HOLD FOR RELEASE
UNTIL PRESENTED
BY WITNESS
May 9, 2013

Statement of
Dr. John M. Grunsfeld
Associate Administrator
Science Mission Directorate
National Aeronautics and Space Administration

before the

Committee on Science, Space, and Technology
Subcommittee on Space
U.S. House of Representatives

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear today to discuss the topic of extrasolar planets, or simply exoplanets, which are defined as planets that orbit a star other than our own Sun.

NASA thrives on the synergy created by a critical mass of brilliant scientific and engineering talent, supported by a broad range of expert professionals. We work, as an Agency, to send humans to an asteroid and on to orbit Mars. We work, as an Agency, to understand the universe from the beginning of time to the future of Earth's climate. NASA's budget request for 2014 fully funds the James Webb Space Telescope for launch in 2018, and supports a Mars lander for launch in 2020. The request supports development of critical human exploration capabilities, and space technology to enable our future in space. With the 2014 request NASA is planning a first-ever mission to identify, capture, and redirect an asteroid into orbit around the Moon. This mission represents an unprecedented technological challenge -- raising the bar for human exploration and discovery, while helping protect our home planet and bringing us closer to a human mission to Mars in the 2030s. The President's budget request for NASA advances a strategic plan for the future that builds on U.S. preeminence in science and technology, improves life on Earth, and protects our home planet.

Within the broader agency mission, NASA's Exoplanet Exploration Program focuses on answers to fundamental questions that are likely as old as humankind itself: 1) Are there other planets in the universe? 2) Are there other planets just like Earth out there? and 3) Are we alone? While these questions have been the subject of speculation since humankind first gazed to the heavens and wondered what was out there, the scientific study of these intriguing objects is relatively new; the first confirmed discoveries of exoplanets did not occur until the 1990s. In the intervening years, scientists have discovered over 850 exoplanets, with new ones being discovered almost daily. In just the last 4 years, NASA's Kepler mission has contributed 122 confirmed exoplanets and more than 2,700 exoplanet candidates, and scientists expect that a large fraction of those candidates will ultimately be confirmed as exoplanets. Confirmed exoplanets are planets that astronomers have proven to a high degree of confidence, using multiple observations and, sometimes, two or more different instruments. This is an exciting time for exoplanet exploration, and the next few years will permit major leaps forward in our understanding of how many there are, how they formed, and whether they might have conditions that are hospitable to life as we know it – a condition that is called habitability.

Thanks to the Kepler mission, we now know that when you go outside and look up at the night sky, virtually every star you see has at least one planet around it. Based on the latest Kepler results, scientists estimate that at least 17 percent of all the stars out there have rocky planets orbiting them. Of even greater interest, the results suggest that 15 percent of M stars -- the smallest, coolest class of stars, but also by far the most common type of star in the galaxy -- have rocky planets in the habitable zone. This number tells us that the nearest potentially habitable planet could be only 15 light-years away. Moreover, if that trend holds for other classes of stars, it would mean that there are approximately 50 billion potentially habitable rocky planets spread throughout our own galaxy.

NASA's Exoplanet Exploration Program is leading the quest to discover and characterize exoplanets and search for life in the universe. There are several key exoplanet detection techniques in use today, with the most prolific being the radial velocity and the transit techniques. The radial velocity technique uses Doppler shifts in the light of a star to detect the tiny wobble caused by a planet orbiting around it. This technique is employed by astronomers to detect exoplanets using large ground-based telescopes around the world including by NASA-funded scientists at the Keck telescopes in Hawaii. The transit technique measures the tiny decrease in the brightness of a star that occurs when an orbiting planet passes in front of it. The transit technique is the method used by NASA's Kepler mission to detect exoplanets. NASA's Spitzer and Hubble Space Telescopes (HST) have also used the transit technique for characterization of exoplanet atmospheres, as will NASA's James Webb Space Telescope (the Webb Telescope) when it launches in 2018. Other techniques for exoplanet detection and characterization include direct imaging and gravitational microlensing. Direct imaging uses a coronagraph or occulting mask to block light from the central star so the much fainter planet nearby can be discerned. The Keck telescopes, HST, and, when launched, the Webb Telescope are all capable of direct imaging. Microlensing uses Einstein's gravitational bending of light to find planets orbiting distant stars or isolated planets free floating in interstellar space. NASA is studying a wide-field infrared survey telescope, the highest priority large-scale space-based activity of the National Academy of Sciences' most recent decadal survey in astronomy and astrophysics, which will use this technique to detect exoplanets, and may employ other technology to characterize exoplanets.

