

ResMed

Sophisticated Breathing Simulators Developed with Embed and C Support Library



ResMed biomedical research engineer Natalie Zotelo demonstrates Embed-based breathing simulator to Peter Darnell, Senior VP Model-Based Embedded Tools, Altair Engineering.

"ResMed sees their continuing use of [Embed] as beneficial in simultaneously maximizing quality, minimizing development time, and enhancing customer experience through use of realistic patient models."

Natalie Zotelo
Biomedical Research Engineer
ResMed

ResMed is a leading developer, manufacturer, and marketer of products for screening, treatment, and long-term management of sleep-disordered breathing and other respiratory ailments. ResMed's products provide therapeutic relief for a variety of breathing disorders; the products are based on complex algorithms that rely on patient interaction for effective treatment. In product testing, such interactions present problems because traditional breathing simulators provide limited physiological realism and zero response to therapy. The alternative — clinical trials on real patients — is slow, expensive, and possesses zero repeatability.

These limitations prompted ResMed to develop breathing simulators based on more sophisticated computer models of physiology, utilizing Embed (formerly called VisSim Embedded). Embed has demonstrated its benefits to ResMed for all stages of product development, from initial algorithm testing and product testing with virtual patients, to clinical education.

Embed is used to create both virtual and physical simulators. ResMed's extensive library of Embed-based virtual patients covers a wide range of target pathologies, including obstructive sleep apnea, neuromuscular



INDUSTRY

Medical Devices

CHALLENGE

Develop breathing simulators based on sophisticated computer models of physiology

SOLUTION

Use Embed to create both virtual and physical simulators that cover a wide range of target pathologies

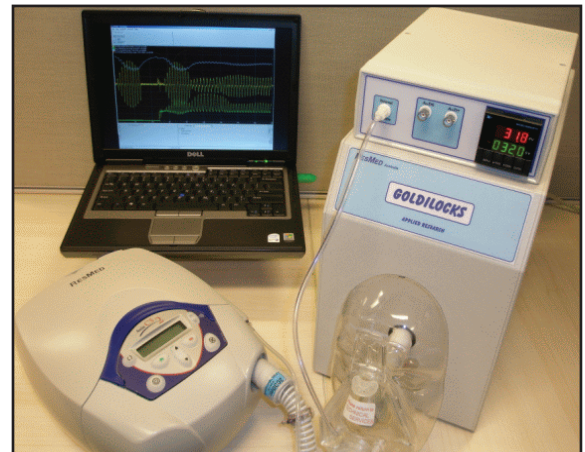
BENEFITS

- Model-Based Firmware Development environment covered all stages of development, from initial algorithm testing and product testing with virtual patients to clinical education
- Fast code execution accelerated equivalence testing, resulting in shorter clinical trials and faster time to market
- Customer experience was enhanced with realistic patient models

disease, and congestive heart failure (Cheyne-Stokes respiration).

Initial Use

ResMed used Embed to develop a "bench patient" — a simulated patient with periodic breathing during sleep — to respond to its adaptive servo-ventilation product. A PC running the Embed simulation in real time was linked to a customized test lung, which in turn was connected to the ResMed therapy device (see picture at right). In this HIL simulation, the PC closed the loop around the hardware test lung such that the bench patient's response to therapy was very similar to that of a real patient with the target pathology.



Simulated "bench patient" responding to adaptive servo-ventilation.

This therapy response was achieved by detailed high-fidelity modeling of the underlying human physiology coupled with Embed's fast execution capability, which allowed computational response in real time. The bench patient greatly accelerated equivalence testing of ResMed's second-generation therapy device, which resulted in shorter clinical trials and reduced time to market.

Speeding Up the Simulation

ResMed continued to expand the functionality of its simulated patients by incorporating a collapsible upper-airway and pulsatile heart model. The downside of this added complexity was that Embed's normal interpreted simulation speed could no longer run in real time. To restore real-time (or faster) capability, ResMed automatically generated ANSI C code from major subsystems of the Embed diagram. Each subsystem was replaced by an Embed-generated DLL that ran up to five times faster than its block diagram counterpart.

Using the Support Library on an RT-Linux Embedded Target

By purchasing the source code to the Embed support library, ResMed was able to bring its own models to any embedded platform. Using RTAI Linux and the Embed-generated code, ResMed could perform its product testing on high bandwidth patient models.

Complete Virtual Patient and Therapy Device

The Embed physiology models can also be applied as a clinical training simulator. Using Embed's built-in blocks for animation, plotting, and user interface, Embed models of the device's user interface panel, therapy device, and air delivery circuit were created and added to models of the therapy device, thus creating an entire virtual system: a virtual therapy device treating a virtual patient. Customers and sales personnel can interact with the simulated device in the same way they would in a clinical setting. By adjusting the therapy, a user can see real-time patient outcomes, including respiration, blood gas tensions, and the patient's respiratory effort. The free Viewer makes the simulation readily available to ResMed's global clients.

The VisSim™ product line has been renamed to Embed™ and Embed SE™



For more information

Authorized Distributors



**EMBEDDED SYSTEMS
SOLUTIONS**
www.embeddedindia.com

#5 606, World Trade Center, Bangalore
altairsales@embeddedindia.com
080-6764 8888/36, +91 98450 83528
www.embeddedindia.com/contact.html