2019
CASE STUDY

Big Risks Come in Small Packages

Using Phantom high-speed cameras, ballistics researchers observe what happens to a commercial aircraft wing after it collides with a small unmanned aerial vehicle (UAV).

As more drones continue to pepper the skies, it's important to understand how they interact with larger flying objects—particularly, manned aircraft. Unfortunately, these interactions aren't always pretty: in September, 2017, for example, a U.S. Army Black Hawk collided with a consumer drone, destroying the drone and causing minor damage to the helicopter's rotor blades.

Incidents like this naturally make you think: in a fight between a two-pound drone and several-thousand-pound aircraft, the latter will make it out mostly unscathed. But experiments utilizing high-speed imaging suggest otherwise.

The Impact Physics group at the University of Dayton Research Institute (UDRI) recorded collisions between a 2.1-pound drone and commercial aircraft wing. The lab, which specializes in ballistics impact testing, already had data on other objects, including birds and hail. "But at the time, there wasn't much data showing what a drone could do," says Kevin Poorman, lead researcher. "Not only is the drone population exploding, but people are using these aircraft differently. They used to be strictly recreational, but now they manage traffic, deliver packages and inspect bridges, crops and cell towers. Before we go too far down this road, we need to understand what happens if and when they encounter manned aircraft."

IS BIGGER BETTER?

Until now, the only way to study midair collisions was through computer simulations and modeling. But to truly understand the problem, Poorman—who has been conducting bird strike tests at UDRI for decades—knew he had to create an actual collision.

Using three Phantom high-speed cameras, Poorman and his team recorded a drone-aircraft collision in their laboratory, then slowed the footage down to observe and analyze the impact damage. The team collaborated with the Sinclair College National UAS Training and Certification Center, which supplied the wing—part of a Mooney M20 aircraft—and a popular hobbyist drone. While the Mooney M20 doesn't meet the requirements of a commercial passenger plane, its wing structure and thickness is comparable to what you'd find on larger aircraft.

The team fired the drone at the wing using the lab's largest air cannon—a 40-foot steel tube with 12-inch bore. Using compressed air, the cannon propelled the drone to 238 mph, which is the approximate combined speed of a drone and plane mid-flight. For comparison, the team then fired a similarly weighted gel "bird" into a different part of the wing. To capture these processes, the researchers utilized three Phantom v2012 high-speed cameras, which they positioned at the top and sides of the wing. These cameras recorded the simulated drone and bird collisions at 10,000 frames per second (fps).

"At over 200 miles per hour, the collisions appear instantaneous in real time," Poorman says. "The Phantom cameras were essential. They slowed the processes down—providing us with high-quality, detailed images, which we needed to observe the impact damage."

Capturing the simulated collisions were three Phantom v2012 high-speed cameras positioned at the top and sides of the wing.

INSIDE UDRI'S IMPACT PHYSICS LAB

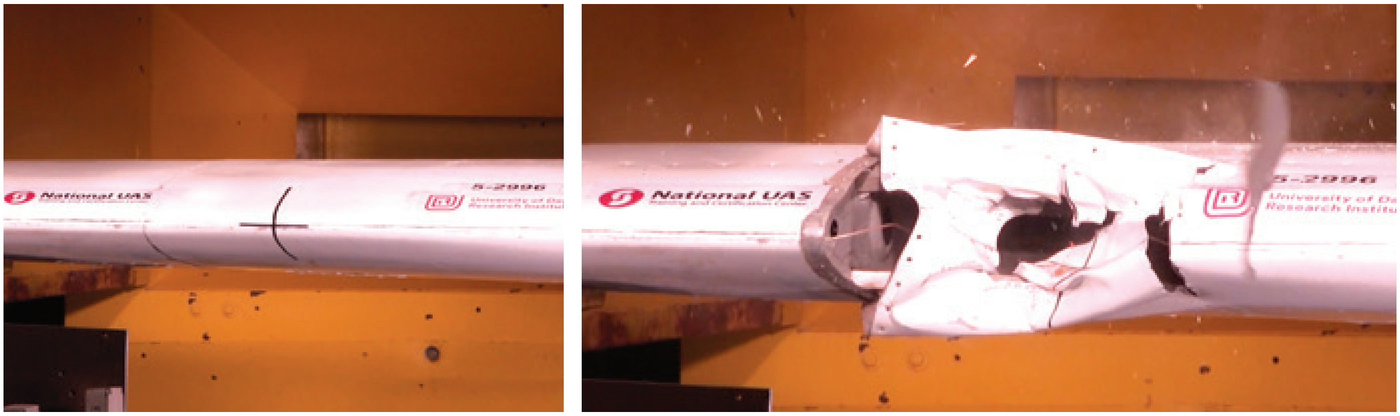
For over 40 years, UDRI Impact Physics researchers have tested and evaluated impact-resistant systems in a variety of fields, including foreign object damage (FOD), light armor design and evaluation, penetration mechanics, hypervelocity impact testing—and more. The group's testing laboratories include 12 gun ranges capable of propelling objects at velocities ranging from tens of feet per second to over 33,000 feet per second.