Current State of Exoplanet Exploration

NASA's Kepler mission is revolutionizing the search for extrasolar planets. Launched in March 2009, NASA's Kepler Space Telescope searches for exoplanet candidates by continuously measuring the brightness of more than 150,000 stars. When a planet candidate passes, or transits, in front of the star from the spacecraft's vantage point, light from the star is blocked. Different sized planets block different amounts of starlight. The amount of starlight blocked by a planet reveals its size relative to its star. Kepler's primary goals are to determine how abundant planets are in our galaxy, what the distribution of sizes and orbits of those planets are, and, ultimately what fraction of stars might harbor potentially habitable, Earth-sized planets.

As of January 2013, Kepler has identified over 2,700 planet candidates, of which over 350 are nearly the same size as the Earth. In addition, there are 816 "Super Earth"-sized planets, planets intermediate in size between the Earth and the planet Neptune—as well as 1,290 Neptune-sized planets; 202 Jupiter-sized planets, and 81 "Super-Jupiter"-sized planets. More than 50 of Kepler's planet candidates orbit in the habitable zone of their host star-- the range of distances from a star where the surface temperature of an orbiting planet might be suitable for liquid water.

NASA's most recent discovery, announced just a few weeks ago, is two new planetary systems that include three super Earth-size planets in the "habitable zone" of their stars. The first system, known as Kepler-62, has five known planets: 62b, 62c, 62d, 62e, and 62f. The second system, Kepler-69, system has two known planets: 69b and 69c. Kepler-62e, 62f, and 69c are the super Earth-sized planets, with diameters just 1.6x, 1.4x, and 1.7x that of the Earth, respectively. The host star of the Kepler-69 system belongs to the same class of stars as our sun, called G-type. It is 93 percent the size of the Sun and 80 percent as luminous and is located approximately 2,700 light-years from Earth in the constellation Cygnus. The host star of the Kepler 62 system is a smaller, cooler K-type star, just 2/3 the size of the Sun and only 1/5 as bright. These exciting discoveries illustrate that we are another step closer to finding a world similar to Earth around a star like our Sun.

Kepler is teaching us that the galaxy is teeming with planetary systems, and giving us hints that nature makes small planets efficiently. Having completed its prime mission, and now some 5 months into its extended mission, the Kepler spacecraft is starting to show its age. We do not know how much longer it will be able to maintain the very precise pointing required for its exoplanet mission, but we do know that Kepler's legacy is secure. It has been a pioneer in expanding our understanding of exoplanets and stellar seismology and its rich legacy will serve as a solid foundation upon which future missions will build.

Along with Kepler, NASA's Hubble and Spitzer Space Telescopes have also successfully detected the feeble signature of an exoplanet in the overwhelming glare of its host star. Specifically, scientists have used the Hubble Space Telescope to measure the absorption of hydrogen, carbon, oxygen, carbon dioxide, and water vapor in the boil-off from the atmosphere of two transiting Hot Jupiter exoplanets. These large, gaseous giant planets are easier to detect due to their size and very short orbital periods. Also, scientists have used the Spitzer Space Telescope to measure the infrared light from a Hot Jupiter exoplanet and used that to make a temperature map of the planet's atmosphere and determine that the planet is whipped by ferocious winds.

