# Feature

## What a Well-Dressed Space Traveler Wears

***Anne Burke***

*SpaceX and Boeing recently unveiled models of space suits that their astronauts will wear. A student science writer discusses the designs and how the suits were made.*

SpaceX and Boeing plan to launch commercial crewed vehicles on missions to the International Space Station in the next several years. Both companies recently unveiled the spacesuits that the crews will wear. The two spacesuits are very different in both design and concept. This article will evaluate the two spacesuits, compare them, and draw some conclusions about future of commercial spacesuits that Sci-fi costumers can use for their own designs.

SpaceX, a private company started by Elon Musk, and space veteran Boeing are both a part of NASA's Commercial Crew Program. According to NASA's revised schedule, both companies plan to make crewed test flights in 2019, following uncrewed test flights in late 2018. The crews for these missions were announced in early August, and the companies also unveiled spacesuits that the crews will wear on these flights.

### *Boeing's Bold Blue Suit*

Boeing's new spacesuits that have been designed for commercial crews are very reminiscent of NASA's classic "pumpkin suit," which is formally known as the Advanced Crew Escape Suit (ACES). Astronauts, aboard the Boeing's CST-100 Starliner capsule will wear bright blue suits that are easily recognizable as spacesuits but are much lighter and more form-fitting.

Former NASA astronaut Chris Ferguson tries on the "Boeing Blue" spacesuit. Photo: Boeing.

Like the ACES, Boeing's Starliner Ascent and Entry Suitsuit is only designed for traveling in spacecraft to the space station; it is not created to be worn in the vacuum of space. Astronauts will still use the protective, white suits that are stored aboard the space station for space walks.

Both Boeing's blue suit and NASA's ACES "pumpkin" suit have one thing in common: both were designed and

Advanced Crew Escape Suit (ACES) "pumpkin" worn by shuttle astronauts (1994-2011). Photo: NASA.



*ISSN 2153-9022*

constructed by the David Clark Company, who began developing pressure suits for rocket plane pilots in the 1940s. Since then, they've been responsible for just about every iconic suit worn by a NASA astronaut in the past 50 years.

For years and years pressure suits were either a neoprene coated nylon material or a urethane coated nylon material. Both materials are very effective at sealing air in, however they're very stiff and very warm and uncomfortable. They did not breathe or allow any moisture to pass through. In the late 1980s, Dave Clark was working with advanced "breathable" materials for next-generation suits, like Gore-Tex, which allowed moisture to pass through.

Making AECS "pumpkin" suit. Photos: Dave Clark Co.

Beginning with Apollo 13, four red bands of cloth were added to commanders' extravehicular suits just to distinguish them from other astronauts. Color has been important in the history of pressure suit design – some of David Clark's early pilot suits used a dull gold nomex to minimize distracting reflections in the cockpit

Its more recent ACES Suit was made orange to help search and rescue operations in the event of an over-the-ocean bailout--but the EVA suits remain white for a simple reason. Materials have color based on how they're woven or how they're dyed. In many cases, dying a material may alter its physical properties, such as UV resistance or some of its insulating properties. That remains a consideration for what materials are used.

With the advent of commercial space programs, suit design with brand stylings is a serious consideration, and Boeing's blue suite is a case in point. Dave Clark has been expanded its staff to include textile designers from the fashion side of the industry. As different materials become available, they can change the outward appearance of the spacesuit without impacting the functionality.

Boeing's blue spacesuits are made of material that is more flexible than that used in older spacesuits. Consequently they are more comfortable and provide greater pressurized mobility. The suits are also about 40 percent lighter than NASA's ACES "pumpkin" suit: 20 lbs. (9 kilograms) vs. 30 lbs. (13.6 kg). The materials that are incorporated into the construction of the suits keep astronauts cooler as well.

The suit is composed of two main layers. The inner layer is made of Gore-Tex fabric, which allows water vapor through but keeps air out, acting almost like a balloon. The outer layer is made of super strong Nomex material, which is lightweight and fire retardant – it is the same material used in firefighters' uniforms.

