MEMORANDUM

Date: June 26, 2017

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: **Balloons and Chicken Sandwiches**

Attached is a comprehensive June 22, 2017 article by Adam Mann for *Science* magazine regarding space technology. The article discusses World View Enterprises and their work in developing stratospheric balloon business activity.

Yes, the article begins with the chicken sandwich launch for the Kentucky Fried Chicken national fast food chain. More importantly, it speaks directly to the scientific research and engineering applications of stratospheric ballooning and the significant evolving success of World View in stratospheric balloon activities for business ventures.

CHH/mjk

Attachment

c: Dr. John Moffatt, Director, Economic Development
Patrick Cavanaugh, Deputy Director, Economic Development

Commercial balloons in the stratosphere could monitor hurricanes and scan for solar storms

By **Adam Mann** | Jun. 22, 2017 , 2:00 PM

The layers of polyethylene, as thin as plastic sandwich bags, sit neatly folded in a wooden box at the headquarters of World View Enterprises in Tucson, Arizona. It seems the stuff of shower curtains, not spaceflight. But once inflated with helium, the plastic envelope will swell into a teardrop-shaped balloon spanning the length of a blue whale, able to soar more than 30 kilometers up into the stratosphere. There, above 99% of the atmosphere, it will offer sweeping panoramas of Earth or clear views into space.

If all goes to plan, this week, World View workers will unfurl the balloon in the chilly, predawn air, laying it carefully on a protective tarp at a desert site about 40 kilometers south of Tucson. As the sun rises, a helium truck will fill it with the gas of 44,000 party balloons. Once engorged, the balloon will take flight for 4 to 7 days, dangling a gondola with World View's own weather instruments and—get this—a Kentucky Fried Chicken sandwich paid for by the fast-food chain.

Despite the marketing stunt, the launch is significant: World View has completed more than 50 short flights to date, and this will be the company's first multiday mission. It aims to demonstrate the promise of a new way to carry scientific instruments to the edge of space, aboard what Taber MacCallum, the company's chief technology officer, calls "an entirely new kind of vehicle."

Scientific ballooning isn't new. NASA has been in the business since 1982, when it assumed control of the National Scientific Ballooning Facility. The $38 million office flies about 10 to 15 balloons per year, lofting scientific payloads for a fraction of the cost of a satellite launch. But they tend to be one-off experiments with wayward paths that drift in the winds. In contrast, World View and Raven Aerostar, a company in Sioux Falls, South Dakota, that also offers research balloon flights, intend to steer their balloons, keeping them in stable positions that could boost a number of earth science applications. They hope to undercut NASA, whose balloon missions cost several million dollars, with flights for just a few hundred thousand dollars. Just as SpaceX and Blue Origin are privatizing access to low-Earth orbit, so, too, are these balloon companies trying to commercialize the stratosphere.