THE DRONE DAMAGE

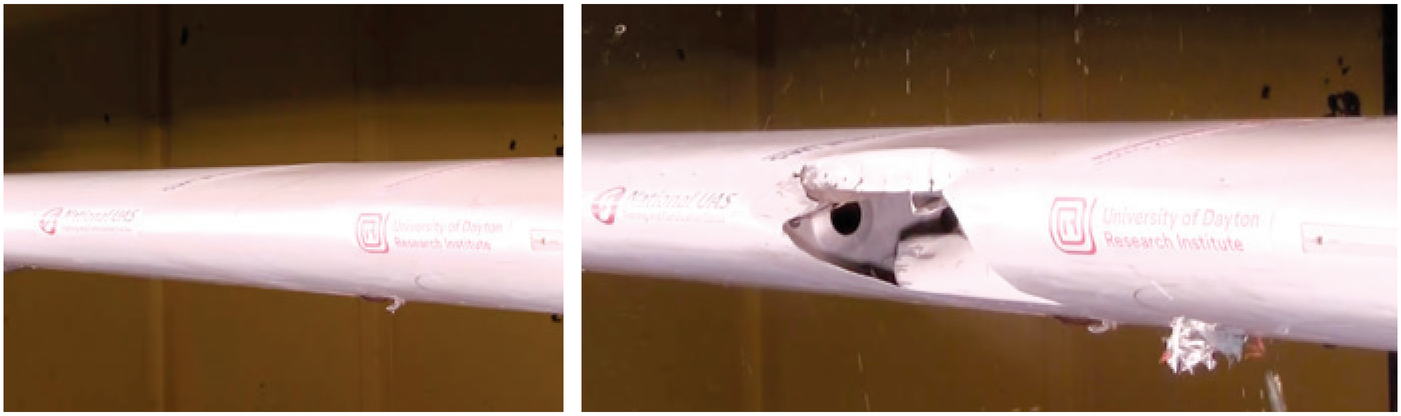
Surprisingly, the drone caused significantly more damage to the aircraft than expected. The high-speed footage reveals that the drone penetrated deep into the wing—damaging the main spar, which is where the weight of the aircraft is suspended. Too much damage to this structural element—which would be even greater for larger drones or faster-moving aircraft—could cause the plane to crash. By comparison, the fake bird didn't create a hole quite as deep. It also didn't cause any internal damage to the plane. "Based on these results, the drone has the potential to do more damage internally on aircraft structure than a bird with similar impact energy," Poorman says.

The hope is that these results bring awareness to the importance of drone regulations—many of which are already in place under the Federal Aviation Administration (FAA). At the same time, they can help inform what else can be done to safeguard manned aircraft, including designing drones that shatter on impact or imposing weight limits.

Poorman and his team presented their findings at the fourth annual Unmanned Systems Academic Summit, held at Sinclair College's Conference Center and its National UAS Training and Certification Center in Dayton, Ohio.



The ballistics team fired a drone at the aircraft wing to simulate a midair collision at 238 mph.



THE PHANTOM v2012: HIGH FRAME RATE, HIGH SENSITIVITY

The Phantom v2012 features ultra-high frame rates, high light sensitivity and a number of advanced features for optimizing workflow. These qualities allowed Poorman and his team to generate high-quality images of a 238-mph collision, which—to the naked eye—appears to occur instantaneously.

- **High frame rates.** The v2012 delivers an impressive speed of 22,000 fps at full 1-megapixel resolution and frame rates over 651,000 fps at reduced resolutions.
- **High sensitivity.** The camera's custom 12-bit CMOS sensor features 28-micron pixels, resulting in a high native ISO of 32000D mono and 6400D color. This allows for excellent image quality at the low exposure times required at such high fps rates

"We've been with Vision Research since the day we started using film cameras for our impact tests," Poorman says. "We graduated from using earlier camera models, including the v7.2, v7.3 and v1611. Now we use 2012s, which are fantastic cameras. They have great light sensitivity and resolution for the frame rates we needed, so the impact images turned out pretty great."

*The **Phantom v2012** features high light sensitivity and ultra-high frame rates at full 1-megapixel resolution, a balancing act that helped the ballistics team generate high-quality images of the collisions.*

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PHANTOM
VISION RESEARCH
AMETEK MATERIALS ANALYSIS DIVISION

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