



By Frank Moring, Jr.

Senior Editor Frank Moring, Jr., blogs at: AviationWeek.com/onspace
moring@aviationweek.com

COMMENTARY

Shakedown

Ares I thrust-oscillation technology finds military, civilian applications

At Marshall Space Flight Center, a relatively simple technology developed to smooth potentially dangerous vibrations in NASA's defunct Ares I crew launch vehicle is finding its way into the wider world as a way to steady buildings, aircraft, ships and other structures reacting to winds, waves and even earthquakes. The passive approach uses the weight of a liquid coupled to a structure to dampen shaking, swaying, fluttering and other oscillations.

NASA has spent about \$5 million refining the technique it calls fluid structure coupling (FSC), but has been reluctant to reveal details because of the military potential growing out of the launch-vehicle application that spawned it originally. Now engineers here have expanded their early analytical and experimental work on the Ares I thrust-oscillation problem to encompass a host of potential applications, including stabilizing nuclear power plants and tall buildings in earthquakes and violent storms, ships and drilling platforms in rough seas, and fuel-filled aircraft wings in turbulent flight conditions.

"Once you [understand] the concept, it has allowed us to ask a lot more questions in a lot more places," says Rob Berry, chief technologist and manager of the FSC project at Marshall. "We're saying anywhere fluid and structures coexist, you can control the coupling. The question is, 'can you control enough fluid, enough coupling, to make it worthwhile?'"

The Ares I application used an FSC device immersed in the upper stage liquid oxygen (LOX) tank to calm



FRANK MORRING, JR./AW&ST

vibrations set up in the vehicle stack as its solid-fuel first stage neared propellant burnout. The thrust oscillation posed a danger to astronauts in the Orion crew capsule at the top of the stack (*AW&ST* July 6, 2009, p. 42). Ultimately, opponents of a government-owned orbital crew vehicle seized on the thrust-oscillation issue as ammunition in their successful efforts to kill the project. But work on the FSC technology continued at a low level, using surplus hardware scrounged from the boneyards of this Apollo-vintage propulsion center and funds from NASA's Office of the Chief Technologist, the heavy-lift Space Launch System (SLS) program, and other sources.

The basic idea is what Jeff Lindner, one of the engineers who invented the FSC launch-vehicle application, calls "a compressible degree of freedom." In the Ares I, Lindner and his colleagues used the weight of the LOX in the upper stage to dampen thrust oscillation by building a system that gave the relatively heavy cryogenic liquid another place to go instead of transmitting vibrations upward from the solid-fuel first stage.

"The bottom of the tank moves up or down, and that fluid goes along for the ride," says Lindner. "If you put a compressible degree of freedom, a

bubble—think of a balloon—in the tank, when it compresses the fluid moves toward it. When it expands, the fluid moves away from it . . . Now we have a very large percentage of the fluid which we control the dynamics of, all by controlling the dynamics of that compressible degree of freedom."

The FSC project is using the 40-story vehicle dynamics test facility originally built for the Saturn Moon rocket, and later modified to handle the Ares I, to demonstrate just how little fluid is needed to stabilize a tall building. The team has mounted oscillating weights near the top of the structure that are massive enough to set the whole building moving with an easily perceptible sway.

In the photo, Lindner handles part of the off-the-shelf green plastic pipe holding 13,000 lb. of water that has an FSC device inside. As long as the system is engaged at the top of the 4.5-million-lb. structure, the oscillating weights barely move the building. But when the valve in Lindner's right hand is closed, isolating the device, water in a nearby transparent tank begins sloshing dramatically as the building sways perceptibly.

"We're able to get greater than a four-times reduction [in lateral motion]," says Berry, noting that the water in the FSC pipe has only 0.3% of the mass of the building.

Berry's group has studied the phenomenon analytically and empirically, and is using the large-scale experiment "to make sure the physics doesn't fall apart." Some of that work may help SLS designers if they need to dampen loads on their big new launch vehicle, but NASA also has embarked on some missionary work.

After passing their findings along to military research and development organizations that may want to make classified use of the techniques, Berry says, NASA has been briefing various civilian entities on FSC. Not surprisingly, engineering firms that specialize in skyscrapers are showing interest, he says, as are shipbuilders and oil companies with deep-sea drilling platforms.

