

Ergonomics in Space Flight – Past, Present, & Future

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Ergonomics in Spaceflight: Past, Present, & Future

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Abstract

From the days of “The Rocket Men” to the uprising of SpaceX, spaceflight has always inspired awe in humanity. If you examine the men that were apart of those first missions, you will find that they were not only the most capable, but won the genetic lottery to become this nations first astronauts. Looking to the times of Mercury, you see the extreme constraints that potential astronaut candidates had to meet in order to go to space. Aside from the rigorous medical testing, potential candidates also had to meet strict height and weight requirements. Early candidates could not be taller than 5 feet 11 inches and would also not be allowed to weigh more than 180 pounds. Fast forward to the “Shuttle Era” some of these constraints were alleviated, but these changes still did not increase the pool of potential candidates by that much. The most recent requirements listed a height requirement of 5 foot 2 inches to 6 foot 3 inches for Commander and Pilot positions, and requirements being even more lenient for mission specialists. With the rise of the commercial space industry, companies need to be prepared to accommodate a larger range of participants. Whether for research or leisure, space travel will need to be able to accommodate that larger pool of possible participants. To achieve the vision of having equal space travel, we must form the spacecraft to the user, and not vice versa.

Dawn of the Space Age

1.0 Sputnik

The cold war brought a technological revolution the world never saw coming. With the innovation of rocket technology and the world on the brink of nuclear world, tensions were high. In 1955, the white house decided they would begin funding a project to launch an earth orbiting satellite for the International Geophysical Year (IGY). The soviets were prepared and on October 4, 1957 Sputnik I was launched as the worlds first artificial satellite and the space race had begun (Garber, 2007). Before the U.S. had a chance to gets its footing the soviet struck again sending Sputnik II with the first ever space flight participant (SFP), Laika, but this was not your average participant. Laika was a dog and she had a pretty interesting setup within Sputnik II. Laika had just enough room to lie down or stand and the interior was padded. She was fitted with a bag for waster, electrodes for vitals, an air regeneration system to provide oxygen, and plenty of food in gelatinous form and water (Williams, 2015). Unfortunately, there was no capability to return Laika to Earth and it was likely that Laika died soon after due to thermal problems. Sputnik II opened a whole new door by giving scientists data on the behaviors of living organisms in a space environment.

2.0 The Start of Manned Spaceflight

With the door opened to space and major world powers pushing to be the ultimate space entity, the clock was on for the first man in space. Before we know it, the soviets were fast on the trigger once again and on April 12,1961, Yuri Gagarin became the first man in space and the first to orbit. The soviets utilized the Vostok 3KA spacecraft which was 2.4 meters in diameter giving cosmonauts just enough room to unstrap and experience

weightlessness. The only reason why Gagarin was chosen for his mission was due to his small stature. He was 5 feet 2 inches tall and weight 153 pounds meaning he did not need much room to operate at full potential as compared to other candidates (Bland, 2010).

During this time, the United States government was putting together an elite team to be the first men to go to space for the states. Strict specifications were put in place by NASA for the prospective pilots that would be chosen. Besides being subject to extremely invasive and experimental testing and the requirement of extensive military flight experience, the Mercury Seven could be no taller than 5 feet 11 inches and must weigh less than 180 pounds. This would allow the chosen few to squeeze in to the tiny 1.7 cubic meters of space inside the Mercury capsule. That space was made even smaller when you included the 120 controls that would be in place. These specifications were vital to a successful mission because any larger and its possible that the astronaut would not have been able to reach controls or would have been extremely uncomfortable in the vehicle. The seat onboard the Mercury capsule were made to fit the astronaut. Each one of the Mercury Seven were fitted in their spacesuit for a seat that made sure they would have the most comfortable setup possible and that the least amount of space would be compromised. The most important measurements to be considered in a recumbent seat layout are: Seated Height, Midshoulder Height, Bideltoid Breadth, Buttocks to Popliteal Length, Heel to Popliteal Length, and Hip Breadth (Gohmert, 2011). Both programs focused on the one-man concept of spaceflight until the time came to make the next move.

