



1
00:00:00,000 --> 00:00:02,840
(Music)

2
00:00:02,860 --> 00:00:12,200
LAUNCH ANNOUNCER: 8... 7... 6... 5... 4...3... 2... Engine start... 1... zero and liftoff

3
00:00:12,220 --> 00:00:14,770
of the Delta two rocket with Kepler,

4
00:00:14,790 --> 00:00:19,440
on a search for planets in some way like our own.

5
00:00:19,460 --> 00:00:25,770
NARRATOR: On March 6, 2009 the Kepler Spacecraft rocketed into the night sky

6
00:00:25,790 --> 00:00:30,560
on its mission to search for Earth-size planets in our galaxy.

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00:00:30,580 --> 00:00:33,300
WILLIAM BORUCKI: It was really an exciting experience to be at the launch.

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00:00:33,320 --> 00:00:41,480
I wondered, is it actually going to get into orbit, is it going to be successful, will it find planets... or will it fall into

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00:00:41,500 --> 00:00:44,720
There's no backup... this is our chance.

10
00:00:44,740 --> 00:00:50,870
So it was really an ethereal experience to be there, watch it blaze into the sky, get into orbit

11
00:00:50,890 --> 00:00:55,040
and then finally hear its signal... it's okay, it will work.

12
00:00:55,060 --> 00:01:00,790
NARRATOR: The spacecraft was designed to search one region of our galaxy for evidence of exoplanets,

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00:01:00,810 --> 00:01:04,730

or planets that are outside our solar system.

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00:01:04,750 --> 00:01:08,940

Using special detectors similar to those found in digital cameras,

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00:01:08,960 --> 00:01:15,670

Kepler will measure the light from many stars and wait for planets to transit in front of them.

16

00:01:15,690 --> 00:01:21,410

The system is sensitive enough to gauge the slight dimming of a star's light output when a planet passes

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00:01:21,430 --> 00:01:24,540

between the star and the telescope.

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00:01:24,560 --> 00:01:29,690

Kepler has the unique ability to study the light from an enormous number of stars

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00:01:29,710 --> 00:01:35,490

while gathering very high quality data about each.

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00:01:35,510 --> 00:01:41,190

NARRATOR: Soon after the launch, Kepler was maneuvered into an Earth trailing orbit around the sun.

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00:01:41,210 --> 00:01:46,970

One month later, the telescope ejected its dust cover... ran its diagnostics...

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00:01:46,990 --> 00:01:51,140

and within a day the first light test was completed.

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00:01:51,160 --> 00:01:58,190

NATALIE BATALHA: We had never actually taken a picture of real stars in the sky... this was the first time.

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00:01:58,210 --> 00:02:04,260

It was going to tell us how the optics were working, are we in focus... is the light coming in as we expected?

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00:02:04,280 --> 00:02:11,100

And at nine o'clock unexpectedly, we got an email from our engineer saying that the data had been transferred

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00:02:11,120 --> 00:02:16,470

So I went into the data den where the big computer monitors are and I pulled up the image.

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00:02:16,490 --> 00:02:24,020

And watching that image stack itself onto my computer screen was like champagne filling a glass

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00:02:24,040 --> 00:02:27,090

with all the stars that were there.

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00:02:27,110 --> 00:02:33,240

I knew that there were four and a half million stars in our field of view, but seeing them displayed there

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00:02:33,260 --> 00:02:40,200

and really understanding the density of stars that we were looking at... it was beautiful.

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00:02:40,220 --> 00:02:46,550

NARRATOR: The Kepler telescope stares continuously at the same section of the galaxy for a month at a time

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00:02:46,570 --> 00:02:49,680

measuring the brightness of its target stars.

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00:02:49,700 --> 00:02:57,560

Once a month, it stops viewing for a few hours to turn back towards Earth to transmit its valuable data.

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00:02:57,580 --> 00:03:03,230

The Mission Operations Team at the Laboratory for Atmospheric Space Physics or LASP

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00:03:03,250 --> 00:03:08,920

at the University of Colorado in Boulder is responsible for controlling the Kepler spacecraft

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00:03:08,940 --> 00:03:11,900

and receiving the data downlinks.

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00:03:11,920 --> 00:03:17,800

The data collected at LASP is sent for processing to the Space Telescope Science Institute

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00:03:17,820 --> 00:03:22,410

on the campus of The Johns Hopkins University in Baltimore, Maryland.

