Flash Forward: Lightning Lab Enhances Safety

Boeing creates lightning to study its effects on aerospace parts

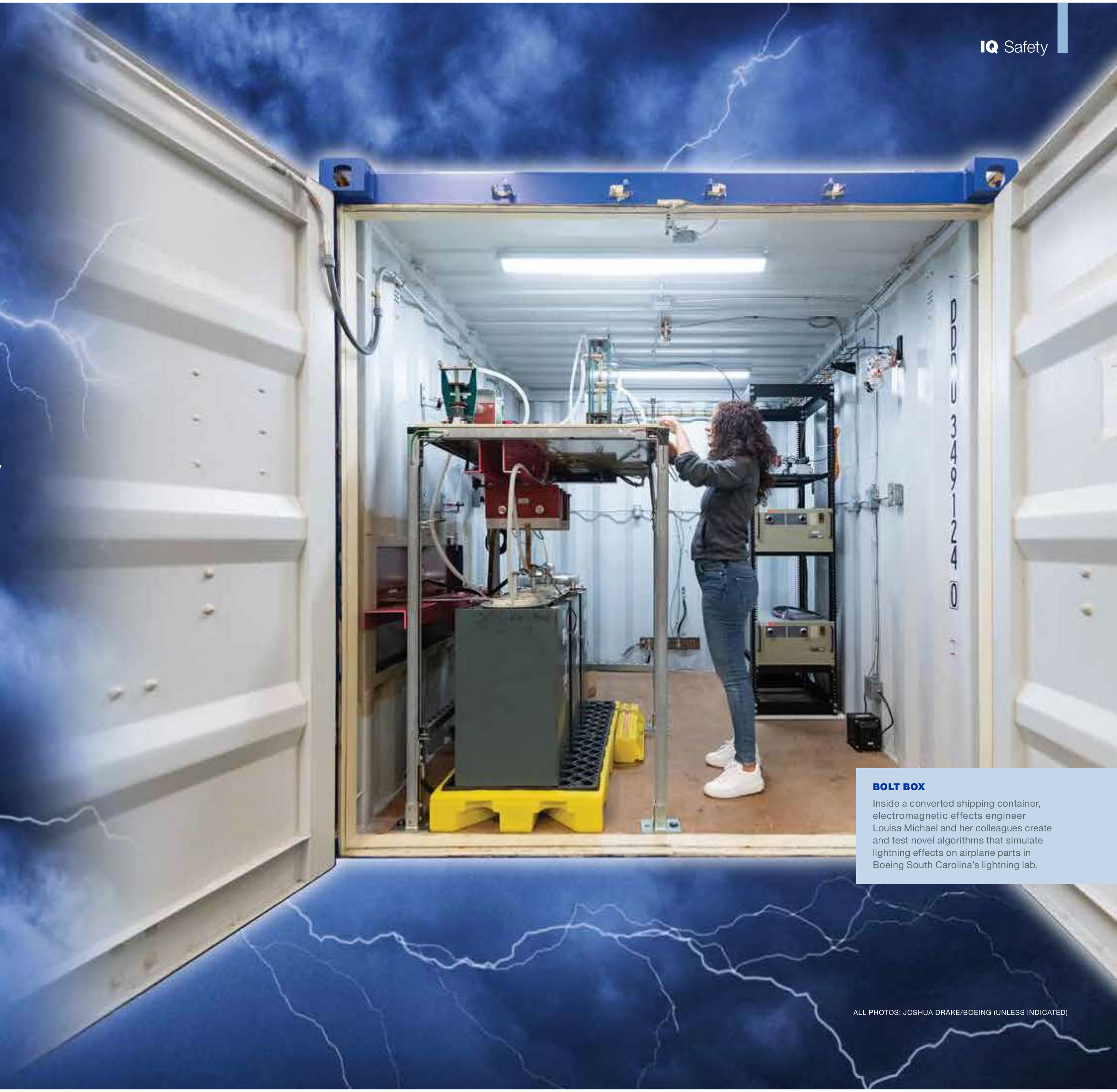
BY MAKSIM GOLDENSHTEYN, BOEING WRITER

It looks like just a storage closet. But you get a sense there's something more going on inside. A sign on the door says, "High Voltage Test in Progress. Do Not Approach Test Area."