"What's important to know is it's mature," Berry says. "This is not just some lab experiments and concepts. We spent the time, because of Ares where we had a real issue to go solve, to understand the physics." ☺



By Michael Bruno

Senior Policy Editor
 Michael Bruno blogs at:
AviationWeek.com/ares
michael_bruno@aviationweek.com

COMMENTARY

Fixing Missed Connections

Air traffic furloughs spur blame, bipartisanship

Members of Congress might have finally found something they can agree on across the aisle: making sure their flights to and from Washington are not disrupted by automatic reductions in air traffic controllers that they themselves mandated as part of the 2011 Budget Control Act (see page 32). The good news for the public is that lawmakers' enlightened self-interest may benefit them too, especially as the U.S. approaches the traditional start of the summer travel season at the end of May. "There is definitely a problem," says Sen. Mike Enzi. "We had people miss votes on Monday night because the supposed furlough that the air traffic controllers had to have in effect delayed some planes for more than 1.5 hours."

To be fair, Enzi last week went on to speak more broadly about the impact of FAA furloughs on travel. But the Wyoming Republican's remarks on the Senate floor are among the first indications that lawmakers themselves are feeling effects, albeit indirectly, of the 2011 act and its recently implemented automatic sequestration cuts. Now, in a twist, the FAA furloughs might be triggering the kind of conversations on FAA priorities that were supposed to happen years ago. At least 38 senators of both parties on April 24 introduced the so-called Dependable Air Service Act, which, if made into law, would not only give the FAA the go-ahead to move money internally to find \$206 million to stem furloughs, but also allow its parent, the Transportation Department, to move funds within its roughly \$72 billion budget to help if

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With FAA furloughs, lawmakers learn 'there is definitely a problem.'

the FAA has exhausted its so-called reprogramming authority, as it asserts. Senate Commerce, Science and Transportation Chairman Jay Rockefeller (D-WVa.) and ranking Republican John Thune (S.D.) also met with Transportation Secretary Ray LaHood the same day and then made positive comments to reporters about congressional assistance, although no details were provided.

Challenges remain, of course, starting with the fact that Senate Majority Leader Harry Reid is pushing his own bill to avert all of sequestration by using projected war spending in future years to head off this year's cuts—a move Republicans have used themselves but are nevertheless calling a gimmick. And House Republicans who control their chamber are already looking past this year's cuts to the next battle of

the budget wars: raising the national debt ceiling in July or August. A bill being pushed by House Budget Chairman Paul Ryan (R-Wis.) aims to shield Republicans in negotiations with the White House by explicitly telling the Treasury Department to pay holders of U.S. debt and Social Security beneficiaries first if Congress does not raise the debt ceiling. Regardless, with Congress out until at least May 6, travelers should expect more delays—and spin. ☹

TRUE MENSCHES

The controversial 2011 Budget Control Act may be eating into the Pentagon's ability to do many things, but backing up Israel is not one of them, according to officials in both countries who have unveiled an unprecedented arm sales package designed to maintain the country's "qualitative military edge," above all.

The total \$10 billion arms sale package to Middle East allies, including Saudi Arabia and the United Arab Emirates, is "one of the most complex and carefully orchestrated arms sale packages in American history," according to a senior U.S. defense official. It includes the overseas sales debut of tiltrotor capability via V-22s to Israel, as well as improved KC-135 refueling tankers that are "more advanced than sold before," the official says. Aside from being an aid to Muslim allies aligned against Iran, the leading tenet of the package, the official says, is "an agreement to make an unprecedented release of capabilities to the Israelis that the Israelis requested for a range of reasons," including advanced radar for fighters and anti-radiation missiles.

Defense Secretary Chuck Hagel says that despite fiscal pressures, President Barack Obama has ensured that Israel receives an "all-time high" of \$3.1 billion in foreign military financing this year. When he visited Jerusalem in March, Obama announced that the U.S. and Israel would begin work on a new, multiyear agreement extending security funding for Israel after 2017.

Israeli Defense Minister Moshe Ya'alon says the new arms and capabilities speak volumes about "America's unshakable commitment" to Israel's security. "We see it all, . . . and we are deeply grateful." ☹