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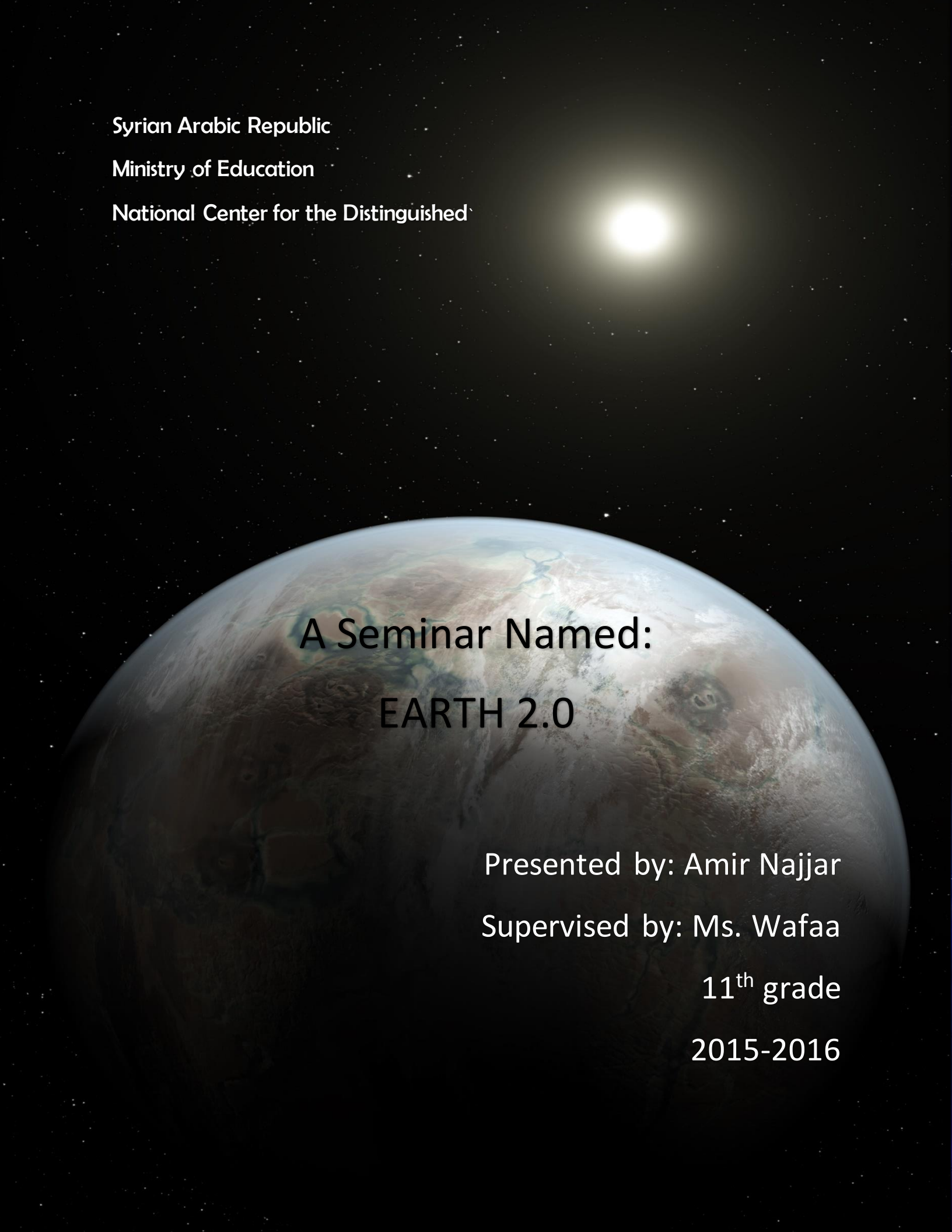

A Seminar Named:

EARTH 2.0

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Supervised by: Ms. Wafaa

11th grade

2015-2016

Contents

Introduction:

-Is it true that we are finding new planets that are similar to Earth's specifications?

-Is it possible to live there?

-What is the famous spacecraft that is finding such planets?

-Who is Earth's Older Cousin? Can we move and live there?

-Is this planet larger or smaller than Earth? Is its distance from its star the same as the distance between Earth and Sun?

-Are there any forms of life on this planet? Or we could implant forms of life in this planet?

-Is this planet a rocky world in the first place?

-We're going to discuss all this in this Seminar.