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00:03:22,430 --> 00:03:29,360

There, the science data is decoded and processed then passed along to the Kepler Science Operations Center

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00:03:29,380 --> 00:03:34,110

at NASA Ames Research Center for calibration and final processing.

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00:03:34,130 --> 00:03:40,670

NICK GAUTIER: The Kepler data is a hundred times better than ground based data that people have seen before

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00:03:40,690 --> 00:03:45,190

We had to spend a lot of time figuring out how to make the instrument work properly

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00:03:45,210 --> 00:03:49,650

and we're still spending a lot of time even now figuring out how to interpret the data

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00:03:49,670 --> 00:03:55,460

and pull out stuff that's a hundred times better than anybody else's data.

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00:03:55,480 --> 00:04:02,330

NARRATOR: After only 43 days of operation, Kepler collected a treasure trove of fascinating data.

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00:04:02,350 --> 00:04:08,620

Some of the first researchers on the Kepler team to benefit from the data were focused on the stars themselves

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00:04:08,640 --> 00:04:11,650

Scientist: Now let me get into the more interesting part...

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00:04:11,670 --> 00:04:17,730

Their research... called asteroseismology... is the effort to understand the structure of stars

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00:04:17,750 --> 00:04:23,590

by studying the unique pulses or quakes that each star generates internally.

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00:04:23,610 --> 00:04:28,240

HANS KJELDSEN: What we study is the periods of vibrations in stars.

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00:04:28,260 --> 00:04:34,850

The basic properties that we measure are the size of the star and the age of the star.

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00:04:34,870 --> 00:04:39,480

So, if you don't know the size of the star, you actually also don't know the size of the planet.

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00:04:39,500 --> 00:04:44,970

So what we are simply doing is that we use the vibrations to measure the size of stars and therefore,

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00:04:44,990 --> 00:04:48,750

we also know the size of the planets.

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00:04:48,770 --> 00:04:53,730

Kepler will from now on be the mission that you go to when you want the real data.

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00:04:53,750 --> 00:04:56,280

It is a revolution.

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00:04:56,300 --> 00:05:04,140

NARRATOR: An early challenge for the Kepler science team was to validate the quality of their first 43 days of

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00:05:04,160 --> 00:05:10,470

They chose to observe a previously discovered exoplanet to prove that their methods would work.

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00:05:10,490 --> 00:05:15,010

JON JENKINS: Hat-P-7b is one of three known transiting planets that were discovered in Kepler's field of view

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00:05:15,030 --> 00:05:18,040

before we launched, so of course we put them on our target list.

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00:05:18,060 --> 00:05:23,030

On the first day that we looked at data from Kepler during commissioning... we looked at this star's light curve.

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00:05:23,050 --> 00:05:28,400

The big surprise was that we were able to see the planet going behind the star.

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00:05:28,420 --> 00:05:34,860

So as the planet goes in its orbit towards the backside it gets brighter because you're seeing more of its sun wa

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00:05:34,880 --> 00:05:40,670

But then it winks out for about two hours as it goes flying behind the star.

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00:05:40,690 --> 00:05:47,450

And the amazing thing is that this drop in brightness of this secondary occultation is only one hundred parts pe

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00:05:47,470 --> 00:05:52,930

But one hundred parts per million is a magic number because and that's the size of the drop in brightness that

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00:05:52,950 --> 00:05:59,630

for an Earth size planet transiting or crossing the face of a Sun size star.

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00:05:59,650 --> 00:06:04,330

NARRATOR: Several ground observatories around the globe are partnering with the Kepler Mission

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00:06:04,350 --> 00:06:09,380

to provide independent confirmations about planetary transits of stars.

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00:06:09,400 --> 00:06:16,430

Kepler detects changes in brightness of many stars that appear to have the signature of a planetary transit.

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00:06:16,450 --> 00:06:23,040

Often these are later found to be something else, such as a smaller star eclipsing a larger one.

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00:06:23,060 --> 00:06:29,980

The ground observatories help to confirm actual planets from these "false positive" readings.

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00:06:30,000 --> 00:06:33,100

GEOFF MARCY: The Keck telescope in Hawaii is crucial for Kepler.

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00:06:33,120 --> 00:06:39,760

It does two things, it verifies the existence of the planets by looking for the wobble of the host star

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00:06:39,780 --> 00:06:44,770

yanked gravitationally by the planet, and it allows us to measure the mass of the planet,

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00:06:44,790 --> 00:06:47,700
the bulk mass, by how much the star wobbles.