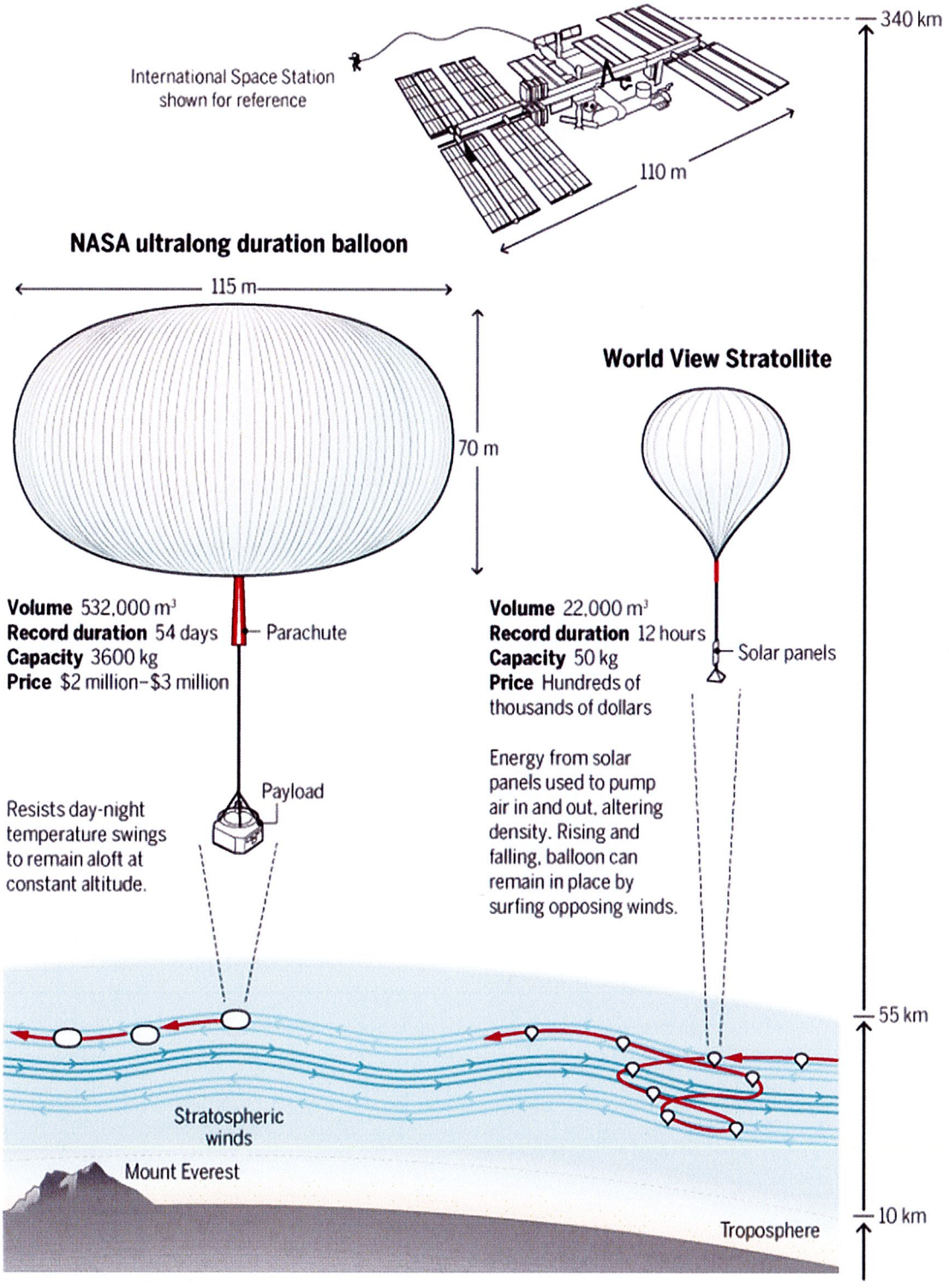
"You want to put a telescope up? You want to do atmospheric monitoring? You want to study the sun? You want to look down on the oceans or land?" asks planetary scientist Alan Stern, World View's chief scientist. "Across these and a whole series of other research fields there are just immense applications."

MacCallum is known for out-there projects. In the early 1990s, he and his future wife, World View CEO Jayne Poynter, holed up in Biosphere 2, a massive, sealed ecosystem in the Arizona desert that inspired their first venture, Paragon Space Development Corporation, which builds life support systems for space exploration. In 2012, the two of them created World View along with Stern, a former NASA science administrator and principal investigator of the New Horizons mission that flew past Pluto. Its first project was to design the balloon that lifted Alan Eustace, a Google executive, to an altitude of 41 kilometers for his 2014 record-shattering free-fall jump.

After that, they thought World View would mostly be about bringing rich thrill-seekers to the edge of space. But then the calls started coming in. As the company began test flights for human-rated gondolas, researchers started asking whether they could piggyback small instruments. "We were like, 'Doesn't NASA do this for you?'" MacCallum recalls. "And they said, 'Yeah, but NASA takes years and it's too expensive: could you guys fly this one?'"

Into thin air

Stratospheric balloons are a low-cost way to get above 99% of the atmosphere: nearly as good as space. NASA uses large balloons that drift at constant altitudes for months. Upstart commercial companies like World View Enterprises use smaller balloons that can stay in one place by surfing stratospheric winds.



K. SUTLIFF/*SCIENCE*

MacCallum's father was a gamma ray astronomer who did balloon-borne experiments, so he quickly realized the value of this potential customer base. In 2015, the company flew its first scientific payload for an external paying customer, testing a video and tracking system that researchers at Montana State University (MSU) in Bozeman will use to record the total solar eclipse in August. That flight also carried a small radiation-hardened computer that MSU students were testing, along with an ozone gas sensor for the University of North Florida in Jacksonville.

World View has since carried other experiments, including a gamma ray detector and a remote-sensing system. The company says that dozens of customers are now waiting for a flight. "We're seeing expanding interest in something we didn't even think existed a few years ago," MacCallum says.