3.0 The Move to Multi-Passenger Flights

With great strides made during the Mercury program, the decision was made to look in to the possibility of launching more than one human on a craft. Just like previous times

the Soviets beat the Americans to the punch but at an extreme cost. In 1964 the Soviets launched Voskhod 1 which was a modified version of the same capsule that took Yuri Gagarin up but it now features spots for three cosmonauts. In order to accommodate the additional passengers, dangerous steps were taken. The ejection seat was removed and the cosmonauts did not wear a spacesuit meaning if a depressurization occurred, all three cosmonauts would die quickly (Bland, 2010). NASA followed soon after with the rise of the Gemini program. This capsule had the capability to carry two astronauts at once but size was still seen as a “precious commodity” with the interior only being 50% larger than the Mercury capsule. With this extra room NASA had the ability to alter their requirements and begin accepting applicants up to 6 feet in height. Next the Apollo program which brought a larger spacecraft and additional occupant. Also with the addition of the lunar module, astronauts had much more room to move around the cabin during the 3-day journey to and from the moon. This came in handy because with long duration spaceflight, restricting the astronauts from moving brings up physical and psychological problems.

Modern Space Era

1.0 More Modern Approach to Space Travel

With end of the space race and eyes set on the development of the International Space Station, NASA began looking in to larger spacecraft designed for reuse. Looking in to these larger spacecraft allowed for a change in the size requirements of astronauts. The size requirement varied to the position taken on by the astronaut. The absolute minimum height is 5 feet and the maximum is 6 feet 4 inches. The weight of each astronaut must be healthy and proportional to their height ranging from 100 pounds to 210 pounds. The most recent requirements listed a height requirement of 5 foot 2 inches to 6 foot 3 inches for

Commander and Pilot positions, and requirements being even more lenient for mission specialists (["Astronaut Requirements," 2015](#)). With the larger Space Shuttle form fitted seats were no longer necessary since there was a plenty of space to simply put regular seats in that would fit your average astronaut. The key thing we recognize from past programs we realize how much space plays a role in the restrictions that are put in place for astronauts. The shuttle era showed us that with more space, different types of people were able to be accommodated but unfortunately the sheer size of the vehicle also made it one of the most expensive to fly and would simply not work when you look at how we would handle spaceflight in the future. Looking to the future we can see signs of plenty of change in the size of vehicles.

2.0 Commercial Space Transportation

The retirement of the Space Shuttle brought questions to what the ideal astronaut would then be. As we learned in the previous space programs, size is integral to the determination of who can exactly ride. In order to maximize the efficiency and minimize the cost for new spacecraft, commercial providers are developing capsules. These capsules are substantially more spacious than the mercury capsule, the newest ones being built to accommodate 7 people, which allows for a range that is pretty consistent to what the Space Shuttle required. The two commercial providers that will be providing service to and from the ISS for American astronauts are SpaceX and Boeing. Both of these capsules were designed with comfort in mind understanding that in this day and age astronauts need space in order to do their job well and with the powerful boosters we have now, we have the ability to make these capsules much more spacious. With all this extra space though, we can not become careless because that's how you put someone in a situation that they

physically can not complete a task. Each and every part of their body needs to meet the specifications whether it be reaching controls or tailoring to a space suit, height and weight will always play a role in selection.

Future of Space Transportation

1.0 Space Tourism

As we look in to the future of spaceflight, we have a lot of preparation to do. Companies are preparing to start launching your everyday person to space for leisure giving people a one of a kind experience and making space travel normal. While this is a great goal for the industry to push for and can change space travel, we need to be aware of the problems. We are simply not at the point to launch just anyone yet. Space suit technology is still way to expensive to fit and tailor suits for people on a 3-hour flight. We also need to look at the effects of allowing, for example, a 280-pound human on a full space craft and its effects on the vehicles center of gravity, how the person fits in to his seat, and of course his suit. The idea of being able to accommodate the extreme dimensions is a great thought but for the time being, restrictions need to be set in order to properly ensure the success of the mission, short or long. Each capsule will always have its own specific dimension requirements but over time that range will continue to increase.

2.0 Looking to The Future

Spaceflight is a constantly evolving industry and we are seeing that it is rapidly becoming a more normal occurrence. Soon we could be seeing point to point travel via spacecraft or long distance spaceflight going beyond the moon. Before we get there we need to understand the vehicle that's going to get us there. Task analyses are going to play

a huge role in determining the type of human that can take part in these journeys and if we wish to see success in our future, this is a must. Going over things from comfort of the seat, accessibility of displays and controls, and the ease of vehicle ingress/egress, are going to give us an idea of how tall and much someone can weigh so that they don't danger themselves or the rest of the crew (Sumaya, 2011). If we continue to tailor the development of spacecraft to the 99th percentile, it will be increasingly difficult to get your average person in space. You can not design a vehicle without knowing the person that will be using it and that's what we need to remember as we move on in this rapid period of change in the industry.

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