Inside the room is a blue shipping container with metal tubes, lights and meters attached on one side. Boeing electromagnetic effects engineer Louisa Michael and her colleagues twist some knobs. Attach some wires. And double-lock the thick container doors.

Then they leave the room — out the door with the warning sign.

They're ready to make lightning.



BOLT BOX

Inside a converted shipping container, electromagnetic effects engineer Louisa Michael and her colleagues create and test novel algorithms that simulate lightning effects on airplane parts in Boeing South Carolina's lightning lab.

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Lightning in a Lab

Just north of Charleston, South Carolina, in one of Boeing's lightning labs, the Electromagnetic Effects (EME) team drives high levels of electric current through aerospace components large and small. The idea is to mimic the effects lightning strikes can have on airplanes and study how the parts respond.

When capacitors discharge the current, the resulting strike emits a booming pop, but without the blue plasma arc typical of the bolts seen flashing across the night sky. Those in nature carry millions of volts and billions of joules of energy. For safety and practicality, the strikes in the lab are scaled, so the results can be extrapolated mathematically to predict what might happen in the real world.

Michael and fellow researchers are part of the Boeing Research & Technology organization. They simulate these strikes through numerical modeling and by running actual current through airplane materials.

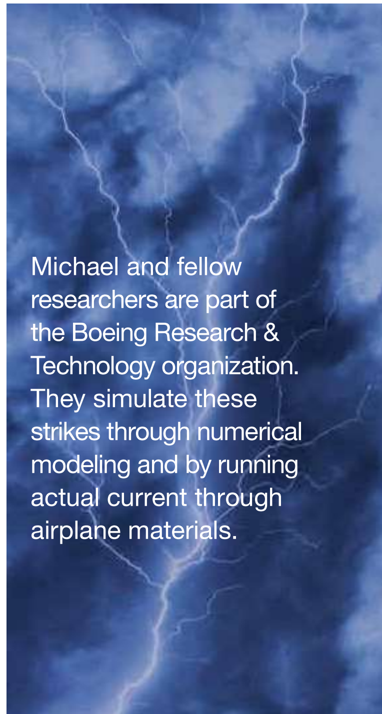

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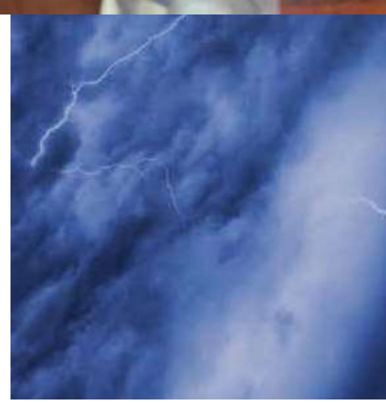
PHOTO: KAITLIN STANSELL/BOEING



SPARKING IDEAS

(Above and left) Michael sets up the lab and test fixture and validates all necessary safety measures were taken before generating lightning-like electric current to pass through composite airplane parts.

ELECTRIFIED

Ben Westin (left), an electromagnetic effects engineer, and Michael check the test fixture and turn on its voltage measurement tools.

LIGHTNING ROD

Michael confirms the test fixture is no longer energized by using a grounding rod, a designated electrical path used to safely release any remaining static voltage.

Getting struck by lightning is a metaphor for something extremely rare. But it does happen on occasion to airplanes, so the physics at play in the lightning lab is relevant to just about every airplane in service.

Airplanes are designed to withstand lightning strikes as they soar through the clouds and through weather. And when a strike happens, ground inspections identify any potential damage and evaluate if any repairs are needed before the airplane returns to service.

Lightning protection is engineered into Boeing airplanes and their sensitive electronic components. The EME crew's research can inform how parts are designed, the recommended allowable damage limits, and maintenance and repair practices.