So far, the company's steerable balloons, which measure about 30 meters across, can't carry more than 50 kilograms. But they offer a key advantage over NASA's much larger "superpressure" balloons. The NASA balloons, which swell into a peculiar pumpkin shape more than 100 meters across in the upper atmosphere, are designed to stay at a constant altitude by resisting day-night temperature swings that inflate and deflate the balloon. That means they can remain aloft for months, but it also means they are beholden to the prevailing winds and drift across continents.

World View and Raven Aerostar want to take advantage of the stratosphere's tiered winds, which blow in different directions at different altitudes, to steer a balloon—or keep it in one spot. Using energy from solar panels to pump air into or out of a separate compartment, the balloons can raise and lower their density and therefore their altitude. By analyzing patterns of prevailing winds recorded in weather databases, the companies have sent balloons in almost any direction or even along figure-eight trajectories to hover over large swaths of Earth like a geostationary satellite (hence the name World View has given its balloons—Stratollites, for stratospheric satellites).

"That's opening up a new frontier for balloons," says Scott Wickersham, general manager of Raven. For decades, Raven has manufactured balloons for NASA as well as for commercial customers including Google, whose Project Loon has been using steerable balloons to test expanding internet access to underserved regions.

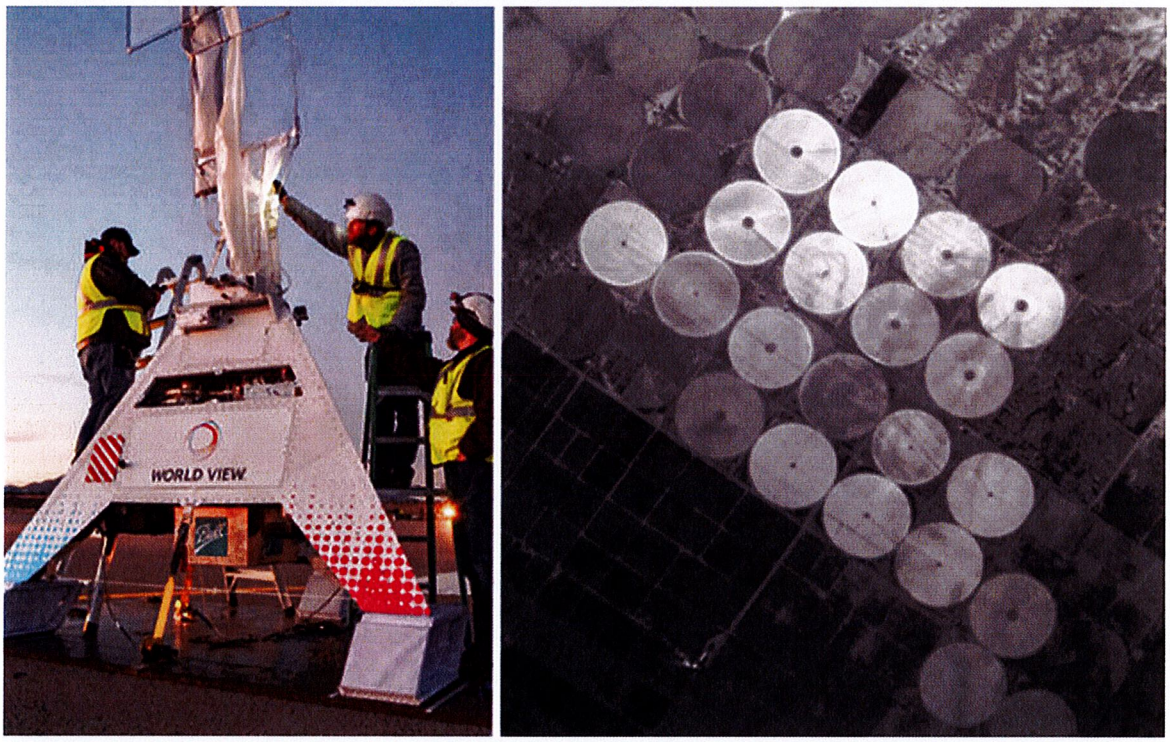
Stationary high-altitude balloons could carry cameras to monitor flash floods and forest fires or scanning lasers to remotely sense soil moisture and vegetation growth. Many researchers also see them as an ideal platform for radars that would probe the winds and clouds below. Geostationary satellites, which orbit 36,000 kilometers above Earth, are too distant for radar studies; they are limited to passively detecting microwaves and other radiation from the clouds and ground. Lower-altitude satellites and aircraft zip overhead quickly, meaning they can only take infrequent snapshots. And ground-based radars can't see past mountains or over the curve of Earth.

