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## The State of the Universe
January 9th, 2014

We've heard about some incredible astronomical discoveries, the same phenomena that inspired me to study astrophysics at the University of California, Berkeley and pursue a master's degree at Wesleyan University working on dark matter in the small galactic satellites of the Milky Way. Later, as a Presidential Management Fellow with NASA, I had the opportunity to learn first-hand about a whole new world of astronomical discovery that exists in the time before the telescope is even launched: the innovation required to transform a vision into physical hardware.

I chose to work at Northrop Grumman to be a part of the privileged team building the world's most powerful space observatory: NASA's James Webb Space Telescope.

Thousands of astronomers across the nation had come together to draft a vision for the future of astronomy, asking when did the first galaxies form in the universe? And seeking ways to explore Earth-like planets. The engineering community accepted that challenge. But the tools and technology we needed to make that vision a reality didn't exist.

To see those first galaxies, astronomers needed a mirror so big that it wouldn't fit in any rocket… so we designed a mirror that folds. In order to detect the faintest glow of infrared light ever observed, they needed it cold… so we built five tennis court-sized sunshield layers to block the sun. To explore Earth-like planets, astronomers needed a new generation of tools… so engineers created the most sophisticated scientific instruments ever built.

Combining all of these technologies, we as a nation, together with our international partners, are building a telescope 100 times more powerful than Hubble. The science will change what we know about the universe. And we'll make these discoveries when the Webb Telescope launches in 2018.

But we don't have to wait; we're creating innovation now. We've invented ten new technologies for this mission that are already impacting fields like aerospace, semiconductors, and even medicine.

For example: to enable Webb's razor sharp vision, we had to manufacture mirrors more precisely shaped than anything anyone had done before. It can be hard to grasp just how smooth these mirrors are. If we took one of Webb's eighteen hexagonal mirrors, and made it as big as the state of Texas, the bumps and imperfections on its surface would only be about the height of a grasshopper. Polishing a mirror this perfectly is one challenge; measuring it is another. For the

Webb Telescope mirrors, we had to invent a new sensor to make those measurements. Doctors are using that sensor today to measure human eyes, and as a result are able to better diagnose ocular disease.

Four patents have been issued as a result of innovations driven by the Webb Telescope. Collectively, all of these technologies have led to millions of dollars in revenue for U.S. companies.

The changes to science and technology are astounding. But most importantly, missions of this magnitude change people. They require us to train our government and industry workers across the country to do things they've never done before: to engineer, to build, to manufacture to a level never before achieved. These missions enable academic centers of excellence, to hire and train new scientists to understand things we've never understood before.

Astronomy missions are also about inspiration. When people experience firsthand the wonders of science and engineering created by NASA, by companies like Northrop Grumman and our partners across the country… that inspiration can be life changing.

That inspiration can spark a person to decide to ask questions, to explore, to build, and to create. By uniting scientific vision with technological innovation, we're able to create engineering marvels. Our investment in science has clear benefits today, and can open the door to a better future.