ILLUMINATING

The team was able to use lab-simulated lightning to zap a fastener with high levels of electric current and study its reaction. This provides essential data for model validation.

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>
> **LOUISA MICHAEL, ELECTROMAGNETIC EFFECTS ENGINEER**

BALL OF LIGHT

Following safety procedures after the test, all equipment is checked with a grounding rod to ensure it's safe for the team to interact with. This includes the voltage divider, the device used to set up the lightning strike at the correct voltage.

Collaborative Partnerships

Michael joined the EME team in 2020 with a doctorate from the University of Cambridge. Her current work is an unexpected departure from her research, which focused on sensitized explosions that could break down rock more efficiently.

It served as her first foray into multi-physics modeling, or mathematical simulation, that accounts for interactions between the four states of matter: gases, liquids, elastoplastic solids and plasma.

"It was cool to work with detonations," Michael said of her early research. "And I thought I could never top that. And yet, I ended up working with lightning."

After several industry-led projects as a postdoctoral researcher, Michael joined a new Cambridge team working in partnership with Boeing's EME group. The aim was to create novel algorithms simulating the effects of lightning on airplane parts.

While the task was different from her past projects, Michael says that mathematically, the challenge itself was quite similar: employing differential equations to describe a physical problem. Her work and research at Cambridge and the university's collaboration with Boeing led to Michael joining the EME team full time.

At Boeing South Carolina's EME lab, the experiments take place in an enclosed shield room, with Michael and colleagues observing from a separate wing of the facility. A thermal camera measures how lightning heats up each part. A high-speed camera takes footage of flying particles. And an open-shutter camera captures all light emitted: from the moment the current strikes the material and creates a spark to outgassing.

MAKING A MARK

(From left) Brian Egenriether, an electromagnetic effects engineer, Michael and Westin compare the residue products of scaled and large lightning strikes.

