GRAVITY AND SPACE TRAVEL

Produced by the staff of the Charles Hayden Planetarium, Museum of Science, Boston

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SEGMENT 1: Introduction

NARRATOR

The launch of a spacecraft is one of the most dramatic moments of any space mission.

But long before it reaches the launchpad, engineers and mission planners have a seemingly simple question to answer—how will the spacecraft get to its destination?

Many spacecraft can't take the most direct route to their journey's end. It would simply take too much propellant.

The solution, surprisingly, is to take a longer, less direct route and interact with the planets themselves to change the speed of the spacecraft.

This process is known as a "gravity assist," and it actually depends a lot on transferring momentum, the product of an object's mass and velocity.

SEGMENT 2: Roller-Skaters

NARRATOR

To get an idea of how momentum works here on Earth, imagine a pair of roller-skaters.

Skater One holds still, while Skater Two moves towards her.

If Skater One whips Skater Two around as she passes, Skater Two's speed will increase a little, but it's not much of a difference.

Now imagine that Skater One is also moving. This is where momentum comes into play. This time, when Skater Two passes and Skater One whips her around, Skater One is also transferring a large amount of her momentum to Skater Two.

As a result, Skater One slows down, while Skater Two's speed increases dramatically.

To get a large change in speed, motion is key.

SEGMENT 3: New Horizons and Jupiter

NARRATOR

Let's look at an example of how momentum is transferred from a planet to a spacecraft during a gravity assist.

The New Horizons spacecraft, launched in 2006, is the first spacecraft to visit Pluto.

If New Horizons had taken a direct route from Earth to Pluto, the trip would have taken at least twelve years to complete.

Instead, in 2007, a year after its launch, New Horizons passed Jupiter for a planned gravity assist.

It's important to remember that Jupiter is moving very fast, orbiting the Sun at a velocity of nearly 50,000 kilometers, or 29,000 miles, per hour.

It's also extremely massive, over 300 times the mass of Earth.

Since momentum is the product of velocity and mass, this means Jupiter has plenty of momentum to spare. It has so much, in fact, that it doesn't even notice the tiny amount that is transferred to the spacecraft during the flyby.

But for a small object like New Horizons, the stolen momentum causes an enormous change in speed, boosting it by over 14,000 kilometers, or almost 9,000 miles, per hour.

This one encounter cut three years off the spacecraft's journey!

SEGMENT 4: Gravity Assist Slow Down

NARRATOR

Gravity assists are very handy for speeding a spacecraft up, but they can also be used to slow it down.

If a spacecraft approaches a planet in a more head-on direction, rather than coming from behind, engineers can get the planet to steal momentum from the spacecraft, instead of the other way around.

Again, the planet doesn't really notice, but the spacecraft radically slows down.

SEGMENT 5: Multiple Trajectories

NARRATOR

Many missions require the use of multiple gravity assists and many years of travel to reach their destinations.

These trajectories can take years to plan, and require us to know the positions of multiple planets far in advance.

But, by making use of the objects in the Solar System, gravity assists allow spacecraft to travel to destinations that otherwise would be too expensive or time-consuming to reach.

They have allowed us to explore everything from the Sun itself out to the edge of interstellar space, and to see things we never thought we'd see.