2017
CASE STUDY

When Lightning And Lightning Rods Connect

Vision Research high-speed Phantom cameras enable researchers to observe lightning rods in action.

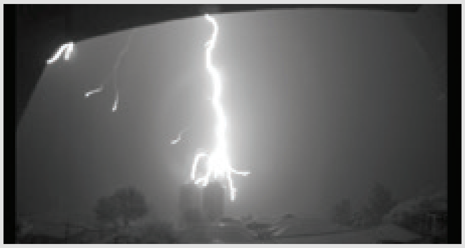
Marcelo Saba is a modern-day Doc Brown—except that instead of capturing lightning to power a DeLorean time machine in *Back to the Future*, Saba captures lightning with high-speed cameras to advance our understanding of current lightning protection systems.

Benjamin Franklin first outlined the principle of the lightning rod in 1749. Fast forward a few hundred years, and our buildings are taller—making lightning more dangerous in populated, urban environments. As a result, our lightning protection systems have had to become more sophisticated. Now, the lightning rod is just one small part of an entire system consisting of air terminals (the "rods"), conductor cables, ground rods, and surge suppressors. While these systems are critical in preventing or lessening lightning strike damage to buildings and other tall structures, current research on how exactly lightning attaches to the rods is mostly theoretical—based largely on laboratory observations of electrical discharges.

That's where Saba and his team come in.

In the past, several obstacles have prevented researchers from recording high-speed video images of lightning as it connects to rods on the 200-foot tall common buildings found in almost every city. For one, cameras need to be placed close enough to the chosen structure in order to capture the lightning in an observable way. Additionally, the filming process requires a long observation time to capture the strike to the building–if one even happens at all.

But now, for the first time, Saba and his team of researchers have captured the lightning attachment process using Vision Research high-speed cameras. Not only do the results broaden scientists' understanding of how lightning connects with lightning rods, but they also provide the necessary field-data that can help improve current lightning protection systems.



STORM CHASERS

Saba first started using high-speed cameras to observe lightning in 2003. "There were just a few studies out there–one or two at the time," the Brazilian researcher explained. "We realized there were so many aspects that could be explored and understood if we had high-speed cameras to make the details visible." Not only would the cameras enable Saba to observe the lightning strikes, which last only 1.5 seconds on average, at a much slower pace, but they also correlate easily with other equipment, such as electric and magnetic field sensors.

Saba's research took him from his native São Paulo, Brazil to the United States, where he spent time in Kansas and South Dakota studying cloud-to-ground lightning, positive polarity strikes, bipolar strikes and then finally upward-moving lightning. "We tried to record lightning during the summers for about three or four years," Saba said. "But storms come and go."

After returning to São Paulo, Saba captured an upward-moving strike occurring off the top of a 425-foot tower, using a Vision Research Phantom Miro 310 high-speed camera. In the background of the video, however, Saba noticed cloud-to-ground lightning striking two 14-story apartment buildings–an observation that inspired him to focus his research on lightning rods. "We wanted to understand how the rods work," Saba said. "Is the rod passive or active? Does it launch a charge that tries to connect to the lightning's downward charge, or does it 'wait' for the lightning to strike it?"

Although very tall structures are more likely to be struck by lightning, they almost always initiate upward lightning flashes. But apart from theories and models generated in laboratories, no observational data existed of lightning as it attaches to shorter, 200-foot buildings–a process that affects the majority of structures and buildings in almost every city. "There were only a few recordings from very tall buildings, but that's not where people live," Saba said. "The common building is not that tall."

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VISION RESEARCH LIGHTNING-FAST CAMERAS

To record the images of the lightning striking the pair of São Paulo apartment buildings, the researchers used two Vision Research high-speed digital cameras, a Phantom v711 and Phantom v12.1, working at 40,000 and 7,000 frames per second (fps), respectively. By using more than one camera, the researchers were able to film the lightning from multiple angles using varying fields of view of the two buildings.

Saba and his team also used a CineMag, Vision Research's proprietary storage device that incorporates secure, non-volatile flash memory for raw footage. After shooting the lightning, the researchers were able to "download" the footage off of the camera's RAM and onto the CineMag in seconds, eliminating camera downtime mid-shoot when transferring the footage to a computer. "Believe it or not, this makes a big difference," Saba said. "Lightning strikes are random, so less downtime means we reduce our chance of missing a strike."

But even with the right equipment, recording lightning is no easy task. "It's a challenging process," Saba said. "We have to wait for the right lightning strike on the building where we have our cameras pointed. We also have to have all our auxiliary equipment set up and ready to go." But the team's patience paid off. Since January 2012, the researchers were able to capture a total of six strikes on the pair of apartment buildings.

Phantom v711

IMPROVEMENTS IN BUILDING & PEDESTRIAN SAFETY

The high-frame rate and proximity of the cameras to the buildings allowed Saba and his researchers to observe important details about lightning that will advance the understanding of lightning rods and improve current lightning protection systems. In particular, the researchers were able to calculate the striking distance and speed of the two connecting leaders–the discharge that flows down from the stormcloud and the discharge that flows up from the rod–all of which is critical data in lightning protection studies. In this instance, the downward leader moved at 120 miles per second, while the charge from the rod moved upwards at roughly 30 miles per second .

The field-data provided by Saba's experiments promises to inform the design of future lightning protection systems for common buildings. Not only that, but the ability to observe lightning rods in action promises to advance scientists' understanding of how people can be injured by lightning – even if they're not directly struck. "Upward currents from our heads or shoulders might not connect to the charge coming down, but they'll still try to. Currents of several amperes may flow through your body. We expect that with this information, we can understand why people who aren't struck by lightning can still be injured by it."