson is the UK's largest supplier of ready-mixed concrete, the nation's most widely-used and durable construction material. The company produces aggregates (crushed rock, sand and gravel), ready-mixed concrete, asphalt, cement and cement related materials from around 300 manufacturing sites across the UK.

"Quarrying remains one of the most dangerous industries to work in, since 2000 over 3500 workers have suffered an injury reportable to HSE, 31 of those being fatal."
[HSE in Quarry Health and Safety]

While Hanson has a very good track record of safety, they were looking to be pioneers in making a step change in improvements to quarry safety. In particular, they wanted to reduce the number of collisions involving heavy plant.

Challenge: To reduce the number of potentially life-endangering collisions involving heavy plant in UK quarry sites.

Requirement: The development of a technology-based proximity detection system to prevent imminent collisions.

Solution: The creation of an intelligent electronic system based on GNSS (Global Navigation Satellite System) technology.

Microsynthesis was commissioned to develop an intelligent electronic system that could be used to detect and prevent imminent collisions between plant, vehicles, other machinery and pedestrians. Following an investigation into all the problems and related issues occurring through quarry sites, Microsynthesis worked through the preliminary and definition stages of the project, culminating in the production of comprehensive specification and requirements documents. This was the start of a complex and in-depth research and development project which encountered significant engineering challenges but resulted in original performance achievements in the technology areas adopted.

Microsynthesis
microelectronic development engineering

Microsynthesis is an electronics design house and a developer and provider of technical engineering solutions. We offer solution specification, prototyping and product development in addition to individual professional services.

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The Development Process

The Hanson Quarry Products collision avoidance system was a complex and in-depth project which required a great deal of primary research and skilled electronic engineering. Microsynthesis used its seven-stage approach when addressing this challenge:

- **Identify the problem** – Hanson asked Microsynthesis to reduce the risk of accidents so preliminary work was required to identify and define the problem. Often it is not obvious to either party without in depth examination what exactly is the problem that needs to be solved. We visited quarries to carry out this work. We found that the real problem was that plant operators did not have sufficient visibility around their vehicles and that they were too busy controlling the machines to be constantly looking in mirrors and at the camera monitors. The ever changing quarry landscape posed additional difficulties.

- **Investigate the issues** – To fully understand the problem and the situation we visited a number of different quarries, spending time observing the movement of machines and people. We observed various quarry operations and interviewed site managers and machine operators. We found that there was a great deal of variation in operation and procedure between sites and between the different roles within those sites.

- **Specify the solution** – Very much a key stage in engineering a solution of this scale. From the previous investigative work it was clear that a solution would need to be an active detection system, leaving workers to concentrate on their core jobs. It would have to be 100% reliable due to its safety-critical nature and it should not interfere with or prescribe beyond reason the methods of quarrying adopted within the group. Microsynthesis specified in detail a collision avoidance system with robust failure-mitigation features that would detect and measure the distance between potential hazards and use factors such as speed, direction of travel and location to calculate a risk level and warn against severe risks.

- **Evaluate available technologies** – We do not wish to reinvent the wheel so Microsynthesis investigates, examines and evaluates available technologies and solutions that may be used to satisfy part or all of the requirements. For this project, various technologies for detecting distance were evaluated. These included sonar, radar, laser, survey-grade GNSS (GPS) and machine-vision. Also technologies for establishing a reliable radio communications link were examined. This evaluation is another very important process in the development cycle and dictates the way the project will progress, the development and unit costs, the skills and other resources required and the timeframe for completion. During our research we did not find any suitable existing technologies that met all the requirements for both the proximity detection section and the radio section. Therefore we had to source suitable software and hardware components for the basis of further development work.

- **Develop new technologies** – The technology chosen for accomplishing proximity detection was GNSS (GPS). Survey-grade GNSS would provide the necessary accuracy but did not satisfy the cost requirement nor the infrastructure installation requirement. It was therefore necessary to use consumer-grade GNSS but to develop application-specific routines and sophisticated algorithms to significantly reduce the positional errors that would otherwise be present. Microsynthesis partnered with Fastrax (now part of u-blox), one of Europe's leading providers of GPS receivers, to develop firmware and modifications to the standard receiver designs that would eliminate or greatly reduce many of the mathematical errors. The outcome of this was a prototype design that was tested and repeatedly delivered positional accuracy of 15cm in differential mode, even in the hostile intended environment, without the need for base-stations or any external augmentation system (i.e. it was completely autonomous). This was a great engineering achievement. Microsynthesis also developed a reliable digital radio communication system suited to the ever-changing topology. A 'time-slice' method was used, made possible by the very precise timing and synchronisation available through GNSS.

- **Engineer the product** – The individual function components were developed and prototyped in isolation but there is a significant engineering process required to convert those units into an operational system. Microsynthesis used high-reliability design techniques suitable for safety-critical applications which ensured the safety of life and equipment even in the event of full or partial system failure. The intelligence of the design constantly calculated risk based on a number of factors and provided a visual and audible warning to operators when needed. The product was controlled by two 16-bit microcontrollers which carried out safety functions in different ways and monitored the performance of each other. There were also external monitoring and supervisory circuits ensuring the system was always fully functional and warning users of any malfunction.

- **Help the customer** – Clearly every project should satisfy the brief and help the customer. Microsynthesis takes care throughout a project to ensure that sight is never lost of this intention and where possible, to have measureable outcomes. The output from this project was a proximity-detection subsystem that could be used by Hanson to integrate into their machines to help them improve their safety standards. Our help does not stop there; we also help with product commercialisation, with manufacture and with monitoring the performance of the system in service to ensure quality and to note potential improvement.