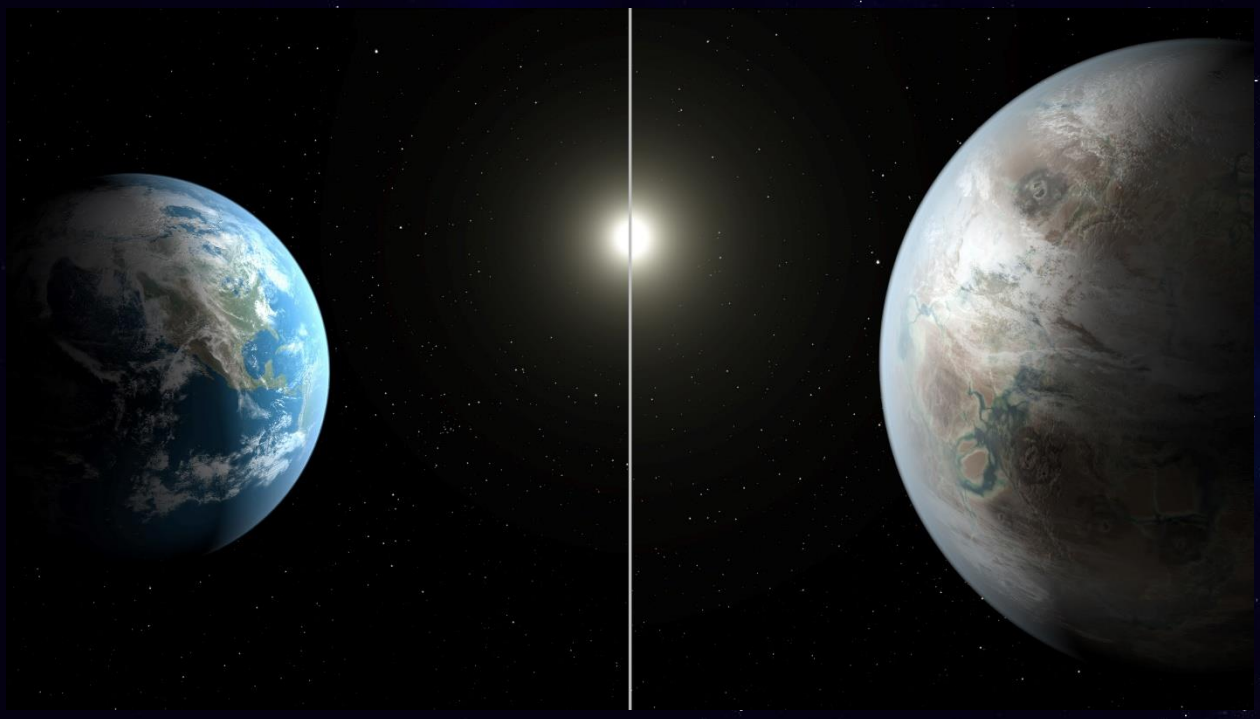

Figure 1 - EARTH and Kepler-452b

Kepler Spacecraft and its mission:

Kepler is a space observatory launched by NASA to discover Earth-like planets orbiting other stars[1]. The spacecraft, named after the German astronomer Johannes Kepler[2], was launched on March 7, 2009[3].

Kepler is part of NASA's Discovery Program of relatively low-cost, focused primary science missions.

The spacecraft's specifications:

The spacecraft has a mass of 1,039 kilograms.[4] The spacecraft has about 12-degree diameter field of view (FOV). The photometer has a soft focus to provide excellent photometry, rather than sharp images.

Figure 2 - Kepler Spacecraft

Camera:

The focal plane of the spacecraft's camera is made out of 42 CCDs at 2200x1024 pixels, which made it at the time the largest camera yet launched into space, possessing a total resolution of 95 megapixels.[5] [6]

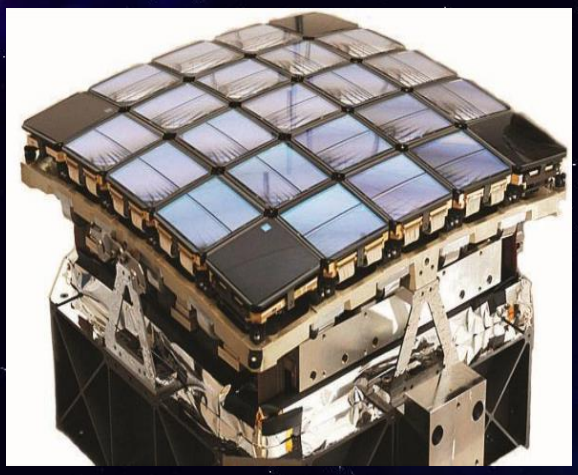

Figure 3 - The Spacecraft's Camera

Even though at launch Kepler had the highest data rate of any NASA mission. Data that is stored and downlinked includes science stars, p-mode stars, smear, black level, background and full field-of-view images.[7] [8]

