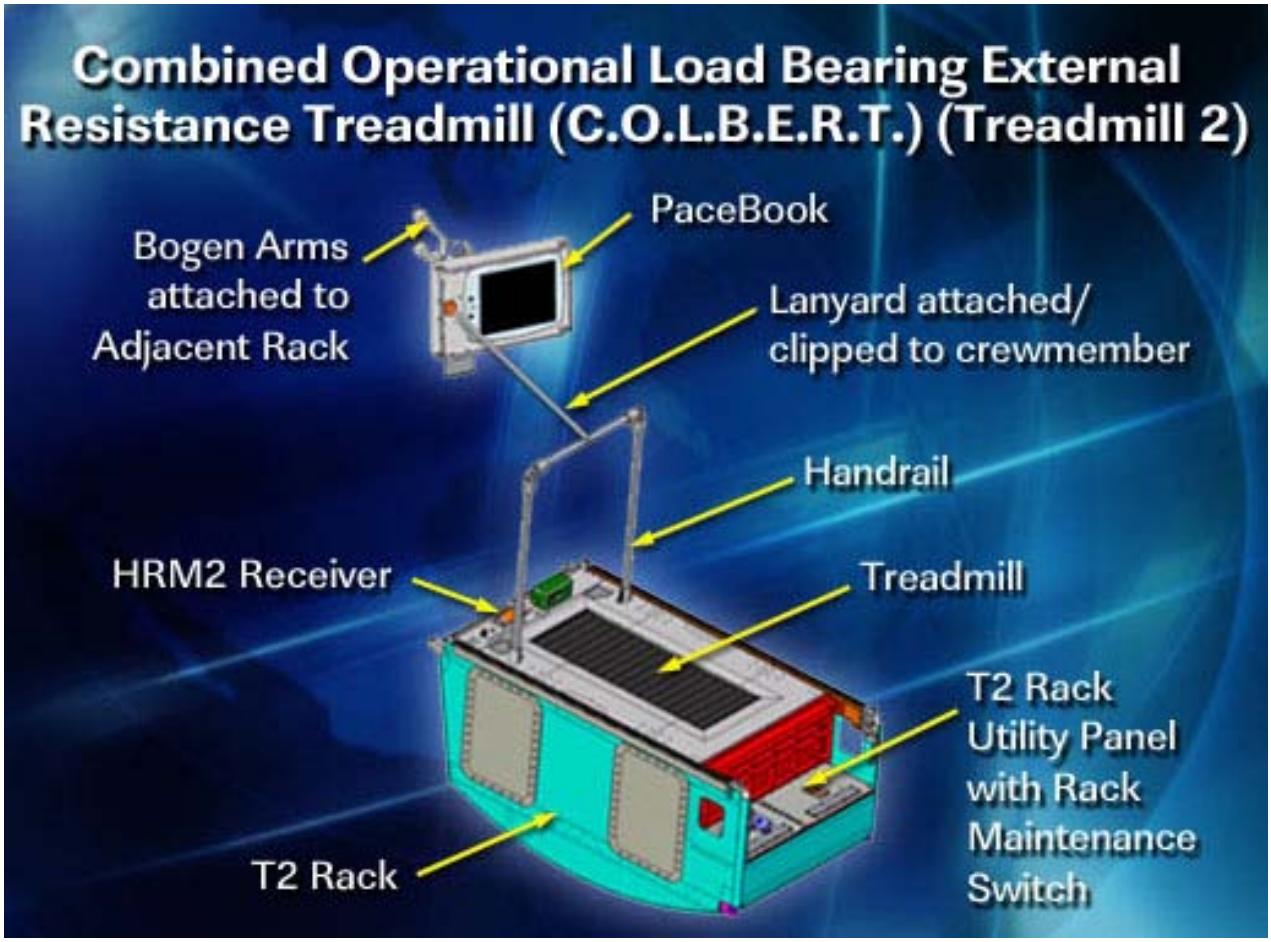
IDS Business Support,
Communications and
Community Affairs
P.O. Box 516
St. Louis, MO 63166

Astronauts begin using new treadmill with Boeing designed isolation system



There's a reason they call it pounding the pavement. Running can generate high impact forces, a special concern when you're exercising on an orbiting satellite. Astronauts on the International Space Station who run on a treadmill can create enough force to compromise station structural integrity and microgravity science. Fortunately, a new system designed and built by Boeing will absorb these impact forces and make the astronauts' on-orbit run silky smooth.