Future Exoplanet Exploration Missions

Moving forward from the current exoplanet missions in operation and development, NASA recently selected a new mission, the Transiting Exoplanet Survey Satellite (TESS), as part of its Explorer Program. Planned to launch in 2017, TESS will undertake a two-year, all-sky search for transiting exoplanets around the nearest and brightest 500,000 stars. While Kepler has taught us about the abundance of planets of all sizes in one particular region of our galaxy, TESS will reveal the exoplanets that are nearest to our Solar System. TESS is expected to discover thousands of new planets – including Earth-sized, rocky planets – and those systems will be ideal candidates for characterization by future missions such as the Webb Telescope and a wide-field infrared survey telescope.

Building on the pioneering observations of the Hubble and Spitzer Space Telescopes and the exoplanet surveys of Kepler and TESS, the Webb Telescope will use transit spectroscopy to determine atmospheric and physical properties of planets ranging in size from Jupiters to super Earths; it will be able to study the composition, chemistry, and physical conditions of exoplanet atmospheres. Additionally, the Webb Telescope will use direct imaging to find and study young (i.e., still warm) Jupiters and Saturns as well as rings of dust, and icy/rocky planetessimals (asteroid and Kuiper Belts) in many exoplanet systems.

Beyond the Webb Telescope, a wide-field infrared survey telescope would complement Kepler's exoplanet census by finding thousands of planets down to Earth-size that orbit either in or outside of the habitable zone of their star. NASA is studying such a mission. As part of that study, NASA is also studying the use of an existing large space telescope system and the addition of a coronagraph capable of studying the atmospheres of exoplanets around other stars through direct imaging. By providing the first opportunity for in-space operations of a high-contrast coronagraph, such a mission would lead the way toward a future telescope capable of characterizing in detail Earth-like planets around other stars and searching for evidence of life beyond our Solar System.

NASA is aware that exoplanets are of great interest to the entire science community and the general public. The science of exoplanets brings together many scientific disciplines. That is one reason why all of the data from NASA's space telescopes, including Kepler, Hubble, and Spitzer, is made openly available for analysis by scientists other than the members of the science teams for those telescopes. This has resulted in an explosion of discoveries about exoplanets, including some of the discoveries already mentioned. For citizen scientists, PlanetHunters.org offers a web site where anyone can search through Kepler data and discover exoplanets. So far, over 18 million observations have been analyzed, and 34 candidate planets had been found. In October 2012 it was announced that two volunteers from the Planet Hunters initiative had discovered a novel Neptune-sized planet which is part of a four star double binary system. This is the first planet discovered to have a stable orbit in such a complex stellar environment.

Exoplanet Technology Development Infrastructure

To make the exoplanet discoveries possible, and to reduce both the risk and cost of future exoplanet exploration missions, NASA is investing in exoplanet detection technology. NASA has developed high contrast imaging testbeds, an advanced visible nulling testbed, deformable mirrors for ultraprecise wavefront control, and a vacuum surface gauge for surface characterization and deformable mirror calibration. Moreover, NASA has computational models and software including coronagraph modeling tools, integrated thermo-optical-mechanic modeling tools, and generalized error-budgeting tools to design space-based telescopes and instruments capable of detecting and studying exoplanets.

Conclusion

NASA has in place a comprehensive program to detect and characterize exoplanets. With the progress we have already made, I am confident that it is not a question of whether or not we will find an Earth-like exoplanet, but when. With our programs, the active participation of a rapidly growing scientific community, and our partners, we will continue to make major strides forward in our understanding of the science of exoplanets. It is programs like Kepler that capture the imagination of everyday people, including our students of today who will be the scientists and engineers of tomorrow. NASA has exciting missions such as the Webb Telescope, TESS, and the wide field infrared survey telescope after Kepler to reach even farther back in time, to explore other regions of the universe, and to start characterizing and analyzing the atmospheres of exoplanets. The future of exoplanet research is bright, and NASA will continue to play a leadership role in that future. I look forward to answering any questions you may have.