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00:06:47,720 --> 00:06:55,250
Verifying planets and getting their masses and hence their densities is a key part of the Kepler project.

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00:06:55,270 --> 00:07:02,350
NARRATOR: This validation is critical to the process of identifying new planets, such as the Kepler team's first

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00:07:02,370 --> 00:07:06,700
of five exoplanets announced at the end of 2009.

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00:07:06,720 --> 00:07:10,320
WILLIAM BORUCKI: The discovery of these five planets... four of them were Jovian-like,

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00:07:10,340 --> 00:07:13,930
that is, big gas giants with densities that were surprising.

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00:07:13,950 --> 00:07:17,140
All the way from water... that to styrofoam. A real surprise.

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00:07:17,160 --> 00:07:23,230
But one of them was a planet very much like Neptune, probably rocky inside with an atmosphere.

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00:07:23,250 --> 00:07:30,240
And so this was a very interesting planet and a planet very close to its star yet it didn't bloat like the Jupiter-like

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00:07:30,260 --> 00:07:34,720
So again, a lot of information about the structure of these extrasolar planets

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00:07:34,740 --> 00:07:38,530
that will help us understand those planets and our own.

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00:07:38,550 --> 00:07:45,890
NARRATOR: By June of 2010, the Kepler team had identified between 300 to 700 planet candidates.

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00:07:45,910 --> 00:07:51,120

They released a data set containing about 300 of these possible planets to their research partners

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00:07:51,140 --> 00:07:55,240

around the world to help accelerate their search.

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00:07:55,260 --> 00:07:59,440

SARA SEAGER: Kepler is revolutionizing the field of exoplanet science.

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00:07:59,460 --> 00:08:05,970

For the first time a large number of planet candidates can be studied using extremely high quality data.

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00:08:05,990 --> 00:08:12,250

We're talking about hundreds and hundreds of planets using the best data we have ever seen here on Earth.

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00:08:12,270 --> 00:08:17,930

This will lead to the discovery of many, many new exoplanets, and a better understanding

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00:08:17,950 --> 00:08:21,590

of the types of star systems and planets out there.

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00:08:21,610 --> 00:08:30,550

What I find most fascinating is that Kepler is making discoveries of phenomena that we have never before with

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00:08:30,570 --> 00:08:38,690

NARRATOR: As the team continued to analyze their data, they found a system with multiple planets orbiting a

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00:08:38,710 --> 00:08:43,190

This important discovery was announced in August of 2010.

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00:08:43,210 --> 00:08:49,360

JON JENKINS: Kepler 9 is a very special system because it's the first time that anybody has detected a system

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00:08:49,380 --> 00:08:54,240

where multiple planets are transiting or crossing the face of their stars.

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00:08:54,260 --> 00:08:59,840

Moreover, we found a third planet much smaller and in a much tighter orbit, one point six days.

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00:08:59,860 --> 00:09:04,220

It's one point six Earth radii making it a super-Earth.

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00:09:04,240 --> 00:09:10,160

So we find two Saturn-sized planets and one super-Earth-size planet that represents Kepler's first super-Earth.

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00:09:10,180 --> 00:09:15,630

as well as the first discovery of multiple transiting planets in one system.

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00:09:15,650 --> 00:09:22,180

NARRATOR: As they continued to process new data and refine their existing data, the Kepler team made perh

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00:09:22,200 --> 00:09:25,190

their most important discovery yet.

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00:09:25,210 --> 00:09:32,970

NATALIE BATALHA: By January of 2011 Kepler reached another major milestone, which was the announcem

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00:09:32,990 --> 00:09:36,120

of its first rocky planet, Kepler-10b.

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00:09:36,140 --> 00:09:42,170

This planet is only slightly larger than the Earth, one point four times the radius of the Earth.

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00:09:42,190 --> 00:09:45,610

And about four and a half times as massive as the Earth.

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00:09:45,630 --> 00:09:54,120

But what's really exciting about this planet discovery is that the average density unquestionably says

111

00:09:54,140 --> 00:09:56,530

that this is a rocky world.

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00:09:56,550 --> 00:10:01,270

And it is the first such world that is unquestionably rocky.

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00:10:01,290 --> 00:10:06,960

NARRATOR: Kepler continues to stare at the stars as it watches for shadows in transit.

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00:10:06,980 --> 00:10:13,610

These shadows will hold the key to a wealth of new discoveries that the Kepler team hopes will answer the que

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00:10:13,630 --> 00:10:17,250

“Are Earths common or rare in our galaxy?”