Besides lighter, sleeker construction, Boeing's blue spacesuit has many advanced features, such as touchscreen-friendly, light-weight leather gloves that allow astronauts to interact with the Starliner capsule's tablets.

Gloves enabled for tablets and touch screens. Photo: Boeing.

Other innovations include integrated, zippered boots that are slip resistant and breathable. They were designed in partnership with Reebok athletic shoe company.

Reebok-designed integrated zippered boots. Photo: Boeing.

Zippers installed in the torso area make it easier for the astronauts to comfortably transition between sitting and standing positions.


Waist zipper eases sitting and standing. Photo: Boeing.

The helmet of the suit also has a number of innovations. The shell is soft, with both the helmet and visor incorporated into the suit. ACES and older models had detachable hard helmets. The wide polycarbonate visor gives astronauts better peripheral vision.


Soft helmet zips instead of latching. Photo: Boeing.

The suit also helps connect astronauts to ground and space crews through an advanced communications cap assembly worn within the helmet.


Communications cap worn within helmet. Photo: Boeing.

Vents keep the astronauts cool and enable the suit to pressurize immediately, a key safety feature for the suit to act as the emergency backup to the spacecraft's redundant life-support systems. If all went well, then a spacesuit would not be needed.

Airflow diverter vent keeps astronaut cool. Photo: Boeing.

Features of Boeing's Starliner spacesuit. Photo: Boeing.

There's a lot of science and engineering in a spacesuit, but the stitching on the suit and the layering of fabric is also somewhat of an art. Fabric cannot be engineered the way metal can, so only testing reveals whether it will hold up under the required pressure.

During testing, each suit undergoes double and triple the amount of pressure that they are expected to withstand in space.


Testing suit in simulator. Photo: Boeing.


Helmet folds back when not in use. Photo: Boeing.

Once the suit is considered safe in terms of pressure, next comes mobility tests, where crew members sit in their seats and complete tasks that reveal how easy it is to work in it.

Boeing's blue suit design is much simpler than the older NASA suits. That is a big improvement because complicated systems have more ways they can break, so simple is better on something like this, according to the suit's designers.

It takes between 10 to 15 minutes for an astronaut to put on the suit. That is fast compared to the heavier, more cumbersome suits in the past. This speed is not just for convenience – it is practical, because the suit must be put on quickly in case of an in-flight emergency.

## *SpaceX Sleek White Suit*

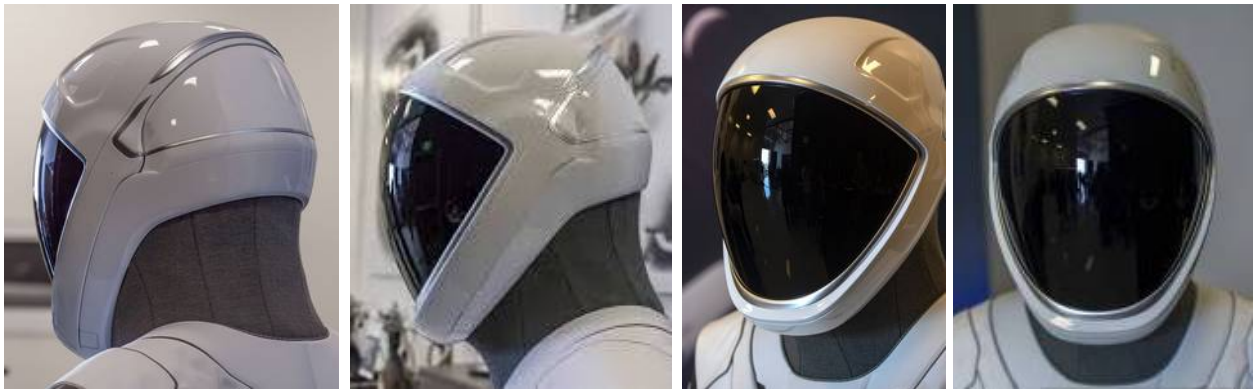
The design that Elon Musk first showed off on Instagram for the SpaceX Crew Dragon spacesuit is striking and unique. Its ultra-modern appearance looks straight out of a science-fiction movie.

