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SySTEM Alert!

Tomorrow is almost here.

Crash test

Researchers at NASA's Langley Research Center hoist the small airplane 100 feet into the air with cables. The Cessna 172 has no passengers inside. Suddenly, the airplane begins to fall. In seconds it crashes violently onto the ground below. In the collision, it flips over, and the tail snaps. The plane is ruined.

An awful accident? A careless error? The result of a cable someone forgot to secure? No, it wasn't a mistake at all. In fact, it was the third time that the researchers purposely dropped a plane out of the sky.

AGAINST THE CLOCK

After an accidental plane crash, time is of the essence for rescue workers. If there are survivors, being able to find the crash site and address their injuries quickly can easily mean the difference between life and death. For this reason, airplanes are equipped with ELTs – emergency locator transmitters. In the event of a crash, these devices send out a signal that can be used to locate the site. Except that sometimes they don't send out their signal. The main reason an ELT would fail to do this is that it is damaged in the crash.

It stands to reason that if ELTs can be made to survive more crashes, more lives might be saved. And this, at last, is the reason that NASA researchers purposely crashed three airplanes. They are gathering data for the purpose of making ELTs more resistant to crash damage. In particular, they are looking at whether there are ways to install the devices that would leave them less vulnerable.

ELTs are made of two parts – a beacon and an antenna. The beacon is usually attached to the fuselage, the body of the plane. If the beacon detects it has been in a crash, it transmits its signal to the other part of the ELT, an antenna. The antenna is on the outside of the plane. The antenna broadcasts the signal far and wide. If the antenna isn't damaged, the signal is picked up by an orbiting satellite. Rescue teams access this information to help find the crash site.

HIGH-PRESSURE SITUATION

In each test, the crashes were designed to be catastrophic – but survivable. Crash test dummies were placed in the cockpits of the planes to simulate passengers.

Researchers wanted to get precise information about what happened to the planes during the crashes. For this reason, the crashes were recorded with high-speed cameras. Dots were painted on the outsides of the crafts. The dots help the researchers interpret the footage of the crash. They provide reference points on the planes to show how they compress and buckle in the extreme pressure.

The researchers also made the decision to crash the plane onto a mound of dirt instead of concrete. You might think that concrete would provide a tougher test, as it is so much harder than dirt. But a crash onto dirt can actually be more damaging. The reason is pretty simple. Sometimes a plane will skid on concrete, and this can diminish the force of the crash. But a plane that lands in dirt tends to come to a quicker stop. And a more sudden stop is a more violent stop.

The data will need to be analyzed before conclusions can be drawn. Hopefully, a solution will be found that will improve the odds of survival for those in air traffic accidents.

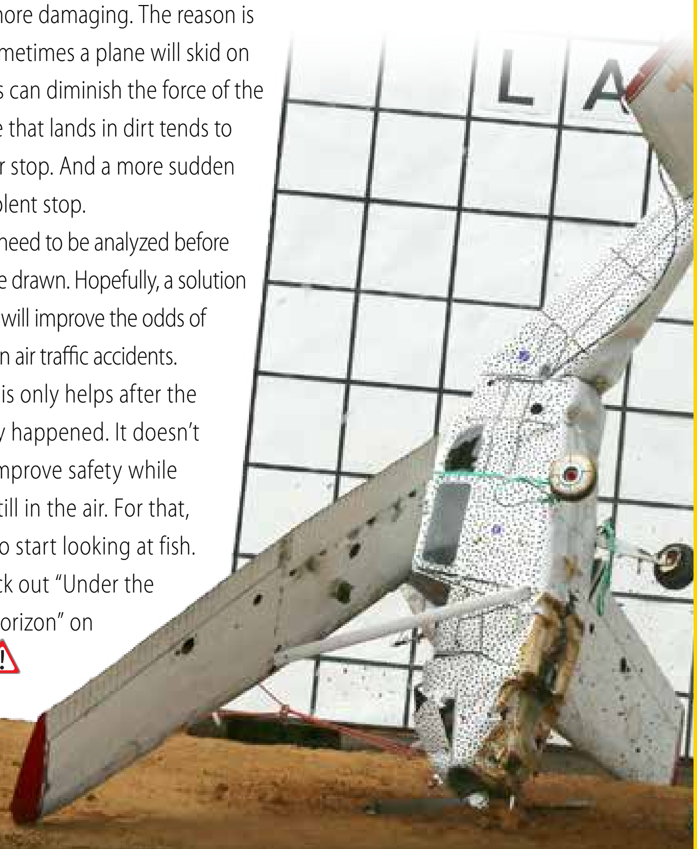
Of course, this only helps after the worst has already happened. It doesn't do anything to improve safety while passengers are still in the air. For that, we might need to start looking at fish. Wait, what? Check out "Under the water, over the horizon" on the back page.