[1] Koch, David; Gould, Alan (March 2009). "Kepler Mission". NASA. Retrieved March 14, 2009.
[2] DeVore, Edna (June 9, 2008). "Closing in on Extrasolar Earths". *SPACE.com*. Retrieved March 14, 2009.
[3] NASA Staff. "Kepler Mission/QuickGuide". NASA. Retrieved April 20, 2011.
[4] Atkins, William (December 28, 2008). "Exoplanet Search Begins with French Launch of Corot Telescope Satellite". iTWire. Retrieved May 6, 2009.
[5] NASA Staff. "Kepler: Spacecraft and Instrument". NASA. Retrieved May 1, 2009.
[6] NASA Staff (April 16, 2009). "Kepler's Diamond Mine of Stars". NASA. Retrieved May 1, 2009.
[7] NASA Staff (February 2009). "Kepler: NASA's First Mission Capable of Finding Earth-Size Planets" (PDF). NASA. Retrieved March 14, 2009.
[8] "PyKE Primer - 2. Data Resources". NASA. Retrieved March 12, 2014.

Primary Mirror:

The Kepler primary mirror is 1.4 meters in diameter, the largest mirror located outside Earth orbit. Manufactured by glass maker Corning using ultra-low expansion (ULE) glass, the mirror is specifically designed to have a mass only 14% that of a solid mirror of the same size.[9] [10]

In order to produce a space telescope system with sufficient sensitivity to detect relatively small planets, as they pass in front of stars, a very high reflectance coating on the primary mirror was required.

Using ion assisted evaporation, Surface Optics Corp. applied a protective 9-layer silver coating to enhance reflection.[11] [12]

Communications:

NASA contacts the spacecraft using the X band communication link twice a week for command and status updates. Scientific data are downloaded once a month using the K_a band link at a maximum data transfer rate of approximately 550 KBps. The Kepler spacecraft conducts its own partial analysis on board and only transmits scientific data deemed necessary to the mission in order to conserve bandwidth.[13]

Kepler's Story:

In January 2006, the project's launch was delayed eight months because of budget cuts and consolidation at NASA. It was delayed again by four months in March 2006 due to fiscal problems. [14]

The Kepler observatory was launched on March 7, 2009, at 03:49:57 UTC aboard a Delta II rocket from Cape Canaveral Air Force Station, Florida.[15] [16]

[9] "Kepler Primary Mirror". NASA. Retrieved April 5, 2013.
[10] "Corning To Build Primary Mirror For Kepler Photometer". Retrieved April 5, 2013.
[11] Fulton L., Michael; Dummer, Richard S. (2011). "Advanced Large Area Deposition Technology for Astronomical and Space Applications". *Vacuum & Coating Technology* (December 2011): 43–47. Retrieved April 6, 2013.
[12] Staff (September 25, 2007). "Ball Aerospace Completes Primary Mirror and Detector Array Assembly Milestones for Kepler Mission". *Ball Aerospace and Technologies Corp*. spaceref.com. Retrieved April 6, 2013.
[13] Ng, Jansen (March 8, 2009). "Kepler Mission Sets Out to Find Planets Using CCD Cameras". *DailyTech*. Retrieved March 14, 2009.
[14] Borucki, W. J. (May 22, 2010). "Brief History of the Kepler Mission". NASA. Retrieved April 23, 2011.
[15] Aarhus University Staff (March 14, 2009). "KASC Scientific Webpage". Kepler Asteroseismic Science Consortium. Retrieved March 14, 2009.
[16] NASA Staff. "Kepler Launch". NASA. Retrieved September 18, 2009.

