# CASE STUDY: DEVELOPMENT OF THE TORNADO ADVANCED RADAR/MAP DISPLAY INFORMATION SYSTEM (TARDIS)

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This article provides a technical overview of the Tornado Advanced Radar/Map Display Information System (TARDIS) being developed by BAE Systems for the Tornado GR4 aircraft using Wind River® platforms.

## INTRODUCTION

BAE Systems Avionics Systems was awarded a $70 million contract[1] to provide 128 radar map display systems for the U.K. Royal Air Force[2] Tornado GR4 ground attack aircraft[3] (shown in Figure 1). The system, known as the Tornado Advanced Radar/Map Display Information System (TARDIS), was developed in the United Kingdom and is replacing obsolete radar projected map display systems. TARDIS is a state-of-the-art system using active-matrix liquid crystal displays, the latest radar processing techniques, map generation software, and graphics using Wind River platform technologies[4] and commercial off-the-shelf (COTS) hardware.

TARDIS provides digital color display screens for the Tornado pilot and navigator, which can be used cooperatively or independently, and performs data fusion of radar data and digital moving map display data to provide advanced, enhanced situational awareness for low-level terrain navigation and avoidance capabilities. The Tornado navigator's view of TARDIS is shown in Figure 2.

*Figure 1. RAF Tornado GR4 aircraft Image courtesy of BAE Systems*

*Figure 2. Tornado Navigator seat with TARDIS display (center) Image courtesy of BAE Systems*

## SYSTEM ARCHITECTURE

The TARDIS map display system is an evolution of a VxWorks®-based map display system that BAE Systems Avionics Systems developed for other military aircraft. The TARDIS map display system architecture is a multiprocessor VMEbus design, comprising multiple PowerPC VME single board computers (SBC) running the VxWorks 5.5 real-time operating system (RTOS). The control processor consists of a Curtiss- Wright Controls SVME/DMV-179 COTS SBC[5], and the display processor is a Curtiss-Wright Controls SVME/DMV-712[6], which has been developed as part of a collaborative effort between BAE Systems in the U.K. and Curtiss-Wright in Canada.

The digital moving map display device software executing on the PowerPC processors under VxWorks performs interprocessor communication over the VMEbus backplane, using Wind River shared memory objects multiprocessing middleware. This enables data to be shared between VxWorks tasks running on the control and display processors in an efficient manner, while providing a degree of abstraction from the underlying VMEbus architecture and scalability. The VxWorks-based device software running on the display processor uses OpenGL graphical libraries to drive the active-matrix liquid crystal displays.

## DEVICE SOFTWARE OPTIMIZATION

BAE Systems has defined a device software optimization strategy based on the use of Wind River General Purpose Platform, VxWorks Edition to develop the TARDIS map display device software as part of its CMM Level 5 software development processes[7]. Wind River General Purpose Platform enables BAE Systems engineers to accelerate the development of their UML-based design through a development suite that contains proven tools to develop, build, debug, and optimize their C and C++ device software through a user interface. In addition, the VxWorks RTOS provides commonality across the TARDIS control and display processors through software abstraction from the underlying hardware architectures. This strategy enables BAE Systems engineers to gain experience, develop expertise, and maximize their productivity through consistent use of the development tool suite.