Jonathan Gourley, a hydrologist at the National Oceanic and Atmospheric Administration's (NOAA's) National Weather Center in Norman, Oklahoma, says radars aboard stationary balloons could look down into the most violent thunderstorms, known as supercells, clocking their updrafts and downdrafts, which affect hailstone size, thunderstorm longevity, and perhaps even their potential to produce tornadoes. "If we can observe these in detail—which can only really be accomplished from a quasi-geostationary platform in the stratosphere like a balloon—I think it'll make great advancements in our theory and modeling of thunderstorms," he says.

Floating above a hurricane, a balloon-borne radar could measure the storm's eye-wall circulation and wind intensity to aid forecasts of its next move. It could also scan calmer air to track populations of migrating birds, bats, and insects, says meteorologist Kenneth Howard, Gourley's collaborator at NOAA. Howard and Gourley have spoken to World View about their ideas and are asking NASA and NOAA for funding for test flights and instrument development.

Other World View customers want to turn their instruments heavenward. Along with colleagues, solar physicist Craig DeForest of the Southwest Research Institute (SwRI) in Boulder, Colorado, has created the SwRI Solar Instrument Pointing Platform (SSIPP), a solar observatory that uses a gyroscope to stabilize itself and remain pointed at the sun while swinging below a balloon. DeForest and his team flew SSIPP under a World View Stratollite last September. Ultimately, Howard says, a flotilla of stationary balloons around the world could monitor the sun 24 hours a day, watching for solar flares and other energetic bursts that send radiation and particles toward Earth, where they can interfere with satellites or even the electric grid on the ground.

Steerable balloons also offer a way to perform experiments within the clouds. Atmospheric scientist John Dykema of Harvard University wants to do a small-scale test of a radical technique for fighting climate change: spraying aerosols into the stratosphere to reflect sunlight and cool the planet. Dykema and his collaborators plan to create a kilometer-long swath of reflective ice crystals in the frigid upper atmosphere by releasing water vapor behind a future World View balloon. For about 6 hours, the balloon will measure conditions within and outside this artificial cloud. Follow-up missions will study whether the ice affects abundances of ozone, which blocks dangerous ultraviolet light, and measure the crystals' impact on incoming sunlight and outgoing radiation.



A February launch of a World View balloon carried a Ball Aerospace camera (left) into the stratosphere, where it took images (right) of the ground from a stable position more than 23 kilometers up.

(LEFT TO RIGHT) WORLD VIEW ENTERPRISES; BALL AEROSPACE

Most of these projects will require longer flights than World View has achieved so far. Whereas NASA's record duration is 55 days for its largest and highest-flying balloons, and the Google Loon project has managed to loft their smaller balloons for more than 180 days at lower altitudes, World View has yet to fly for longer than half a day. This week's flight will carry upgraded solar panels that can store enough power during the day to operate the balloon at night. Should it succeed, the company doesn't see any major obstacles to multiweek missions. They also need to follow in the footsteps of NASA and build larger balloons, able to lift hundreds or thousands of kilograms.

Only World View and Raven Aerostar have designed steerable balloons, but other companies also fly scientific experiments. Near Space Corporation has been offering high-altitude flights for government, academic, and commercial customers since 1996. A Spanish startup founded in 2009, Zero 2 Infinity, has taken educational payloads for Israeli high school students to 31 kilometers, and it ultimately hopes to provide tourist flights to the edge of space.

NASA welcomes the new commercial players, with some reservations. "We're excited but also concerned," says engineer Deborah Fairbrother, the balloon program's chief officer on Wallops Island in Virginia. "We've got some very stringent NASA requirements for our safety, and public safety, and we just want to make sure they're doing it safely." World View coordinates all launches with the Federal Aviation Administration to avoid endangering air traffic. And the company says that when punctured, a balloon descends slowly, with plenty of time to release the payload on a steerable parachute. But even veteran programs like NASA's routinely run into snafus. At the agency's most recent launch in April, its balloon began to leak and lose altitude just 3 days into its mission.

Yet Howard, one of the company's most devout evangelists, is confident the kinks can be worked out. After learning about World View, he drove a 4500-kilogram storm-chasing radar to the company's headquarters last September to see whether it could be flown. The company isn't quite up to the job—yet. But Howard predicts that in time the sky will be dotted with balloons.

"I don't doubt that in a very few years, on a clear summer night one will be able to see several stratospheric balloons overhead reflecting moonlight against a background of stars," he says.

Posted in: **Space**, **Technology**
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