The launch was a success and all three stages were completed by 04:55 UTC. The cover of the telescope was jettisoned on April 7, 2009, and the first light images were taken on the next day.[17] [18]

Figure 4 - Kepler 's launch on March 7, 2009

On April 20, 2009, it was announced that the Kepler science team had concluded that further refinement of the focus would dramatically increase the scientific return. On April 23, 2009, it was announced that the focus had been successfully optimized by moving the primary mirror 40 micrometers towards the focal plane and tilting the primary mirror 0.0072 degree.[19]

On May 13, 2009, at 00:01 UTC, Kepler successfully completed its commissioning phase and began its search for planets around other stars.[20]

On June 19, 2009, the spacecraft successfully sent its first science data to Earth. It was discovered that Kepler had entered safe mode on June 15. A second safe mode event occurred on July 2. The spacecraft resumed normal operation on July 3 and the science data that had been collected since June 19 was downlinked that day.[21]

[17] DeVore, Edna (April 9, 2009). "Planet-Hunting Kepler Telescope Lifts Its Lid". SPACE.com. Retrieved April 14, 2009.
[18] NASA Staff (April 16, 2009). "NASA's Kepler Captures First Views of Planet-Hunting Territory". NASA. Retrieved April 16, 2009.
[19] NASA Staff (April 23, 2009). "04.23.09 – Kepler Mission Manager Update". NASA. Retrieved April 27, 2009.
[20] NASA Staff (May 14, 2009). "05.14.09 – Kepler Mission Manager Update". NASA. Retrieved May 16, 2009.
[21] NASA Staff (July 7, 2009). "2009 July 7 Mission Manager Update". NASA. Retrieved April 23, 2011.

Kepler downlinked roughly twelve gigabytes of data[22] about once per month[23], an example of such a downlink was on November 22–23, 2010.[24]

On July 14, 2012, one of the four reaction wheels used for fine pointing of the spacecraft failed.[25] While Kepler requires only three reaction wheels to accurately aim the telescope, another failure would leave the spacecraft unable to continue in its mission. This is a potential threat to the extended mission.[26]

On January 17, 2013, NASA announced that one of the three remaining reaction wheels showed increased friction, and that *Kepler* would discontinue operation for ten days as a possible way of solving the problem. If this second wheel should also fail, the *Kepler* mission would be over.[27] [28]

On January 29, 2013, NASA reported the successful return to normal science collection mode,[29] though the reaction wheel still exhibits elevated and erratic friction levels.[30]

On May 11, 2013, another reaction wheel failed, and the spacecraft was put in point rest state (PRS) by May 15, 2013. In PRS, the spacecraft uses a combination of thrusters and solar pressure to control pointing. The fuel use is low, which allows time to attempt recovery of the spacecraft.[31]

The spacecraft automatically went into a thruster-controlled safe mode with the solar panels facing the Sun and with an intermittent communication link with the Earth. In this state the fuel would last for several months. Commands were sent to the spacecraft to put it into Point Rest State. This state reduced fuel consumption - fuel reserves would last for several years in this state. This state

[22] NASA Staff (September 23, 2009). "Kepler Mission Manager Update". NASA. Retrieved September 25, 2009.
[23] NASA Staff (November 5, 2009). "Kepler Mission Manager Update". NASA. Retrieved November 8, 2009.
[24] NASA Staff (December 6, 2010). "Data Download; Data Release; 2010 ground-based observing complete; AAS meeting". Retrieved December 21, 2010.
[25] Roger Hunter (July 24, 2012). "Kepler Mission Manager Update". NASA.
[26] Maggie McKee (July 24, 2012). "Kepler glitch may lower odds of finding Earth's twin". New Scientist.
[27] Hunter, Roger (January 17, 2013). "Kepler Mission Manager Update". NASA. Retrieved January 18, 2013.
[28] Marchis, Franck (January 17, 2013). "Kepler is Sick and Resting: 'Mountain View, we have a problem'". Cosmic Diary. Retrieved January 18, 2013.
[29] Hunter, Roger (January 29, 2013). "Kepler Mission Manager Update: Kepler Returns to Science Mode". NASA. Retrieved January 30, 2013.
[30] Roger Hunter. "Kepler Mission Manager Update, 29.03.2013". NASA.
[31] NASA - Kepler Mission Manager Update (May 21, 2013)

also makes communication possible at any time. Work was started on the possibility of getting at least one reaction wheel working again.[32] [33]

In July 2013, the spacecraft remained in point rest state while recovery efforts were planned.[34] By August 15, 2013, attempts to resolve issues with two of the four reaction wheels failed. An engineering report was ordered to assess the spacecraft's remaining capabilities. [35] [36] [37]

As of January 2015, Kepler and its follow-up observations had found 1,013 confirmed exoplanets in about 440 stellar systems, along with a further 3,199 unconfirmed planet candidates.[38] [39]