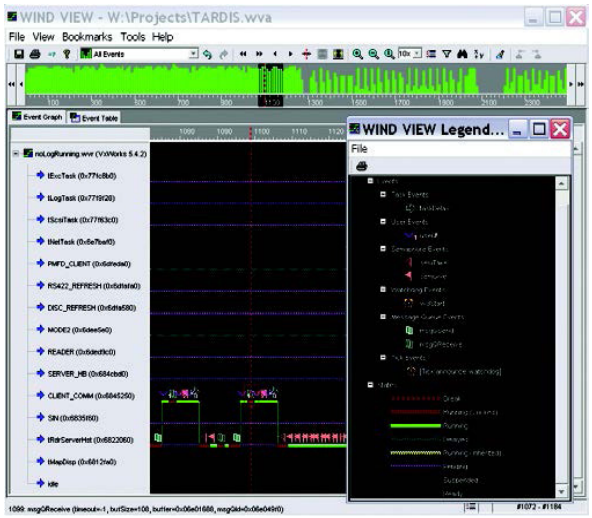


*Figure 3. Wind River System Viewer perspective of TARDIS map display*

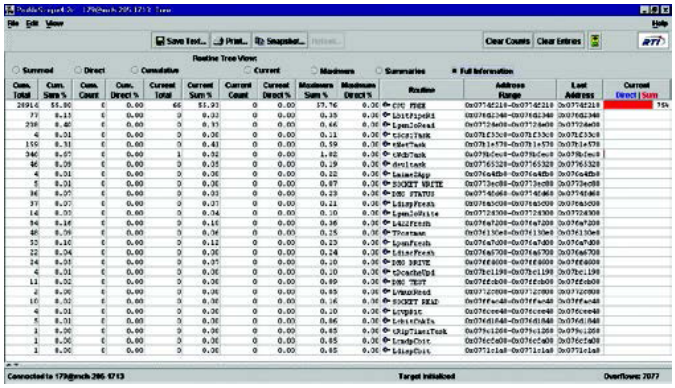

*Figure 4. Performance Profiler perspective of map display*

During the development of the display processor board and VxWorks board support package (BSP), BAE Systems used the Wind River ICE JTAG emulator to accelerate the hardware bring-up of the board, with assistance from Wind River Professional Services.

BAE Systems used the Wind River System Viewer (formerly known as WindView) during the system integration phase to observe the real-time performance of the TARDIS subsystems, which provided BAE Systems engineers with immediate feedback as to whether the integrated subsystems were operating as required. Figure 3 presents a System Viewer trace log that shows CLIENT_COMM task receiving data via a VxWorks message queue via a call to the VxWorks API msgQReceive(). The System Viewer search facility can be used to find a corresponding call to msgQSend() for this specific message, and the latency of transfer of the message can be determined accurately due to the fact that each event in the System Viewer log has been timestamped using a high-resolution timestamp driver running on the PowerPC processor.

BAE Systems engineers also used the Wind River ScopeTools suite to provide dynamic visualization of memory utilization, CPU utilization, and function and variable trace within the TARDIS map display device software. In particular, BAE Systems engineers used Wind River Performance Profiler (formerly ProfileScope) to observe the behavior of the OpenGL graphical libraries and the interactions with other aspects of the device software and graphics display hardware. This enabled BAE Systems engineers to focus their performance optimization efforts on areas that yielded the greatest improvements to the system, providing increased responsiveness to the Tornado pilot and navigator.

Figure 4 shows the Performance Profiler display for the TARDIS application in a quiescent state, showing CPU utilization by task in descending order. The CPU_FREE task is a TARDIS application task that monitors system load and logs data to nonvolatile RAM, which can be uploaded for offline processing.

## SUMMARY

BAE Systems Avionics Systems used Wind River platforms to develop a state-of-the-art radar map display system for the U.K. Royal Air Force's Tornado GR4 aircraft, to provide the pilot and navigator with advanced, enhanced situational awareness for low-level terrain navigation and avoidance capabilities.

BAE Systems used the Wind River platforms development tools suite and VxWorks RTOS to develop sophisticated functionality, with optimized performance under challenging development timescales.

## ABOUT THE AUTHOR

Eur Ing Paul Parkinson is a senior systems architect with Wind River, working with customers in the aerospace and defense (A&D) sectors in the UK and Nordic countries.His professional interests include integrated modular avionics (IMA) and Intelligence Surveillance Target Acquisition Reconnaissance (ISTAR) systems. He blogs on A&D industry issues on the Wind River website at http://blogs.windriver.com/parkinson.

## ABOUT BAE SYSTEMS

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BAE Systems has major operations across five continents, with customers and partners in more than 100 countries. The company has more than 97,000 people and generates annual sales of approximately £13 billion through its wholly owned and joint-venture operations.

## NOTES

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7. "BAE Systems Avionics Achieves Software Excellence Standard of CMM Level 5," BAE Systems, September 2003, www.baesystems.com/Newsroom/NewsReleases/2003/press_25092003.html.

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