Career Fields

- Pilot
- Radio operator
- Videographer

Why lift a Cessna 172 a hundred feet into the air only to drop it onto the ground?

Credit: NASA.gov



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Pluto or bust

Image credit: NASA.gov

In 2006, a space probe called *New Horizons* was launched into space from Earth. In 2015, it flew close enough to its target, Pluto, to take high-quality photographs. That is a travel time of nine years. Imagine throwing a ball with the idea that in nine years, it would hit its target. That would take a pretty spectacular aim.

When NASA scientists aim, they use math. Lots of it. The math involved in sending a probe to another planet is so complex that scientists use supercomputers to do the calculations. And even then, it is hard for them to be sure they've got it just right. Probes in deep space must be monitored from Earth to ensure they are still on the right track. If need be, course corrections must be sent to the probe. But the calculations have to be exceptionally good from the get-go, or course corrections won't matter.

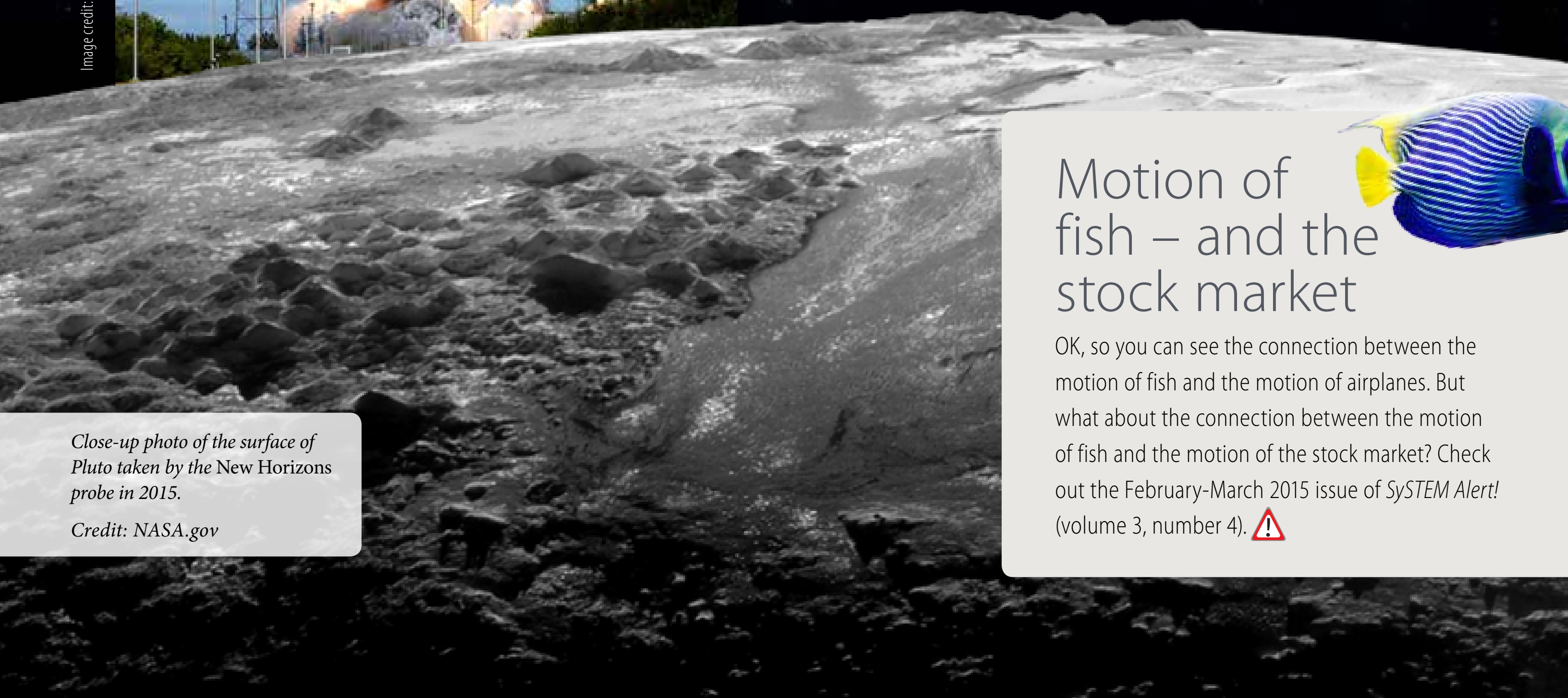
The difficulty of aiming for another planet is caused by more than just the incredible distance involved. Consider these details:

1. The target is moving. Planets in our solar system orbit the Sun. (Pluto is called a dwarf planet, but it also orbits.) So, if scientists put a probe on a rocket and send it into space, they have to aim not for where the planet *is* but for where *it will be* by the time the probe gets there. Fortunately, planets have fairly predictable orbits around the Sun.
2. Earth is also moving. Just like the other planets, Earth orbits the Sun. But the planets take different amounts of time to complete their orbits. It takes Earth 365 days. It takes Pluto more than 90,000 Earth-days to make its full trip around the Sun.
3. Earth is not just moving – it is also spinning. This spinning causes night and day. At different times during a 24-hour period, the rocket waiting to be launched on Earth will be pointing at different points in the sky.

OK, so NASA scientists managed to launch their *New Horizons* probe at a moving target while the Earth itself was moving and spinning. And of course nine years away. Does that sound difficult enough for you? Well, actually, that isn't the end of it. Every object in the solar system has a gravitational field. Even when a probe is far from an object, the object's gravity can still affect the path of the probe. There are also streams of particles in our solar system that make up what is called the solar wind. The solar wind can also have an effect on the paths of objects moving in space.

The feat that NASA scientists achieved by sending the *New Horizons* probe to Pluto is incredible. It is made more rather than less incredible by the fact that this isn't the first time they've managed to do something like this. But for their effort, they went down in history and got some amazing photographs that couldn't have been taken any other way. Take a look for yourself.

Image credit: NASA.gov



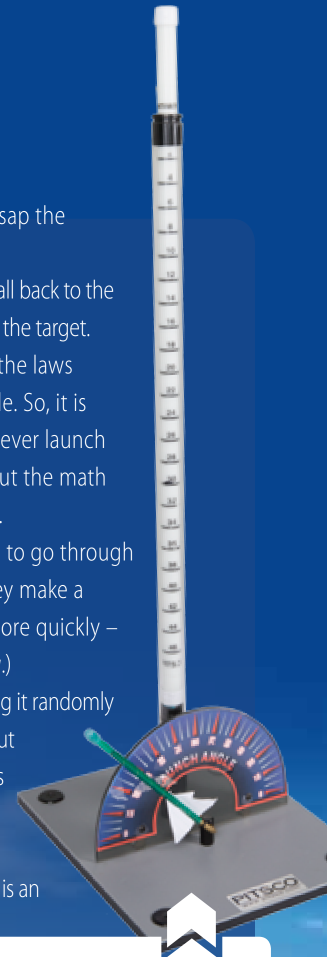
Close-up photo of the surface of Pluto taken by the New Horizons *probe in 2015.*

Credit: NASA.gov

Motion of fish – and the stock market

OK, so you can see the connection between the motion of fish and the motion of airplanes. But what about the connection between the motion of fish and the motion of the stock market? Check out the February-March 2015 issue of *SySTEM Alert!* (volume 3, number 4).

On target: straw rockets



The Pitsco Straw Rocket Launcher might not be quite as sophisticated as the technology used to launch probes into space. And you might not shoot a straw rocket to Pluto. But anyone who uses one still has the same essential problem of shooting a projectile at a target. Let's imagine someone trying to hit a target on the ground several feet away.

The Straw Rocket Launcher uses a puff of air to propel a rocket made from a drinking straw. The force of the puff of air can be adjusted. The angle that the rocket is launched at can also be adjusted, and when the rocket is fired, it flies off at that angle. The rocket would continue to fly away at that angle forever except for two forces acting on it: gravity and drag.