On January 6, 2015, NASA announced the 1000th confirmed exoplanet discovered by the Kepler Space Telescope. Four of the newly confirmed exoplanets were found to orbit within habitable zones of their related stars: three of the four, Kepler-438b, Kepler-442b and Kepler-452b, are near-Earth-size and likely rocky; the fourth, Kepler-440b, is a super-Earth.[40]

[32] "Kepler Mission Manager Update". NASA. May 15, 2013. Retrieved June 14, 2013.
[33] "Kepler Mission Manager Update". NASA. May 21, 2013. Retrieved June 14, 2013.
[34] NASA - Kepler Mission Manager Update: Preparing for Recovery
[35] "NASA Ends Attempts to Fully Recover Kepler Spacecraft, Potential New Missions Considered". August 15, 2013. Retrieved August 15, 2013.
[36] Overbye, Dennis (August 15, 2013). "NASA's Kepler Mended, but May Never Fully Recover". *New York Times*. Retrieved August 15, 2013.
[37] Wall, Mike (August 15, 2013). "Planet-Hunting Days of NASA's Kepler Spacecraft Likely Over". *Space.com*. Retrieved August 15, 2013.
[38] Wall, Mike (June 14, 2013). "Ailing NASA Telescope Spots 503 New Alien Planet Candidates". *Space.com*. TechMediaNetwork. Retrieved June 15, 2013.
[39] "NASA's Exoplanet Archive KOI table". NASA. Retrieved February 28, 2014.
[40] Clavin, Whitney; Chou, Felicia; Johnson, Michele (January 6, 2015). "NASA's Kepler Marks 1,000th Exoplanet Discovery, Uncovers More Small Worlds in Habitable Zones". *NASA*. Retrieved January 6, 2015.

Kepler-452b:

Kepler-452b is an exoplanet orbiting the G-class star Kepler-452. It was identified by the Kepler space telescope, and its discovery was publicly announced by NASA on 23 July 2015.[41] It is the first potentially rocky super-Earth[42] planet discovered orbiting within the habitable zone of a star very similar to the Sun.[43] Using the criteria of the Earth Similarity Index, it is the sixth-most Earth-like exoplanet known to date.

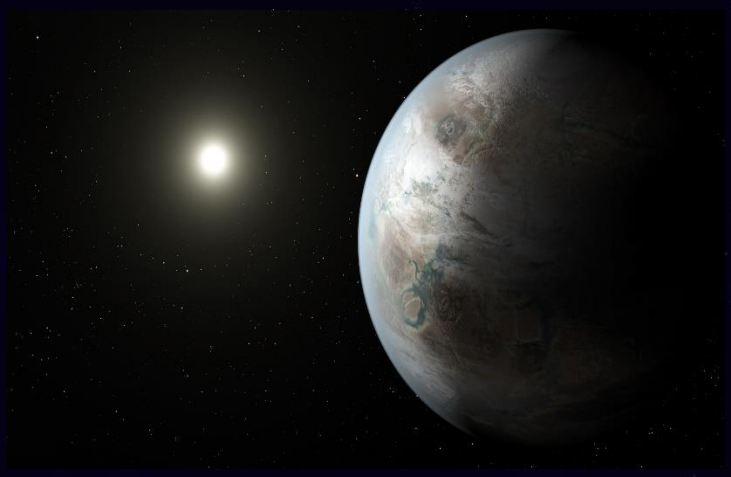

Figure 5 - Artistic Concept of Kepler-452b

The planet is about 1,400 light-years away from the Solar System; at the speed of the New Horizons spacecraft, about 59,000 km/h (37,000 mph), it would take approximately 26 million years to get there.[44]

The planet takes 385 Earth days to orbit its star.[45] It is 60% bigger than Earth, and lies within the conservative habitable zone of its parent star.[46] [47]

[41] Jenkins, Jon M.; Twicken, Joseph D.; Batalha, Natalie M.; Caldwell, Douglas A.; Cochran, William D.; Endl, Michael; Latham, David W.; Esquerdo, Gilbert A.; Seader, Shawn; Bieryla, Allyson; Petigura, Erik; Ciardi, David R.; Marcy, Geoffrey W.; Isaacson, Howard; Huber, Daniel; Rowe, Jason F.; Torres, Guillermo; Bryson, Stephen T.; Buchhave, Lars; Ramirez, Ivan; Wolfgang, Angie; Li, Jie; Campbell, Jennifer R.; Tenenbaum, Peter; Sanderfer, Dwight; Henze, Christopher E.; Catanzarite, Joseph H.; Gilliland, Ronald L.; Borucki, William J. (23 July 2015). "Discovery and Validation of Kepler-452b: A 1.6 R⊕ Super Earth Exoplanet in the Habitable Zone of a G2 Star". *The Astronomical Journal* **150** (2): 56. doi:10.1088/0004-6256/150/2/56. ISSN 1538-3881. Retrieved 24 July 2015.