The treadmill, called the Combined Operational Load Bearing External Resistance Treadmill (COLBERT), after the Comedy Central comedian Stephen Colbert, plays a crucial role in keeping astronauts' muscles and bones strong in the zero gravity of space. But engineers need to protect the health of the station, too, and that's where Boeing's vibration isolation and stabilization (VIS) system comes in.

"While running, you can generate up to 600 pounds of impact force each time your foot hits the ground. If you take a treadmill and put it up on the first floor of your home and run on it, the whole house will vibrate," said Ian Fialho, a Boeing Associate Technical Fellow who led the concept development and dynamics design of the system. "It is a tremendous amount of load and the space station would not survive it. We needed to reduce the 600 pounds of force to about 10 pounds at the station interface"

COLBERT uses Boeing's VIS system, to keep the treadmill stable during crew exercise while reducing the impact on the station. The VIS consists of eight custom designed two-stage isolators that function like shock absorbers in a car to mitigate vibrations that reach the station's structure. The entire treadmill is integrated into a standard payload rack, which was provided by the Boeing team in Huntsville, Alabama. The VIS isolates the entire 2,200 pound rack from the ISS.

The treadmill, procured by Wylie Bioastronautics, is a modified high-end commercial off-the-shelf treadmill that has been used in Navy submarines, sports medicine and rehabilitation applications. The ISS crew has already installed COLBERT in the Node 2 "Harmony" module and encountered no issues during installation. Eventually, the treadmill will be moved into the Node 3 "Tranquility" module when it arrives on orbit in 2010. Activation and checkout of the treadmill began October 9. Boeing engineers have been monitoring and analyzing isolation performance using a suite of sensors that measure both treadmill and station loads and accelerations. Thus far, the VIS system is working exceptionally well.

"The VIS creates a floating platform, and the goal of our design is to minimize any disturbances or impacts that running on the treadmill could cause to the station structure," said Craig Tyer, a Boeing design engineer who led the mechanical design of the system. "With the VIS working properly the crew members can get the exercise they need while not impacting the microgravity environment on the station"

NASA astronaut Nicole Stott, Expedition 20/21 flight engineer, equipped with a bungee harness, exercises on the Combined Operational Load Bearing External Resistance Treadmill (COLBERT) in the Harmony node of the International Space Station.

The first ISS treadmill was an actively controlled system that used a gyroscope and linear actuators to reduce motion. The new Boeing system uses a passive design that relies on isolators and the weight of the system to minimize any disturbance to station. Why the different approach to isolating

disturbances for the two treadmill designs? "In going to a second treadmill, one thing NASA absolutely didn't want was any active components. The gyroscope has had reliability problems," said Fialho.

The long-term benefits of the Boeing design? "Active systems are complex and require power to operate. What we have here is a reliable passive system that requires zero power as far as the isolation system goes," said Fialho. The isolators can be easily replaced if needed and the system has a design life of about 10 years. "The VIS was designed to work with a standard payload rack having additional mass or ballast in order to control the motion of the entire treadmill system within the small amount of sway space," added Tyer.

"The challenge with this particular system is that you are dealing with human subjects with varied running styles, interacting with a machine in a weightless environment. We used state-of-the-art multibody dynamic modeling techniques and did a lot of testing to correlate our models prior to flight, " said Fialho. The other big challenge in designing the isolation system, according to Fialho, is the limited amount of available sway space. "In order to isolate, you must allow for motion, but standard payload racks have no more than an inch of clearance all around. That's a big challenge as you don't have a lot of space to isolate these significant loads down to really low levels."

The VIS was assembled at the Boeing Houston Product Support Center. Boeing employed approximately 30 to 40 people on the project. The VIS design

was adapted, in part, from Boeing's previous work on isolation systems for various microgravity payload racks. Engineers relied on test facilities at NASA's Glenn Research Center to simulate the zero-G environment of space. "NASA has a rack emulator with a treadmill that floats on an air bearing floor. It allows motion in three directions and is the closest emulation of the weightless environment of space," said Fialho. This extensive testing was conducted in late 2007 and early 2008. Boeing began its VIS efforts in October 2006. "We had this idea and went from concepts to building developmental test hardware to building the flight hardware in about two years – it was very accelerated." said Fialho. When the treadmill was named after Colbert, Fialho says it added a lot more visibility to his program. The engineering team also worked closely with the astronaut office on the project.

Tyer is proud of his role on the treadmill. "It is really cool to see your hardware working up on station and see the end result. It is also exciting to start a project and to be able to see it all the way through the end."

Contact:

Edmund G. Memi
Boeing Space Exploration
(281) 226-4029
edmund.g.memi@boeing.com

Adam Morgan
Boeing Space Exploration
(281) 226-4030
adam.k.morgan@boeing.com

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