- The **gravity** created by Earth's tremendous mass pulls the rocket downward. Little by little, it overcomes the force of the launch. Soon, the straw rocket is no longer rising. When it has reached the highest spot in its ascent, that spot is called the apogee. After the apogee, it begins its descent.
- **Drag**, the other force, is caused by the molecules of air coming in contact with the surface of the straw rocket. When the tiny molecules collide with the rocket, they also sap the upward force of the rocket little by little.

Because of these forces, the rocket will inevitably fall back to the ground. The only question is where it falls in relation to the target.

The forces involved are precisely governed by the laws of the universe. For that reason, they are predictable. So, it is technically possible to do a lot of math before you ever launch the rocket and then hit the target on the first try. But the math required for the *perfect* calculation is very complex.

Most who use the Straw Rocket Launcher have to go through some good old-fashioned trial and error before they make a perfect hit. (Math can help make this process go more quickly – using the quadratic equation or the formula $f = ma$.)

However, trial and error doesn't mean just shooting it randomly until you happen to hit the target! Trial and error is about learning from errors and continually improving. There is nothing shameful about having to do this. Even the scientists at NASA, some of the brightest minds on our planet, rely on trial and error to an extent. Every launch is an experiment of sorts. It relies on a lot of skill and a little bit of luck. ⚠

CHECK OUT:
www.pitsco.com/StrawRocket

Under the water, over the horizon

Ah, to be a fish. To wriggle your body, wave your fins, and float weightlessly through an aquatic wonderland. That might sound blissful, but that graceful glide can actually be pretty frustrating to those who study fish. The problem is that understanding how fish propel themselves means understanding how their motion moves the water around them. And the water, flowing continuously, moves in incredibly complex ways.

Think of how much easier it is to understand the motion of a person skiing across a field. The skier pushes her body by pushing two ski poles against the ice. The poles have clear contact points with the ice, and these are the only contact points apart from the skis. But a fish is completely engulfed in water that continuously flows around its body and rearranges itself. (This comparison, used by the researchers, originally came from writer Laurel Hamers.)

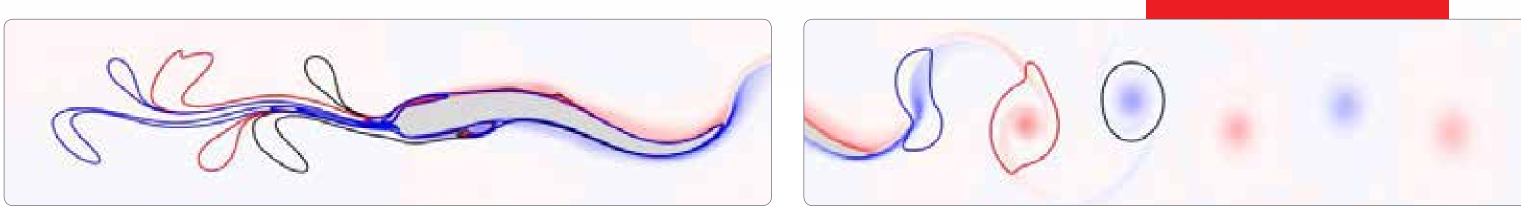
And now, say the researchers, they might have taken a big step toward solving that difficulty.

When fish swim, they produce swirls in the water around them. The fancy scientific name for these swirls is vortices. And the really fancy scientific name for these is *Lagrangian coherent structures*. What these three words – we'll just call them vortices – have in common is the fact they can be observed separately from the rest of the water around.

Essentially, what the scientists discovered is they can study how fish move by observing just these vortices – rather than having to observe the movement of all the water.

This research began with fish, but it might not end there. The technique of isolating these vortices might work for studying other types of objects moving through fluids. For example, airplanes in the sky. (Air is a fluid, though not a liquid.) Airplanes also cause vortices in the air around them. These vortices can cause instability in the plane's flight. Perhaps we could learn ways to make more aerodynamic airplanes by using this same technique to study these vortices. ⚠

Career Fields
- **Aerospace engineer**



This image shows three coherent vortices before (left) and after (right) being shaped by the fish. Credit: F. Huhn/ETH

Gravity? Not a problem

It's a pretty simple activity. The small tissue paper parachute is attached to the Rip Cord, and the Rip Cord is attached to the Rip Cord Stand. When the string is pulled, the Rip Cord lets go of the parachute and the parachute falls. Quickly, however, the chute fills with air and it drifts rather than plummets to the ground. How does it do this?