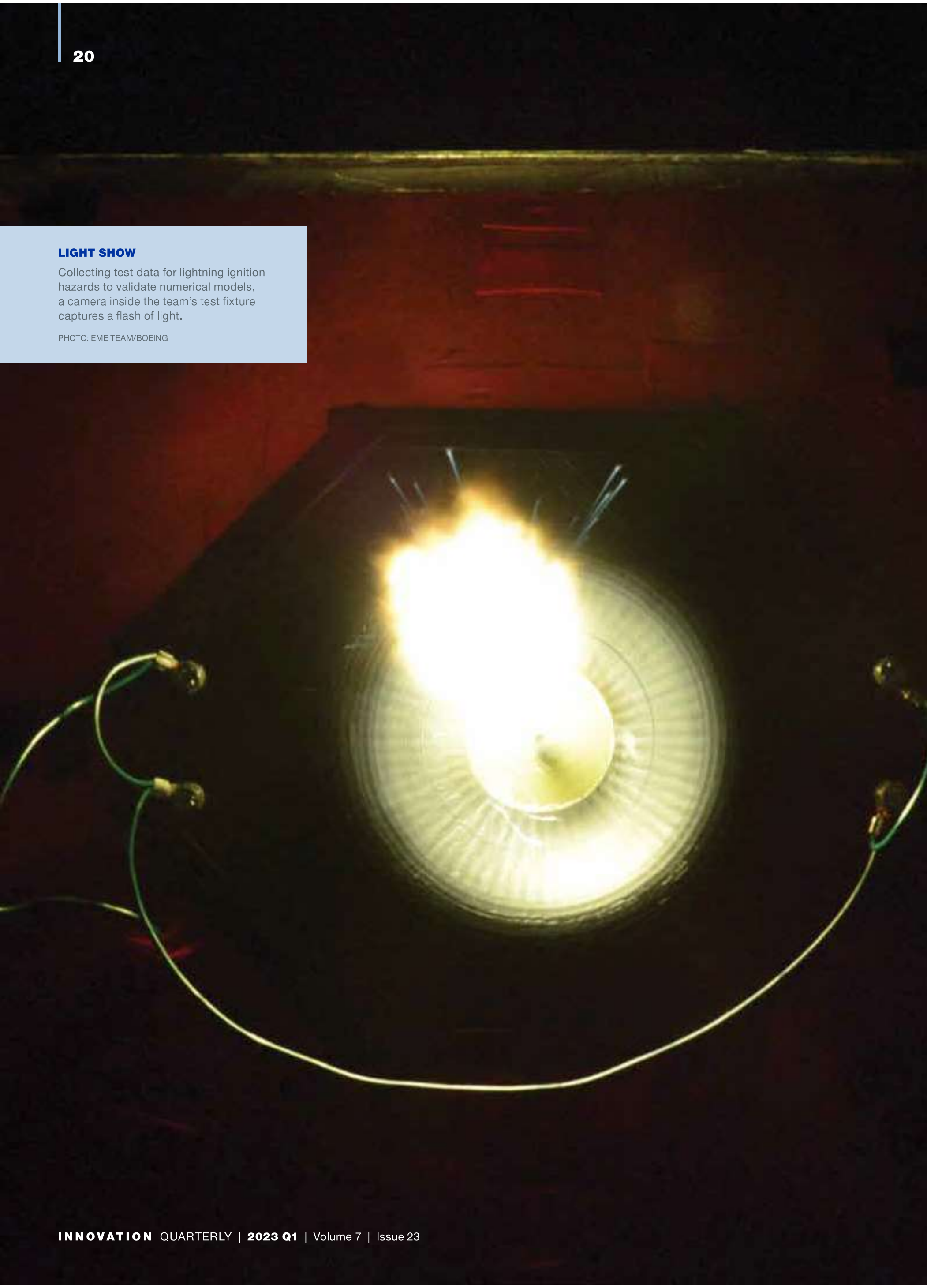
FLASH DRIVE

Michael (left) and Derek Tuck, an electromagnetic effects engineer, review data produced by the EME lab's lightning pulser.

PHOTO: KAITLIN STANSELL/BOEING

TIGHT LIGHT

Westin examines the test coupon for signs of visible lightning-induced delamination.



LIGHT SHOW

Collecting test data for lightning ignition hazards to validate numerical models, a camera inside the team's test fixture captures a flash of light.

PHOTO: EME TEAM/BOEING

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LOUISA MICHAEL, ELECTROMAGNETIC EFFECTS ENGINEER

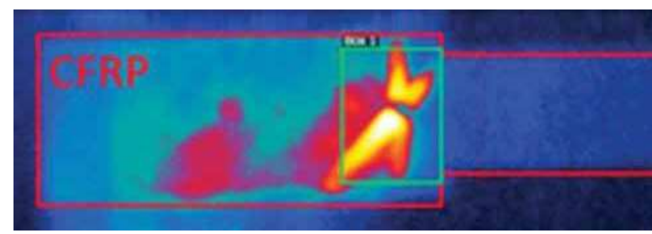
Nuts and Bolts and Volts

The Boeing-Cambridge partnership continues to shape the EME unit's approach to future research and model-based engineering. The studies can assess the impact of lightning down to an airplane's nuts and bolts. Teams will ultimately determine how Boeing might apply findings to its aerospace technology.

Now two years into her role, continuing to work with Cambridge has allowed Michael to keep one foot in both worlds — industry and academia — after finding an unexpected niche.

“There's this small part of the world focused on lightning and aviation research. An even smaller subset falls in the intersection between academia and industry,” Michael said. “It's fascinating to work on such complex but very real problems.

“I get to experience them firsthand. I get to collaborate with other people around the world who share my expertise in this area,” she continued. “And all this would have not been possible without the very talented Cambridge research team and my exceptional Boeing EME teammates. It's pretty exciting to see all of that coming together.” **IQ**



HUED BY HEAT

The team measures composite temperatures using thermal imaging to understand the complex physics of lightning and subsequent effects. CFRP stands for carbon fiber reinforced plastics.

PHOTO: EME TEAM/BOEING

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See lightning happen.

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