[42] "The Habitable Exoplanets Catalog – Planetary Habitability Laboratory @ UPR Arecibo". *upr.edu*.

[43] Chou, Felicia; Johnson, Michele (23 July 2015). "NASA's Kepler Mission Discovers Bigger, Older Cousin to Earth" (Press release). NASA. Retrieved 23 July 2015.

[44] "NASA telescope discovers Earth-like planet in star's 'habitable zone'". *BNO News*. 23 July 2015. Retrieved 23 July 2015.

[45] Overbye, Dennis (23 July 2015). "Kepler Data Reveals What Might Be Best 'Goldilocks' Planet Yet". *The New York Times*. Retrieved 23 July 2015.

[46] Feltman, Rachel (23 July 2015). "Scientists discover 12 new potential Earth-like planets". *The Washington Post*. Retrieved 23 July 2015.

[47] Witze, Alexandra (23 July 2015). "NASA spies Earth-sized exoplanet orbiting Sun-like star". *Nature*. Retrieved 23 July 2015.

It has a probable mass five times that of Earth, and its surface gravity is twice Earth's, though calculations of mass for exoplanets are only rough estimates.

If it is a terrestrial planet, it is most likely a super-Earth with many active volcanoes due to its higher mass and density. The clouds on the planet would be thick and misty, covering much of the surface as viewed from space. From the surface, its star Kepler-452 would look almost identical to the Sun as viewed from the Earth.[48]

However, the star is six billion years old, making it 1.5 billion years older than the Sun. At this point in its star's evolution, Kepler-452b is receiving 10% more energy from its parent star than Earth is currently receiving from the Sun.[49] If Kepler-452b is a rocky planet, it may be subject to a runaway greenhouse effect similar to that seen on Venus.[50]

This new planet wasn't discovered long ago, it was discovered less than two months ago, so there isn't much information about it.

Conclusion:

It might really be true that we are finding planets that are similar to Earth, but that doesn't mean that we will be able to live there.

Kepler-452b is 1400 light years away from us, which means that to reach a certain distance *"d"* (which is the distance between our Solar System and Kepler-452b, it needs 1400 years at the speed of light.

$d = ?, v = 5 * 10^8\ m.s^{-1}, t = 1400\ years = 1400 * 365 * 24 * 3600 = 441504 * 10^5\ s.$

$d = v * t = 5 * 10^8 * 441504 * 10^5 = 220752 * 10^{14}\ m.$

So the distance between EARTH and Kepler-452b is now calculated.

Now let's calculate the required velocity (speed) in order to reach Kepler-452b in 10 years (which is the same required time to reach Pluto):

$d_f = 220752 * 10^{14}\ m, v_f = ?, t = 10\ years = 10 * 365 * 24 * 3600 = 31536 * 10^4\ s.$

[48] NASA Kepler press conference. 23 July 2015.
[49] Chou, Felicia; Johnson, Michele (23 July 2015). "NASA's Kepler Mission Discovers Bigger, Older Cousin to Earth" (Press release). NASA. Retrieved 23 July 2015.
[50] Lugmayr, Luigi (23 July 2015). "Kepler-452b details unveiled". I4U News. Retrieved 23 July 2015.

$v_f = \frac{d}{t} = \frac{220752 * 10^{14}}{31536 * 10^4} = 7 * 10^{10}\, m.s^{-1}$.

This speed is 140 times greater than the speed of light. But before thinking about this speed, we should reach the speed of light, so thinking about a backup plan to live on a second EARTH is currently impossible.

But who knows what the future may hold, so we might be able to reach this planet one day.

Of course, there are other exoplanets similar to EARTH (not only Kepler-452b), like Kepler-483b and Kepler-442b, but Kepler-452b is the best candidate so far.

Let's assume that we are able to reach Kepler-452b in an acceptable time, this planet may not hold the requisites to live there, as it receives up to 10% more energy from its star, and we don't even know (*as of yet)* if it is a habitable planet.

So after all, maybe plan EARTH 2.0 may not be achievable, it will remain a dream until we make new discoveries.

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