In fact, one of the most fascinating aspects of SpaceX's spacesuit is that it was created by Hollywood costume designer Jose Fernandez. Fernandez designed costumes for blockbusters like "Wonder Woman," "Wolverine," "Batman vs. Superman" and "Captain America: Civil War."

The suit is mostly white with black details and it seems almost too slim and aesthetically sleek to be a fully functional spacesuit. But, according to Musk at a news conference in February, "It definitely works. You can just jump in a vacuum chamber with it, and it's fine." But aside from Musk's comments and images supplied by the company, SpaceX has not revealed many of the details or features of its suit.

Certain aspects of the suit will be required for it to function as intended and keep the astronauts safe. For example, NASA's ACES spacesuits feature an emergency breathing system, a liquid cooling system, an automatic inflatable parachute, and emergency food and water supplies. In the event of depressurization, ACES suits are also able to fully pressurize, a feature they share with Boeing's suit.

The images supplied by SpaceX show a spacesuit that appears to be lighter than either the ACES or Boeing's blue suit. The company chose a minimalist approach, while also making it functional. The hard-shell helmet that looks like a futuristic motorcycle helmet is the first item that draws attention, A big part of it was 3D printed, and it has various complex mechanisms to retract the visor and to lock it. Microphones are integrated into the helmet and it is also air cooled. It is evident from the minimalist design that a lot of effort was put into making it look simple and reliable for astronauts.



SpaceX spacesuit 3-D printed, solid-shell helmet. Photos: SpaceX

Futuristic SpaceX suit. Photo: SpaceX

One of the striking features of the suit body is the lack of connectors for power, water, air and so on. These are provided by a single connector on the right thigh. This means that astronauts will only have to connect in the Crew Dragon from a single panel.

To date, SpaceX has not yet released detailed information the suit, including the materials used, or the mechanisms that it uses for cooling or pressurization. It has also not revealed the company manufacturing the suit for SpaceX.

Astronaut in SpaceX Crew Dragon spacesuit in launch position inside spacecraft. Photo: SpaceX.

## *Future Commercial Suit Designs*

One thing seems clear: fashion is here to stay as a part of commercial spacesuit designs. More companies getting into the space business are partnering with fashion designers to create suits that are both functional and aesthetically pleasing.

For example, Virgin Galactic selected Adidas, a sports equipment manufacturer, to design its pilot suits. Adidas formed Y-3, a collaborative effort with Yoji Yamamoto, an acclaimed Japanese fashion designer. Y-3 will also create uniforms and footwear worn by space tourists during suborbital flights.

The fabric of these futuristic outfits consists of Nomex Meta Aramid, which is as impenetrable and resistant as Kevlar, and offers impressive insulation in various extreme conditions (freezing cold, intense heat, fire, radiation etc.) Kevlar is much more rigid, whereas Nomex offers superior flexibility and freedom of movement, while being extremely lightweight. This way, the commercial spaceflight pilot can remain in the cockpit longer without experiencing any discomfort or unpleasantness.

## *References*


"Commercial Crew Astronauts Prepare for Launch – What will They Wear," Space.com

"Examining Boeing's New Starliner Spacesuit," Adam Savage's TESTED.

"Exploring the Aesthetics of NASA's Iconic Space Suit Design," Adam Savage's TESTED.


Prototype Virgin Galactic spacesuit, designed by Adidas and fashion designer Yoji Yamamoto. Photo: Virgin Galactic.


"How to Build a Spacesuit That's Actually (Sort Of) Comfortable," Fast Company.

"Suit Up," Boeing.

"SpaceX gives press exclusive access to Crew Dragon spacesuit and simulator," Teslarati.

"Y3 Is Developing the First Ever Apparel Collection for Space Travel," Hyperbeast.

"Fashion's Space Race: Why The Spacesuit Is A Huge Future Branding Opportunity For Designers," Forbes.



***Anne Burke*** *is a student studying science communications at Columbia College in South Carolina. Her interests include STEM education, and anything space-related. She enjoys writing, and gains experience writing articles for publications.*