The parachutes made from tissue paper work just like the bigger, more durable kind that skydivers use when they leap out of airplanes. The principle is the same.

A falling object has several forces acting on it. One, gravity, pulls it toward Earth. Actually, gravity pulls the object toward the center of the Earth, but the ground will decisively stop the object before it gets there.

The other important force acting on the object is air resistance – a type of drag. As the object bumps into molecules of air, these molecules slow it down just a little in its fall. Imagine dropping through tree branches. It is easy to envision how branches could slow the fall of an object. The air molecules do the same thing, except that each tiny air molecule has much less of an effect than a branch. But with enough of them . . .

And that is the secret of a parachute. A parachute is designed to spread out wide so that it encounters as many molecules of air as possible. Its big shape does not let the air molecules flow easily around it. A more aerodynamic object such as the nose of a plane would channel the air around it to minimize contact with the air. But a parachute is purposely not aerodynamic!

Every falling object has some air resistance. But a parachute builds up so much of it that it counteracts the force of gravity pulling the object down. It doesn't completely cancel it out, or the object (or unlucky skydiver) would never reach the ground. But it slows the object just enough for a safe landing.

All the materials you need

The Rip Cord, Rip Cord Stand, and materials for parachutes are available from Pitsco Education.

CHECK OUT:
www.pitsco.com/Parachute

Image credit: Jason Kellogg

A quiz for every issue of the free SySTEM Alert! newsletter can be found at www.pitsco.com/sySTEMalert.

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Student name: ______________________ **Class/Hour**: __________

SySTEM Alert! Quiz (Volume 4, Number 2)

This quiz covers the information in *SySTEM Alert!* volume 4, number 2. Circle the letter of the correct answer or write the letter by the question number.

1. Emergency locator transmitters (ELTs) are made of two main parts. What are these parts?
   A. flight recorder and battery
   B. beacon and battery
   C. antenna and flight recorder
   D. beacon and antenna

2. There are several reasons why it is difficult to aim a spacecraft at another planet. Which of the following is not a reason for this?
   A. There are many obstacles in the path floating in space.
   B. The target planet is moving.
   C. Earth is moving.
   D. Earth is spinning.

3. What is an apogee?
   A. a special low-light camera that can be used in space
   B. a type of distress signal sent out by an emergency locator transmitter
   C. the highest point in an object's ascent (climb)
   D. a parachute design

4. Why did NASA researchers paint dots on an airplane for its test crash?
   A. The dots helped researchers interpret the footage of the crash, showing where the plane buckled and compressed.
   B. As the plane would be ruined by the crash anyway, the researchers decided to give it a funny paint job.
   C. The dots were made of special paint capable of measuring the crash forces on the plane.
   D. The dots were part of a publicity campaign for the test crash event.

5. When fish swim, they produce swirls in the water around them. What are these called?
   A. whirlpools
   B. tsunamis
   C. apogees
   D. vortices

6. A parachute slows its fall by building up _______.
A. antigravity
B. air resistance
C. Lagrangian coherent structures
D. kinetic energy

7. What was the name of the space probe from Earth that passed by Pluto in 2015?
A. New Horizons
B. Voyager
C. New Dawn
D. Nostromo

8. How long did the space probe from the previous question travel before it reached Pluto?
A. seven years
B. eight years
C. nine years
D. 10 years

9. Why can an airplane crash on dirt actually be more destructive than a crash on concrete?
A. Packed dirt is actually harder than concrete.
B. The dirt causes the plane to come to a quicker stop, whereas the concrete can cause it to skid.
C. The pieces of dirt can get inside the emergency locator transmitter.
D. This is a trick question. A crash on concrete is always more destructive.

10. What is the main reason it is so hard to study the way fish move the water around them?
A. Water is clear and therefore hard to see.
B. The water flows in very complex ways.
C. The movements of water are very small.
D. The fish themselves block the view.

Bonus question:
If humans ever travel to Pluto, the journey could last several years. Why would such a long trip be hard on humans, and what could the crew bring along to make the trip more tolerable?